SGT UNIVERSITY
SHREE GURU GOBIND SINGH TRICENTENARY UNIVERSITY
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Faculty of Engineering and Technology

Department of Mechanical Engineering

4 Year Full-Time Education Program

Bachelor of Technology (Mechanical Engineering) with specialization in Robotics/ Electric Vehicle/ Computer Science Engineering

With effect from Year 2023

TABLE OF CONTENTS

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1. NATURE AND EXTENT OF THE PROGRAM

B. Tech. in Mechanical Engineering is an undergraduate engineering degree program that focuses on the study of mechanics, energy, and motion. The program is designed to prepare students for a career in the field of mechanical engineering by providing them with the knowledge and skills necessary to design, develop, and maintain machinery and mechanical systems.

The B. Tech. Mechanical Engineering program is typically delivered through a combination of classroom lectures, students interactive sessions, industry expert lectures, seminars, hands-on workshops, live projects, laboratory sessions, and practical training.

The curriculum of the program includes courses in engineering mechanics, thermodynamics, materials science, manufacturing processes, and computer-aided design (CAD). Students also undertake projects and internships to gain hands-on experience in the field of mechanical engineering. Students also opt for minor to expertise him or herself in the booming areas like robotics, electric vehicles and computer science.

Upon completion of the program, graduates can pursue a variety of career paths in the field of mechanical engineering. They can work in industries such as automotive, aerospace, power generation, manufacturing, and robotics. Some common job roles for B. Tech. Mechanical Engineering graduates include design engineer, production engineer, quality control engineer, project engineer, and research and development engineer. They can also pursue higher education and research opportunities in mechanical engineering or related fields.

In conclusion, B. Tech. Mechanical Engineering is an exciting and challenging undergraduate program that offers students a solid foundation in mechanical engineering principles and practical skills. Graduates of this program have a wide range of career opportunities and can make significant contributions to the field of mechanical engineering.

2. PROGRAM EDUCATION OBJECTIVES (PEOs)

After completing B. Tech. Mechanical Engineering, students will be able to:

PEO No.	Education Objective
PEO1	Graduates of the B. Tech. Mechanical Engineering program will demonstrate technical proficiency and expertise in core mechanical engineering principles, enabling them to effectively contribute to the design, analysis, and implementation of mechanical systems and processes.
PEO2	Graduates will be adept at identifying, formulating, and solving complex engineering problems, applying their knowledge of mathematics, science, and engineering principles. They will possess the ability to adapt to changing technological and societal demands, applying critical thinking and innovative approaches to overcome challenges.
PEO3	Graduates will understand the ethical and professional responsibilities associated with the practice of engineering. They will demonstrate integrity, accountability, and a commitment to social, environmental, and economic sustainability in their professional endeavors.
PEO4	Graduates will exhibit leadership qualities and entrepreneurial mindset, enabling them to initiate and manage engineering projects effectively. They will be equipped with the knowledge of business principles and possess the skills to work in diverse professional environments or to establish their own ventures.
PEO5	Graduates will have a strong sense of social awareness and responsibility, recognizing the impact of engineering on society. They will actively contribute to the betterment of their communities through engineering solutions that address societal needs and concerns.

3. GRADUATE ATTRIBUTES

Sl. No.	Attributes	Description
1	Engineering Knowledge	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex mechanical engineering problems
2	Problem Analysis	Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, engineering sciences and mechanical Engineering
3	Design/ Development of Solutions	Design solutions for complex mechanical engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
4	Conduct	Conduct investigations of mechanical engineering complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
5	Modern Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
6	The Engineer and Society	Apply reasoning informed by contextual knowledge to assess societal, health, safety,

		legal and cultural issues and the consequent responsibilities relevant to professional mechanical engineering practice.
7	Environment and Sustainability	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings
10	Communication	Communicate effectively on complex mechanical engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11	Project Management and Finance:	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	Life-long Learning:	Recognize the need for and have the preparation and ability to Engage in independent and life-long learning in the broadest context of technological Change.

4. QUALIFICATION DESCRIPTORS:

The B. Tech. Mechanical Engineering program is designed to provide students with a comprehensive education in the principles and practices of mechanical engineering. The qualification descriptor of the B. Tech. Mechanical Engineering program includes:

1. Knowledge and Understanding: B. Tech. Mechanical Engineering graduates are expected to have a thorough understanding of the fundamental principles, theories, and concepts of mechanical engineering, including engineering mechanics, thermodynamics, materials science, and manufacturing processes.
2. Skills and Abilities: B. Tech. Mechanical Engineering graduates should be able to apply their knowledge and understanding to design, analyze, and optimize mechanical systems and components. They should also have skills in computer-aided design (CAD), computational modeling, and experimental methods.
3. Professionalism and Ethics: B. Tech. Mechanical Engineering graduates should have a clear understanding of the ethical and professional responsibilities of engineers, including the importance of safety, sustainability, and social responsibility.
4. Practical Experience: B. Tech. Mechanical Engineering programs typically include practical training and work experience opportunities, such as internships, co-operative education, or capstone projects. These experiences are designed to provide students with hands-on experience and prepare them for their future careers.
5. Career Opportunities: Graduates of B. Tech. Mechanical Engineering programs can pursue a variety of career paths in industries such as automotive, aerospace, power generation, manufacturing, and robotics. They can work as design engineers, production engineers, quality control engineers, project engineers, and research and development engineers. They can also pursue higher education and research opportunities in mechanical engineering or related fields.

Overall, the B. Tech. Mechanical Engineering qualification descriptor emphasizes the importance of a strong theoretical foundation, practical skills and experience, and ethical and professional conduct. Graduates of B. Tech. Mechanical Engineering programs are well-prepared to pursue a variety of mechanical engineering careers or further education in the field

5. PROGRAM OUTCOME

PO No.	Attribute	Competency
PO1	**Engineering Knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization in mechanical engineering for the solution of complex engineering problems.
PO2	**Problem Analysis**	Identify, formulate, review research literature, and analyze complex mechanical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Problem Analysis**	Design solutions for complex mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tools Usage**	Create, select, and apply proper procedure, resources, and current engineering and mechanical tools including prediction and modeling to complex engineering activities in mechanical engineering with an understanding of the limitations.
PO6	**The Engineer and Society**	Apply reasoning inferred by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**	Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9	**Individual and Team work**	Function effectively as an individual, and as a member or leader in diverse teams, and multidisciplinary settings.
PO10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Lifelong Learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

6. PROGRAM SPECIFIC OUTCOME

PSO No.	Competency
PSO1	Apply viable aptitudes, learning in significant streams, for example, Thermal, Design, Mechatronics, Manufacturing, Robotics, Smart Vehicles, Production and Industrial Engineering.
PSO2	Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
PSO3	Improve team building, teamwork and leadership skills of the students with high regard for ethical values and social responsibilities. Communicate effectively and demonstrate knowledge of project management and independent research.

7. COURSE STRUCTURE

SEMESTER – I

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Engineering Mathematics-I	3	0	0	3	40	60	100
	Programming for Problem-Solving	2	0	0	2	40	60	100
	Engineering Workshop	1	0	0	1	40	60	100
	MGE-I	4	0	0	4	40	60	100
	AECC-I	2	0	0	2	20	30	50
	VAC-I	2	0	0	2	20	30	50
	Design Thinking & Innovation Lab	0	0	4	2	20	30	50
	Programming for Problem-Solving Lab	0	0	4	2	20	30	50
	Engineering Workshop Lab	0	0	4	2	20	30	50
Total		**14**	**0**	**12**	**20**	**260**	**390**	**650**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses

SEMESTER – II

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	T	P	C	IAE	ESE	Total
	Engineering Mathematics-II	3	0	0	3	40	60	100
	Basics of Electrical & Electronics Engineering	2	0	0	2	40	60	100
	Engineering Graphics and Design	1	0	0	1	40	60	100
	MGE-II	4	0	0	4	40	60	100
	AECC-II	2	0	0	2	20	30	50
	VAC-II	2	0	0	2	20	30	50
	New Age Skills	0	0	4	2	20	30	50
	Basics of Electrical & Electronics Engineering Lab	0	0	4	2	20	30	50
	Engineering Graphics and Design Lab	0	0	4	2	20	30	50
Total		**14**	**0**	**12**	**20**	**260**	**390**	**650**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses

SEMESTER – III

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Engineering Mechanics	3	0	0	3	40	60	100
	Engineering Thermodynamics	3	0	0	3	40	60	100
	Program Electives Course - I	3	0	0	3	40	60	100
	MGE-III	4	0	0	4	40	60	100
	AECC-III	2	0	0	2	20	30	50
	VAC-III	2	0	0	2	20	30	50
	SEC-I (SolidWorks)	0	0	4	2	20	30	50
	Engineering Mechanics Lab	0	0	2	1	20	30	50
	Summer Internship	0	0	2	1	20	30	50
	Total	**17**	**0**	**8**	**21**	**260**	**390**	**650**
Minor Degree		**L**	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Minor Elective Course-I	3	0	0	3	40	60	100
	Minor Elective Course-I Lab	0	0	2	1	20	30	50
	Total	**20**	**0**	**10**	**25**	**320**	**480**	**800**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses

SEMESTER – IV

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Strength of Materials	3	0	0	3	40	60	100
	Material Engineering & Technology	3	0	0	3	40	60	100
	Manufacturing Processes	3	0	0	3	40	60	100
	Program Electives Course - II	3	0	0	3	40	60	100
	AECC-IV	2	0	0	2	20	30	50
	VAC-IV	2	0	0	2	20	30	50
	SEC-II (ANSYS)	0	0	4	2	20	30	50
	Strength of Materials Lab	0	0	2	1	20	30	50
	Material Engineering & Technology Lab	0	0	2	1	20	30	50
	Manufacturing Processes Lab	0	0	2	1	20	30	50
Total		**16**	**0**	**10**	**21**	**280**	**520**	**800**
Minor Degree		**L**	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Minor Elective Course-II	3	0	0	3	40	60	100
	Minor Elective Course-II Lab	0	0	2	1	20	30	50
Total		**19**	**0**	**12**	**25**	**340**	**610**	**950**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses

SEMESTER –V

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Kinematics of Machines	3	0	0	3	40	60	100
	Fluid Mechanics	3	0	0	3	40	60	100
	Applied Thermodynamics	3	0	0	3	40	60	100
	Biology for Engineers	3	0	0	3	40	60	100
	Program Electives Course - III	3	0	0	3	40	60	100
	Personality Development & Career Building	2*	0	0	-	-	-	-
	SEC-III (MATLAB)	0	0	4	2	20	30	50
	Kinematics of Machines Lab	0	0	2	1	20	30	50
	Fluid Mechanics Lab	0	0	2	1	20	30	50
	Applied Thermodynamics Lab	0	0	2	1	20	30	50
	Industrial Training - I	0	0	2	1	20	30	50
	Total	**15+2***	**0**	**12**	**21**	**300**	**450**	**750**
Minor Degree		**L**	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Minor Elective Course-III	3	0	0	3	40	60	100
	Minor Elective Course-III Lab	0	0	2	1	20	30	50
	Total	**18+2***	**0**	**14**	**25**	**360**	**540**	**900**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses. '*' means Mandatory course with Non-Credit.

SEMESTER –VI

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Dynamics of Machines	3	0	0	3	40	60	100
	Fluid Machines	3	0	0	3	40	60	100
	Design of Machine Elements	3	0	0	3	40	60	100
	Instrumentation and Control Engineering	3	0	0	3	40	60	100
	Program Electives Course - IV	3	0	0	3	40	60	100
	Quantitative Aptitude & Logical Reasoning	2*	0	0	-	-	-	-
	SEC-IV (Digital Manufacturing)	0	0	4	2	20	30	50
	Dynamics of Machines Lab	0	0	2	1	20	30	50
	Fluid Machines Lab	0	0	2	1	20	30	50
	Design of Machine Elements Lab	0	0	2	1	20	30	50
	Instrumentation and Control Engineering Lab	0	0	2	1	20	30	50
Total		**15+2***	**0**	**12**	**21**	**300**	**450**	**750**
Minor Degree		**L**	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Minor Elective Course-IV	3	0	0	3	40	60	100
	Minor Elective Course-IV Lab	0	0	2	1	20	30	50
Total		**18+2***	**0**	**14**	**25**	**360**	**540**	**900**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses .'*' means Mandatory course with Non-Credit.

SEMESTER –VII

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Industrial Engineering	3	0	0	3	40	60	100
	Heat and Mass Transfer	3	0	0	3	40	60	100
	Automation in Manufacturing	2	0	0	2	40	60	100
	Machine Learning for Mechanical Engineering	1	0	0	1	40	60	100
	Program Electives Course - V	3	0	0	3	40	60	100
	Heat and Mass Transfer Lab	0	0	2	1	20	30	50
	Automation in Manufacturing Lab	0	0	4	2	20	30	50
	Machine Learning for Mechanical Engineering Lab	0	0	4	2	20	30	50
	Industrial Training-II	0	0	2	1	20	30	50
	Capstone Project	0	0	4	2	20	30	50
	Total	**12**	**0**	**16**	**20**	**300**	**450**	**750**
Minor Degree		**L**	**T**	**P**	**C**	**IAE**	**ESE**	**Total**
	Minor Elective Course-V	3	0	0	3	40	60	100
	Minor Elective Course-V Lab	0	0	2	1	20	30	50
	Total	**15**	**0**	**18**	**24**	**360**	**540**	**900**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses.

SEMESTER –VIII

Course Code	Course Title	Credit Distribution (Hours/Week)				Marks Distribution		
		L	T	P	C	IAE	ESE	Total
	Operation Research Techniques	3	0	0	3	40	60	100
	Program Electives Course - VI	3	0	0	3	40	60	100
	Entrepreneurship and Digital Product Management	0	0	4	2	20	30	50
	Research Project/ Dissertation	0	0	24	12	80	120	200
	Total	**06**	**0**	**28**	**20**	**180**	**270**	**450**

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, C: Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination, MGE: Multidisciplinary Generic Electives, AECC: Ability Enhancement Compulsory Courses, VAC: Value Added Courses, SEC: Skill Enhancement Courses.

Multidisciplinary Generic Electives (MGE)
Multidisciplinary Generic Electives is credited and choice-based. The students make a choice from pool of MGE offered by the Faculty under the University. (Reference: University Umbrella Multidisciplinary Generic Electives)

Value Added Courses (VAC)
Value Added Courses is credited and choice-based. The students make a choice from pool of VAC offered by the Faculty under the University. (Reference: University Umbrella Value Added Courses)

Ability Enhancement Compulsory Courses (AECC)
Ability Enhancement Compulsory Courses is credited and choice-based. The students make a choice from pool of AEC offered by the Faculty under the University. (Reference: University Umbrella Ability Enhancement Compulsory Course)

Skill Enhancement Courses (SEC)
Ability Enhancement Compulsory Courses is credited and choice-based. The students make a choice from pool of AEC offered by the Faculty under the University.

Semester III, V & VII

Internship

Semester	Scheme	Duration
Semester III	Summer Internship	4-6 Weeks
Semester V	Industrial Training-I	4-6 Weeks
Semester VII	Industrial Training-II	4-6 Weeks

OVERALL CREDIT DISTRIBUTION TABLE

SEMESTER	HOURS PER WEEK			Total Credit	Marks Distribution		
	L	T	P	TC	IAE	ESE	Total
SEMESTER – I	**14**	**0**	**12**	**20**	**260**	**390**	**650**
SEMESTER – II	**14**	**0**	**12**	**20**	**260**	**390**	**650**
SEMESTER – III	**16**	**0**	**10**	**21**	**260**	**390**	**650**
SEMESTER – IV	**16**	**0**	**10**	**21**	**280**	**520**	**800**
SEMESTER – V	**15+2***	**0**	**12**	**21**	**300**	**450**	**750**
SEMESTER – VI	**15+2***	**0**	**12**	**21**	**300**	**450**	**750**
SEMESTER – VII	**12**	**0**	**16**	**20**	**300**	**450**	**750**
SEMESTER – VIII	**06**	**0**	**28**	**20**	**180**	**270**	**450**
Total	**108+4***	**0**	**112**	**164**	**2140**	**3310**	**5450**

Note – L: Lecture Hour, T: Tutorial Hour, P: Practical Hour, TC: Total Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination.'*': Mandatory course with Non-Credit.

OVERALL CREDIT DISTRIBUTION TABLE WITH MINOR

SEMESTER	HOURS PER WEEK			Total Credit	Marks Distribution		
	L	T	P	TC	IAE	ESE	Total
SEMESTER – I	**14**	**0**	**12**	**20**	**260**	**390**	**650**
SEMESTER – II	**14**	**0**	**12**	**20**	**260**	**390**	**650**
SEMESTER – III	**19**	**0**	**12**	**25**	**320**	**480**	**800**
SEMESTER – IV	**19**	**0**	**12**	**25**	**340**	**610**	**950**
SEMESTER – V	**18+2***	**0**	**14**	**25**	**360**	**540**	**900**
SEMESTER – VI	**18+2***	**0**	**14**	**25**	**360**	**540**	**900**
SEMESTER – VII	**15**	**0**	**18**	**24**	**360**	**540**	**900**
SEMESTER – VIII	**06**	**0**	**28**	**20**	**180**	**270**	**450**

Total	**123+4***	**0**	**122**	**184**	**2440**	**3760**	**6200**

Note – L: Lecture Hour, T: Tutorial Hour, P: Practical Hour, TC: Total Credits, IAE: Internal Assessment Examination, ESE: End Semester Examination.'*': Mandatory course with Non-Credit.

8. SEMESTER-WISE COURSE DETAILS

SEMESTER - I

Course Code	Course Title
	Engineering Mathematics-I
	Programming for Problem-Solving
	Engineering Workshop
	MGE-I
	AECC-I
	VAC-I
	Design Thinking & Innovation Lab
	Programming for Problem-Solving Lab
	Engineering Workshop Lab

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer science and engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	**Engineering Mathematics-I**
Academic Year	I
Semester	I
Number of Credits	3
Course Prerequisite	+2 math
Course Synopsis	To provide the students with sufficient knowledge in calculus and matrix algebra, this can be used in their respective fields.

Course Outcomes:

At the end of the course students will be able to:

CO1	Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of system of linear equation.
CO2	Identify the special properties of a matrix such as the eigen value, eigen vector, employ orthogonal transformations to express the matrix into diagonal form, quadratic form and canonical form.
CO3	Equip themselves familiar with the functions of several variables and mean value theorems.
CO4	Familiarize with special functions to evaluate some proper and improper integrals using beta and gamma functions.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO3**
CO1	3	2	-	-	-	-	-	-	-	-	-	1	1	-	1
CO2	3	2	-	-	-	-	-	-	-	-	-	1	1	-	1
CO3	3	2	-	-	-	-	-	-	-	-	-	1	1	-	1
CO4	3	1	-	-	-	-	-	-	-	-	-	1	1	-	1
Average	3	1.75	-	-	-	-	-	-	-	-	-	1	1	-	1

Course Content:

L (Hours/	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

Week)			
3	**-**	**-**	**3**

Unit	Content and Competency
1	1. Explain Matrices. (C2: Comprehension) 2. Describe vectors: addition and scalar multiplication, matrix multiplication. (C2: Comprehension) 3. Demonstrate Linear systems of equations and Linear Independence. (C3: Application) 4. Identify rank of a matrix, inverse of a matrix, Symmetric, skew-symmetric and orthogonal matrices. (C1: Knowledge) 5. Define Determinants; Eigen values and eigenvectors, eigen bases. (C1: Knowledge) 6. Demonstrate Diagonalization of matrices. (C3: Application) 7.Illustrate Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms. (C3: Application)
2	1. Describe Cramer's Rule. (C2: Comprehension) 2. Implement Gauss elimination and Gauss-Jordan elimination. (C6: Evaluation) 3. Create Gram-Schmidt orthogonalization. (C5: Synthesis)
3	1. Describe Vector Space, linear dependence of vectors, basis, dimension. (C2: Comprehension) 2. Define Linear transformations (maps). (C1: Knowledge) 3. Demonstrate range and kernel of a linear map. (C3: Application) 4. Define rank and nullity. (C1: Knowledge) 5. Explain Inverse of a linear transformation. (C2: Comprehension) 6. Implement rank-nullity theorem. (C6: Evaluation) 7. Describe composition of linear maps. (C2: Comprehension) 8. Identify Matrix associated with a linear map. (C1: Knowledge)
4	1. Describe Laplace Transforms & Inverse Laplace Transforms. (C2: Comprehension) 2. Explain solution based on definition, change of scale property. (C2: Comprehension) 3. Explain 1st & 2nd shifting properties. (C2: Comprehension) 4. Implement LT division by t, LT of derivative, LT by multiplication by t. (C6: Evaluation) 5. Define Convolutions & application on LT & Inverse LT. (C1: Knowledge)

Learning Strategies and Contact Hours

Learning Strategies	Contact Hours
Lecture	32
Practical	
Seminar/Journal Club	2

Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	2
Revision	4
Others If Any:	
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Quiz	Mid Semester Examination 2
Seminars	University Examination
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback			
References:	Textbooks: 1. B. S. Grewal, “Higher Engineering Mathematics”, 44/e, Khanna Publishers, 2017.			

	2. Erwin Kreyszig, “Advanced Engineering Mathematics”, 10/e, John Wiley& Sons, 2011.
	References: 1. N. P. Bali, “Engineering Mathematics”, Lakshmi Publications. 2. George B. Thomas, Maurice D. Weir and Joel Hass, “Thomas Calculus”, 13/e, Pearson Publishers, 2013. 3. H. K. Dass, “Advanced Engineering Mathematics”, S. Chand and complany Pvt. Ltd. 4. Michael Greenberg, “Advanced Engineering Mathematics”, Pearson, Second Edition.

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science and Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	**Programming for Problem Solving**
Academic Year	I
Semester	I
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Understand various computer components.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand various computer components, design flowchart and write program in C programming language.
CO2	Identify and represent numbers in different number system.
CO3	Understand, explain and use different data types and operators to write programs.
CO4	Formulate, evaluate and analyze the problems by applying programming concepts using decision control statements and loop control statements.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PS O4**
CO1	1	1	1	1	-	-	-	-	-	-	-	1	**1**	-	**1**	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-	**1**	-	**1**	-
CO3	-	1	-	1	-	-	-	-	-	-	-	-	**1**	-	**1**	-
CO4	1	2	1	2	2	-	-	-	3	-	1	-	**1**	-	**1**	-
Average	**1**	**1.25**	**0.5**	**1**	**0.5**	-	-	-	**0.75**		**0.5**	**0.5**	**1**		**1**	

Course Content:

L (Hours/ Week)	**T (Hours/Week)**	**P (Hours/Week)**	**CL (Hours/Week)**	**Total Hour/Week**

2	**-**	**-**	**-**	**2**

Unit	Content and Competency
1	1. Explain the Operating System [Unix, Linux, Windows]. (C2: Comprehension) 2. Explain the Programming Environment, and Write & Execute the first program. (C2: Comprehension) 3. Recall the purpose Digital Computer. (C1: Knowledge) 4. Recite the concept of an algorithm, their termination and correctness. (C1: Knowledge) 5. Analyze Algorithms to programs: specification, top-down development and stepwise refinement. (C4: Analysis) 6. Analyze Programming, Use of high level programming language for the systematic development of programs. (C4: Analysis) 7. Design and implementation of correct, efficient and maintainable programs. (C5: Synthesis) 8. Describe number systems and conversion methods. (C2: Comprehension)
2	1. Generalize the concept of Standard I/O in “C”. (C5: Synthesis) 2. Explain the concepts of Data Types: Character types, Integer, short, long, unsigned, single and double-precision floating point. (C2: Comprehension) 3. Define storage classes: automatic, register, static and external. (C2: Comprehension) 4. Analyze the Operators and Expressions: Using numeric and relational operators, mixed operands and type conversion, Logical operators, and Bit operations. (C4: Analysis)
3	1. Explain the concepts of Conditional Program Execution: Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch. (C2: Comprehension) 2. Recall the purpose and importance of Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue. (C1: Knowledge) 3. Describe Modular Programming: Passing arguments by value, scope rules and global variables, separate compilation, and linkage, building your own modules. (C2: Comprehension) 4. Outline the purpose and significance of Arrays: Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size. (C1: Knowledge) 5. Explain the principles of Structures: usage of structures, declaring structures, and assigning of structures. (C2: Comprehension)
4	1. Recall the purpose and basic functions of Pointers to Objects using pointers as function arguments. (C1: Knowledge)

	2. Explain the principles of Dynamic memory allocation. (C2: Comprehension) 3. Generalize the concept of Standard C Preprocessor. (C5: Synthesis) 4. Defining and calling macros. (C2: Comprehension) 5. Explain Standard C Library: Input/Output : fopen, fread, etc, string handling functions, Math functions : log, sin, alike Other Standard C functions. (C2: Comprehension)

Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	20
Practical	
Seminar/Journal Club	1
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	1
Case/Project Based Learning (CBL)	2
Revision	4
Others If any:	
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2
Objective Structured Clinical Examination (OSCE)	University Examination
Objective Structured Practical Examination (OSPE)	Dissertation
Quiz	Multiple Choice Questions (MCQ)
Seminars	Short Answer Questions (SAQ)
Problem Based Learning (PBL)	Long Answer Question (LAQ)
Journal Club	Practical Examination & Viva-voce
	Objective Structured Clinical Examination (OSCE)
	Objective Structured Practical Examination

	(OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz	✓	✓	✓	✓
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Clinical assessment				
Clinical/Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	2. Student's Feedback			

References:	Textbooks: 1. B. S. Grewal "Higher Engineering Mathematics" 44/e, Khanna Publishers, 2017. 2. Erwin Kreyszig "Advanced Engineering Mathematics" 10/e, John Wiley& Sons, 2011.
	References: 1. R.K. Jain and S. R.K.Iyengar "Advanced Engineering Mathematics" 3/e, Alpha Science International Ltd., 2002. 2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas "Calculus" 13/e, Pearson Publishers, 2013

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Engineering Workshop**
Academic Year	I
Semester	I
Number of Credits	1
Course Prerequisite	NIL
Course Synopsis	Engineering Workshop deals with different processes by which components of a machine or equipment are made. The subject aims at imparting knowledge and skill components in the field of basic workshop technology. It deals with different hand and machine tools required for manufacturing simple metal components and articles.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Recall the different manufacturing processes used in the industry for fabricating components with various materials.
CO2	Demonstrate the ability to fabricate components manually.
CO3	Analyze dimensional accuracies and tolerances achievable through different manufacturing processes. Interpret electrical signals.
CO4	Understand electrical and electronics circuits fundamentals and design individual components

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	2	-	3	1	-	-	-	-	-	1	3	2	1
CO2	3	2	2	-	-	1	-	-	-	-	2	3	3	2	-
CO3	3	2		-	-	-	-	-	-	-	1	3	3	2	-
CO4	3	2	3	3	1	-	-	-	-	-	2	3	3	2	1
Average	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
1		**0**	**0**	**1**
Unit	**Content & Competencies**			
1	Introduction to Manufacturing Processes and their Classification (C1, C2) Recall the different manufacturing processes and their classification. (C1) Analyze the classification of manufacturing processes. (C2) Evaluate the significance of manufacturing processes in various industries. (C2) Overview of Manufacturing Processes (C1) Identify the main aspects of manufacturing processes. (C1) Classification of Manufacturing Processes (C2) Classify manufacturing processes based on their characteristics. (C2) Importance of Manufacturing Processes in Various Industries (C2) Assess the significance of manufacturing processes in different industries. (C2) Additive Manufacturing (C2, C3) Recognize the concept of additive manufacturing. (C2) Examine the principles and techniques employed in additive manufacturing. (C3) Evaluate the applications and benefits associated with additive manufacturing. (C3) Industrial Safety: Introduction and Types of Accidents (C1, C2) Recall the fundamental concepts of industrial safety. (C1) Differentiate between various types of accidents. (C2) Understanding Accidents and Their Types (C2) Analyze accidents and their categorization. (C2) Common Causes of Accidents in Industrial Settings (C2) Identify the frequent reasons behind accidents in industrial environments. (C2) Common Sources of Accidents and Safety Methods (C2, C3) Identify common sources of accidents in industrial settings. (C2) Implement safety methods and practices to prevent accidents in the workplace. (C3) Conduct risk assessments and apply hazard control measures. (C3) First Aid in Industrial Settings (C2, C3) Recognize the importance of providing first aid in industrial environments. (C2) Demonstrate knowledge of basic first aid techniques and procedures. (C3) Manage common workplace injuries and emergencies effectively. (C3) Objectives of Layout and Types of Plant Layout (C2, C3) Understand the goals and objectives of layout design. (C2) Differentiate between various types of plant layout, such as process, product, cellular, and fixed position. (C3) Evaluate the advantages and limitations associated with each type of layout. (C3)			
2	Basic Principles of Hot & Cold Working (C1-C3) Recall the basic principles of hot and cold working. (C1)			

	Understand the differences between hot and cold working processes. (C2) Analyze the basic principles of hot and cold working. (C3) Hot & Cold Working Processes (C2-C4) Explain the overview of the rolling process. (C2) Introduce the concept of extrusion. (C2) Understand the fundamentals of forging. (C3) Provide an introduction to the drawing process. (C3) Apply wire drawing techniques. (C4) Explain the overview of the spinning process. (C4) Sheet Metal Operations (C2-C4) Demonstrate measuring, layout marking, and precision techniques. (C2) Apply shearing techniques in sheet metal operations. (C3) Perform punching, blanking, and piercing processes. (C3) Introduce different forming operations. (C3) Apply bending techniques in sheet metal operations. (C4) Describe various joining methods for sheet metal. (C4) Timber: Advantages, Types, and Defects (C1-C2) Recognize the advantages and characteristics of timber. (C1) Classify different types of timber. (C2) Identify common defects in timber and understand their impact. (C2) Carpentry Tools and Metal Classification (C2-C3) Identify essential carpentry tools and explain their uses. (C2) Classify metals based on their properties. (C3) Fitting Tools and Operations (C2-C4) Provide an overview of fitting tools and their applications. (C2) Explain different fitting operations. (C3) Demonstrate techniques for precise fitting. (C4) Glass Cutting (C2-C3) Introduce various glass cutting techniques. (C2) Describe the tools and methods used for glass cutting. (C3)
3	Introduction to Casting Processes (C1-C3) Provide an overview of casting processes. (C1) Understand patterns and their types. (C2) Explain pattern allowances for casting. (C2) Introduce sand casting. (C2) Understand sand properties and constituents. (C3) Explain the preparation of sand molds. (C3) Gating System and Melting of Metal (C2-C3) Explain the basics of the gating system in casting. (C2) Discuss melting techniques for metal casting. (C3) Provide an overview of the cupola furnace. (C3) Casting Defects and Remedies (C2-C4) Identify common casting defects and their causes. (C2) Discuss remedies for casting defects. (C3) Explain quality control in casting processes. (C4) Plastic Molding Techniques (C2-C3) Introduce plastic molding techniques. (C2) Discuss different plastic molding processes. (C3) Metalworking Machines: Lathe, CNC, Shaper, and Planner (C2-C4) Provide an overview of the lathe machine. (C2)

	Explain lathe operations and techniques. (C3) Introduce CNC machining. (C3) Discuss the basics of the shaper and planner machines. (C4) Introduction to Welding (C1-C3) Explain the basics of welding processes. (C1) Classify different welding processes. (C2) Provide an overview of welding equipment and safety measures. (C3) Welding Defects, Remedies, Soldering, and Brazing (C2-C4) Identify common welding defects and their causes. (C2) Discuss remedies for welding defects. (C3) Introduce soldering and brazing techniques. (C4)
4	Electrical Fundamentals (C1-C3) Understand the measurement of voltage, current, frequency, and phase difference. (C2) Perform power and power factor calculations. (C2) Explain single-phase and three-phase supply systems. (C3) Wiring and Circuit Control (C2-C3) Demonstrate the wiring of wire fans and tube lights. (C2) Implement two-way control circuit wiring. (C3) Install MCBs and ELCBs for load circuits. (C3) Electronics Fundamentals (C1-C3) Introduce basic electronic components. (C2) Conduct testing of resistors, inductors, capacitors, and diodes. (C3) Understand the principles of BJTs (Bipolar Junction Transistors). (C3) Testing and Measurement Instruments (C2-C3) Explain the operation and usage of power supplies. (C2) Understand the principles and application of function generators. (C3) Explore the fundamentals of oscilloscope and perform measurements. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	10
Practical	--
Seminar/Journal Club	1
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	1
Others If any:	--
Total Number of Contact Hours	15

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid-Semester Examination 1	✓	✓	✓	✓
Mid-Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Workshop Technology Vol. I & II - Hazra & Chaudhary, Asian Book Comp., New Delhi., Vol-I: ISBN-10: 8185099146, Vol-II: ISBN: 9788185099156. **ii)** Workshop Technology (Manufacturing Process) –S K Garg, Laxmi Publications; Fourth Edition (2018), ISBN-10: 8131806979 **iii)** Principles of Manufacturing Materials and Processes - Campbell, J.S. - McGraw- Hill, NewEdition, ISBN-10: 0070992525

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Design Thinking and Innovation Lab**
Academic Year	I
Semester	I
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Design Thinking and Innovation is a practical course that introduces students to the principles and methodologies of design thinking, a human-centered approach to problem-solving. This course explores the process of identifying and solving complex problems, fostering creativity, and promoting innovation. Through hands-on exercises, projects, and case studies, students will deeply understand design thinking principles and gain practical skills to apply them in various contexts.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply design thinking principles to generate innovative ideas and solutions.
CO2	Differentiate between traditional problem-solving and design thinking approaches.
CO3	Understand the different stages of the design thinking process and apply them in real-world scenarios.
CO4	Create prototypes for complex problems and validate them with the users.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	2	3	3	-	3	3	-	-	-	-	3	1	3	2	`1
CO2	2	3	2	-	-	2	-	-	-	-	2	3	3	2	2
CO3	2	3	2	-	-	3	-	-	-	-	1	3	3	2	2

CO4	2	3	3	3	3	2	-	-	-	-	2	3	3	2	1
Average	2	3	2.5	0.8	1.5	2.5	-	-	-	-	2	2.5	3.0	2.0	1.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**4**	**4**

Sr. No.	Content & Competencies
1	Introduction to Design Thinking (Week 1-2) Understanding the concept of Design Thinking and its significance (C1) Exploring the role of Design Thinking in problem-solving and innovation (C1) Different Stages of Design Thinking (C2) Empathize: Understanding the importance of empathy in the design process (C2) Define: Defining the problem statement and framing the design challenge (C2) Ideate: Generating creative ideas and exploring multiple solutions (C2) Prototype: Building tangible representations of ideas (C2) Test: Iteratively testing and refining prototypes to gather feedback (C2) Problems Solved using Design Thinking (C2-C3) Identifying the types of problems that can benefit from Design Thinking (C2) Analyzing how Design Thinking can be applied across various industries and disciplines (C3) Case Studies and Videos (C3-C4) Reviewing case studies illustrating the application of Design Thinking in real-world scenarios (C3) Watching videos showcasing Design Thinking processes and outcomes (C3)
2	Empathize and Define(Week 3-4) Techniques to Understand and Empathize with Users' Needs (C2) Conducting user interviews and observations (C2) Applying active listening and empathy techniques (C2) Engaging in participatory design activities (C2) Analyzing user feedback and insights (C2) Key Points for Defining the Problem Statement (C3) Understanding the importance of a well-defined problem statement (C3) Identifying the key elements of a problem statement (C3) Focusing on user needs and desired outcomes (C3) Formulating clear and concise problem statements (C3)

	Creating User Personas and Customer Journey Maps (C3) Developing user personas based on research and insights (C3) Mapping the customer journey to understand the user experience (C3) Analyzing pain points and opportunities for improvement (C3) Incorporating personas and journey maps into the design process (C3) Hands-on Activities and Case Studies (C4) Engaging in hands-on activities to apply user-cantered design techniques (C4) Analysing and discussing case studies illustrating successful user-centred design (C4) Collaborating on design challenges and problem-solving exercises (C4) Reflecting on lessons learned and applying insights to real-world scenarios (C4)
3	Ideation(Week 5-6) Methods to Brainstorm Ideas and Approaches (C2) Understanding the importance of brainstorming in the ideation process (C2) Exploring different brainstorming techniques, such as free association, mind mapping, and SCAMPER (C2) Stimulating creativity through techniques like analogies, random word associations, and reverse thinking (C2) Fostering a collaborative and inclusive brainstorming environment (C2) Using Criteria to Select the Best Ideas and Approaches (C3) Defining evaluation criteria based on project goals, user needs, and feasibility (C3) Applying decision matrices or scoring systems to compare and prioritize ideas (C3) Conducting effective group discussions and consensus-building to select the best ideas (C3) Considering the potential impact, viability, and alignment with project constraints (C3) Hands-on Activities and Creativity Techniques (C3) Engaging in hands-on activities, such as design challenges and ideation exercises (C3) Applying creativity techniques like SCAMPER, mind mapping, random stimuli, and role reversal (C3) Stimulating divergent thinking through techniques like brainstorming variations and quantity-focused exercises (C3) Encouraging experimentation and risk-taking to foster creative thinking (C3) Practice Sessions and Case Study Discussions (C4) Participating in practice sessions to apply brainstorming and idea selection techniques (C4) Analyzing and discussing case studies showcasing successful ideation and innovation (C4) Reflecting on lessons learned and applying insights to real-world challenges

	(C4) Collaborating with peers in group activities to share ideas and feedback (C4)
4	Prototype & Test(Week 7-10) Designing a Prototype (C2) Understanding the purpose and benefits of prototyping in the design process (C2) Selecting appropriate prototyping methods based on project goals and constraints (C2) Creating low-fidelity prototypes using paper, cardboard, or digital tools (C2) Developing high-fidelity prototypes using software, 3D printing, or other relevant tools (C2) Approaches to Testing and Validating the Prototype (C3) Defining objectives and research questions for prototype testing (C3) Conducting user testing sessions to gather feedback and insights (C3) Employing methods such as usability testing, A/B testing, and surveys (C3) Iteratively refining and improving the prototype based on user feedback (C3) Hands-on Activities and Design Exercises (C3) Engaging in hands-on activities to create prototypes and iterate designs (C3) Participating in design exercises that simulate real-world challenges (C3) Collaborating with peers to gather feedback and iterate on designs (C3) Applying design principles and user-centered approaches in prototype development (C3) Class Presentation of Prototypes (C4) Preparing a comprehensive presentation of the prototype, design process, and user feedback (C4) Showcasing the functionality, usability, and value of the prototype (C4) Engaging in class discussions and receiving feedback from peers and instructors (C4) Reflecting on the design decisions and lessons learned throughout the prototyping process (C4)
5	Implementation Challenges(Week 11-12) Overcoming Implementation Challenges (C2) Identifying common challenges and barriers when implementing design thinking (C2) Developing strategies to overcome resistance and skepticism (C2) Creating a supportive organizational culture for design thinking adoption (C2) Addressing resource constraints and time limitations (C2) Collaborative Approaches to Implement Design Thinking (C3) Promoting cross-functional collaboration and teamwork (C3) Establishing multidisciplinary design teams for diverse perspectives (C3) Adopting co-creation and participatory approaches (C3)

	Encouraging open communication and knowledge sharing (C3) Evaluation Techniques (C3) Defining evaluation criteria and metrics for design thinking initiatives (C3) Conducting qualitative and quantitative assessments of design thinking outcomes (C3) Using feedback loops and iterative improvement cycles (C3) Incorporating user feedback and stakeholder perspectives in the evaluation process (C3) Case Study Discussion (C4) Analyzing and discussing case studies showcasing successful design thinking implementation (C4) Extracting lessons learned and best practices from real-world examples (C4) Applying insights from case studies to identify opportunities and strategies for implementation (C4) Engaging in group discussions to reflect on challenges and potential solutions (C4)
6	Innovation in Design Thinking (Week 13-14) Identifying Innovation in Design Thinking (C2) Understanding the role of innovation in design thinking processes (C2) Identifying innovative solutions and approaches in real-world design cases (C2) Analyzing design thinking projects for their innovative aspects (C2) Recognizing the impact of innovation on user experiences and business outcomes (C2) Staying Curious and Seeking New Insights and Ideas (C3) Cultivating a mindset of curiosity and openness to new perspectives (C3) Actively seeking diverse sources of inspiration and knowledge (C3) Applying techniques such as active listening, asking questions, and conducting research (C3) Embracing a continuous learning approach to stay updated on emerging trends (C3) Techniques to Enhance Creativity and Overcome Obstacles (C3) Exploring techniques for idea generation, such as brainstorming, mind mapping, and SCAMPER (C3) Overcoming creative blocks and fostering a positive mindset (C3) Embracing experimentation and risk-taking to explore unconventional ideas (C3) Applying problem-solving frameworks to address obstacles and challenges (C3) Assignment Forum Discussion (C4) Engaging in assignment forums to discuss innovation-related topics (C4) Sharing perspectives, insights, and experiences with fellow students (C4) Providing feedback and constructive criticism to peers (C4) Reflecting on and refining ideas through discussions and collaborative learning (C4)

7	Final Project Presentation(Week 15) Presentation of Final Project (C4) Preparing a comprehensive presentation of the final design thinking project (C4) Demonstrating the design process, key insights, and solutions (C4) Showcasing the impact and value of the project for users and stakeholders (C4) Engaging the audience through effective storytelling and visual aids (C4) Collecting Feedback and Evaluation Techniques (C4) Implementing techniques to collect constructive feedback on the project (C4) Conducting peer reviews and evaluations to gather diverse perspectives (C4) Incorporating feedback to refine and improve the project (C4) Using evaluation criteria to assess the effectiveness of the project (C4) Final Course Evaluation (C3) Reflecting on the learning outcomes and achievements of the entire course (C3) Assessing personal growth and development in design thinking skills (C3) Identifying strengths, areas for improvement, and future learning goals (C3) Providing an overall evaluation of the course structure, content, and delivery (C3) Final Course Feedback Form (C2) Engaging in a structured feedback process to provide input on the course (C2) Sharing suggestions, comments, and recommendations for improvement (C2) Offering insights on the effectiveness of the course materials and learning activities (C2) Contributing to the continuous improvement of the design thinking program (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	15
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	15

Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.

<table>
<tr><td colspan="2">2. Feedback between the semester through google forms.
Course Exit Survey will be taken at the end of the semester.</td></tr>
<tr><td>References:</td><td>(List of reference books)</td></tr>
<tr><td></td><td>i) Innovation By Design by Chakravarthy, Battula Kalyana, and Janaki Krishnamoorthy, Springer India, 2013, ISBN 978-81-322-0901-0
ii) Innovation by Design: How Any Organization Can Leverage Design Thinking to Produce Change, Drive New Ideas, and Deliver Meaningful Solutions by Thomas Lockwood, New Page Books, US; 1st edition (28 November 2017), ISBN: 1632651165.
iii) Innovation by Design by Gerard Gaynor, Amacom, A Division of American Management Associ135 West 50th Street New York, NY, United States, ISBN:978-0-8144-0696-0</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Programming for Problem Solving Lab**
Academic Year	I
Semester	I
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Understand various computer components.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand various computer components, design flowchart and write program in C programming language.
CO2	Identify and represent numbers in different number system.
CO3	Understand, explain and use different data types and operators to write programs.
CO4	Formulate, evaluate and analyze the problems by applying programming concepts using decision control statements and loop control statements.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	1	2	-	3	1	-	-	-	-	-	1	3	2	1
CO2	3	2	2	-	-	1	-	-	-	-	2	3	3	2	-
CO3	3	2		-	-	-	-	-	-	-	1	3	3	2	-
CO4	3	2	3	3	1	-	-	-	-	-	2	3	3	2	1
Average	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Content & Competencies		
Sr. No.	**Title**	
1	a) Write a C program to find sum and average of three numbers. (C1: Knowledge) b) Write a C program to find the sum of individual digits of a given positive integer. (C1: Knowledge)	
2	a) Write a C program to generate the first n terms of the Fibonacci sequence. (C1: Knowledge) b) Write a C program to generate prime numbers from 1 to n. (C1: Knowledge) c) Write a C program to check whether given number is Armstrong Number or not. (C1: Knowledge)	
3	a) Write a C program to check whether given number is perfect number or not. (C1: Knowledge) b) Write a C program to check whether given number is strong number or not. (C1: Knowledge)	
4	a) Write a C program to find the roots of a quadratic equation. (C1: Knowledge) b) Write a C program to perform arithmetic operations using switch statement. (C1: Knowledge)	
5	a) Write a C program to find factorial of a given integer using non-recursive function. (C1: Knowledge) b) Write a C program to find factorial of a given integer using recursive function. (C1: Knowledge)	
6	a) Write C program to find GCD of two integers by using recursive function. b) Write C program to find GCD of two integers using non-recursive function.	
7	a) Write a C program to find both the largest and smallest number in a list of integers. (C1: Knowledge) b) Write a C program to Sort the Array in an Ascending Order. (C1: Knowledge) c) Write a C program to find whether given matrix is symmetric or not. (C1: Knowledge)	
8	a) Write a C program to perform addition of two matrices. (C1: Knowledge) b) Write a C program that uses functions to perform multiplication of two Matrices. (C1: Knowledge)	
9	a) Write a C program to use function to insert a sub-string in to given main string from a given position. (C1: Knowledge) b) Write a C program that uses functions to delete n Characters from a given position in a given string. (C1: Knowledge)	
10	a) Write C program to count the number of lines, words and characters in a given text. (C1: Knowledge) b) Write a C program to find the sum of integer array elements using pointers. (C1:	

	Knowledge)
11	a) Write a C program to Calculate Total and Percentage marks of a student using structure. (C1: Knowledge)
Note:	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**

Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	Textbooks: 1. B. S. Grewal "Higher Engineering Mathematics" 44/e, Khanna Publishers, 2017. 2. Erwin Kreyszig "Advanced Engineering Mathematics" 10/e, John Wiley& Sons, 2011.
	References: 1. R.K. Jain and S. R.K. Iyengar "Advanced Engineering Mathematics" 3/e, Alpha Science International Ltd., 2002. 2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas "Calculus" 13/e, Pearson Publishers, 2013

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Engineering Workshop Lab**
Academic Year	I
Semester	I
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Engineering Workshop deals with different processes by which components of a machine or equipment are made. The subject aims at imparting knowledge and skill components in the field of basic workshop technology. It deals with different hand and machine tools required for manufacturing simple metal components and articles.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Recall the different manufacturing processes commonly used in the industry to fabricate components with various materials.
CO2	Demonstrate hands-on fabrication of components.
CO3	Analyze dimensional accuracies, tolerances, and electrical signals associated with different manufacturing processes.
CO4	Understand the basics of electrical and electronics circuits and design custom components.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	-	3	1	-	-	-	-	-	1	3	2	1
CO2	3	2	2	-	-	1	-	-	-	-	2	3	3	2	-
CO3	3	2		-	-	-	-	-	-	-	1	3	3	2	-

CO4	3	2	3	3	1	-	-	-	-	-	2	3	3	2	1
Average	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Sr. No.	**Content & Competencies**
1	To study different types of measuring tools used in metrology and determine the least counts of vernier callipers, micrometers and vernier height gauges. (C1-C4)
2	To prepare a job on a lathe involving facing, outside turning, taper turning, step turning, radius making and parting-off. (C1-C6)
3	To study different types of fitting tools and marking tools used in fitting practice. (C1-C3)
4	To prepare a layout on a metal sheet by making and prepare rectangular tray pipe-shaped components e.g., funnel. (C1-C6)
5	To prepare joints for welding suitable for butt welding and lap welding. (C1, C2, C3, C6)
6	To study various types of carpentry tools and prepare simple types of at least two wooden joints. (C1-C4, C6)
7	Measurement of voltage and current by multimeter and performing testing of various components. (C1-C4)
8	To study cathode ray oscilloscope and perform measurements for a different signal. (C1-C4)
9	To study 1) Safety precaution. 2) Electrical safety devices & protection like MCB, ELCB and Fuse. (C1-C3)
10	To prepare of wiring diagram 1) Ceiling fan and Tube light 2) Two-way control switch. (C1-C3)
11	To study the breadboard and PCB connection for Electronics circuit (C1-C3,

	C6)
12	To study soldering and de-soldering techniques for Electronics circuits. (C1-C3)
13	To study different case studies using Arduino. (C1-C4)
Note:	1. At least ten experiments/ jobs are to be performed/ prepared by students in the semester. 2. At least 8 experiments/ jobs should be performed/prepared from the above list; the remaining two may either be performed/prepared from the above list or designed and set as per the scope of the syllabus of the Engineering Workshop.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--

Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
	i) Workshop Technology Vol. I & II - Hazra & Chaudhary, Asian Book Comp., New Delhi., Vol-I: ISBN-10: 8185099146, Vol-II: ISBN: 9788185099156. **ii)** Workshop Technology (Manufacturing Process) –S K Garg, Laxmi Publications; Fourth Edition (2018), ISBN-10: 8131806979. **iii)** Principles of Manufacturing Materials and Processes - Campbell, J.S. - McGraw- Hill, New Edition, ISBN-10: 0070992525

SEMESTER - II

Course Code	Course Title
	Engineering Mathematics-II
	Basics of Electrical & Electronics Engineering
	Engineering Graphics and Design
	MGE-II
	AECC-II
	VAC-II
	New Age Skills Lab
	Basics of Electrical & Electronics Engineering Lab
	Engineering Graphics and Design Lab

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	**Engineering Mathematics-II**
Academic Year	I
Semester	II
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	Create and analyze mathematical models using first and higher order differential equations to solve application problems such as electrical circuits, orthogonal trajectories and Newton's law of cooling and also familiarize the student in various topics in numerical analysis such as interpolation, numerical differentiation, integration and direct methods for solving linear system of equations.

Course Outcomes:

At the end of the course students will be able to:

CO1	Demonstrate solutions to first order differential equations by various methods and solve basic application problem related to electrical circuits, orthogonal trajectory and Newton's law of cooling.
CO2	Discriminate among the structure and procedure of solving a higher order differential equations with constant coefficients and variable coefficients
CO3	Apply various numerical methods to solve linear and non-linear equations
CO4	Familiar with numerical integration and differentiation

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PS O4**
CO1	3	2	1	2	-	-	-	-	-	-	-	1	1	1	1	-
CO2	3	3	1	2	-	-	-	-	-	-	-	1	1	1	1	-
CO3	3	3	1	2	-	-	-	-	-	-	-	1	1	1	1	-
CO4	3	2	1	2	-	-	-	-	-	-	-	1	1	-	1	-

Average	**3**	**1.75**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**0.75**	**1**	**-**

Course Content:

L (Hours/ Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**-**	**-**	**3**

Unit	Content and Competency
1	1. Define Linear differential equations with constant coefficients: Solutions of second and higher order differential equations; Inverse differential operator method. (C1: Knowledge) 2. Explain method of undetermined coefficients and method of variation of parameters. (C2: Comprehension)
2	1. Describe Linear differential equations with variable coefficients: Solution of Cauchy's and Legendre's linear differential equations. (C2: Comprehension) 2. Define Nonlinear differential equations - Equations solvable for p, equations solvable for y, equations solvable for x, general and singular solutions. (C1: Knowledge) 3. Implement Clairauit's equations and equations reducible to Clairauit's form. (C6: Evaluation)
3	1. Describe Partial Differential equations: Formulation of Partial differential equations by elimination of arbitrary constants/functions. (C2: Comprehension) 2. Solution of non-homogeneous Partial differential equations by direct integration. (C6: Evaluation) 3. Solution of homogeneous Partial differential equations involving derivative with respect to one independent variable only. (C6: Evaluation) 4. Derivation of one dimensional heat and wave equations and their solutions by variable separable method. (C6: Evaluation)
4	1. Explain Double and triple integrals: Evaluation of double and triple integrals. (C2: Comprehension) 2. Evaluation of double integrals by changing the order of integration and by changing into polar co-ordinates. (C6: Evaluation) 3. Application of double and triple integrals to find area and volume. (C3: Application) 4. Describe Beta and Gamma functions: definitions, Relation between beta and gamma functions and simple problems. (C2: Comprehension)

Teaching Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	32
Practical	
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	2
Revision	4
Others If any:	
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Quiz	Mid Semester Examination 2
Seminars	University Examination
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓

Mid Semester Examination 2		✓	✓	✓	✓
University Examination		✓	✓	✓	✓
Feedback Process		1. Student’s Feedback			
References:	Textbooks: 1. B. S. Grewal “Higher Engineering Mathematics” 44/e, Khanna Publishers, 2017. 2. Erwin Kreyszig “Advanced Engineering Mathematics” 10/e, John Wiley& Sons, 2011.				
	References: 1. R.K. Jain and S. R.K. Iyengar “Advanced Engineering Mathematics” 3/e, Alpha Science International Ltd., 2002. 2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas “Calculus” 13/e, Pearson Publishers, 2013				

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer science and engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	Basics of Electrical and Electronics Engineering
Academic Year	I
Semester	I
Number of Credits	2
Course Prerequisite	Basic aspects of electrical engineering.
Course Synopsis	This course gives idea about basic circuit solution methods, introduction to electrical machines and basics of domestic electrical installations

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand & apply Kirchoff's laws, network theorems, time domain analysis for RL & RC series circuit.
CO2	Understand and analyze phase diagram and waveforms for purely resistive, purely inductive and purely capacitive as well as series and parallel R-L, R-C & R-L-C circuits and also circuit Resonance.
CO3	Understand concepts of Real, Reactive & apparent power and Power factor. Understand 3- phase supply and star and delta connection and their relationships.
CO4	Understand about types of batteries & its important Characteristics. Understand basic calculations for energy consumption & power factor improvement.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	1	-	-	1	-	-	-	-	-	-	2	-	-	-	-
CO2	3	1	-	-	1	-	-	-	-	-	-	2	-	1	1	-
CO3	3	1	-	-	1	-	-	-	-	-	-	2	-	-	1	-

CO4	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**-**
Average	**1.75**	**-**	**1**	**-**	**-**	**0.75**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**0.25**	**0.5**	**-**

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	CL (Hours/Week)	Total Hour/Week
2	**0**	**0**	**2**	**2**

Unit	Content	Competency
1	1. Explain Circuit Analysis: Ohm's Law, KCL, KVL Mesh and Nodal Analysis. (C2: Comprehension) 2. Define Circuit parameters, energy storage aspects. (C1: Knowledge) 3. Implement Superposition Theorem and Thevenin’s Theorem, 4. Implement Norton's, Reciprocity, Maximum Power Transfer Theorem, and Describe Millman's Theorem. (C2: Comprehension) 5. Define Star-Delta Transformation. (C1: Knowledge) 6. Application of theorem to the Analysis of D.C. circuits. (C3: Application)	
2	1. Explain A.C. Circuits: R-L, R-C, R-L-C circuits (series and parallel), Time Constant. (C2: Comprehension) 2. Describe Phase representation.(C2: Comprehension) 3. Implement Response of RL, R-C and R-L-C circuit to sinusoidal input Resonance-series and parallel R-L-C Circuits. (C6: Evaluation) 4. Explain Q-factor. (C2: Comprehension) 5. Explain Bandwidth. (C2: Comprehension) 6. Describe Cathode Ray Oscilloscope: Basic CRO circuit (Block Diagram), (C2: Comprehension) 7. Describe Cathode ray tube (CRT) & its component. (C2: Comprehension)	
3	1. Explain Semiconductor Physics: Basic concepts.(C2: Comprehension) 2. Differentiate Intrinsic and extrinsic semiconductors.(C2: Comprehension) 3. Differentiate diffusion and drift currents. (C2: Comprehension) 4. Implement P-N junction diode: Ideal diode, P-N junction under open-circuit and closed-circuit. (C6: Evaluation)	

	5. Describe Diode Current Equation. (C2: Comprehension) 6. Describe Diode Resistance. (C2: Comprehension) 7. Demonstrate Transition and Diffusion Capacitance. (C3: Application) 8. Define Effect of Temperature. (C1: Knowledge) 9. Define Carrier Life Time. (C1: Knowledge) 10. Demonstrate Continuity Equation. (C3: Application) 11. Explain Special Diodes: Zener Diode, Photodiode, Light Emitting Diodes, applications of Diodes. (C2: Comprehension)
4	1. Explain Digital Electronics: Boolean algebra. (C2: Comprehension) 2. Implement Truth tables of logic gates (AND, OR, NOT), NAND, NOR as universal gates. (C6: Evaluation) 3. Define Bipolar junction transistor. (C1: Knowledge) 4. Describe transistors: construction, transistor operations, BJT characteristics, load line, operating point, leakage currents. (C2: Comprehension) 5. Application of BJT: CB, CE configurations. (C3: Application) 6. Introduction to FETs and MOSFETs. (C1: Knowledge)

Teaching Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	20
Practical	
Seminar/Journal Club	1
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	1
Revision	4
Others If any:	
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**

Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Quiz	Mid Semester Examination 2
Seminars	University Examination
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	Student's Feedback			

References:	Textbooks: 1. Fundamentals of Electrical Circuits by Charles k.Alexander, Mattew N.O. Saidiku, Tata McGraw Hill company. 2. V.N. Mittle "Basic Electrical Engineering", Tata McGraw Hill Edition, New Delhi, 1990. 3. Electrical Technology by Surinder Pal Bali, Pearson Publications. 4. R.S. Sedha, "Applied Electronics" S. Chand & Co., 2006. 5. Electronic Devices and Circuits, R.L. Boylestad and Louis Nashelsky, 9th edition, PEI/PHI 2006.
	References: 1. Fundamentals of Electrical Engineering by Rajendra Prasad, PHI Publications, 2nd edition 2. Muthusubramanian R, Salivahanan S and Muraleedharan K A, "Basic Electrical, Electronics, and Computer Engineering", Tata McGraw Hill, Second

	Edition, (2006). 3. Industrial Electronics by G.K. Mittal, PHI 4. Nagsarkar T K and Sukhija MS, “Basics of Electrical Engineering”, Oxford Press (2005).

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Engineering Graphics and Design**
Academic Year	I
Semester	II
Number of Credits	1
Course Prerequisite	NIL
Course Synopsis	Engineering Graphics and Design is considered the language of engineers. This course is introduced to provide basic understanding of the importance of designing aspects in engineering applications. The topics are covered in a sequence and start from the basic concepts of introduction to computer-aided design and then designing of planes and solids. Towards the end of the course, it is expected that students would be matured to visualize the engineering components from any drawing sheet, followed by the projection techniques. A number of chosen problems will be solved to illustrate the concepts clearly.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the utilization of drawing instruments and the process of dimensioning given drawings.
CO2	Acquire skills in visualization and become proficient in employing projection methods.
CO3	Demonstrate the ability to create various views by employing line, plane, and solid projections.
CO4	Utilize edges, vertices, and curves to construct accurate and detailed drawings

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	-	1	0	3	-	-	-	-	2	-	-	3	2	1

CO2	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO3	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO4	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
Average	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1

Course Content:

L **(Hours/Week)**	**T** **(Hours/Week)**	**P** **(Hours/Week)**	**Total Hour/Week**
1	**0**	**0**	**1**

Unit	**Content & Competencies**
1	Importance of Engineering Graphics and Drawing (C1) Understand the significance of engineering graphics and drawing in engineering disciplines. (C1) Explore the applications and benefits of engineering drawings. (C1) Introduction to Drawing Instruments (C1-C2) Provide an overview of essential drawing instruments. (C1) Familiarize with drawing tools and their functions. (C2) Types of Lines (C1-C2) Differentiate between various types of lines used in engineering drawing. (C1) Understand line conventions and their significance. (C2) Dimensioning and Lettering (C2-C3) Explain the principles and practices of dimensioning in engineering drawings. (C2) Demonstrate techniques for clear and accurate lettering. (C3) Types of Projections (C2-C3) Introduce different types of projections, including orthographic, isometric, and perspective. (C2) Understand the purpose and applications of each projection type. (C3) Theory of Orthographic Projections (C3) Explain the principles and fundamentals of orthographic projections. (C3) Explore the relationship between object and image in orthographic projection. (C3) First Angle and Third Angle Projections (C3) Understand the differences between first angle and third angle projections. (C3) Explain the application and usage of each projection method. (C3) Projection of Points (C3) Demonstrate techniques for projecting points in orthographic drawings. (C3) Understand how points are represented in different views. (C3)
2	Projection of Lines (C2-C4) Understand lines that are parallel to one or both planes. (C2) Determine the projection of lines that are contained by one or both planes. (C3)

	Project lines that are perpendicular to a plane. (C3) Handle lines that are inclined to one plane and parallel to the other. (C4) Project lines that are inclined to both planes. (C4) Determine the true length of a line and its inclinations to the reference planes. (C4) Identify the traces of a line. (C3) Introduction to Types of Planes (C1) Provide an overview of the different types of planes used in engineering drawing. (C1) Projection of Planes by Change of Position Method (C2-C4) Project a plane that is perpendicular to another plane. (C2) Project a plane that has an axis parallel to both planes. (C3) Project a plane that has an axis parallel to one plane and inclined to the other plane. (C4)
3	Types of Solids (C1) Provide an overview of different types of solids in solid geometry. (C1) Polyhedrons and Solids of Revolution (C2) Understand polyhedrons and their properties. (C2) Introduce solids of revolution. (C2) Projection of Solids (C2-C4) Project solids with axes perpendicular to a plane. (C3) Project solids with axes parallel to both planes. (C4) Project solids with axes parallel to one plane and inclined to the other plane. (C4) Surface Development of Simple Solids (C3-C4) Develop the surface of cubes. (C3) Develop the surface of cylinders. (C4) Develop the surface of prisms. (C4) Develop the surface of pyramids. (C4) Develop the surface of other simple solids. (C4)
4	Principle of Projection (C2) Understand the principle of projection in engineering graphics. (C2) Explore the basics of how objects are projected onto planes. (C2) Principal Planes of Projection (C2-C3) Introduce the principal planes of projection. (C2) Understand the relationship between the principal planes. (C2) Apply techniques for selecting the appropriate views from the principal planes. (C3) Projections from Pictorial Views (C3) Perform projections from the front view using first angle projection. (C3) Perform projections from the top view using first angle projection. (C3) Perform projections from the side view using first angle projection. (C3) Perform projections from the front view using third angle projection. (C3) Perform projections from the top view using third angle projection. (C3)

	Perform projections from the side view using third angle projection. (C3) Full Sectional View (C3) Create a full sectional view of an object. (C3) Understand the purpose and applications of sectional views. (C3) Isometric Scale and Projection (C3-C4) Introduce the isometric scale. (C3) Convert orthographic views into an isometric projection. (C4) Create an isometric view or drawing. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	10
Practical	--
Seminar/Journal Club	1
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	1
Others If any:	--
Total Number of Contact Hours	15

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid-Semester Examination 1	✓	✓	✓	✓
Mid-Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
	i) Bhatt, N. D. (2019). Engineering Drawing: Plane and Solid Geometry: [in First Angle Projection Method]. India: Charotar Publishing House Pvt. Limited. ISBN: 9789380358963, 9380358962. **ii)** Dhananjay A. Jolhe (2008), "Engineering Drawing", Tata McGraw Hill Publishers. ISBN: 9780070648371, 0070648379. **iii)** JOHN, K. C. (2009). Engineering Graphics for Degree. India: PHI Learning, ISBN: 9788120337886, 8120337883.

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**New Age Skill Lab**
Academic Year	I
Semester	II
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Knowledge of MS Word, MS Excel, MS PowerPoint, and MS Access.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the concept of MS Word.
CO2	Understand the concept of MS Excel.
CO3	Understand the concept of MS PowerPoint.
CO4	Understand the concept of MS Access.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	0	3	-	-	-	-	2	1	1	3	2	1
CO2	2	1	1	1	3	-	-	-	-	2	1	1	3	2	1
CO3	2	1	1	1	3	-	-	-	-	2	1	1	3	2	1
CO4	2	1	1	1	3	-	-	-	-	2	1	1	3	2	1
Average	2	1	1	0.75	3	-	-	-	-	2	1	1	3.0	2.0	1

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**4**	**4**

Content & Competencies

Unit	Content	
1	Create a news-paper document with at least 200 words using MS Word, (C5: Synthesis)	

	a. Use margins as, top: 1.5, bottom: 2, left: 2, right: 1 inch. b. Use heading “Gandhi Jayanti”, font size: 16, font color: red, font face: Arial Black. c. With first letter “dropped” (use drop cap option) of the first paragraph containing a picture at the right side d. Use three columns from the second paragraph onwards till the half of the page. e. Then use heading “Computer basics”
2	Create a Mathematical question paper using MS Word, at least five equations (C5: Synthesis) a. With fractions, exponents, summation function b. With at least one m*n matrix c. Basic mathematical and geometric operators. d. Use proper text formatting, page color and page border.
3	Create a flowchart using MS Word, (C5: Synthesis) a. Proper shapes like ellipse, arrows, rectangle, and parallelogram. b. Use grouping to group all the parts of the flowchart into one single object
4	Create a table using table menu with word, (C5: Synthesis) a. At least 5 columns and 10 rows. b. Merge the first row into one cell. c. Merge the second row into one cell, then split the second row into three cells
5	Create a table using MS excel “Student result” with following conditions. a. The heading must contain, Sl. No., Name, Mark1, Mark2, Mark3, Total, average and result with manual entry. (C5: Synthesis) b. Use formulas for total and average. c. Find the name of the students who has secured the highest and lowest marks. d. Round the average to the nearest highest integer and lowest integer (use ceiling and floor function respectively).
6	Do as directed using MS excel (C5: Synthesis) a. Create a notepad file as per the following fields Sl no name th1 th2 th3 th4 th5 total % grade b. Import this notepad file into excel sheet using „data◊from text‟ option. c. Grade is calculated as, i. If %>=90, then grade A ii. If %>=80 and =70 and =60 and
7	Create a power-point presentation with minimum 5 slides. a. The first slide must contain the topic of the presentation and name of the presentation. (C5: Synthesis) b. Must contain at least one table. c. Must contain at least 5 bullets, 5 numbers. d. The heading must be, font size: 32, font-face: Arial Rounded MT Bold, font-color: blue. e. The body must be, font size: 24, font-face: Comic Sans MS, font-color: green. f. Last slide must contain „thank you‟
8	Create a power-point presentation with minimum 10 slides 24 (C5: Synthesis) a. Use word art to write the heading for each slides. b. Insert at least one clip-art, one picture c. Insert at least one audio and one video

	d. Hide at least two slides
9	Create a power-point presentation with minimum 5 slides a. Use custom animation option to animate the text; the text must move left to right one line at a time. (C5: Synthesis) b. Use proper transition for the slides.
10	Create a database using MS Access "Student" with, (C5: Synthesis) a. At least one table named "mark sheet" with field name "student name, roll number, mark1, mark2, mark3, mark4, total" b. The data types are, student name: text, roll number: number, mark1 to mark4: number, total: number. Roll number must be the primary key. c. Enter data in the table. The total must be calculated using update query. d. Use query for sorting the table according to the descending/ascending order of the total marks
11	With addition to the table above, (C5: Synthesis) a. Add an additional field "result" to the "mark sheet" table. b. Enter data for at least 10 students c. Calculate the result for all the students using update queries, if total>=200, then pass, else fail. d. Search the students, whose name starts with "sh". e. Show the names and total marks of the students who have passed the examination.
Note:	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--

Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
References:	1. Microsoft Word, Excel, and PowerPoint: Just for Beginners, 2015 2. Microsoft Excel Formulas & Functions For Dummies, 5ed, 2020.

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Basics of Electrical and Electronics Engineering Lab**
Academic Year	I
Semester	II
Number of Credits	2
Course Prerequisite	+2 Physics
Course Synopsis	To design electrical systems. To analyze a given network by applying various network theorems. To know the response of electrical circuits for different excitations. To study various electrical measuring instruments and transducers. To summarize the performance characteristics of electrical machines

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the basic concepts and terminology of electrical quantities
CO2	Analyze the DC circuit using various network theorems
CO3	Understand the response of different types of electrical circuits to different excitations
CO4	Understand the measurement, calculation and relation between the basic electrical parameter.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	2	-	1	0	3	-	-	-	-	2	-	-	3	2	1
CO2	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO3	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO4	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
Average	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Content & Competencies	
Unit	**Title**
1	Familiarization of electrical Elements, sources, measuring devices and transducers related to electrical circuits. (C1: Knowledge)
2	Verification of KVL and KCL. (C6: Evaluation)
3	Verification of Thevenin’s and Norton’s theorems. (C6: Evaluation)
4	Verification of superposition theorem. (C6: Evaluation)
5	Verification of maximum power transfer theorem. (C6: Evaluation)
6	Calculations and Verification of Impedance and Current of RL, RC and RLC series circuits. (C6: Evaluation)
7	Verification of relation between phase and line quantities in a 3-phase balanced star and delta connected systems. (C6: Evaluation)
8	Measurement of Active and Reactive Power in a balanced Three-phase circuit. (C6: Evaluation)
9	Torque-Speed Characteristics of a Separately/Self Excited DC Shunt/Compound Motor. (C1: Knowledge)
10	Load test on single phase transformer. (C1: Knowledge)
11	Demonstration of measurement of electrical quantities in DC and AC systems. (C6: Evaluation)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
References:	Electrical and electronics engineering, person publication 2017

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Engineering Graphics and Design Lab**
Academic Year	I
Semester	II
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	Engineering Graphics and Design is considered the language of engineers. This course is introduced to provide basic understanding of the importance of designing aspects in engineering applications. The topics are covered in a sequence and start from the basic concepts of introduction to computer-aided design and then designing of planes and solids. Towards the end of the course, it is expected that students would be matured to visualize the engineering components from any drawing sheet, followed by the projection techniques. A number of chosen problems will be solved to illustrate the concepts clearly.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the use of drawing instruments and dimensioning of given drawings.
CO2	Acquire visualization skills and use of projection methods.
CO3	Able to draw different views using projection of lines, planes and solids.
CO4	Use of edges, vertices and curves to construct the drawing.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	-	1	0	3	-	-	-	-	2	-	-	3	2	1
CO2	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO3	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1
CO4	2	1	1	1	3	-	-	-	-	2	-	-	3	2	1

Average	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Unit	**Content & Competencies**
1	Different types of lines with illustration and application (C1-C3)
2	Use of Drawing instruments and understands the design sheet layout with dimensioning and lettering. (C1-C4)
3	Applications of drawing commands in AutoCAD. (C1-C4)
4	Projection of points in all four quadrants. (C1-C3)
5	Projection of straight lines parallel, perpendicular, inclined to projection planes and traces of lines. (C1-C3)
6	Projection of plane in perpendicular and inclined positions. (C1-C3)
7	Projection of cones and solid cylinders with axes parallel, perpendicular and inclined to both the reference planes. (C1-C3)
8	Projection of prisms and pyramids with axes parallel, perpendicular, and inclined to both the reference planes. (C1-C3)
9	Orthographic projection of simple machine elements and engineering drawings. (C1-C4)
10	Isometric projection of simple machine elements and engineering drawings. (C1-C4)
11	Sectional views of simple machine elements and engineering drawings. (C1-C4)
Note:	1. At least ten jobs are to be performed/ prepared by students in the semester, either using AutoCAD software or on Drawing sheets using drawing instruments. 2. At least 8 experiments/ jobs should be performed/prepared from the above list; the remaining two may either be performed/prepared from the above list or designed and set as per the scope of the syllabus of the Engineering Graphics and Design.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4

Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
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SEMESTER - III

Course Code	Course Title
	Engineering Mechanics
	Engineering Thermodynamics
Program Electives Course - I	
	Refrigeration & Air Conditioning
	Automobile Engineering
	Numerical Methods
	Product Design for Manufacturing
	Composite Materials
	MGE-III
	AECC-III
	VAC-III
	SEC-I (SolidWorks)
	Engineering Mechanics Lab
	Summer Internship
Minor Elective Course-I (Robotics)	
	Robotics Engineering & Applications
	Robotics Engineering & Applications Lab
Minor Elective Course-I (Electric Vehicles)	
	Introduction to Hybrid and Electric Vehicles
	Introduction to Hybrid and Electric Vehicles Lab
Minor Elective Course-I (Computer Science Engineering)	

	Object-Oriented Programming
	Object-Oriented Programming Lab

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Engineering Mechanics
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	Engineering Mathematics-I & II
Course Synopsis	The Engineering Mechanics course is to expose students to problems in mechanics as applied to real-world scenarios. In this subject, students learn how to apply the laws of mechanics to actual engineering problems. Through this subject, students develop the analytical skills of splitting the larger practical problems into a number of small problems like make free body diagrams and solve them easily.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Solve the engineering problems in case of equilibrium conditions and calculate the reaction forces of various supports of different structures.
CO2	Solve the problems involving dry friction and virtual work. Apply concepts of conservation of energy and momentum to solve real life problems
CO3	Determine the centroid, centre of gravity and moment of inertia of various surfaces and solids.
CO4	Calculate the outcome of applied forces acting on a rigid body using principle of kinematics.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	-	2	-	1	-	-	1	2	-	3	3	2

CO2	3	2	3	-	2	3	1	1	-	-	2	-	3	2	3
CO3	3	3	2	2	2	-	-	-	-	-	-	-	3	3	2
CO4	3	3	2	2	1	-	-	-	-	-	-	-	3	3	2
Average	3	2.75	2.25	2	1.75	0.75	0.5	0.25	-	0.25	2	-	3	2.75	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Mechanics and Fundamental Principles (C1) Overview of mechanics as a branch of physics (C1) Understanding fundamental principles governing the behavior of objects and systems (C1) Coplanar Forces and Equilibrium of Particles (C2) Analysis of coplanar forces and their effects (C2) Equilibrium conditions for particles in a plane (C2) Free Body Diagrams and Equilibrium of Particle in Space (C2) Construction and interpretation of free body diagrams (C2) Equilibrium conditions for particles in three-dimensional space (C2) Single Equivalent Force and Equilibrium of Rigid Bodies in Two Dimensions (C2-C3) Reduction of multiple forces to a single equivalent force (C2) Equilibrium conditions for rigid bodies in two dimensions (C3) Analysis of Plane Trusses (C3-C4) Introduction to plane trusses and their importance in structural analysis (C3) Method of joints for analyzing forces in truss members (C3) Method of sections for determining forces in specific truss members (C4) Identification and treatment of zero-force members in trusses (C4) Definition of Virtual Work and Principle of Virtual Work (C3-C4) Understanding the concept of virtual work (C3) Application of the principle of virtual work to analyze mechanical systems (C4) Examining the relationship between virtual displacements and virtual forces (C4)
2	Characteristics of Dry Friction (C1) Introduction to dry friction and its properties (C1) Understanding the factors affecting frictional forces (C1) Problems Involving Dry Friction (C2) Analysis of problems involving dry friction forces (C2) Application of frictional forces in practical scenarios (C2) Ladder and Wedges (C2-C3) Analysis of ladder problems considering frictional forces (C2)

	Understanding the behavior of wedges in static equilibrium (C3) System of Connected Rigid Bodies (C3) Analysis of systems composed of connected rigid bodies (C3) Evaluation of forces and moments in interconnected bodies (C3) Conservative Forces and Potential Energy (C3-C4) Understanding conservative forces and their characteristics (C3) Calculation and application of potential energy in mechanical systems (C4) Potential Energy Criteria for Equilibrium (C4) Application of potential energy criteria to assess equilibrium conditions (C4) Determining stable and unstable equilibrium based on potential energy (C4) Centroid and Moments of Area (C2) Understanding the concept of centroid and its applications (C2) Calculation of moments of area using integration methods (C2) Theorems of Pappus and Guldinus (C3) Application of Pappus and Guldinus theorems for determining areas and volumes (C3) Analysis of irregular shapes using these theorems (C3) Moment and Product of Inertia of Plane Areas (C3-C4) Calculation of moment of inertia for different plane areas (C3) Determination of product of inertia for composite bodies (C4) Transfer Theorems and Polar Moment of Inertia (C4) Application of transfer theorems in determining moments of inertia (C4) Calculation of polar moment of inertia for circular sections (C4) Principal Axes and Mass Moment of Inertia (C4) Understanding principal axes and their significance (C4) Calculation of mass moment of inertia for rigid bodies (C4)
3	Position, Velocity, and Acceleration (C1) Introduction to position, velocity, and acceleration of particles (C1) Calculation of displacement, speed, and direction (C1) Rectilinear Motion (C2) Analysis of motion along a straight line (C2) Determination of velocity and acceleration in rectilinear motion (C2) Curvilinear Motion of a Particle (C2) Study of motion along a curved path (C2) Decomposition of motion into tangential and normal components (C2) Radial and Transverse Components (C3) Analysis of motion components in radial and transverse directions (C3) Determination of radial and transverse acceleration (C3) Rotation of Rigid Bodies about a Fixed Axis (C3) Understanding rotational motion of rigid bodies (C3) Calculation of angular displacement, velocity, and acceleration (C3) General Plane Motion (C4) Analysis of motion in a plane with translation and rotation (C4) Calculation of velocity and acceleration components in plane motion (C4) Absolute and Relative Motion Method (C4) Differentiating between absolute and relative motion methods (C4)

	Application of both methods in analyzing motion scenarios (C4) Instantaneous Center of Rotation in Plane Motion (C4) Determination of instantaneous center of rotation (C4) Utilizing the concept of instantaneous center in analyzing plane motion (C4) Linear Momentum (C2) Introduction to linear momentum and its properties (C2) Calculation of momentum for particles and systems of particles (C2) Equation of Motion (C3) Derivation and application of equations of motion (C3) Solving problems involving motion using the equations of motion (C3) Angular Momentum (C3) Calculation of angular momentum for particles and rigid bodies (C3) Understanding the concept of moment of inertia and its significance (C3) D'Alembert's Principle (C4) Introduction to D'Alembert's principle and its applications (C4) Analysis of motion using D'Alembert's principle (C4)
4	Principle of Work and Energy for a Particle (C2) Introduction to the principle of work and energy (C2) Calculation of work, potential energy, and kinetic energy (C2) Application of the principle of work and energy to analyze particle motion (C2) Principle of Work and Energy for a Rigid Body in Plane Motion (C3) Extension of the principle of work and energy to rigid bodies (C3) Calculation of work, potential energy, and kinetic energy for rigid bodies (C3) Application of the principle of work and energy to analyze rigid body motion (C3) Conservation of Energy (C4) Introduction to the concept of energy conservation (C4) Application of energy conservation in analyzing motion and mechanical systems (C4) Solving problems involving conservation of energy (C4) Principle of Impulse and Momentum for a Particle (C2) Understanding the principle of impulse and momentum (C2) Calculation of momentum and impulse for particles (C2) Application of the principle of impulse and momentum in analyzing particle motion (C2) Principle of Impulse and Momentum for a Rigid Body in Plane Motion (C3) Extension of the principle of impulse and momentum to rigid bodies (C3) Calculation of momentum and impulse for rigid bodies (C3) Application of the principle of impulse and momentum in analyzing rigid body motion (C3) Conservation of Momentum (C4) Introduction to the concept of momentum conservation (C4) Application of momentum conservation in analyzing collisions and motion (C4) Solving problems involving conservation of momentum (C4) System of Rigid Bodies (C4) Understanding systems of connected rigid bodies (C4)

	Analysis of equilibrium and motion of interconnected rigid bodies (C4) Application of equations of equilibrium and motion to solve problems (C4) Impact and Coefficient of Restitution (C4) Introduction to impact and types of impacts (C4) Calculation of velocities and energy changes during impacts (C4) Understanding the coefficient of restitution and its significance (C4) Introduction to Advanced Methods of Structural Analysis (C2) Overview of advanced methods for analyzing structures (C2) Introduction to recent developments and techniques in structural analysis (C2) Recent Methods of Analyzing Structures for Equilibrium (C3) Detailed study of advanced methods for analyzing structures (C3) Application of advanced methods in solving complex structural analysis problems (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	22
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	8
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)

Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid-Semester Examination 1	✓	✓	✓	✓
Mid-Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
	i) J. V. Rao, D. H. Young, S. Timoshenko, Sukumar Pati (2013), Engineering Mechanics, Tata McGraw Hill Education. ISBN: 978-1-259-06266-7 **ii)** Irving H. Shames (2012), Engineering Mechanics – Statics and Dynamics, 4th Edition, Prentice-Hall of India Private limited. ISBN: 978-8-131-72883-3

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Engineering Thermodynamics**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	+2 Physics and Chemistry
Course Synopsis	This course provides a basic grounding in the principles and methods of classical thermodynamics. It concentrates on: understanding the thermodynamic laws in relation to familiar experience; phase change, ideal gas and flow processes; using sources of data like thermodynamic tables and charts; application of the basic principles to the operation of various vapour and gas power cycles; and fuels and combustion.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To learn the basic principles of classical thermodynamics.
CO2	To apply the laws of thermodynamics to various systems and analyze the significance of the results.
CO3	To analyze the performance of thermodynamic gas and vapour power cycles.
CO4	To understand the ideal gas mixtures.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	2	0	2	0	0	0	0	0	2	2	3	1
CO2	3	1	3	2	2	1	2	0	0	0	0	3	1	3	3
CO3	3	3	3	3	0	1	2	0	0	1	0	3	-	3	3
CO4	3	3	1	3	2	2	2	0	0	0	0	3	-	3	2
Average	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Basic concepts of Thermodynamics (C1) Understand the fundamental principles and laws of thermodynamics. (C1) Define thermodynamic systems, surroundings, and boundaries. (C1) Differentiate between closed and open systems. (C1) Identify key components and properties of thermodynamic systems. (C1) Thermodynamics and Energy (C1, C2) Define thermodynamics as the study of energy and its transformations. (C1) Explain different forms of energy (kinetic, potential, internal, and mechanical). (C1) Apply the principle of energy conservation in thermodynamic systems. (C2) Understand the concept of work and heat transfer. (C1) Closed and open systems (C1, C2) Differentiate between closed and open systems in thermodynamics. (C1) Identify examples of closed and open systems in real-world applications. (C1) Analyze energy interactions between closed and open systems and their surroundings. (C2) Apply the principles of energy conservation and mass flow to closed and open systems. (C2) Properties of a system - State and equilibrium (C1, C2) Define thermodynamic properties: pressure, temperature, volume, and mass. (C1) Understand the concept of a system's state and its dependence on properties. (C1) Identify and analyze equilibrium conditions for thermodynamic systems. (C2) Apply equations of state to describe property relationships. (C2) Processes and cycles (C1, C2, C3) Define thermodynamic processes and cycles. (C1) Differentiate between reversible and irreversible processes. (C2) Analyze characteristics and efficiency of various thermodynamic cycles. (C3) Apply principles of processes and cycles to solve problems. (C3) Forms of energy, Work and heat transfer (C1, C2) Identify different forms of energy: mechanical, thermal, chemical, and electrical. (C1) Understand the concepts of work and heat transfer in thermodynamic systems. (C1) Analyze types of work and heat transfer in thermodynamic processes. (C2) Apply principles of energy conversion through work and heat transfer. (C2) Temperature and Zeroth law of thermodynamics (C1, C2) Define temperature and measurement scales (Celsius, Fahrenheit, Kelvin). (C1) Understand the concept of thermal equilibrium and the Zeroth law. (C1) Apply the Zeroth law to determine temperature relationships between systems. (C2) First law of thermodynamics (C1, C2, C3)

	Define the first law as the conservation of energy principle. (C1) Understand the concept of internal energy and its relationship with work and heat transfer. (C1) Apply the first law to analyze energy balance in closed systems. (C2) Apply the first law to steady-state and flow engineering devices. (C3) Energy balance for closed systems (C3, C4) Apply the concept of energy balance to closed systems undergoing thermodynamic processes. (C3) Analyze energy transfer through work and heat in closed systems. (C3) Solve problems related to energy balance in closed systems. (C4) First law applied to steady state and flow engineering devices (C3, C4) Apply the first law to steady-state processes in engineering devices. (C3) Analyze energy transfer and conversion in steady-state flow systems. (C3) Evaluate efficiency and performance of flow engineering devices. (C4) Transient flow processes (C3, C4) Understand transient flow processes and their significance in thermodynamic systems. (C3) Analyze time-dependent changes in properties during transient flow processes. (C4) Apply principles of transient flow processes to solve practical problems. (C4) Charging & discharging of tanks (C3, C4) Understand the process of charging and discharging tanks in thermodynamic systems. (C3) Analyze changes in pressure, temperature, and volume during tank charging and discharging. (C4) Apply principles of energy conservation and mass flow to tank charging and discharging. (C4)
2	Limitations of the first law of Thermodynamics (C2, C4) Discuss the limitations of the first law in predicting the direction and feasibility of processes. (C2) Explain the inability of the first law to account for the quality of energy and the presence of irreversibility. (C4) Analyze scenarios where the first law appears to be violated but is consistent with the second law of thermodynamics. (C4) Thermal energy reservoirs (C1) Define thermal energy reservoirs as idealized systems with infinite heat capacity. (C1) Understand the concept of thermal equilibrium between a reservoir and a system. (C1) Explain the role of thermal energy reservoirs in establishing reference temperatures. (C1) Kelvin-Planck statement of the second law of thermodynamics (C2, C4) State the Kelvin-Planck statement, which states that no engine can have a thermal efficiency of 100%. (C2) Understand the concept of heat transfer between reservoirs and working fluids in heat engines. (C2)

	Analyze the implications of the Kelvin-Planck statement on the design and operation of heat engines. (C4) Clausius statement of the second law of thermodynamics (C2, C4) State the Clausius statement, which states that heat cannot spontaneously flow from a colder body to a hotter body. (C2) Understand the concept of entropy and its relationship to heat transfer. (C2) Analyze the implications of the Clausius statement on the direction of heat transfer and the feasibility of processes. (C4) Equivalence of Kelvin-Planck and Clausius statements (C2, C4) Understand the equivalence between the Kelvin-Planck and Clausius statements of the second law. (C2) Explain how the two statements provide complementary perspectives on the limitations of heat engines and refrigerators. (C4) Refrigerators, Heat Pumps, and Air Conditioners (C1, C2) Define refrigerators, heat pumps, and air conditioners as devices that transfer heat from low-temperature reservoirs to high-temperature reservoirs. (C1) Explain the working principles and components of refrigeration cycles. (C2) Analyze the coefficient of performance (COP) as a measure of efficiency for refrigeration and heat pump systems. (C2) Perpetual Motion Machines (C1, C4) Define perpetual motion machines as hypothetical devices that violate the laws of thermodynamics. (C1) Understand why perpetual motion machines are not possible due to energy conservation and the second law of thermodynamics. (C4) Analyze historical attempts to create perpetual motion machines and the reasons for their failure. (C4) Reversible and Irreversible processes (C2, C3) Differentiate between reversible and irreversible processes in terms of the direction and feasibility of energy transfer. (C2) Explain the concept of entropy generation in irreversible processes. (C3) Analyze the characteristics and limitations of reversible and irreversible processes. (C3) Carnot cycle (C2, C3) Explain the Carnot cycle as an idealized reversible thermodynamic cycle. (C2) Understand the Carnot efficiency as the maximum efficiency achievable by a heat engine operating between two temperature reservoirs. (C2) Analyze the temperature-entropy diagram and the processes involved in the Carnot cycle. (C3) Entropy (C2, C3) Define entropy as a measure of the disorder or randomness of a system. (C2) Understand the relationship between entropy and the second law of thermodynamics. (C2) Analyze changes in entropy during reversible and irreversible processes. (C3) The Clausius inequality (C2, C3) State the Clausius inequality, which relates the heat transfer and the change in entropy of a system. (C2)

	Understand the implications of the Clausius inequality for the direction and feasibility of processes. (C3) Apply the Clausius inequality to analyze the entropy changes in various thermodynamic processes. (C3) Availability and irreversibility (C3, C4) Define availability as the maximum useful work that can be obtained from a system. (C3) Understand the concept of irreversibility and its relationship to the availability of energy. (C4) Analyze the availability and irreversibility in thermodynamic processes and systems. (C4)
3	Properties of pure substance (C1, C2) Define pure substances and their characteristics. (C1) Identify and describe important properties of pure substances such as temperature, pressure, specific volume, and internal energy. (C1) Understand the significance of phase changes in pure substances. (C2) Analyze the behavior of pure substances under different thermodynamic conditions. (C2) Property diagram for phase change processes (C1, C2) Interpret and construct property diagrams (e.g., temperature-entropy, pressure-enthalpy) for phase change processes. (C1) Understand the behavior of pure substances during phase transitions (e.g., solid-liquid, liquid-vapor). (C2) Analyze the changes in properties and energy during phase change processes. (C2) Carnot vapor cycle (C2, C3) Explain the Carnot vapor cycle as an idealized thermodynamic cycle for steam power plants. (C2) Understand the processes involved in the Carnot vapor cycle, including isentropic compression and expansion. (C2) Analyze the efficiency and performance of the Carnot vapor cycle. (C3) Rankine cycle (C2, C3) Define the Rankine cycle as a practical steam power cycle used in power plants. (C2) Identify and understand the processes in the Rankine cycle, such as heat addition, expansion, and condensation. (C2) Analyze the efficiency and performance of the Rankine cycle. (C3) Combined gas-vapor power cycles (C2, C3) Understand combined gas-vapor power cycles that combine gas turbine and steam turbine systems. (C2) Analyze the advantages and performance characteristics of combined cycles. (C3) Evaluate the efficiency and power output of combined gas-vapor power cycles. (C3) Analysis of power cycles (C2, C3) Analyze and compare the performance of various power cycles, such as the

	Carnot cycle, Rankine cycle, and combined cycles. (C2) Evaluate the thermal efficiency, work output, and heat transfer in power cycles. (C3) Identify factors that affect the performance and efficiency of power cycles. (C3) Carnot cycle (C2, C3) Understand the Carnot cycle as an idealized reversible thermodynamic cycle. (C2) Analyze the processes involved in the Carnot cycle, including isothermal expansion and compression. (C2) Calculate the maximum efficiency of a Carnot cycle. (C3) Conditions for exact differentials (C3) Understand the concept of exact differentials in thermodynamics. (C3) Identify the conditions for a differential to be exact. (C3) Apply the concept of exact differentials in thermodynamic analysis. (C3) Maxwell relations (C3) Understand the Maxwell relations as mathematical relationships among partial derivatives of thermodynamic properties. (C3) Apply Maxwell relations to analyze the behavior of thermodynamic systems. (C3) Use Maxwell relations to derive additional relationships between thermodynamic properties. (C3) Clapeyron equation (C3) Define the Clapeyron equation as an equation that relates the rate of change of pressure with temperature during phase transitions. (C3) Understand the significance of the Clapeyron equation in understanding phase changes. (C3) Apply the Clapeyron equation to analyze phase transition processes. (C3) Joule-Thompson coefficient and Inversion curve (C3) Define the Joule-Thompson coefficient as a measure of the temperature change during a throttling process. (C3) Understand the concept of the inversion curve and its relationship to the Joule-Thompson effect. (C3) Analyze the behavior of a substance during a Joule-Thompson process and its implications for cooling or heating applications. (C3)
4	Ideal and real gases (C1, C2) Differentiate between ideal and real gases based on their behavior. (C1) Understand the assumptions and limitations of the ideal gas law for describing real gases. (C2) Analyze the deviations of real gases from ideal behavior under different conditions. (C2) Van der Waals equation (C2, C3) Explain the Van der Waals equation as a modification of the ideal gas law to account for intermolecular forces and molecular volume. (C2) Understand the parameters in the Van der Waals equation and their physical significance. (C2) Analyze the behavior of real gases using the Van der Waals equation. (C3)

	Principle of corresponding states (C2, C3) Describe the principle of corresponding states, which states that gases at the same reduced conditions exhibit similar behavior. (C2) Understand the reduced properties and their use in comparing gases. (C2) Analyze the behavior of gases using the principle of corresponding states. (C3) Ideal gas equation of state and other equations of state (C1, C2) State the ideal gas equation of state and its applicability to ideal gases. (C1) Introduce other equations of state, such as the Virial equation and the Redlich-Kwong equation. (C2) Analyze the advantages and limitations of different equations of state for describing real gases. (C2) Compressibility factor (C2, C3) Define the compressibility factor as the ratio of the actual volume to the volume predicted by the ideal gas law. (C2) Understand the significance of the compressibility factor in characterizing gas behavior. (C2) Analyze the behavior of gases using the compressibility factor and its relationship to the equation of state. (C3) Evaluating internal energy, enthalpy, entropy, and specific heats (C2, C3) Understand the definitions and physical significance of internal energy, enthalpy, entropy, and specific heats. (C2) Apply the first law of thermodynamics to evaluate changes in internal energy and enthalpy. (C3) Use equations and relationships to calculate changes in entropy and specific heats for ideal and real gases. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
	i) P.K. Nag, Basic and Applied Thermodynamics, Tata McGraw-Hill Publishing Company Ltd., ISBN-978-0-070-15131-4 ii) Yunus A. Cengel, Thermodynamics: An Engineering Approach, Tata McGraw-Hill Publishing Company Ltd., ISBN978-0-073-30537-0 iii) C.P. Arora, Thermodynamics, Tata McGraw Hill Publishing Company Ltd., ISBN-978-0-074-62014-4

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Refrigeration & Air Conditioning**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	+2 Physics and Chemistry
Course Synopsis	Refrigeration and air conditioning is used to cool products or a building environment. The refrigeration or air conditioning system transfers heat from a cooler low-energy reservoir to a warmer high-energy reservoir.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Possess the knowledge of system components of refrigeration and air conditioning.
CO2	Design and implement refrigeration and air conditioning systems using standards.
CO3	Apply the knowledge of psychrometry in calculating cooling load and heating load calculations.
CO4	Apply the knowledge of system components of refrigeration and air conditioning.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	2	1	-	-	-	-	3	3	3	1
CO2	3	2	3	3	2	2	2	-	-	-	-	2	3	3	3
CO3	3	3	3	3	2	2	2	-	-	-	-	2	3	3	3
CO4	3	3	3	3	2	2	2	-	-	-	-	3	3	3	2
Average	3	2.5	3	3	1.75	2	1.75	-	-	-	-	2.5	3	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week

3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Vapor compression refrigeration cycles (C2, C3) Understand the basic principles and components of vapor compression refrigeration systems. (C2) Analyze the thermodynamic processes involved in vapor compression refrigeration cycles, including compression, condensation, expansion, and evaporation. (C3) Calculate the coefficient of performance (COP) for vapor compression refrigeration cycles. (C3) Air refrigeration cycles (C2, C3) Explain the working principles and components of air refrigeration systems. (C2) Analyze the thermodynamic processes involved in air refrigeration cycles, including compression, cooling, expansion, and heating. (C3) Evaluate the performance and efficiency of air refrigeration cycles. (C3) Simple saturated vapor compression refrigeration cycle (C2, C3) Describe the simplified version of the vapor compression refrigeration cycle with a single evaporator and condenser. (C2) Understand the thermodynamic processes and components involved in the simple saturated vapor compression refrigeration cycle. (C2) Analyze the performance and COP of the simple saturated vapor compression refrigeration cycle. (C3) P-H charts (C2) Understand the use of pressure-enthalpy (P-H) charts in thermodynamics and refrigeration systems. (C2) Interpret P-H charts to determine the state and properties of refrigerants at different points in the cycle. (C2) Multi-stage compression (C3) Explain the concept of multi-stage compression in refrigeration systems. (C3) Understand the benefits and applications of multi-stage compression for improving system efficiency. (C3) Analyze the thermodynamic processes and performance of refrigeration cycles with multi-stage compression. (C3) Multi-evaporator system (C3) Describe the concept and configuration of multi-evaporator systems in refrigeration. (C3) Understand the advantages and applications of multi-evaporator systems for different cooling requirements. (C3) Analyze the thermodynamic processes and performance of refrigeration cycles with multi-evaporator systems. (C3) Cascade system (C3) Explain the principle and operation of cascade refrigeration systems. (C3) Understand the concept of using multiple refrigeration cycles with different refrigerants in cascade systems. (C3)

	Analyze the benefits and performance of cascade refrigeration systems for achieving ultra-low temperatures. (C3) Vapor absorption systems (C2, C3) Describe the working principles and components of vapor absorption refrigeration systems. (C2) Understand the thermodynamic processes involved in vapor absorption refrigeration cycles, including absorption, desorption, and refrigerant circulation. (C3) Analyze the performance, efficiency, and COP of vapor absorption refrigeration systems. (C3)
2	Refrigerant classification (C1) Understand the classification of refrigerants based on their chemical composition and characteristics. (C1) Differentiate between primary refrigerants, secondary refrigerants, and tertiary refrigerants. (C1) Explain the significance of refrigerant classification for system design, operation, and safety. (C1) Designation of refrigerants (C1) Explain the commonly used refrigerant designation systems, such as the ASHRAE numbering system. (C1) Understand the naming conventions and codes used to identify refrigerants, such as R-22, R-134a, and R-410A. (C1) Interpret refrigerant designations to determine properties, composition, and application suitability. (C1) Alternate refrigerants (C2, C3) Discuss the need for alternative refrigerants due to environmental concerns and regulations. (C2) Identify and evaluate alternative refrigerants, such as hydro fluorocarbons (HFCs), hydro chlorofluorocarbons (HCFCs), and natural refrigerants (e.g., ammonia, carbon dioxide). (C2) Analyze the advantages, limitations, and safety considerations of using alternate refrigerants. (C3) Global warming and ozone-depleting aspects (C2, C3) Understand the environmental impact of refrigerants on global warming and ozone depletion. (C2) Discuss the role of refrigerants in contributing to greenhouse gas emissions and the depletion of the ozone layer. (C2) Analyze the regulations and initiatives aimed at reducing the use of ozone-depleting and high-global-warming-potential refrigerants. (C3) Refrigerant compressors - Reciprocating and Rotary (C2) Explain the working principles and characteristics of reciprocating compressors used in refrigeration systems. (C2) Describe the operation and advantages of rotary compressors in refrigeration applications. (C2) Analyze the performance and efficiency of reciprocating and rotary compressors in refrigeration systems. (C2)

	Condensers (C2) Define condensers and their role in the refrigeration cycle. (C2) Describe different types of condensers used in refrigeration systems, such as air-cooled condensers and water-cooled condensers. (C2) Analyze the heat transfer and performance characteristics of condensers. (C2) Evaporators (C2) Explain the function and importance of evaporators in the refrigeration cycle. (C2) Describe different types of evaporators, including air-cooled evaporators and flooded evaporators. (C2) Analyze the heat transfer and performance characteristics of evaporators. (C2) Expansion devices (C2) Define expansion devices and their role in regulating the flow and pressure of refrigerants. (C2) Discuss different types of expansion devices, such as thermostatic expansion valves (TXVs) and electronic expansion valves. (C2) Analyze the impact of expansion devices on system efficiency. (C2) Cooling towers (C2) Explain the function and operation of cooling towers in refrigeration systems. (C2) Discuss the different types of cooling towers, including open and closed circuit cooling towers. (C2) Analyze the heat rejection process and performance of cooling towers. (C2)
3	Moist air properties (C2) Understand the properties of moist air, including temperature, humidity, pressure, specific volume, and enthalpy. (C2) Identify and define terms such as dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, and specific humidity. (C2) Calculate and analyze the properties of moist air using psychrometric equations and tables. (C2) Psychrometric chart (C2) Understand the construction and layout of a psychrometric chart. (C2) Interpret and use the psychrometric chart to analyze the properties and behavior of moist air. (C2) Locate and interpret points on the psychrometric chart to determine properties such as temperature, humidity ratio, enthalpy, and dew point. (C2) Different psychrometric process analysis (C3) Analyze different psychrometric processes, such as heating, cooling, humidification, dehumidification, and mixing of moist air. (C3) Determine the changes in properties of moist air during various processes on the psychrometric chart. (C3) Calculate and analyze the energy transfers, heat gains or losses, and changes in humidity during psychrometric processes. (C3) Psychrometric calculations (C3) Perform calculations involving psychrometric properties, such as sensible heating/cooling, latent heating/cooling, and adiabatic mixing of air streams.

	(C3) Apply psychrometric equations and formulas to determine the required air conditions for specific applications, such as air conditioning, ventilation, and drying processes. (C3) Interpret the results of psychrometric calculations and make informed decisions regarding system design and operation. (C3) Humidification and dehumidification processes (C3) Analyze the humidification and dehumidification processes in psychrometrics, including adiabatic mixing, direct evaporative cooling, and indirect evaporative cooling. (C3) Calculate the required amount of water, heat transfer, and changes in air properties during humidification and dehumidification processes. (C3) Understand the impact of humidification and dehumidification on air quality, comfort, and energy consumption. (C3)
4	Air conditioning systems - classification (C2) Understand the classification of air conditioning systems based on their application, such as residential, commercial, and industrial. (C2) Identify different types of air conditioning systems, including central air conditioning, split systems, packaged units, and variable refrigerant flow (VRF) systems. (C2) Discuss the features, advantages, and limitations of each type of air conditioning system. (C2) Cooling load calculations (C3) Perform cooling load calculations to determine the amount of cooling required for a space or building. (C3) Consider factors such as solar heat gain, internal heat sources, occupancy, ventilation requirements, and thermal properties of the building envelope. (C3) Use load calculation methods, such as the heat balance method or the cooling load temperature difference (CLTD) method, to estimate the cooling load. (C3) Different types of loads (C3) Identify and analyze different types of loads in air conditioning systems, including sensible heat load, latent heat load, ventilation load, and internal load. (C3) Calculate and allocate the cooling load based on the specific requirements of each load component. (C3) GRSHF (Global Refrigerant System Efficiency Factor) and ERSHF (Energy Efficiency Ratio of Sensible Heat Factor) (C3) Understand the concepts of GRSHF and ERSHF as measures of system efficiency in air conditioning. (C3) Calculate and analyze the GRSHF and ERSHF values based on the system's performance and energy consumption. (C3) Evaluate the impact of system design and equipment selection on GRSHF and ERSHF. (C3) Estimation of total load (C3) Estimate the total cooling load for a given space or building by considering the combined effect of all load components. (C3)

	Account for factors such as diversity, peak load conditions, and partial loads in the estimation process. (C3) Determine the appropriate cooling capacity and equipment sizing based on the total load estimation. (C3) Air distribution patterns (C2) Understand the importance of proper air distribution in achieving comfort and efficient cooling. (C2) Discuss different air distribution patterns, such as mixing ventilation, displacement ventilation, and stratified air distribution. (C2) Analyze the advantages and limitations of each air distribution pattern in different applications. (C2) Dynamic and frictional losses in air ducts (C3) Understand the concept of dynamic losses and frictional losses in air duct systems. (C3) Calculate and analyze the pressure drop, velocity, and flow distribution in duct systems due to dynamic and frictional losses. (C3) Select appropriate duct sizes and designs to minimize energy losses and optimize air distribution. (C3) Equal friction method (C3) Explain the equal friction method for duct sizing and system balancing. (C3) Apply the equal friction method to determine the appropriate duct sizes for different sections of the air distribution system. (C3) Account for factors such as air velocity, static pressure, and total pressure in the equal friction method calculations. (C3) Fan characteristics of duct system (C3) Understand the interaction between fans and the air duct system in terms of pressure, airflow, and system performance. (C3) Analyze the fan characteristics, such as fan curves, fan laws, and fan efficiency. (C3) Select fans based on the required airflow, static pressure, and noise considerations in the duct system. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5

Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. Arora, C. P., (2008), Refrigeration and Air Conditioning, Tata McGraw-Hill Publishing Company Ltd. ISBN: 978-0-070-08390-5. 2. Manohar Prasad, (2003), Refrigeration and Air conditioning, New Age International. 3. W. F. Stocker and J. W. Jones, (2002), Refrigeration and Air conditioning, McGraw Hill. ISBN: 978

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Automobile Engineering**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	NA
Course Synopsis	The Automobile Engineering provides in depth knowledge of vehicle engineering, incorporating elements of mechanical, electrical, electronics, software and safety engineering it is applied to the design, manufacture and operation of motorcycle, automobile, buses and trunks and their respective engineering subsystem.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Acquire fundamental knowledge of the various types of vehicles.
CO2	Understand the transmission system of an Automobile.
CO3	Understand and analyze the different types of Suspension systems used in Automobile.
CO4	Analyze and evaluate brake performance.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	1	-	-	-	-	1	1	2	2	3	1
CO2	3	2	3	2	1	1	-	-	1	1	-	3	1	3	3
CO3	3	3	3	3	2	2	-	-	1	-	1	2	-	3	3
CO4	3	2	3	3	2	1	-	-	-	-	-	2	-	3	2
Average	3	2.25	2.75	2.5	1.5	1	-	-	0.5	0.5	0.5	2.25	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Classification of vehicles (C1) Understand the classification of vehicles based on their intended use, such as passenger cars, commercial trucks, motorcycles, and off-road vehicles. (C1) Identify and differentiate between different vehicle types, including sedans, SUVs, hatchbacks, pickup trucks, and motorcycles. (C1) Discuss the features, size, capacity, and typical applications of each vehicle classification. (C1) Drives and general layout (C1) Understand the different types of vehicle drives, including front-wheel drive, rear-wheel drive, all-wheel drive, and four-wheel drive. (C1) Explain the general layout of a vehicle, including the engine placement (front, rear, or mid), transmission location, and wheel arrangement. (C1) Discuss the advantages, disadvantages, and performance characteristics of different drive systems and layouts. (C1) Engine - Diesel and Petrol engines for automobiles (C2) Describe the construction, working principle, and combustion process of diesel and petrol engines used in automobiles. (C2) Differentiate between diesel and petrol engines in terms of fuel injection, ignition system, compression ratio, and operating characteristics. (C2) Discuss the advantages and disadvantages of diesel and petrol engines in terms of efficiency, power output, emissions, and cost. (C2) Two-stroke and four-stroke engines (C2) Explain the differences between two-stroke and four-stroke engines in terms of their operating cycles and valve configurations. (C2) Discuss the advantages and disadvantages of two-stroke and four-stroke engines in terms of power output, fuel efficiency, emissions, and maintenance requirements. (C2) Compare the performance characteristics of two-stroke and four-stroke engines in terms of power delivery, torque, and RPM range. (C2) Comparison of performance (C3) Analyze and compare the performance of diesel and petrol engines based on factors such as power output, torque, specific fuel consumption, and emissions. (C3) Evaluate the performance characteristics of two-stroke and four-stroke engines in terms of power density, efficiency, and durability. (C3) Consider the application-specific requirements and intended use when comparing the performance of different engine types. (C3) Factors affecting choice (C3) Identify and discuss the factors that affect the choice of engine type in automobiles, such as fuel availability, cost, emissions regulations, performance requirements, and vehicle application. (C3) Analyze the trade-offs and considerations in selecting between diesel and petrol engines or two-stroke and four-stroke engines based on the specific requirements and constraints. (C3) Power requirements of an automobile (C3)

	Understand the power requirements of an automobile in terms of the energy needed to overcome various resistances and perform desired tasks. (C3) Discuss the factors affecting the power requirement, including vehicle weight, aerodynamic drag, rolling resistance, grade (gradient), and desired performance characteristics. (C3) Calculate and analyze the power requirements based on the vehicle parameters and operating conditions. (C3) Factors affecting resistance and power requirement (C3) Identify and analyze the factors that contribute to the resistance faced by an automobile, such as rolling resistance, air resistance (wind drag), and grade resistance (uphill or downhill). (C3) Discuss the influence of vehicle design, weight, aerodynamics, tire characteristics, road conditions, and driving behavior on resistance and power requirements. (C3) Understand the relationship between resistance, power requirement, vehicle speed, and fuel consumption. (C3)
2	Power transmission system (C2) Understand the concept and components of a power transmission system in a vehicle. (C2) Identify the main components involved in transmitting power from the engine to the wheels. (C2) Discuss the importance of an efficient power transmission system for vehicle performance and drivability. (C2) Requirement of transmission system (C2) Identify and explain the requirements of a transmission system in a vehicle, such as torque multiplication, speed variation, smooth power delivery, and gear selection. (C2) Discuss the role of the transmission system in adapting engine power to different driving conditions and optimizing vehicle performance. (C2) Clutches (C2) Understand the purpose and function of clutches in a power transmission system. (C2) Discuss the different types of clutches used in vehicles, including plate clutches, semi-automatic clutches, and automatic clutches. (C2) Explain the operation and advantages of each type of clutch. (C2) Gearbox: manual shift four-speed and positive speed gearboxes (C3) Describe the construction and operation of manual shift four-speed gearboxes. (C3) Understand the concept of gear ratios and their impact on vehicle speed and torque. (C3) Discuss the advantages and limitations of manual shift four-speed gearboxes. (C3) Synchromesh devices (C3) Explain the purpose and function of synchromesh devices in manual transmissions. (C3)

	Understand how synchromesh devices facilitate smooth and synchronized gear shifting. (C3) Discuss the operation and benefits of synchromesh devices in improving drivability and reducing gear grinding. (C3) Fluid transmission: fluid flywheel and torque converter-automatic transmission (C2) Describe the operation and components of fluid flywheel and torque converter-automatic transmissions. (C2) Understand the advantages and disadvantages of fluid transmission systems compared to manual transmissions. (C2) Discuss the operation and benefits of fluid flywheels and torque converters in providing smooth power transmission and torque multiplication. (C2) Drive line - differential, conventional, and non-slip types (C2) Understand the purpose and function of the drive line in transmitting power from the transmission to the wheels. (C2) Explain the operation and components of different types of differentials, including conventional and non-slip differentials. (C2) Discuss the role of differentials in distributing power between the wheels and improving vehicle stability and traction. (C2) Drive axle (C2) Explain the function and components of the drive axle in a vehicle. (C2) Understand the role of the drive axle in transmitting power from the differential to the wheels. (C2) Discuss different types of drive axles, including solid axles and independent suspension axles. (C2) Analyze the impact of drive axle design on vehicle performance and handling. (C2)
3	Suspension system - requirements (C2) Understand the requirements of a suspension system in a vehicle, such as providing comfort, stability, and handling. (C2) Identify the main functions of a suspension system, including absorbing road shocks, maintaining tire contact with the road, and controlling vehicle dynamics. (C2) Discuss the importance of a well-designed suspension system for ensuring passenger comfort and vehicle safety. (C2) Rigid axle and independent suspension (C2) Explain the differences between rigid axle and independent suspension systems. (C2) Discuss the advantages and disadvantages of each type of suspension system in terms of ride quality, handling, and cost. (C2) Understand the impact of suspension system design on vehicle performance and comfort. (C2) Types of suspension - leaf spring, coil spring, torsion rod, and air suspension (C2) Describe different types of suspension systems used in vehicles, including leaf spring, coil spring, torsion rod, and air suspension. (C2)

	Explain the working principles and characteristics of each type of suspension system. (C2) Discuss the applications and benefits of different suspension types based on vehicle requirements and load capacities. (C2) Shock absorbers (C2) Understand the role of shock absorbers in a suspension system. (C2) Explain how shock absorbers work to dampen the oscillations and vibrations of the suspension system. (C2) Discuss the importance of properly functioning shock absorbers for maintaining vehicle stability and control. (C2) Front axle - types, front wheel geometry, conditions for true rolling (C2) Identify different types of front axles used in vehicles, such as solid axles and independent suspension axles. (C2) Understand the importance of front wheel geometry in achieving true rolling and proper steering characteristics. (C2) Discuss the conditions required for true rolling, including camber, caster, and toe angles. (C2) Steering geometry - Ackermann and Davis steering, steering linkages (C2) Explain the principles of Ackermann and Davis steering geometries. (C2) Understand the purpose and function of steering linkages in transmitting steering inputs to the front wheels. (C2) Discuss the advantages and limitations of different steering geometries and linkages. (C2) Steering gear box - power and power-assisted steering (C2) Describe the operation and components of steering gearboxes in vehicles. (C2) Understand the difference between manual steering and power-assisted steering systems. (C2) Discuss the benefits and operation of power steering systems in reducing driver effort and improving maneuverability. (C2) Wheel alignment - Tyres: materials and types, static and rolling properties of pneumatic tyres (C2) Explain the importance of proper wheel alignment for vehicle stability and tire wear. (C2) Describe the materials and construction of pneumatic tires used in vehicles. (C2) Discuss the static and rolling properties of tires, including tire pressure; tread design, and traction characteristics. (C2) Understand the impact of tire properties on vehicle handling, braking, and fuel efficiency. (C2)
4	Braking system - hydraulic braking systems (C2) Understand the principles and components of hydraulic braking systems in vehicles. (C2) Explain the operation of hydraulic brake systems, including the master cylinder, brake lines, wheel cylinders, and brake calipers. (C2) Discuss the advantages of hydraulic brakes over mechanical braking systems. (C2) Drum type and disc type brakes (C2)

	Differentiate between drum-type and disc-type brakes. (C2) Describe the construction and operation of drum brakes and disc brakes. (C2) Compare the performance characteristics and advantages of drum and disc brakes. (C2) Power and power-assisted brakes (C2) Understand the concept of power brakes and their role in increasing braking force. (C2) Explain the operation of power-assisted brakes, such as vacuum-assisted and hydraulic-assisted brakes. (C2) Discuss the benefits of power-assisted brakes in reducing driver effort and improving braking performance. (C2) Factors affecting brake performance (C2) Identify the factors that can affect brake performance, such as friction materials, brake pad wear, brake fluid quality, and temperature. (C2) Discuss how environmental conditions and driving style can influence brake performance. (C2) Tests on brakes - skid and skid prevention (C2) Explain the importance of brake testing and evaluation for ensuring proper brake performance. (C2) Discuss different brake tests, including brake fade, brake balance, and brake efficiency tests. (C2) Understand the concept of skidding and the methods used for skid prevention, such as anti-lock braking systems (ABS) and electronic stability control (ESC). (C2) Chassis - types of bodies (C1) Identify different types of vehicle bodies, such as sedan, hatchback, SUV, pickup truck, and van. (C1) Understand the characteristics and purposes of different body types in relation to passenger accommodation and cargo carrying capacity. (C1) Chassis frame - integral body (C1) Explain the concept of a chassis frame and its role in providing structural support and rigidity to the vehicle. (C1) Discuss the advantages and disadvantages of chassis frames in terms of weight, cost, and versatility. (C1) Understand the concept of an integral body where the body and chassis are combined into a single unit. (C1) Vehicle stability (C2) Understand the concept of vehicle stability and its importance for safe and predictable handling. (C2) Discuss the factors that influence vehicle stability, such as weight distribution, center of gravity, suspension design, and tire characteristics. (C2) Explain how design features, such as anti-roll bars and electronic stability control (ESC), contribute to improving vehicle stability. (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				

<table>
<tr><td>VIVA</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Assignment / Presentation</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Unit test</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Practical Log Book/ Record Book</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mid Semester Examination 1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Mid Semester Examination 2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>University Examination</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Feedback Process</td><td colspan="4">1. Student’s Feedback
2. Course Exit Survey</td></tr>
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2. Feedback between the semester through google forms.
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<tr><td>References:</td><td colspan="4">(List of reference books)</td></tr>
<tr><td></td><td colspan="4">i) Dr. Kirpal Singh, Automobile Engg. Vol.-1, Standard Publishers
ii) Crouse &Angline Automotive Mechanics Tata McGraw Hill
iii) R.B. Gupta Automobile Engineering SatyaPrakashan</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Numerical Methods**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	Engineering Mathematics I & II
Course Synopsis	The technological advancements have significantly increased the range of engineering problems that needs to be solved reliably. Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations. This course is designed to give an overview of numerical methods of interest to students. However, the focus being on the techniques themselves, rather than specific applications, the contents are relevant to varied fields such as engineering, management, economics, etc.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply various numerical methods and appreciate a trade off in using them.
CO2	Understand the source of various types of errors and their effect in using these methods.
CO3	To distinguish between Numerical and Analytical methods along with their Merits and demerits.
CO4	Understand the use of digital computers in implementation of these methods.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	2	1	2	-	-	-	-	2	3	3	2	-
CO2	3	3	2	3	2	1	-	-	-	-	-	2	-	-	2
CO3	3	2	2	2	2	2	-	-	-	-	-	3	-	-	-
CO4	3	2	2	2	3	1	-	-	-	-	2	3	-	3	-
Average	3	2.25	1.75	2.25	2	1.5	-	-	-	-	2	2.75	0.75	1.25	0.5

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to linear systems & Errors (C1) Provide an overview of linear systems and their significance in various fields. (C1) Explain the concepts of accuracy and precision in the context of numerical calculations. (C1) Discuss the sources of errors in numerical computations, including truncation and round-off errors. (C1) Introduce the binary number system and its relevance in computer-based calculations. (C1) Explain the propagation of errors and how they can affect the accuracy of numerical solutions. (C1) Linear Systems and Equations (C2) Discuss the matrix representation of linear systems and their advantages in solving simultaneous equations. (C2) Explain Cramer's rule and its application in solving linear systems. (C2) Introduce Gauss elimination as a method for solving linear systems through row operations. (C2) Discuss matrix inversion and its importance in solving linear systems efficiently. (C2) Introduce LU decomposition as an alternative method for solving linear systems. (C2) Iterative Methods and Relaxation Methods (C3) Introduce iterative methods as an approach for solving linear systems by iteratively improving an initial guess. (C3) Explain relaxation methods, such as the Jacobi and Gauss-Seidel methods, as specific iterative techniques for solving linear systems. (C3) Discuss the convergence criteria and limitations of iterative methods. (C3) Illustrate the application of iterative methods through examples and numerical simulations. (C3) Eigen Values (C3) Introduce eigen values as a fundamental concept in linear algebra. (C3) Explain the significance of eigen values in understanding the behavior of linear systems. (C3) Discuss methods for computing eigen values, such as the power method and the QR algorithm. (C3) Illustrate the applications of eigen values in various fields, including stability analysis and data compression. (C3)
2	Solving Algebraic & differential problems (C2)

	Introduction to Algebraic Equations (C2) Introduce the concept of algebraic equations and their importance in various scientific and engineering applications. (C2) Explain the different types of algebraic equations, such as linear, quadratic, and polynomial equations. (C2) Discuss the significance of solving algebraic equations in obtaining numerical solutions and understanding the behavior of systems. (C2) Bracketing methods: Bisection, Regula-Falsi (C3) Introduce bracketing methods as numerical techniques for finding roots of algebraic equations. (C3) Explain the bisection method and its principles for narrowing down the root interval. (C3) Discuss the Regula-Falsi method (also known as false position method) and its advantages in achieving faster convergence. (C3) Illustrate the implementation of bracketing methods through examples and numerical simulations. (C3) Open Methods: Secant, Fixed point iteration, Newton-Raphson (C3) Introduce open methods as numerical techniques for finding roots of algebraic equations without the need for a bracketed interval. (C3) Explain the principles of the Secant method, including the use of secant lines to approximate the root. (C3) Discuss the fixed point iteration method and its application in solving equations by finding a fixed point of a function. (C3) Introduce the Newton-Raphson method and its advantages in achieving fast convergence through the use of derivatives. (C3) Illustrate the implementation of open methods through examples and numerical simulations. (C3) Multivariate Newton's method (C4) Introduce the multivariate Newton's method as an extension of the Newton-Raphson method to systems of equations. (C4) Discuss the principles of the multivariate Newton's method and the calculation of Jacobian matrices. (C4) Explain the advantages and limitations of the multivariate Newton's method in solving systems of equations. (C4) Illustrate the application of the multivariate Newton's method through examples and numerical simulations. (C4) Numerical differentiation; error analysis; higher-order formulae (C3) Introduce numerical differentiation as a technique for approximating derivatives of functions. (C3) Discuss the different methods for numerical differentiation, such as forward difference, backward difference, and central difference. (C3) Explain the error analysis associated with numerical differentiation and the concept of truncation error. (C3) Introduce higher-order formulae for numerical differentiation, such as Richardson extrapolation and higher-order central difference formulas. (C3) Illustrate the implementation of numerical differentiation techniques and the use

	of higher-order formulae through examples and numerical simulations. (C3)
3	Integral methods, Interpolation, and curve fitting (C3) Integration and Integral Equations (C3) Introduce integration as a numerical technique for approximating definite integrals. (C3) Explain the trapezoidal rule and Simpson's rule as methods for numerical integration. (C3) Discuss the principles of quadrature methods for more accurate integration, such as Gaussian quadrature. (C3) Illustrate the implementation of integration techniques through examples and numerical simulations. (C3) Linear regression, Least squares, Total Least Squares (C4) Introduce linear regression as a statistical method for fitting a linear relationship between variables. (C4) Explain the least squares method for estimating the coefficients in a linear regression model. (C4) Discuss the principles of total least squares, which considers errors in both the dependent and independent variables. (C4) Illustrate the application of linear regression, least squares, and total least squares through examples and numerical analysis. (C4) Interpolation and Curve Fitting (C3) Introduce interpolation as a method for approximating values within a given set of data points. (C3) Explain Newton's difference formulae for polynomial interpolation, including forward, backward, and central differences. (C3) Discuss cubic splines as a technique for curve fitting, which provides a smooth and continuous representation of data. (C3) Illustrate the application of interpolation and curve fitting techniques through examples and numerical simulations. (C3)
4	ODEs: Initial Value Problems (C3) Introduction to ODE-IVP (C3) Introduce ordinary differential equations (ODEs) and their significance in modeling dynamic systems. (C3) Explain initial value problems (IVPs) as a specific type of ODEs with initial conditions. (C3) Discuss the importance of solving IVPs in understanding the behavior and evolution of systems. (C3) Euler's methods (C3) Explain Euler's methods as simple numerical techniques for solving first-order ODE-IVPs. (C3) Discuss the principles of the forward Euler method and the backward Euler method. (C3) Illustrate the implementation of Euler's methods through examples and numerical simulations. (C3) Runge-Kutta methods (C4) Introduce Runge-Kutta methods as more accurate and versatile numerical

	techniques for solving ODE-IVPs. (C4) Discuss the principles of the classical fourth-order Runge-Kutta method. (C4) Explain the concept of higher-order Runge-Kutta methods and their benefits in terms of accuracy and stability. (C4) Illustrate the implementation of Runge-Kutta methods through examples and numerical simulations. (C4) Predictor-corrector methods (C4) Introduce predictor-corrector methods as a combination of explicit and implicit methods for solving ODE-IVPs. (C4) Discuss the principles of predictor-corrector methods, such as the Adams-Bashforth-Moulton method. (C4) Explain the advantages of predictor-corrector methods in terms of accuracy and stability. (C4) Illustrate the implementation of predictor-corrector methods through examples and numerical simulations. (C4) Extension to multi-variable systems (C4) Discuss the extension of numerical methods to handle systems of ODEs, involving multiple variables. (C4) Explain the principles of solving multi-variable ODE-IVPs using matrix equations and vector-based techniques. (C4) Illustrate the implementation of numerical methods for multi-variable systems through examples and numerical simulations. (C4) Adaptive step size (C4) Discuss the concept of adaptive step size in numerical ODE solving, where the step size is adjusted dynamically based on error estimates. (C4) Explain the principles of adaptive step size algorithms, such as the Runge-Kutta-Fehlberg method (RK45). (C4) Illustrate the benefits of adaptive step size in terms of efficiency and accuracy through examples and numerical simulations. (C4) Stiff ODEs (C4) Introduce stiff ODEs as a special class of ODEs where the dynamics vary significantly over different time scales. (C4) Discuss the challenges associated with solving stiff ODEs and the importance of specialized numerical methods. (C4) Introduce stiff ODE solvers, such as the implicit methods and Rosenbrockmethods, that are specifically designed for stiff ODEs. (C4) Illustrate the application of stiff ODE solvers through examples and numerical simulations. (C4) Boundary Value Problems (C3) Shooting method (C3) Introduce boundary value problems (BVPs) as a type of ODEs with boundary conditions. (C3) Explain the shooting method as a numerical technique for solving BVPs by transforming them into IVPs. (C3) Discuss the principles of the shooting method, including the selection of initial guesses and the use of root-finding algorithms. (C3)

	Illustrate the implementation of the shooting method through examples and numerical simulations. (C3) Finite differences (C3) Introduce finite difference methods as numerical techniques for approximating derivatives in ODEs. (C3) Discuss the principles of finite difference methods for solving BVPs by discretizing the domain and approximating derivatives. (C3) Explain the different types of finite difference schemes, such as central differences and forward/backward differences. (C3) Illustrate the implementation of finite difference methods for solving BVPs through examples and numerical simulations. (C3) Over/Under Relaxation (SOR) (C3) Introduce the over relaxation and under relaxation methods as iterative techniques for solving BVPs. (C3) Discuss the principles of the successive over relaxation (SOR) method, including the relaxation parameter and convergence criteria. (C3) Illustrate the implementation of the SOR method for solving BVPs through examples and numerical simulations. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--

Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Mahinder Kumar Jain, S R K Iyengar, R K Jain, "Numerical Methods: Problems And Solutions", January 2020, New Age International Private Limited, ISBN-13 :978-9388818926 **ii)** Richard W. Hamming, "Numerical Methods for Scientists and Engineers", Dover Publications Inc, New edition, ISBN-13 : 978-0486652412

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Product Design for Manufacturing
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	Product Design for Manufacturing is the general engineering art of designing products in such a way that they are easy to manufacture. This design practice not only focuses on the design aspect of a part but also on the product ability. In simple language it means relative ease to manufacture a product, part or assembly. DFM describes the process of designing or engineering a product in order to facilitate the manufacturing process in order to reduce its manufacturing costs. This course will impart knowledge of various methods and approaches used in design of manufacturing. Moreover, students will get familiar to DFMA software through case studies. In the end of course, student will be able to utilize the knowledge gained through coursework for the development of new product.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply customer-oriented, manufacturing and life cycle sensitive approach to product design and development with product design principles and structured design methodologies.
CO2	Possess methods and approaches for principles and evaluation methods of various aspects of designing components
CO3	Develop a manufacturability of new product as per the requirement.
CO4	Demonstrate the knowledge of DFMA software for case studies

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**

CO1	3	2	1	2	2	1	1	1	2	2	3	3	3	2	2
CO2	3	2	2	3	1	1	1	1	1	1	2	2	3	2	1
CO3	3	1	2	2	2	2	2	1	2	1	2	2	3	1	2
CO4	3	2	1	1	2	1	1	2	3	2	3	3	3	2	1
Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Product Design (C1) Provide an overview of product design as a discipline and its importance in various industries. (C1) Explain the key steps involved in the product design process, from concept development to final production. (C1) Discuss the role of product designers in creating innovative and functional solutions to meet user needs. (C1) Asimow's Model (C2) Introduce Asimow's Model as a framework for product design, which includes the functional, structural, and aesthetic aspects of a product. (C2) Explain the significance of considering multiple design parameters and constraints in the product design process. (C2) Illustrate the application of Asimow's Model through case studies and examples from real-world product design. (C2) Product Design Practice in Industry (C3) Explore the practices and methodologies followed in the industry for product design. (C3) Discuss the importance of collaboration, research, and market analysis in designing successful products. (C3) Highlight the role of prototyping, testing, and iteration in refining product designs. (C3) Provide insights into the challenges and considerations involved in integrating design, engineering, and manufacturing in the industry. (C3) Strength Consideration in Product Design (C3) Explain the importance of strength consideration in product design, particularly in ensuring the structural integrity and safety of the product. (C3) Discuss the factors influencing the strength requirements, such as anticipated loads, material properties, and environmental conditions. (C3) Introduce methods for analyzing and evaluating the strength of product components and assemblies, such as finite element analysis (FEA) and stress

	calculations. (C3) Illustrate the application of strength considerations through case studies and examples from different industries. (C3) Design for Stiffness and Rigidity (C4) Explore the concept of stiffness and rigidity in product design and their influence on the performance and functionality of the product. (C4) Discuss design strategies and principles for enhancing stiffness and rigidity, such as proper material selection, geometric considerations, and reinforcement techniques. (C4) Explain how simulation and analysis tools can be used to optimize designs for stiffness and rigidity. (C4) Illustrate the application of design for stiffness and rigidity through case studies and examples of products in various fields. (C4)
2	Principles and Evaluation Methods of Various Aspects of Design for X (C4) Introduction to Design for X (C1) Provide an overview of Design for X (DFX) as a set of principles and methodologies to enhance the design process and improve product performance. (C1) Explain the importance of considering various aspects of DFX, such as manufacturing, environment, serviceability, and repairability. (C1) Discuss the benefits of implementing DFX principles, including cost reduction, improved quality, and increased customer satisfaction. (C1) Design for Machining (C3) Discuss the principles and considerations for designing products that are suitable for machining processes. (C3) Explain the importance of optimizing designs for machining efficiency, material utilization, and dimensional accuracy. (C3) Introduce evaluation methods, such as Design for Manufacturability (DFM) analysis and simulation tools, to assess the manufacturability of designs. (C3) Provide examples and case studies demonstrating effective design for machining practices. (C3) Design for Sheet Metal Working (C3) Discuss the principles and considerations for designing products that involve sheet metal fabrication processes. (C3) Explain the importance of designing for efficient material utilization, ease of fabrication, and structural integrity in sheet metal applications. (C3) Introduce evaluation methods, such as Design for Sheet Metal Assembly (DFMA) analysis and forming simulations, to assess the manufacturability of sheet metal designs. (C3) Provide examples and case studies showcasing effective design for sheet metal working practices. (C3) Design for Injection Molding (C3) Discuss the principles and considerations for designing products that are intended for injection molding processes. (C3) Explain the importance of designing for moldability, part uniformity, and dimensional stability in injection molded components. (C3)

	Introduce evaluation methods, such as mold flow analysis and Design for Injection Molding (DFIM) guidelines, to assess the manufacturability of injection molded designs. (C3) Provide examples and case studies illustrating effective design for injection molding practices. (C3) Design for Environment (C3) Discuss the principles and considerations for designing products with a focus on environmental sustainability. (C3) Explain the importance of minimizing material waste, energy consumption, and environmental impact throughout the product lifecycle. (C3) Introduce evaluation methods, such as Life Cycle Assessment (LCA) and Design for Disassembly (DFD), to assess the environmental performance of designs. (C3) Provide examples and case studies demonstrating effective design for environment practices. (C3) Design for Service and Repair (C3) Discuss the principles and considerations for designing products that are serviceable and repairable throughout their lifecycle. (C3) Explain the importance of ease of maintenance, accessibility of components, and availability of spare parts in service and repair operations. (C3) Introduce evaluation methods, such as Design for Serviceability (DFS) analysis and serviceability testing, to assess the serviceability and reparability of designs. (C3) Provide examples and case studies highlighting effective design for service and repair practices. (C3)
3	Manufacturability Requirements (C2) Discuss the importance of considering manufacturability requirements during the product design phase. (C2) Explain how manufacturability impacts the efficiency, cost, and quality of the manufacturing process. (C2) Identify key manufacturability considerations, such as material selection, process capability, tooling requirements, and dimensional tolerances. (C2) Discuss the role of design for manufacturability (DFM) techniques in optimizing product designs for efficient and cost-effective manufacturing. (C2) Forging Design (C3) Introduce the principles and considerations for designing products that are suitable for forging processes. (C3) Explain the advantages and limitations of forging as a manufacturing method for producing metal components. (C3) Discuss design guidelines for optimizing part geometry, draft angles, fillet radii, and material flow during the forging process. (C3) Illustrate the application of forging design principles through examples and case studies. (C3) Pressed Component Design (C3) Discuss the principles and considerations for designing products that involve pressed component manufacturing processes, such as stamping or deep drawing.

	(C3) Explain the advantages and limitations of pressed component manufacturing in terms of material usage, cost, and complexity. (C3) Discuss design guidelines for optimizing blank size, formability, and dimensional accuracy in pressed component designs. (C3) Illustrate the application of pressed component design principles through examples and case studies. (C3) Casting Design (C3) Introduce the principles and considerations for designing products that are suitable for casting processes, such as sand casting or investment casting. (C3) Explain the advantages and limitations of casting as a manufacturing method for producing complex-shaped components. (C3) Discuss design guidelines for optimizing part geometry, wall thickness, draft angles, and gating/riser systems in casting designs. (C3) Illustrate the application of casting design principles through examples and case studies. (C3) Die Casting and Special Castings (C4) Discuss the principles and considerations for designing products that are suitable for die casting processes or special casting methods, such as gravity die casting or lost wax casting. (C4) Explain the advantages and limitations of die casting and special castings in terms of production speed, complexity, and surface finish. (C4) Discuss design guidelines for optimizing part geometry, gating systems, draft angles, and tooling considerations specific to die casting and special casting processes. (C4) Illustrate the application of die casting and special casting design principles through examples and case studies. (C4)
4	Assembly and Assembly Process (C3) Introduce the concept of assembly and the importance of efficient assembly processes in product manufacturing. (C3) Explain the principles of designing for assembly (DFA) to optimize product assembly, including minimizing part count, reducing complexity, and improving ease of assembly. (C3) Discuss different assembly methods, such as manual assembly, automated assembly, and robotic assembly. (C3) Highlight the significance of proper fixture design, tolerance analysis, and error-proofing techniques in ensuring successful assembly. (C3) Design for Assembly (DFA) and Applications (C4) Explain the principles and methodologies of Design for Assembly (DFA), including the Boothroyd/Dewhurst Method. (C4) Discuss the application of DFA in product design and manufacturing to improve assembly efficiency, reduce costs, and enhance quality. (C4) Present case studies showcasing the implementation of DFA principles using DFMA software (Design for Manufacturing and Assembly). (C4) Highlight the benefits and outcomes achieved through the application of DFA techniques in real-world scenarios. (C4)

	Quality Function Deployment (QFD) (C3) Introduce Quality Function Deployment (QFD) as a technique for translating customer requirements into specific product design and manufacturing characteristics. (C3) Explain the QFD process, including capturing customer voice, identifying critical-to-quality characteristics, and establishing design and process parameters. (C3) Discuss the application of QFD in new product development to ensure alignment between customer expectations and product attributes. (C3) Highlight the benefits of using QFD in improving customer satisfaction, reducing design iterations, and enhancing product quality. (C3) Quality Engineering and Taguchi Method (C4) Introduce quality engineering as an approach to design and manufacture products that meet customer expectations and achieve high levels of quality. (C4) Explain the principles and methodologies of the Taguchi Method, including robust design and parameter optimization. (C4) Discuss the application of quality engineering and the Taguchi Method in identifying and minimizing the impact of process and design variations on product quality. (C4) Highlight the benefits of incorporating quality engineering and the Taguchi Method in reducing product variability, improving reliability, and enhancing customer satisfaction. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Geoffrey Boothroyd, Peter Dewhurst and Winston Anthony Knight (2009),

	Product Design for Manufacture and Assembly, Taylor & Francis e-Library. ISBN: 978-1-420-08927-1. ii) A.K. Chitale and R.C. Gupta, (2005), Product Design and Manufacturing, 6th Edition, Printice Hall of India, ISBN: 9788120342828 .

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Composite Materials**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	+2 Physics and Chemistry
Course Synopsis	Composites are a unique class of materials made from two or more distinct materials that when combined are better than each would be separately. They are non-corroding, non-magnetic, radar transparent and they are designed to provide strength and stiffness where it is needed. This course will describe different types of composites. Student will also get the idea about design and manufacturing methods involved in making of composites. Joining method and failure theories for composites are also discussed in this course. Since composites are affordable high-performance material and expanded commercial as well as industrial utilization, hence this course is quite useful.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Analyze the economic aspects of using composites.
CO2	Conduct mechanical testing of composite structures and analyse failure modes.
CO3	Design and manufacture composite materials for various applications.
CO4	Explain the relevance and limitations of the destructive and non-destructive test methods used for

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	-	-	2	2	-	2	1	-	2	3	3	1
CO2	3	3	3	3	-	-	1	-	1	0	2	3	3	3	2

CO3	3	2	3	2	3	-	2	-	-	-	2	2	2	3	1
CO4	3	2	-	2	1	-	2	-	1	-	-	2	2	3	2
Average	3	2.25	2.25	1.75	1	0.5	1.75	-	1	0.25	1	2.25	2.5	3	1.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Define composites as materials composed of two or more distinct components, typically a reinforcement and a matrix, combined to enhance overall material properties. (C2) Explain the concept of reinforcement and matrix materials in composite structures and their roles in determining the performance characteristics of composites. (C2) Discuss the advantages of composites over conventional materials, such as high strength-to-weight ratio, corrosion resistance, and tailored properties. (C2) Reinforcements and Matrices (C2) Define reinforcements as the materials added to composites to provide strength and stiffness, such as fibers (e.g., carbon, glass) or particles. (C2) Define matrices as the materials surrounding and holding the reinforcements together, often polymers, metals, or ceramics. (C2) Discuss the different types of reinforcements used in composites, including fibers (continuous, discontinuous), particles, and fabrics. (C2) Discuss the different types of matrices used in composites, such as polymer matrices (thermoset, thermoplastic), metal matrices, and ceramic matrices. (C2) Types of Composites (C2) Explain the various types of composites based on the reinforcement and matrix materials used, such as fiber-reinforced composites, particle-reinforced composites, and laminate composites. (C2) Discuss the characteristics and applications of specific types of composites, including carbon fiber composites, glass fiber composites, and aramid fiber composites. (C2) Explain the concept of hybrid composites, which combine different types of reinforcements or matrices to achieve specific performance requirements. (C2) Carbon Fiber Composites (C3) Discuss carbon fiber composites as a specific type of composite material using carbon fibers as the reinforcement and polymer or carbon matrices. (C3) Explain the exceptional properties of carbon fiber composites, such as high strength, stiffness, and low weight, making them suitable for aerospace, automotive, and sports applications. (C3) Discuss the manufacturing processes for carbon fiber composites, including lay-

	up, filament winding, and prepreg techniques. (C3) Highlight the challenges and considerations in working with carbon fiber composites, such as cost, environmental impact, and recycling. (C3) Properties of Composites in Comparison with Standard Materials (C3) Compare the properties of composites (e.g., strength, stiffness, thermal conductivity) with those of standard materials, such as metals, ceramics, and polymers. (C3) Discuss the advantages and limitations of composites in terms of specific properties, such as high strength-to-weight ratio and anisotropic behavior. (C3) Highlight the potential for tailoring composite properties through reinforcement and matrix selection, fiber orientation, and fabrication techniques. (C3) Applications of Metal, Ceramic, and Polymer Matrix Composites (C3) Discuss the applications of metal matrix composites (MMCs), ceramic matrix composites (CMCs), and polymer matrix composites (PMCs) in various industries. (C3) Highlight the specific advantages and applications of each type of matrix composite, such as MMCs in automotive parts, CMCs in aerospace components, and PMCs in sporting goods. (C3) Discuss the considerations and challenges in selecting and designing with matrix composites for specific applications, including cost, manufacturability, and performance requirements. (C3)
2	Hand and Spray Lay-up (C4) Explain the hand lay-up technique for composite fabrication, where reinforcement materials are manually placed onto a mold surface and impregnated with resin. (C4) Discuss the spray lay-up method, which involves spraying a mixture of reinforcement fibers and resin onto a mold surface to build up the composite structure. (C4) Highlight the advantages and limitations of hand and spray lay-up techniques, including versatility, cost-effectiveness, and potential for air voids or inconsistent fiber distribution. (C4) Press Moulding (C4) Explain press moulding as a process in which composite materials are placed in a mold and subjected to heat and pressure to cure and shape the final product. (C4) Discuss the different press moulding techniques, such as compression moulding and transfer moulding, and their suitability for various composite materials and applications. (C4) Highlight the benefits of press moulding, including efficient production, consistent part quality, and the ability to achieve complex shapes. (C4) Injection Molding (C4) Explain the injection molding process for composites, where a molten resin is injected into a mold cavity containing reinforcement fibers. (C4) Discuss the advantages of injection molding, such as high production rates, precise control of fiber orientation, and the ability to manufacture intricate parts. (C4)

	Highlight the considerations and challenges in injection molding of composites, including fiber length and alignment control, material flow, and tooling design. (C4) Resin Injection (C4) Explain resin injection as a method for impregnating reinforcement fibers with resin in a controlled manner. (C4) Discuss the different resin injection techniques, such as vacuum infusion, resin transfer molding (RTM), and resin film infusion (RFI). (C4) Highlight the benefits of resin injection, including uniform resin distribution, reduced voids, and the ability to produce large, complex parts. (C4) RRIM (Reinforced Reaction Injection Molding) (C4) Explain the RRIM process, a variant of injection molding where reactive resins and reinforcement fibers are injected into a mold cavity and react to form a composite. (C4) Discuss the advantages of RRIM, such as high strength, excellent surface finish, and reduced cycle times compared to traditional composites. (C4) Highlight the applications of RRIM in automotive, construction, and other industries. (C4) Filament Winding (C4) Explain the filament winding process, where continuous reinforcement fibers (filaments) are wound onto a rotating mandrel and impregnated with resin. (C4) Discuss the benefits of filament winding, such as precise fiber alignment, high strength-to-weight ratio, and the ability to produce cylindrical or curved composite structures. (C4) Highlight the considerations and challenges in filament winding, including fiber tension control, resin impregnation, and mandrel design. (C4) Pultrusion (C4) Explain the pultrusion process, which involves continuous pulling of reinforcement fibers through a resin bath, followed by curing to form a composite profile. (C4) Discuss the advantages of pultrusion, such as high production rates, consistent fiber alignment, and the ability to produce linear composite profiles with complex cross-sections. (C4) Highlight the applications of pultrusion in construction, infrastructure, and aerospace industries. (C4) Centrifugal Casting (C4) Explain centrifugal casting as a method for producing cylindrical composite parts by rotating a mold while pouring resin and reinforcement into the mold cavity. (C4) Discuss the advantages of centrifugal casting, including improved fiber alignment, reduced voids, and the ability to produce hollow components. (C4) Highlight the applications of centrifugal casting in industries such as aerospace, marine, and sporting goods. (C4) Fiber/Matrix Interface (C5) Explain the fiber/matrix interface in composites as the region where the reinforcement fibers interact with the matrix material. (C5)

	Discuss the theories of adhesion at the interface, including absorption and wetting, inter diffusion, electrostatic forces, chemical bonding, and mechanical interlocking. (C5) Highlight the importance of a strong fiber/matrix interface in achieving optimal mechanical properties and load transfer in composites. (C5) Measurement of Interface Strength (C5) Discuss the methods and techniques used to measure the strength of the fiber/matrix interface, such as pull-out tests, micro bond tests, and microscopy analysis. (C5) Explain the significance of interface strength measurement in assessing the quality and performance of composite materials. (C5) Highlight the challenges and limitations associated with interface strength characterization. (C5) Influence of Interface on Mechanical Properties of Composites (C5) Explain how the quality and properties of the fiber/matrix interface can significantly affect the mechanical properties of composites, such as strength, stiffness, and fracture toughness. (C5) Discuss the mechanisms by which the interface influences properties, including stress transfer, interfacial debonding, and crack propagation. (C5) Highlight the importance of optimizing the interface properties and compatibility between fibers and matrices to achieve desired composite performance. (C5) Characterization of Systems: Carbon Fiber/Epoxy, Glass Fiber/Polyester, etc. (C5) Discuss the specific characterization methods used for different composite systems, such as carbon fiber/epoxy, glass fiber/polyester, and other combinations. (C5) Explain the techniques for evaluating key properties, including tensile strength, flexural strength, impact resistance, and thermal properties of composite systems. (C5) Highlight the importance of material characterization in material selection, design optimization, and quality control of composites. (C5)
3	Stiffness and Strength: Geometrical Aspects - Volume and Weight Fraction (C5) Discuss the relationship between the volume fraction and weight fraction of reinforcement in composites and their influence on stiffness and strength. (C5) Explain the concept of volume fraction as the ratio of the volume of the reinforcement phase to the total composite volume. (C5) Discuss the effects of varying volume and weight fractions on the mechanical properties of composites, including increased stiffness and strength with higher reinforcement fractions. (C5) Unidirectional Continuous Fiber, Discontinuous Fibers, Short Fiber Systems, Woven Reinforcements - Length and Orientation Distributions (C5) Describe different types of reinforcement configurations in composites, including unidirectional continuous fibers, discontinuous fibers, short fiber systems, and woven reinforcements. (C5)

	Discuss the significance of fiber length and orientation distributions in determining the mechanical properties of composites, such as anisotropy, directional strength, and stiffness. (C5) Explain the challenges and considerations associated with controlling fiber length and orientation in composite manufacturing processes. (C5) Mechanical Testing: Determination of Stiffness and Strength of Unidirectional Composites; Tension, Compression, Flexure, and Shear (C6) Discuss the mechanical testing methods used to determine the stiffness and strength of unidirectional composites, including tension, compression, flexure, and shear tests. (C6) Explain the principles and techniques involved in conducting these tests, including sample preparation, loading configurations, and data analysis. (C6) Highlight the importance of mechanical testing in characterizing the mechanical properties and performance of composites for design and material selection. (C6) Fracture: Typical Fracture Processes; Effect of Transverse Ply; Review of Fracture Mechanics Methods and Application to Composites (C6) Explain the typical fracture processes in composites, including matrix cracking, fiber/matrix debonding, delamination, and fiber pull-out. (C6) Discuss the effect of transverse ply on fracture behavior in composite laminates and the challenges associated with interlaminar fracture. (C6) Review the principles of fracture mechanics and its application to analyze and predict fracture behavior in composite materials. (C6) Impact: Typical Impact Damage; Role of Fiber, Matrix, and Interface; Low and High-Speed Impact Test Methods (C6) Discuss the typical impact damage mechanisms in composites, including matrix cracking, delamination, and fiber breakage. (C6) Explain the roles of fiber, matrix, and interface in determining the impact resistance and damage tolerance of composites. (C6) Describe the low and high-speed impact test methods used to evaluate the impact behavior and performance of composites. (C6) Fatigue: Behavior of Notched and Unnotched Specimens; Tension Testing of Composites; Fatigue Damage - Effect of Matrix and Fiber Properties; Implications for Component Design (C6) Discuss the behavior of composites under fatigue loading, including the fatigue life of notched and unnotched specimens. (C6) Explain the influence of matrix and fiber properties on fatigue performance and the mechanisms of fatigue damage in composites. (C6) Discuss the implications of fatigue behavior for component design, including considerations for material selection, load cycles, and stress concentrations. (C6) Environmental Effects: Influence of Moisture and Other Contaminants on Fiber, Matrix, Interface; Effect on Mechanical Properties; Stress Corrosion Cracking; Influence of High and Low Temperatures (C6) Discuss the influence of environmental factors, such as moisture and contaminants, on the mechanical properties of composites, including

	degradation of fiber, matrix, and interface. (C6) Explain the effects of high and low temperatures on the performance and behavior of composites, including thermal expansion, thermal degradation, and thermal cycling effects. (C6) Discuss the phenomenon of stress corrosion cracking in composites and its implications for material selection and component durability. (C6)
4	Joining – Advantages and Disadvantages of Adhesive and Mechanically Fastened Joints (C5) Compare and contrast the advantages and disadvantages of adhesive joints and mechanically fastened joints in terms of strength, durability, ease of assembly, and disassembly. (C5) Discuss the factors to consider when selecting the appropriate joining method for a specific application, including material compatibility, joint strength requirements, environmental conditions, and manufacturing considerations. (C5) Typical Bond Strengths and Test Procedures (C5) Explain the concept of bond strength in adhesive joints and the factors that influence it, such as surface preparation, adhesive properties, and curing conditions. (C5) Discuss the commonly used test methods to evaluate bond strength, including tensile, shear, and peel tests. (C5) Highlight the importance of standardized test procedures for ensuring reliable and consistent assessment of bond strength. (C5) Design Philosophy and Procedures (Systems Approach) (C6) Introduce the design philosophy and procedures for joining structures, considering the systems approach that encompasses material selection, joint design, fabrication, and assembly. (C6) Discuss the key considerations in joint design, including load-bearing capacity, joint stiffness, fatigue resistance, and serviceability. (C6) Explain the iterative nature of the design process, involving analysis, testing, and optimization to achieve the desired performance and reliability. (C6) Simple Design Studies (Pressure Vessels, Torsion Bar); Factors of Safety (C6) Present design studies on specific applications, such as pressure vessels and torsion bars, highlighting the design considerations, material selection, and factors of safety involved. (C6) Discuss the importance of incorporating appropriate factors of safety to ensure the structural integrity and reliability of the joined components. (C6) Illustrate the iterative design process through examples, considering load analysis, stress calculations, and failure modes. (C6) Case Studies for Failure Design Process, Materials Selection, Manufacturing Method (C6) Explore case studies of failures in joined structures, analyzing the design process, material selection, and manufacturing methods employed. (C6) Discuss the lessons learned from these case studies and the improvements made in subsequent designs to address the failure modes. (C6) Emphasize the importance of considering factors such as loading conditions,

	material properties, joint configuration, and manufacturing quality in failure analysis and design improvements. (C6) Economic Aspects of Using Composites (C5) Discuss the economic considerations associated with using composites in various applications, including cost analysis, life cycle assessment, and benefits such as weight reduction, fuel efficiency, and maintenance savings. (C5) Highlight the trade-offs between the initial material and manufacturing costs of composites and their long-term economic advantages. (C5) Stress Analysis: Free Edge Stresses; Typical Distributions; Significance of Stacking Sequence; Significance of Ply Blocking; Effect on Failure Modes; Experimental Evidence (C6) Explain the concept of free edge stresses in composite structures and their influence on stress distributions and failure modes. (C6) Discuss the significance of stacking sequence and ply orientation in determining the mechanical response and strength of composite laminates. (C6) Explore the effect of ply blocking, interface delamination, and other factors on stress concentration and failure initiation in composite structures. (C6) Discuss the experimental evidence and testing methods used to validate stress analysis models and predictions in composite materials. (C6) Development of Engineer's Theory of Bending for Thin-Walled Beams Comprising Several Different Materials and Analysis of Shear Flow Distribution (C6) Explain the development of the engineer's theory of bending for thin-walled beams composed of different materials, including the analysis of shear flow distribution and its influence on bending behavior. (C6) Discuss the assumptions and simplifications involved in the theory and its application to practical engineering problems. (C6) Highlight the significance of shear flow distribution in determining the strength and stability of composite beams and structures. (C6) Buckling: Strut Buckling, Buckling of Especially Orthotropic Plates, Significance of Bending-Twisting Coupling (C6) Introduce the concept of buckling in structural members, focusing on strut buckling and buckling of orthotropic plates. (C6) Discuss the factors that affect buckling, including material properties, geometric constraints, and loading conditions. (C6) Explain the significance of bending-twisting coupling in composite structures and its influence on buckling behavior and failure modes. (C6)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2

Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓

Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:				
i) B. Frank L. Matthews and Rees D. Rawlings (1999), Composite Materials: Engineering and Science, Woodhead Publishing. **ii)** Ning Hu (2012), Composites and Their Applications, in Tech Publisher **iii)** PavlaTesinova (2011) Advances in Composite Materials: Analysis of Natural and Man-Made Materials, in Tech Publisher.				

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**SEC-I (SolidWorks)**
Academic Year	II
Semester	III
Number of Credits	2
Course Prerequisite	Engineering Graphics & Design
Course Synopsis	This course introduces students to SolidWorks, powerful 3D computer-aided design (CAD) software. Students will learn the fundamental concepts and skills necessary to create 3D models and assemblies. The course focuses on modeling techniques, design intent, parametric modeling, and assembly design.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply SolidWorks tools and techniques to create 3D models.
CO2	Design and assemble complex 3D models using advanced SolidWorks features.
CO3	Generate 2D drawings and documentation from 3D models for manufacturing and assembly purposes.
CO4	Analyze and simulate designs to evaluate their structural integrity and performance.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	-	-	-	1	1	1	3	2	1
CO2	3	3	3	2	3	1	-	-	-	1	1	1	3	3	-
CO3	3	3	3	2	3	1	1	-	-	1	1	1	3	3	-
CO4	3	3	3	3	3	1	1	1	-	1	1	1	3	3	1
Average	3	2.75	2.75	2.25	3	1	0.5	0.25	-	1	1	1	3	2.75	0.5

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0		**0**	**4**	**4**

Sr. No.	**Content & Competencies**
1	Introduction to SolidWorks (4 hours) SolidWorks interface and navigation (C1: Remembering) Sketching tools and constraints (C2: Understanding) Basic modeling techniques (C3: Applying)
2	Creating 3D Parts (10 hours) Advanced sketching techniques (C2: Understanding) Extruding, revolving, and sweeping features (C3: Applying) Fillets, chamfers, and shells (C3: Applying) Hole creation and patterns (C3: Applying)
3	Advanced Part Modeling (8 hours) Advanced feature creation (lofts, sweeps, and sweeps with guide curves) (C4: Analyzing) Complex sketching techniques (C3: Applying) Design intent and parametric modeling (C3: Applying) Configurations and design tables (C4: Analyzing)
4	Assembly Design (8 hours) Creating assemblies and sub-assemblies (C3: Applying) Applying mates and constraints (C3: Applying) Exploded views and animations (C3: Applying) Top-down and bottom-up assembly approaches (C4: Analyzing)
5	Drawing and Detailing (6 hours) Creating 2D drawings from 3D models (C2: Understanding) Dimensioning and annotations (C3: Applying) Bill of Materials (BOM) creation (C2: Understanding) Assembly drawings and section views (C3: Applying)
6	Advanced Assembly Techniques (8 hours) Advanced mates (symmetric, width, and path mates) (C4: Analyzing) Motion studies and collision detection (C4: Analyzing) Designing for assembly and interference detection (C3: Applying) Using configurations in assemblies (C4: Analyzing)
7	Sheet Metal Design (6 hours) Introduction to sheet metal tools (C2: Understanding) Creating sheet metal parts (C3: Applying) Bend allowances and sheet metal features (C3: Applying) Flat patterns and sheet metal drawings (C3: Applying)
8	Advanced Modeling Techniques (8 hours) Surface modeling (C3: Applying) Mold design and analysis (C4: Analyzing) Weldments and structural members (C3: Applying)

	Advanced part and assembly editing (C3: Applying)
9	Simulation and Analysis (6 hours) Introduction to simulation tools (C2: Understanding) Stress analysis and optimization (C4: Analyzing) Static and dynamic simulations (C3: Applying) Result interpretation and validation (C4: Analyzing)
10	Project Work (8 hours) Integration of learned concepts and skills (C5: Creating) Designing and modeling a complex assembly (C5: Creating) Documentation and presentation of the project (C3: Applying)

Teaching - Learning Strategies and Contact Hours

Teaching-Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	10
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	10
Revision	5
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
Problem Based Learning (PBL)	University Examination
Assignment	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Assignment	✓	✓	✓	✓

<table>
<tr><td colspan="2">Practical Log Book/ Record Book</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">University Examination</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Feedback Process</td><td colspan="5">1. Student’s Feedback
2. Course Exit Survey</td></tr>
<tr><td colspan="6">Students Feedback is taken through various steps
1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
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<tr><td>References:</td><td colspan="5">(List of reference books)</td></tr>
<tr><td></td><td colspan="5">1. "Engineering Design with SolidWorks" by David C. Planchard and Marie P. Planchard, SDC Publications, Edition Year: 2007, ISBN: 978-1585034192
2. "SolidWorks 2021 Tutorial" by David C. Planchard and Marie P. Planchard, SDC Publications, Edition Year: 2021, ISBN: 978-1-63057-409-3
3. "SolidWorks 2021 Black Book" by Gaurav Verma and Matt Weber, Cadcamcae Works, Edition Year: 2020, ISBN: 978-1774590096
4. "Mastering SolidWorks" by Matt Lombard, Sybex, Edition Year: 2018, ISBN: 978-1119300571</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Engineering Mechanics Lab
Academic Year	II
Semester	III
Number of Credits	1
Course Prerequisite	NIL
Course Synopsis	This practical lab work will give students an insight about the basics of applied engineering mechanics.

Course Outcomes:

At the end of the course students will be able to:

CO1	To understand the concepts of forces
CO2	To understand the conditions of static and dynamic equilibrium.
CO3	To understand the basic principles of physics applied to Engineering Mechanics.
CO4	To know the geometric properties of the different shapes.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	0	0	-	1	0	0	1	1	2	0	0	3
CO2	3	3	3	3	2	-	1	0	2	0	2	2	0	1	2
CO3	3	3	3	3	2	-	1	1	1	2	2	3	1	0	2
CO4	3	3	3	3	2	-	2	1	2	1	2	2	0	0	2
Average	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	0.25	0.25	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

0	0	2	2

Unit	Content & Competencies
1	Verification of triangle law & parallelogram law of forces C1
2	Verification of polygon law of forces C1, C2
3	Verification of the principle of moments using the bell crank lever apparatus C1,
4	Verification of support reactions of a simply supported beam C1, C2
5	Verification of condition of equilibrium of a system of forces C1, C2
6	Verification of axial forces in the members of a truss C1, C2
7	Verification of equilibrium of three-dimensional forces C1, C3
8	Determination of coefficient of friction between two surfaces C3
9	Verification of centroid of different lamina C4
10	Determination of moment of inertia of a flywheel C4

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	10
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--

Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) J. V. Rao, D. H. Young, S. Timoshenko, Sukumar Pati (2013), Engineering Mechanics, Tata

McGraw Hill Education. ISBN: 978-1-259-06266-7
ii) Irving H. Shames (2012), Engineering Mechanics – Statics and Dynamics, 4th Edition, Prentice-Hall of India Private limited. ISBN: 978-8-131-72883-3

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Robotics Engineering and Applications**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	NA
Course Synopsis	To understand the principles of robotic engineering and its applications. To equip students with practical knowledge that will allow them to design, build, and program a robot that can perform a variety of tasks.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand the basic components of robots.
CO2	Differentiate types of robots and robot grippers.
CO3	Analyze forces in links and joints of a robot.
CO4	Program a robot to perform tasks in industrial applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	-	-	-	2	3	2	2
CO2	3	1	1	1	1	1	-	-	-	-	-	2	3	2	2
CO3	3	2	3	3	2	1	-	-	-	-	-	1	2	2	1
CO4	3	2	2	2	1	1	-	-	-	-	-	3	1	2	3
Average	3	1.75	1.75	1.75	1.25	1	-	-	-	-	-	2	2.25	2	2

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**

3		0	0	3
Unit	**Content & Competencies**			
1	Introduction to Robotics (C1) Provide an overview of robotics as a field of study and its applications in various industries, such as manufacturing, healthcare, and exploration. (C1) Explain the fundamental principles and concepts of robotics, including robot anatomy, kinematics, and control. (C1) Components of a Robotic System (C2) Describe the essential components of a robotic system, including the robot manipulator, sensors, actuators, control system, and end-effectors. (C2) Discuss the function and role of each component in the overall operation of the robotic system. (C2) Types and Classification of Robots (C2) Discuss the different types and classifications of robots based on their structure, mobility, and application. (C2) Explain the characteristics and capabilities of industrial robots, mobile robots, humanoid robots, and collaborative robots. (C2) Applications of Robots (C2) Provide examples of real-world applications where robots are used, such as manufacturing assembly lines, medical surgery, warehouse automation, and space exploration. (C2) Discuss the advantages and benefits of using robots in these applications, including increased productivity, improved precision, and enhanced safety. (C2) Drives and Actuators (C3) Explain the various types of drives and actuators used in robotics, such as electric motors, hydraulic systems, and pneumatic systems. (C3) Discuss the advantages, limitations, and considerations associated with each type of drive and actuator. (C3) Control Components (C3) Introduce the control components used in robotic systems, including microcontrollers, programmable logic controllers (PLCs), and feedback control systems. (C3) Explain the role of these components in monitoring and controlling the motion, position, and operation of the robot. (C3) Serial Manipulator & Parallel Manipulator (C4) Differentiate between serial manipulators and parallel manipulators in terms of their kinematic structure and characteristics. (C4) Discuss the advantages and limitations of each type of manipulator and their applications in different industries. (C4) Explain the principles of forward and inverse kinematics for both serial and parallel manipulators. (C4)			
2	Grippers (C3) Discuss the importance of grippers in robotic systems for manipulating and grasping objects. (C3) Explain the different types of grippers, including mechanical grippers, magnetic			

	grippers, and vacuum cup grippers. (C3) Describe the principles of operation and the advantages and limitations of each type of gripper. (C3) Mechanical Gripper (C3) Explain the working principle of a mechanical gripper, including the design of jaws or fingers for grasping objects. (C3) Discuss the factors influencing the grasping force and the considerations for selecting an appropriate mechanical gripper. (C3) Grasping Force (C3) Define the concept of grasping force and its significance in robotic manipulation tasks. (C3) Explain the factors affecting the grasping force, such as the gripper design, actuation mechanism, and object properties. (C3) Discuss the importance of optimizing the grasping force for efficient and reliable object handling. (C3) Engelberger-g-factors-Mechanisms for Actuation (C4) Introduce the concept of Engelberger-g-factors, which are factors used to evaluate the performance of industrial robots. (C4) Discuss the various mechanisms used for actuating grippers, such as pneumatic, hydraulic, electric, or a combination of these. (C4) Explain the advantages and limitations of each actuation mechanism and their impact on gripper performance. (C4) Magnetic Gripper (C3) Describe the working principle of a magnetic gripper, which uses magnetic fields to hold and manipulate objects. (C3) Discuss the applications and considerations for using a magnetic gripper in different scenarios. (C3) Vacuum Cup Gripper (C3) Explain the operation of a vacuum cup gripper, which uses suction to hold and lift objects. (C3) Discuss the factors influencing the effectiveness of a vacuum cup gripper and the considerations for its selection and design. (C3) Considerations in Gripper Selection & Design (C3) Discuss the factors to consider when selecting a gripper, such as the object size, shape, weight, and surface properties. (C3) Explain the importance of gripper adaptability, reliability, and ease of integration with the robotic system. (C3) Highlight the considerations for gripper design, including the choice of materials, actuation mechanisms, and control methods. (C3) Industrial Robots' Specifications (C4) Introduce the specifications used to characterize industrial robots, such as payload capacity, reach, speed, and accuracy. (C4) Discuss the significance of these specifications in determining the suitability of a robot for a specific application. (C4) Selection Based on the Application (C4) Explain the process of selecting an industrial robot based on the requirements

	and constraints of a specific application. (C4) Discuss the factors to consider, such as the work envelope, required tasks, cycle time, and safety considerations. (C4) Highlight the importance of matching the robot's capabilities and specifications to the application's demands for optimal performance. (C4)
3	Drive - Types of Drives (C3) Discuss the different types of drives used in robotic systems, such as electric drives, hydraulic drives, and pneumatic drives. (C3) Explain the working principles and characteristics of each drive type. (C3) Discuss the advantages, limitations, and applications of different drive types in robotic systems. (C3) Types of Transmission Systems (C3) Explain the various types of transmission systems used in robots, including gear transmissions, belt transmissions, and chain transmissions. (C3) Discuss the working principles and characteristics of each transmission system. (C3) Explain the considerations for selecting an appropriate transmission system based on factors such as torque requirements, speed, efficiency, and precision. (C3) Actuators and their Selection while Designing a Robot System (C4) Introduce the concept of actuators and their role in converting electrical, hydraulic, or pneumatic energy into mechanical motion in robotic systems. (C4) Discuss the different types of actuators commonly used in robotics, such as electric motors, hydraulic cylinders, and pneumatic actuators. (C4) Explain the factors to consider when selecting actuators, including power requirements, torque/speed characteristics, size, weight, and control compatibility. (C4) Discuss the trade-offs between different actuator types and the considerations for optimizing actuator selection for specific robot system requirements. (C4) Control Systems: Types of Controllers (C3) Explain the different types of controllers used in robotic systems, including proportional-integral-derivative (PID) controllers, fuzzy logic controllers, and model-based controllers. (C3) Discuss the working principles and characteristics of each controller type. (C3) Highlight the advantages, limitations, and applications of different controller types in robotic systems. (C3) Introduction to Closed-Loop Control (C3) Introduce the concept of closed-loop control in robotics, which involves continuously monitoring and adjusting the robot's performance based on feedback signals. (C3) Explain the benefits of closed-loop control in terms of improved accuracy, stability, and robustness of the robotic system. (C3) Discuss the basic components of a closed-loop control system, including sensors, actuators, feedback loops, and controllers. (C3)
4	Socio-Economic Aspect of Robotization (C5) Discuss the socio-economic implications of robotization, including the impact

	on employment, workforce dynamics, and income distribution. (C5) Examine the potential benefits and challenges associated with increased automation and robotization in various industries and sectors. (C5) Explore the ethical considerations and social implications of widespread robotization, such as privacy concerns and the need for retraining and upskilling of workers. (C5) Economical Aspects for Robot Design (C4) Explain the economic considerations involved in the design and implementation of robotic systems, including cost-benefit analysis, return on investment (ROI), and total cost of ownership (TCO). (C4) Discuss factors such as initial investment, maintenance costs, energy efficiency, and productivity gains in relation to the economic viability of robot design decisions. (C4) Explore strategies for cost optimization in robot design, such as component selection, standardization, and modularization. (C4) Safety for Robot and Standards (C4) Discuss the importance of safety in robotics and the need for adherence to safety standards and regulations. (C4) Explain the various safety considerations in robot design, including risk assessment, hazard identification, and implementation of protective measures. (C4) Discuss common safety features in robotic systems, such as emergency stop buttons, safety interlocks, and protective barriers. (C4) Highlight the role of international standards organizations in defining safety standards for robotics. (C4) Introduction to Artificial Intelligence (C2) Provide an overview of Artificial Intelligence (AI) and its relevance to robotics. (C2) Explain the basic principles of AI, including machine learning, natural language processing, and computer vision. (C2) Discuss the relationship between AI and robotics, and how AI techniques enhance the capabilities of robotic systems. (C2) AI Techniques (C3) Introduce various AI techniques commonly used in robotics, such as neural networks, genetic algorithms, and expert systems. (C3) Explain the working principles and applications of these AI techniques in robotic systems. (C3) Discuss the advantages, limitations, and considerations for implementing AI techniques in robot design. (C3) Need and Application of AI (C3) Explore the need for AI in robotics, including tasks that can benefit from AI capabilities, such as perception, decision-making, and autonomous operation. (C3) Discuss the wide range of applications for AI in robotics, including industrial automation, healthcare, transportation, and entertainment. (C3) Highlight the potential benefits and challenges of integrating AI into robotic

	systems. (C3) New Trends & Recent Updates in Robotics (C4) Provide an overview of new trends and recent advancements in robotics, such as collaborative robots (Cobots), swarm robotics, and human-robot interaction. (C4) Discuss emerging technologies and their impact on the field of robotics, including machine learning, computer vision, and cloud robotics. (C4) Highlight recent developments in robotic research, industry applications, and notable case studies. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) Industrial Robotics / Groover M P /McGraw Hill. (ISBN-10: 0071004424, ISBN-13: 978-0071004428).

ii) S. R. Deb and Sankha Deb (2009), Robotics Technology and Flexible Automation, 2nd Edition, Tata McGraw-Hill Education. ISBN: 978-0-070-07791-1.

iii) John J. Craig (2008), Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson Education. ISBN: 978-8-131-71836-0.

iv) Theory of Applied Robotics /Jazar/Springer. (ISBN- 978-1-4419-1750-8)

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Robotics Engineering and Applications Lab**
Academic Year	II
Semester	III
Number of Credits	1
Course Prerequisite	NA
Course Synopsis	To understand the principles of robotic engineering, and its applications. To equip students with practical knowledge that will allow them to design, build, and program a robot that can perform a variety of tasks.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand the basic components of robots.
CO2	Differentiate types of robots and robot grippers.
CO3	Analyze forces in links and joints of a robot.
CO4	Program a robot to perform tasks in industrial applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	-	-	-	2	3	2	2
CO2	3	1	1	1	1	1	-	-	-	-	-	2	3	2	2
CO3	3	2	3	3	2	1	-	-	-	-	-	1	2	2	1
CO4	3	2	2	2	1	1	-	-	-	-	-	3	1	2	3
Average	3	1.75	1.75	1.75	1.25	1	-	-	-	-	-	2	2.25	2	2

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**

0		0	2	1
Unit	**Content & Competencies**			
1	Study of robotic arm and its configuration. C1			
2	Study the robotic end effectors. C1			
3	Study of different types of hydraulic and pneumatic valves. C1			
4	Robot programming and simulation for pick and place. C3			
5	Robot programming and simulation for Shape identification. C3			
6	Robot programming and simulation for machining (cutting, welding). C3			
7	Robot programming and simulation for writing practice. C4			
8	Robot programming and simulation for any industrial process (Packaging, Assembly). C4			
Note:	1. At least 8 experiments/ jobs are to be performed/ prepared by students in the semester. At least 6 experiments/ jobs should be performed/prepared from the above list; the remaining two may either be performed/prepared from the above list or designed and set as per the scope of the syllabus of the Robotics Engineering and Applications.			

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	08
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	08
Case/Project Based Learning (CBL)	--
Revision	04
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i)	Industrial Robotics / Groover M P /McGraw Hill. (ISBN-10: 0071004424, ISBN-13: 978-0071004428).
ii)	S. R. Deb and Sankha Deb (2009), Robotics Technology and Flexible Automation, 2nd Edition, Tata McGraw-Hill Education. ISBN: 978-0-070-07791-1.
iii)	John J. Craig (2008), Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson Education. ISBN: 978-8-131-71836-0.
iv)	Theory of Applied Robotics /Jazar/Springer. (ISBN- 978-1-4419-1750-8)

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Introduction to Electric and Hybrid Vehicles
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. The material for this course will be prepared in such a manner that it will be useful for post-graduate students, teachers, practitioners and final year undergraduate students.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Describe about working principle of electric vehicles.
CO2	Explain the construction and working principle of various motors used in electric vehicles.
CO3	Understand about working principle of electronics and sensor less control in electric vehicles
CO4	Describe the different types and working principle of hybrid vehicles.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	-	1	1	3	2	3	1	2	2	1	1	3	1	1
CO2	3	2	2	1	3	-	2	-	-	-	1	3	3	2	-
CO3	3	2	3	2	3	1	2	1	-	-	-	2	3	2	-
CO4	3	2	1	-	2	-	1	-	1	1	1	2	3	2	1
Average	3	1.5	1.75	1	2.75	0.75	2	0.5	0.75	0.75	0.75	2	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Electric Vehicle – Need, Types, Cost, and Emissions, End of Life (C2) Need for Electric Vehicles: Understand the environmental and energy efficiency reasons for the adoption of electric vehicles (C2), and analyze the societal and economic benefits of electric vehicles in reducing carbon emissions and dependence on fossil fuels (C3). Types of Electric Vehicles: Classify different types of electric vehicles, including Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCEVs) (C2), and analyze their characteristics, advantages, and limitations (C3). Cost and Emissions: Evaluate the cost considerations associated with electric vehicles, including upfront costs, maintenance, and operational expenses (C3), and analyze the environmental impact and emissions reduction potential of electric vehicles compared to conventional internal combustion engine vehicles (C3). End of Life: Understand the challenges and considerations for the end-of-life management of electric vehicle components, including batteries and other electronic components (C2), and analyze strategies for recycling, reuse, and proper disposal of electric vehicle components (C3). Electric Vehicle Technology – Layouts, Cables, Components, Controls (C4) Vehicle Layouts: Analyze different electric vehicle layouts, such as the Battery Electric Vehicle (BEV) layout, series hybrid layout, parallel hybrid layout, and fuel cell layout (C3), and evaluate their advantages and disadvantages in terms of efficiency, performance, and packaging (C4). Cables and Components: Understand the role and function of key components in electric vehicles, such as electric motors, power electronics, charging systems, and energy storage systems (C2), and analyze the electrical and mechanical requirements for cables and connectors used in electric vehicle systems (C3). Vehicle Controls: Explain the control systems and algorithms used in electric vehicles, including motor control, battery management, regenerative braking, and vehicle dynamics control (C2), and evaluate the performance and efficiency of different control strategies (C3). Batteries – Overview and Types, Plug-in and Life (C2) Battery Overview: Understand the principles and operation of batteries used in electric vehicles, such as Lithium-ion (Li-ion), Nickel-Metal Hydride (NiMH), and Solid-State Batteries (C2), and analyze their characteristics, including energy density, power density, and cycle life (C3). Battery Types: Differentiate between various types of batteries used in electric vehicles based on their chemistry and performance characteristics (C2), and evaluate their suitability for different applications and vehicle types (C3). Battery Plug-in and Life: Explain the concept of plug-in charging for electric

	vehicle batteries (C2), analyze the factors affecting battery life, including charging cycles, temperature, and depth of discharge (C3), and assess strategies for prolonging battery life and maximizing its performance (C4). Ultra-capacitor, Charging – Methods and Standards, Alternate Charging Sources – Wireless & Solar (C3) Ultra-capacitor: Understand the principles and applications of ultra-capacitors in electric vehicles (C2), analyze their advantages and limitations compared to batteries (C3), and evaluate their potential for energy storage and fast charging in electric vehicles (C4). Charging Methods and Standards: Analyze different charging methods for electric vehicles, including AC charging, DC fast charging, and wireless charging (C3), and understand the international standards and protocols for electric vehicle charging infrastructure (C2). Alternate Charging Sources – Wireless & Solar: Evaluate the feasibility and benefits of wireless charging technologies for electric vehicles (C3), analyze the use of solar power as an alternate charging source for electric vehicles (C3), and assess their impact on the efficiency, convenience, and sustainability of electric vehicle charging (C4).
2	Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control (C4) DC Motors: Explain the operating principle and construction of DC motors, including brushed and brushless types (C2), analyze their characteristics such as torque-speed characteristics and efficiency (C3), and design control systems for DC motor speed and direction (C4). Induction Motors: Describe the working principle and construction of induction motors (C2), differentiate between single-phase and three-phase induction motors (C2), analyze their performance characteristics, including torque-speed characteristics and efficiency (C3), and design control systems for induction motor speed and torque (C4). Brushless DC (BLDC) Motors: Understand the operating principle and construction of BLDC motors (C2), analyze their advantages over brushed DC motors and induction motors (C3), and design control systems for BLDC motor speed and position (C4). Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling (C5) Series Hybrid Electric Drive Train: Explain the concept of a series hybrid electric drive train (C2), analyze the power rating design considerations, including selection of electric motor and generator, power electronics, and energy storage systems (C3), and design the peak power source (PPS) system for optimal performance (C4). Parallel Hybrid Electric Drive Train: Understand the working principle of a parallel hybrid electric drive train (C2), analyze the torque coupling and speed coupling mechanisms between the internal combustion engine and electric motor (C3), and design control systems for seamless power distribution and optimal efficiency (C4). Switched Reluctance Motors (SRM) Drives – Basic Structure, Drive Converter,

	Design (C4) SRM Basic Structure: Describe the construction and working principle of switched reluctance motors (SRMs) (C2), analyze their advantages and limitations compared to other motor types (C3), and evaluate their suitability for specific applications (C3). Drive Converter: Understand the role of drive converters in SRM systems (C2), analyze different converter topologies and control strategies for SRMs (C3), and design converter systems for efficient power conversion and motor control (C4). SRM Design: Analyze the factors affecting the design of SRMs, including magnetic circuit design, winding configuration, and rotor geometry (C3), optimize the motor design parameters for desired performance characteristics (C4), and evaluate the impact of design choices on motor efficiency and torque output (C4)
3	Basic Electronics Devices – Diodes, Thyristors, BJTs, MOSFETs, IGBTs, Convertors, Inverters (C3) Diodes: Understand the working principle and characteristics of diodes (C2), analyze their applications such as rectification and voltage regulation (C3), and design diode-based circuits for specific purposes (C3). Thyristors: Describe the operation and characteristics of thyristors (C2), analyze their applications in power control and switching circuits (C3), and design thyristor-based circuits for efficient power conversion (C3). BJTs (Bipolar Junction Transistors): Explain the construction and operation of BJTs (C2), analyze their amplification and switching characteristics (C3), and design BJT-based circuits for signal amplification and switching applications (C3). MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors): Understand the working principle and structure of MOSFETs (C2), analyze their advantages in terms of high switching speed and low power consumption (C3), and design MOSFET-based circuits for power control and amplification (C3). IGBTs (Insulated Gate Bipolar Transistors): Describe the construction and operation of IGBTs (C2), analyze their characteristics combining the advantages of MOSFETs and BJTs (C3), and design IGBT-based circuits for high-power applications (C3). Converters and Inverters: Understand the operation and types of power converters, including rectifiers and DC-DC converters (C2), analyze the principles of power inversion and the operation of inverters (C3), and design converter and inverter circuits for efficient power conversion (C3). Safety – Risks and Guidance, Precautions, High Voltage Safety, Hazard Management (C4) Risks and Guidance: Identify potential risks associated with electronics devices and circuits (C2), provide guidance on safe handling and operation of electronic components and systems (C3), and develop safety protocols and guidelines for working with high voltage and hazardous environments (C4). Precautions: Understand the importance of safety precautions in electronics

	applications (C2), identify potential hazards and risks in different electronic systems (C3), and implement appropriate safety measures, such as grounding, insulation, and protective devices (C4). High Voltage Safety: Demonstrate knowledge of high voltage safety guidelines and regulations (C2), assess potential risks and hazards associated with high voltage systems (C3), and implement safety measures to mitigate risks, including proper insulation, protective clothing, and equipment (C4). Hazard Management: Identify potential hazards in electronic systems and circuits (C2), develop hazard management strategies and protocols (C3), and implement measures to prevent or mitigate risks, such as proper labeling, isolation, and emergency shutdown procedures (C4). Sensors - Autonomous EV cars, Self-Drive Cars (C3) Autonomous EV Cars: Understand the role and importance of sensors in autonomous electric vehicles (C2), analyze different types of sensors used for perception, including cameras, LiDAR, radar, and ultrasonic sensors (C3), and evaluate their performance and integration in autonomous driving systems (C3). Self-Drive Cars: Describe the sensor technologies and systems used in self-driving cars (C2), analyze the sensor fusion techniques for accurate perception and decision-making in autonomous driving (C3), and assess the capabilities and limitations of sensor-based autonomous driving systems (C3)
4	Hybrid Electric Vehicles (HEVs) – Classification – Micro, Mild, Full, Plug-in, EV (C2) Classification: Differentiate between various types of hybrid electric vehicles, including micro, mild, full, plug-in, and electric vehicles (C2). Understand their respective characteristics, benefits, and limitations (C2). Layout and Architecture – Series, Parallel, and Series-Parallel Hybrid (C3) Series Hybrid: Explain the layout and working principle of series hybrid architecture, where the internal combustion engine serves as a generator to charge the battery, and the electric motor provides propulsion (C2). Analyze the advantages and disadvantages of series hybrid systems (C3). Parallel Hybrid: Describe the layout and operation of parallel hybrid architecture, where both the internal combustion engine and the electric motor can provide propulsion power (C2). Analyze the advantages and disadvantages of parallel hybrid systems (C3). Series-Parallel Hybrid: Explain the concept and architecture of series-parallel hybrid systems, which combine elements of both series and parallel hybrids (C2). Analyze the benefits and challenges of series-parallel hybrid configurations (C3). Propulsion Systems and Components (C3) Propulsion Systems: Analyze the different propulsion systems used in hybrid electric vehicles, including internal combustion engines, electric motors, and their integration (C3). Understand the power flow and energy management strategies in hybrid propulsion systems (C3). Components: Identify and describe the key components of hybrid electric vehicles, such as batteries, electric motors, power electronics, regenerative braking systems, and control units (C2). Analyze their functions, characteristics, and interactions within the hybrid system (C3).

	Regenerative Braking, Economy, Vibration, and Noise Reduction (C3) Regenerative Braking: Explain the concept and operation of regenerative braking in hybrid electric vehicles, where the electric motor converts kinetic energy into electrical energy for recharging the battery (C2). Analyze the benefits of regenerative braking in terms of energy efficiency and improved vehicle range (C3). Economy: Evaluate the fuel economy and energy efficiency of hybrid electric vehicles compared to conventional vehicles (C3). Analyze the factors that contribute to improved fuel economy, including the use of electric power and regenerative braking (C3). Vibration and Noise Reduction: Understand the methods and technologies employed in hybrid electric vehicles to reduce vibration and noise levels (C2). Analyze the impact of hybrid systems on vehicle noise and vibration characteristics (C3). Evaluate the effectiveness of vibration and noise reduction measures (C3). Hybrid Electric Vehicles System – Analysis and Types, Controls (C4) Analysis and Types: Perform analysis and evaluation of hybrid electric vehicle systems, considering factors such as power train efficiency, energy storage, and system integration (C4). Differentiate between different types of hybrid systems based on their architecture, power flow, and control strategies (C4). Controls: Understand the control algorithms and strategies used in hybrid electric vehicle systems, including power distribution, energy management, and mode switching (C3). Analyze the role of control systems in optimizing the performance and efficiency of hybrid vehicles (C4).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	4
Small Group Discussion (SGD)	6
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**

Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Introduction to Electric and Hybrid Vehicles Lab
Academic Year	II
Semester	III
Number of Credits	1
Course Prerequisite	Basics of Automobile Engineering
Course Synopsis	This practical course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. The Lab Work will be useful for post-graduate students, teachers, practitioners and final year undergraduate students in the field of Electric and Hybrid Vehicles.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Demonstrate various electric motors drives used in Electric Vehicles.
CO2	Demonstrate use of solar based EV charging station.
CO3	Identify various components of electric and hybrid electric vehicle and analyze its performance.
CO4	Demonstrate the use of BMS in managing energy storage devices of EVs.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	2	3	1	2	2	1	1	3	1	1
CO2	3	2	2	1	3	-	2	-	-	-	1	3	3	2	-
CO3	3	2	3	2	3	1	2	1	-	-	-	2	3	2	-
CO4	3	2	1	-	2	-	1	-	1	1	1	2	3	2	1
Average	3	1.5	1.75	1	2.75	0.75	2	0.5	0.75	0.75	0.75	2	3	1.75	0.5

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Electric Rickshaw Motor kit C1, C2			
2	BLDC motor-based EV C1, C2			
3	PMSM based Electric vehicle C1, C2			
4	Induction motor based electric vehicle C1, C2			
5	Study of off-grid solar Inverter C1, C2			
6	Study of 4 Leg Semikron Stack C1, C2			
7	Solar based EV Charging station C1, C2			
8	Study of electric vehicle system C1, C2			
9	Study of hybrid electric vehicle system C1, C2			
10	Demonstration of battery management System C1, C2, C3, C4			

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	24
Seminar/Journal Club	--
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--

Revision	2
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. 2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004. 3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	B.Tech.
Course Code	
Course Title	**Object Oriented Programming**
Academic Year	II
Semester	III
Number of Credits	3
Course Prerequisite	Programming for Problem Solving using C++
Course Synopsis	Introduces the principles of data abstraction, inheritance and polymorphism. Introduces the principles of virtual functions and polymorphism

Course Outcomes:

At the end of the course students will be able to:

CO1	Define Object Oriented Programming concepts.
CO2	Demonstrate java classes and data abstraction.
CO3	Develop java programs with reusability concept.
CO4	Handle exceptions in programming

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PS O4
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO2	3	3	1	2	-	-	-	-	1	-	-	-	1	1	1	-
CO3	3	3	1	2	-	-	-	-	1	-	-	-	1	1	1	-
CO4	3	2	1	-	-	-	-	-	-	-	-	-	1	-	1	-
Average	3	2.5	0.75	1	-	-	-	-	0.5	-	-	-	1	0.5	1	-

Course Content:

L (Hours/ Week)	T (Hours/Week)	P (Hours/Week)	CL (Hours/Week)	Total Hour/Week
3	**0**	**0**	**0**	**3**

Unit	Content and Competency
1	1. Overview of OOP concepts Abstraction, Encapsulation, Inheritance and Polymorphism. (C2: Comprehension) 2. Explain basics: Structure of a java program, Data types, Declaration of variables, Expressions, Operators, Operator Precedence, Evaluation of expressions, Type conversions. (C2: Comprehension) 3. Define Pointers, Arrays, Pointers and Arrays, Strings, Structures, References. (C1: Knowledge) 4. Demonstrate Flow control statement- if, switch, while, for, do, break, continue, go to statements. (C3: Application) 5. Define Functions - Scope of variables, Parameter passing, Default arguments, inline functions, Recursive functions, Pointers to functions. (C1: Knowledge) 6. Implement Dynamic memory allocation and de-allocation operators-new and delete. (C6: Evaluation) 7.Demonstrate Preprocessor directives (C3: Application)
2	1. Explain Classes and Data Abstraction: Class definition, Class structure, Class objects, Class scope, and this pointer, Friends to a class, Static class members, and Constant member functions. (C2: Comprehension) 2. Describe Constructors and Destructors, Dynamic creation and destruction of objects, Data abstraction, ADT and information hiding. (C2: Comprehension)
3	1. Define Inheritance: Defining a class hierarchy, Different forms of inheritance. (C1: Knowledge) 2. Defining the Base and Derived classes, Access to the base class members, Base and Derived class construction, Destructors. (C1: Knowledge) 3. Explain Virtual base class. (C2: Comprehension) 4. Demonstrate Virtual Functions and Polymorphism: Static and Dynamic binding, virtual functions, Dynamic binding through virtual functions, Virtual function call mechanism, Pure virtual functions. (C3: Application) 5. Explain Abstract classes, Implications of polymorphic use of classes, and Virtual destructors. (C2: Comprehension)
4	1. Define Exception Handling and Benefits of exception handling. (C1: Knowledge) 2. Describe Throwing an exception by try block and Catching an exception. (C2: Comprehension) 3. Explain Exception objects, Exception specifications, Stack unwinding, Rethrowing an exception, and Catching all exceptions. (C2: Comprehension)

Learning Strategies and Contact Hours

Learning Strategies	Contact Hours
Lecture	30
Practical	
Seminar/Journal Club	2
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	2
Problem Based Learning (PBL)	4
Case/Project Based Learning (CBL)	2
Revision	4
Others If any:	
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2
Objective Structured Clinical Examination (OSCE)	University Examination
Objective Structured Practical Examination (OSPE)	Dissertation
Quiz	Multiple Choice Questions (MCQ)
Seminars	Short Answer Questions (SAQ)
Problem Based Learning (PBL)	Long Answer Question (LAQ)
Journal Club	Practical Examination & Viva-voce
	Objective Structured Clinical Examination (OSCE)
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Clinical assessment				
Clinical/Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback			
References:	Core Java Volume I--Fundamentals (11th Edition) Author – Cay S. Horstmann Latest Edition – 11th Edition Publisher – Prentice Hall			

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Object Oriented Programming Lab**
Academic Year	II
Semester	III
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	To prepare students to become familiar with the Standard Java technologies of J2SE

Course Outcomes:

At the end of the course, students will be able to:

CO1	Able to analyze the necessity for Object Oriented Programming paradigm and over structured programming and become familiar with the fundamental concepts in OOP
CO2	Demonstrate an ability to design and develop java programs, analyze, and interpret object oriented data and report results.
CO3	Demonstrate an ability to design an object oriented system, AWT components or multithreaded process as per needs and specifications
CO4	Demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks like console and windows applications both for standalone and Applets programs

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	2	-	3	1	-	-	-	-	-	-	3	2	1
CO2	3	2	2	-	-	1	-	-	-	-	-	-	3	2	-
CO3	3	2		-	-	-	-	-	-	-	-	-	3	2	-
CO4	3	2	3	3	1	-	-	-	-	-	-	-	3	2	1
Average	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	-	-	3.0	2.0	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

0	0	4	4

Content & Competencies	
Sr. No.	**Title and Competency**
1	Write a java program to find the Fibonacci series using recursive and non recursive functions. (C1: Knowledge)
2	Write a java program to multiply two given matrices. (C1: Knowledge)
3	Write a java program for Method overloading and Constructor overloading. (C1: Knowledge)
4	Write a java program to display the employee details using Scanner class. (C1: Knowledge)
5	Write a java program that checks whether a given string is palindrome or not. (C1: Knowledge)
6	Write a java program to represent Abstract class with example. (C1: Knowledge)
7	Write a java program to implement Interface using extends keyword. (C1: Knowledge)
8	Write a java program to create user defined package. (C1: Knowledge)
9	Write an applet program that displays a simple message. (C1: Knowledge)
10	Write a java program that connects to a database using JDBC. (C1: Knowledge)
Note:	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30

Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process		1. Student's Feedback 2. Course Exit Survey
References:	Core Java Volume I-Fundamentals (11th Edition) Author – Cay S. Horstmann Latest Edition – 11th Edition Publisher – Prentice Hall	

SEMESTER - IV

Course Code	Course Title
	Strength of Materials
	Material Engineering & Technology
	Manufacturing Processes
Program Electives Course - II	
	Steam Power Generation
	Total Quality Management
	Production Planning & Control
	Mechanical Vibration
	Tool Design
	AECC-IV
	VAC-IV
	SEC-II (ANSYS)
	Strength of Materials Lab
	Material Engineering & Technology Lab
	Manufacturing Processes Lab
Minor Elective Course-III (Robotics)	
	Mobile Robots
	Mobile Robots Lab
Minor Elective Course-III (Electric Vehicles)	
	Battery Management System
	Battery Management System Lab

Minor Elective Course-III (Computer Science Engineering)	
	Database Management System
	Database Management System Lab

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Strength of Materials**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	Strength of Materials (also known as Mechanics of Materials) is the study of the internal effect of external forces applied to structural member. Stress, strain, deformation deflection, torsion, flexure, shear diagram, and moment diagram are some of the topics covered by this subject.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To suggest suitable material with the help of relationship between elastic constants and thermal consideration of a material.
CO2	To evaluate the strength of materials subjected to various internal forces such as compression, tension, shear and bending loads.
CO3	To apply the basic concepts in designing the machine elements subjected to torsion and axial loading condition.
CO4	To apply the concept of Principal stress and strain in order to prevent the failures in materials subjected to two-dimensional loading condition.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	-	-	-	-	-	-	-	3	3	2	2
CO2	3	3	3	3	1	-	-	-	-	-	-	3	3	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	2	3	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	2	3	3	3
Average	3	2.75	2.75	2.75	1.5	-	-	-	-	-	-	2.5	3	2.75	2.75

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Simple Stresses and Strain (C2, C3): Introduction and Definition of Stress and Strain: Define stress and strain in the context of mechanics of materials (C2). Understand the basic concepts and principles related to stress and strain (C2). Explain the relationship between stress and strain using Hooke's law (C2). Stress-Strain Diagrams: Interpret stress-strain diagrams for ferrous and non-ferrous materials (C3). Analyze the behavior of materials under different stress-strain conditions (C3). Determine the elastic limit, yield strength, and ultimate strength from stress-strain curves (C3). Factor of Safety: Define and calculate the factor of safety in engineering design (C2). Analyze the importance of the factor of safety in ensuring structural integrity and safety (C3). Elongation of Tapering Bars: Analyze the elongation of tapering bars of circular and rectangular cross sections (C3). Calculate the elongation of tapering bars due to axial loading (C3). Evaluate the effects of self-weight on the elongation of tapering bars (C3). Saint-Venant's Principle: Understand Saint-Venant's principle and its application in mechanics of materials (C2). Analyze the stress distribution in a body away from the point of application of load (C3). Compound Bars: Analyze the behavior of compound bars subjected to axial loading (C3). Calculate the stresses and strains in compound bars (C3). Temperature Stresses: Understand the concept of temperature stresses and their effects on materials (C2). Analyze the behavior of materials subjected to temperature changes (C3). Calculate the temperature stresses in different materials and configurations (C3). State of Simple Shear: Define and analyze the state of simple shear in materials (C2). Understand the stress and strain relationships in simple shear (C2). Elastic Constants and their Relationship:			

	Define and calculate the elastic constants (Young's modulus, shear modulus, and Poisson's ratio) (C2). Understand the relationships between the elastic constants (C2). Analyze the implications of elastic constants on material behavior (C3). Compound Stresses (C2, C3): State of Stress at a Point: Define and analyze the state of stress at a point in a material (C2). Understand the different stress components and their significance (C2). General Two-Dimensional Stress System: Analyze the behavior of materials under general two-dimensional stress systems (C3). Calculate the normal and shear stresses on arbitrary planes (C3). Principal Stresses and Principal Planes: Define principal stresses and principal planes (C2). Determine the principal stresses and their orientation (C3). Analyze the significance of principal stresses in material failure (C3). Mohr's Circle of Stresses: Understand the concept and construction of Mohr's circle of stresses (C2). Determine the principal stresses and maximum shear stresses using Mohr's circle (C3).
2	Shear Force and Bending Moment in Beams (C2, C3): Introduction to Types of Beams, Supports, and Loadings: Understand the different types of beams, including simply supported, cantilever, and continuous beams (C2). Identify and describe the various types of supports and their effects on beam behavior (C2). Recognize different loadings on beams, such as point loads, uniformly distributed loads, and uniformly varying loads (C2). Definition of Bending Moment and Shear Force: Define and understand the concepts of bending moment and shear force in beams (C2). Explain the sign conventions used for bending moment and shear force (C2). Understand the relationship between load intensity, bending moment, and shear force in beams (C2). Shear Force and Bending Moment Diagrams: Analyze and calculate the shear force and bending moment at different points along a beam subjected to point loads, uniformly distributed loads, uniformly varying loads, couples, and their combinations (C3). Construct shear force and bending moment diagrams for statically determinate beams (C3). Interpret the diagrams to determine critical points, maximum and minimum values, and regions of positive and negative bending moments and shear forces (C3). Deflection of Beams: Understand the concept of deflection in beams (C2).

	Apply the double integration method and Macaulay's method to calculate the deflection of beams (C3). Analyze different loading conditions and support conditions to determine the deflection of beams (C3). Bending and Shear Stresses in Beams: Introduce the concept of pure bending and its assumptions (C2). Derive the bending equation and understand the relationship between bending moment, flexural rigidity, and curvature (C2). Define the modulus of rupture and section modulus and their significance in analyzing beam strength (C2). Calculate the bending stress distribution in beams of circular, rectangular, 'I,' and 'T' sections (C3). Determine the shear stress distribution in beams and analyze its effects on beam behavior (C3).
3	Torsion in Circular Shaft (C2, C3): Introduction to Torsion: Understand the concept of torsion in circular shafts and its significance in engineering applications (C2). Recognize the assumptions made in the analysis of pure torsion (C2). Derivation of Torsion Equation for Circular Shafts: Derive the torsion equation for circular shafts based on the assumptions of pure torsion (C3). Understand the relationship between applied torque, torsional rigidity, polar modulus, and the resulting shear stress distribution (C3). Power Transmitted by a Shaft: Calculate the power transmitted by a shaft subjected to torsional loading (C3). Understand the relationship between torque, rotational speed, and power transmission (C2). Combined Bending and Torsion: Analyze the combined effects of bending and torsion on a shaft (C3). Understand the interaction between bending and torsional stresses and their influence on the failure of the shaft (C2). Columns and Struts (C2, C3): Introduction to Columns and Struts: Define columns and struts and their importance in structural engineering (C2). Differentiate between short and long columns based on their slenderness ratio (C2). Euler's Theory for Columns: Understand the assumptions and principles behind Euler's theory for column buckling (C2). Derive the Euler's buckling load equation for columns with different end conditions (C3). Recognize the limitations of Euler's theory in predicting column behavior (C2). Rankine-Gordon's Formula for Columns:

	Introduce Rankine-Gordon's formula for analyzing column stability (C2). Apply the formula to calculate the critical buckling load of columns (C3).
4	Thin and Thick Cylinders (C2, C3): Introduction to Cylinders: Understand the concept of cylinders and their applications (C2). Differentiate between thin and thick cylinders based on their dimensions (C2). Thin Cylinders subjected to Internal Pressure: Analyze thin cylinders under internal pressure and calculate hoop stresses, longitudinal stresses, and changes in volume (C3). Understand the assumptions and limitations of thin cylinder analysis (C2). Thick Cylinders subjected to Internal and External Pressure: Analyze thick cylinders subjected to both internal and external pressure using Lame's equation (C3). Determine the radial and hoop stress distribution in thick cylinders (C3). Understand the relationship between internal and external pressure and stress distribution (C2). Theories of Failure (C2, C3): Introduction to Theories of Failure: Introduce the theories of failure and their significance in material failure analysis (C2). Maximum Principal Stress Theory (Rankine's Theory): Explain Rankine's theory of failure based on the maximum principal stress criterion (C2). Apply the theory to analyze materials under different loading conditions (C3). Maximum Shearing Stress Theory (Tresca's Theory): Explain Tresca's theory of failure based on the maximum shearing stress criterion (C2). Apply the theory to analyze materials under different loading conditions (C3). Strain Energy Theory (Beltrami and Haigh): Explain the strain energy theory of failure and its relationship to material failure (C2). Discuss the application of the theory in analyzing material behavior (C3). Maximum Strain Theory (St. Venant's Theory): Explain St. Venant's theory of failure based on the maximum strain criterion (C2). Apply the theory to analyze materials under different loading conditions (C3).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5

Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓

<table>
<tr><td colspan="2">University Examination</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="2">Feedback Process</td><td colspan="4">1. Student’s Feedback
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<tr><td>References:</td><td colspan="5">(List of reference books)</td></tr>
<tr><td></td><td colspan="5">i) Rattan S.S. (2011) “Strength of Materials” McGraw-Hill Education (India) Pvt Limited, ISBN: 9780071072564, 007107256X.
ii) B.S. Basavarajaiah, P. Mahadevappa (2010) “Strength of Materials” CRC Press Publication India, 3rd Edition, ISBN-13 : 978-1439854198.</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Material Engineering & Technology**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	This introductory course combines the academic disciplines of chemistry, physics, and engineering to create a MST curriculum. The course covers the fundamentals of ceramics, glass, metals, polymers, and composites. Designed to appeal to a broad range of students, the course combines hands-on activities, demonstrations and long-term student project descriptions. The basic philosophy of the course is for students to observe, experiment, record, question, seek additional information, and, through creative and insightful thinking.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand how materials are formed and their classification based on atomic arrangement.
CO2	Describe the mechanical behaviour of metallic systems and its importance.
CO3	Evaluate system for fatigue failures.
CO4	Gain knowledge on different classes of materials and their applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	-	1	1	2	-	-	1	-	2	3	3	2
CO2	3	2	2	-	3	-	-	-	-	-	-	2	3	3	2

CO3	3	2	2	3	2	-	2	-	-	-	-	2	3	3	3
CO4	3	2	2	2	1	2	2	-	-	1	-	3	2	2	1
Average	3	2	1.75	2.5	1.75	1.5	2	-	-	0.5	-	2.25	2.75	2.75	2

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Materials Science (C1): Primary and Secondary Bonding in Materials: Understand the concepts of primary and secondary bonding in materials (C1). Differentiate between different types of primary bonding (e.g., ionic, covalent) and secondary bonding (e.g., metallic, vander Waals) (C1). Crystalline and Amorphous Materials: Define and distinguish between crystalline and amorphous materials (C1). Explain the atomic arrangement and structural characteristics of crystalline and amorphous materials (C1). Single Crystal and Polycrystalline Materials: Differentiate between single crystals and polycrystalline materials based on their atomic arrangement (C1). Understand the concept of grain boundaries in polycrystalline materials (C1). Space Lattice and Unit Cell: Define space lattice and unit cell in crystal structures (C1). Explain the concept of crystal systems and Bravais lattice (C1). Understand Miller indices and their significance in crystallography (C1). Closed Packed Structures: Discuss the concept of closed packed structures in crystalline materials (C1). Explain the arrangement of atoms in close-packed planes and the stacking sequence (C1). Principal Metallic Crystal Structures: Identify and describe the principal metallic crystal structures, including body-centered cubic (BCC), face-centered cubic (FCC), and hexagonal close-packed (HCP) (C1). Discuss the stacking faults and their impact on material properties (C1). Classification of Crystal Defects: Understand the classification of crystal defects, including point defects, line defects (dislocations), surface defects, and volume defects (C1).

	Explain the difference between edge and screw dislocations (C1). Effect of Imperfections on Material Properties: Analyze the effect of imperfections (defects) on material properties, such as mechanical, electrical, and thermal properties (C1). Numerical Problems on Crystallography: Solve numerical problems related to crystallography, including calculations involving Miller indices and crystal structures (C2).
2	Basics of Solidification Mechanism (C1): Cooling Curve of Pure Metal and Alloy: Understand the concept of the cooling curve and its significance in solidification (C1). Differentiate between the cooling curve of a pure metal and an alloy (C1). Phase and Phase Diagram: Define phase and explain the concept of phase diagrams (C1). Interpret the different regions, phases, and phase boundaries in a phase diagram (C1). Gibbs's Phase Rule: Explain Gibbs's phase rule and its application in phase diagrams (C1). Interpretation of Mass Fractions using Lever's Rule: Understand Lever's rule and its application in determining mass fractions in phase diagrams (C1). Binary Isomorphous System: Explain the binary isomorphous system and its characteristic features (C1). Analyze and interpret phase diagrams of binary isomorphous systems (C1). Binary Eutectic Alloy System (Lead-Tin System): Describe the binary eutectic alloy system using the Lead-Tin system as an example (C1). Explain the eutectic reaction and the microstructural features in the Lead-Tin system (C1). Binary Peritectic Alloy System (Iron-Nickel System): Describe the binary peritectic alloy system using the Iron-Nickel system as an example (C1). Explain the peritectic reaction and the microstructural features in the Iron-Nickel system (C1). Invariant Reactions: Understand the concept of invariant reactions in phase diagrams and their significance (C1). Iron-Iron Carbide Phase Diagram: Interpret the iron-iron carbide ($Fe-Fe_3C$) phase diagram and understand the phases and reactions present (C1).

	Slow Cooling of Hypo and Hyper Eutectoid Steels: Analyze the slow cooling process of hypo and hyper eutectoid steels using the iron-carbon phase diagram (C2). Temperature-Time-Transformation (TTT) and Continuous Cooling Transformation (CCT) Diagrams: Understand the concepts of TTT and CCT diagrams and their application in heat treatment processes (C2). Effect of Alloying Elements in Steel: Explain the effect of alloying elements on the microstructure and properties of steel (C1). Types of Stainless Steel and Cast Iron: Identify and describe different types of stainless steel and cast iron based on their composition and properties (C1).
3	Heat Treatment (C2): Annealing and Its Types: Define annealing and its purpose in heat treatment (C1). Explain the different types of annealing, such as full annealing, process annealing, and stress relief annealing (C2). Understand the effects of annealing on the microstructure and properties of materials (C2). Normalizing: Describe the process of normalizing and its purpose in heat treatment (C1). Analyze the microstructural changes that occur during normalizing (C2). Hardening and Tempering: Define hardening and tempering and their significance in heat treatment (C1). Explain the process of hardening and the formation of martensite (C2). Describe the tempering process and its effect on the mechanical properties of materials (C2). Aus-tempering and Mar-tempering: Differentiate between aus-tempering and mar-tempering processes (C2). Understand the microstructural changes and resulting properties in materials after aus-tempering and mar-tempering (C2). Microstructure Observation: Explain the methods used for microstructure observation, such as optical microscopy and electron microscopy (C2). Interpret and analyze the microstructural features observed after heat treatment processes (C2). Surface Heat Treatment Processes: Describe different surface heat treatment processes, including carburizing, nitriding, cyaniding, carbonitriding, flame hardening, and induction hardening

	(C2). Understand the purpose and benefits of each surface heat treatment process (C2). Composites - Fiber Reinforced, Metal Matrix, Ceramic Matrix: Define composites and their classification based on the matrix material (C1). Explain the properties and applications of fiber-reinforced composites, metal matrix composites, and ceramic matrix composites (C2). Ceramics - Alumina, Zirconia, Silicon Carbide, Sialons, Reaction Bonded Silicon Nitride (RBSN): Describe the properties and applications of various ceramics, including alumina, zirconia, silicon carbide, sialons, and reaction-bonded silicon nitride (RBSN) (C2). Glasses - Properties and Applications: Explain the properties and applications of glasses (C1). Discuss the unique characteristics of glasses and their suitability for different applications (C2). Magnetic Materials: Define magnetic materials and their properties (C1). Explain the applications and significance of magnetic materials in various industries (C2).
4	Mechanical Properties of Materials (C3): Strengthening Mechanism: Explain the various strengthening mechanisms used to enhance the mechanical properties of materials, such as solid solution strengthening, precipitation hardening, and grain refinement (C3). Understand how each strengthening mechanism affects the strength, hardness, and ductility of materials (C4). Plastic Deformation of Single and Polycrystalline Materials: Describe the process of plastic deformation in single-crystal and polycrystalline materials (C2). Discuss the role of slip and twinning in plastic deformation and their effects on the mechanical properties of materials (C3). Stress-Strain Curves: Interpret stress-strain curves for different ferrous and non-ferrous metals (C3). Analyze the behavior of materials under tension, including the elastic region, yield point, plastic deformation, and ultimate tensile strength (C4). Engineering Stress-Strain and True Stress-Strain Relations: Define engineering stress and strain and their relationship (C1). Explain the concept of true stress and true strain and their significance in material deformation (C3).

	Solve problems involving stress-strain relations and material properties (C4). Tensile Test of Ductile Material: Describe the tensile test procedure for ductile materials (C2). Evaluate mechanical properties such as yield strength, ultimate tensile strength, and elongation using tensile test data (C3). Hardness Measurement Tests: Explain different hardness measurement techniques, such as Rockwell, Brinell, and Vickers hardness tests (C2). Discuss the principles and applications of hardness testing (C3). Fracture of Metals: Differentiate between ductile and brittle fracture modes (C2). Explain the factors influencing fracture behavior and the mechanisms of crack propagation (C3). Fatigue: Define fatigue and discuss its significance in material failure (C2). Explain the concept of the endurance limit for ferrous and non-ferrous metals (C3). Describe fatigue testing procedures and analyze fatigue data (C4). Creep and Stress Rupture: Define creep and explain its mechanism in materials (C2). Describe the stages of creep and the factors affecting creep deformation (C3). Discuss stress rupture and its relationship to creep (C3). Explain the creep test procedure and analyze creep data (C4). SEM and XRD: Explain the principles and applications of scanning electron microscopy (SEM) and X-ray diffraction (XRD) in materials characterization (C3). Understand how SEM and XRD techniques are used to analyze microstructures, crystallographic information, and material defects (C4).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2

Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback			

	2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) V. Raghavan. Materials Science and Engineering, PHI; Fifth edition (30 July 2011), ASIN: B00K7YGKWQ

ii) William D. Callister, David G. Rethwisch, Fundamentals Of Materials Science And Engineering: An Integrated Approach, John Wiley & Sons; 4th Edition edition (8 December 2011), ISBN: 1118061608

iii) William F. Smith and Javad Hashemi (2004), Foundations of materials science and engineering 5th Edition, McGraw Hill, 2009, ISBN: 9780073529240

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Manufacturing Processes**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	This syllabus emphasizes the importance manufacturing sciences in the day-to-day life, and to study the basic manufacturing processes and tools used, It will offer detailed understanding of metal cutting, metrology, metal forming operations, machine tool, plastic processing and other important things which are very needful to a mechanical engineer. The fundamental idea how a design is turned into a product. This form is most likely predetermined, calculated, with a certain physical geometry. Usually, this geometry has certain tolerances that it must meet in order to be considered acceptable. A tolerance outlines the geometric accuracy that must be achieved in the manufacturing process.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To understand the basics and theory of metal cutting.
CO2	To study the metrology and measurement methods used in manufacturing processes.
CO3	Explain the various metal forming and sheet metal operations.
CO4	Explain in detail about machine tools.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	2	-	-	-	-	-	3	2	3	1
CO2	3	3	2	2	2	2	-	-	-	-	-	1	1	3	3
CO3	3	2	3	3	3	2	-	-	-	-	1	1	-	3	3

CO4	3	2	3	3	3	2	-	-	-	-	3	1	-	3	2
Average	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Manufacturing Processes and their Classification (C2): Define manufacturing processes and explain their significance in the production of goods (C1). Classify manufacturing processes based on their characteristics and applications, such as casting, forming, machining, joining, and additive manufacturing (C2). Metal Cutting and Tool Life (C3): Describe the basic tool geometry and nomenclature for single-point cutting tools (C1). Identify different types of chips and explain their characteristics (C2). Discuss the mechanics of chip formation and factors affecting chip formation (C2). Explain the theoretical and experimental methods used to determine the shear angle in metal cutting (C2). Differentiate between orthogonal and oblique metal cutting (C2). Discuss the metal cutting theories, including the Merchant's circle, Taylor's tool life equation, and the relationship between velocity, forces, and power consumption (C3). Explain the concepts of cutting speed, feed, and depth of cut and their effects on the machining process (C2). Discuss the importance of cutting fluids, coolants, and lubricants in metal cutting operations (C2). Explain the temperature profile in cutting and its impact on tool life and workpiece quality (C2). Discuss the factors influencing tool life and the tailor equation of tool life (C3). Describe the types of tool materials and their properties, including hardness, toughness, and wear resistance (C2). Explain the concept of machinability and its relationship to tool life and productivity (C2).
2	Metrology: Standards of Measurements (C2):

	Explain the importance of standards in metrology and their role in ensuring accurate measurements (C2). Discuss the different types of measurement standards, such as primary standards, secondary standards, and reference standards (C2). Linear and Angular Instruments (C2): Describe the working principles and applications of linear measuring instruments, such as vernier calipers, micrometers, and height gauges (C2). Explain the working principles and applications of angular measuring instruments, including protractors, sine bars, and angle gauges (C2). Discuss the use of slip gauges for precise measurement and calibration (C2). Comparators (Mechanical, Electrical, Optical) (C2): Explain the working principles and applications of mechanical comparators, such as dial indicators and mechanical amplifiers (C2). Discuss the working principles and applications of electrical comparators, including LVDT (Linear Variable Differential Transformer) and digital comparators (C2). Describe the working principles and applications of optical comparators, such as profile projectors and shadowgraphs (C2). Screw Thread Measurements and Limit Gauging (C2): Explain the methods used for measuring screw threads, including the three-wire method and thread micrometers (C2). Discuss the concept of limit gauging and its application in assessing the acceptability of screw threads (C2). Gauge Design and Surface Finish Measurements (C3): Explain the principles and considerations involved in the design of gauges for various applications (C2). Discuss surface finish and its importance in determining the quality of a surface (C2). Describe the methods and instruments used for measuring surface finish, including roughness testers and profilometers (C2). Explain the concepts of micro and macro deviation in surface finish evaluation (C2). Discuss the factors that influence surface finish, such as cutting parameters, tool wear, and material properties (C2). Limits, Fits, and Tolerances (C2): Explain the concept of limits, fits, and tolerances in dimensional control (C2). Describe the different types of limits, including unilateral and bilateral limits (C2). Discuss the various types of fits, such as clearance fit, interference fit, and transition fit (C2).

	Explain the hole basis system and shaft basis system for fits and tolerances (C2).
3	Forming Processes: Basic Principle of Hot & Cold Working (C2): Explain the basic principles of hot working and cold working in metal forming processes (C2). Discuss the temperature ranges and effects of hot and cold working on material properties (C2). Hot & Cold Working Processes (C2): Describe the different hot working processes, such as hot rolling, hot forging, and hot extrusion, and their applications (C2). Explain the various cold working processes, including cold rolling, cold forging, and cold extrusion, and their advantages (C2). Classifications of Forming Processes (C2): Discuss the classifications of forming processes based on temperature, deformation rate, and type of material (C2). Explain the differences between bulk forming processes and sheet metal forming processes (C2). Bulk Forming Processes: Rolling, Extrusion, Forging (C2): Explain the principles and applications of the rolling process, including hot rolling and cold rolling (C2). Describe the extrusion process and its variations, such as direct extrusion and indirect extrusion (C2). Discuss the principles of forging processes, including open die forging and closed die forging (C2). Sheet Metal Forming Processes (C2): Introduce the basics of sheet metal working, including the selection of sheet material, thickness, and temperature for forming (C2). Explain the different sheet metal forming operations, such as shearing, cutting, punching, blanking, notching, lancing, bending, beading, embossing, drawing, deep drawing, and spinning (C2). Dieless Forming Processes - Incremental Sheet Forming (ISF) (C2): Describe the incremental sheet forming (ISF) process and its variations, such as single-point incremental forming and two-point incremental forming (C2). Discuss the process parameters involved in ISF, such as tool path strategies and feed rate (C2). Explain the working principle and applications of ISF in sheet metal forming (C2).
4	Introduction to Basic Machine Tools (C1): Provide an overview of basic machine tools and their importance in manufacturing processes (C1). Explain the role of machine tools in shaping, cutting, and machining various

	materials (C1). Constructional Features of Machine Tools (C1): Describe the common constructional features of machine tools, such as beds, carriages, spindles, tool posts, and worktables (C1). Discuss the components and mechanisms that enable the movement and control of machine tools (C1). Specialization and Operations of Machine Tools (C1): Discuss the specialization of machine tools based on their specific functions, such as lathes for cylindrical turning, shapers for shaping surfaces, planners for flat surfaces, drilling machines for creating holes, and milling machines for complex operations (C1). Explain the operations performed by each machine tool, including turning, facing, drilling, milling, shaping, and planning (C1). Devices and Accessories of Machine Tools (C1): Introduce the various devices and accessories used with machine tools, such as chucks, collets, tool holders, cutting tools, and work holding fixtures (C1). Explain the purpose and function of these devices in enhancing the performance and versatility of machine tools (C1). Indexing in Milling Operation (C2): Explain the concept of indexing in milling operations and its significance in creating precise and repeatable workpiece rotations (C2). Discuss the indexing methods and devices used in milling machines, such as indexing heads, rotary tables, and dividing heads (C2). Working Principle of Machine Tools (C1): Describe the working principles of lathe, milling machine, drilling machine, shaper, and planer (C1). Explain how each machine tool performs its specific operations and the role of feed, spindle speed, depth of cut, and cutting speed in achieving desired results (C1). Calculation of Machining Time (C2): Discuss the factors involved in calculating machining time, including cutting speed, feed rate, depth of cut, and the number of passes (C2). Explain the formulas and methods used to estimate machining time for different machining operations (C2). Current Industry Trends (C3): Provide an overview of current trends and advancements in machine tool technology, such as computer numerical control (CNC), automation, integration of sensors and actuators, and Industry 4.0 concepts (C3). Discuss the impact of these trends on productivity, efficiency, and the overall manufacturing process (C3).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) P N Rao, Vol. 1, Foundry, Forming and Welding, McGraw Hill, 5^{th} Edition, ISBN-13: 978-93-5316-050-0. **ii)** Workshop Technology (Manufacturing Process) – S K Garg, Laxmi Publications; Fourth Edition (2018), ISBN-10: 8131806979

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Steam Power Generation**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Engineering Thermodynamics
Course Synopsis	To teach students about the working of various power generation units and steam cycles. To introduce students to steam generators, combustion and firing methods in order to make the fullest use of thermal power potentialities of the country. To enable students, understand functioning of boilers, turbines and pumps used in power generation.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Design optimization and working of boilers and heaters.
CO2	Know about the kind of turbines being used in various industries and their applicability.
CO3	Distinguish between various power generation units and choose one that meets desired economic, environmental, and social requirements.
CO4	Understand the use of oil burners, fans, and igniters.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	2	3	2	1	1	2	-	-	-	1	2	2	3	1
CO2	3	2	3	3	2	1	1	-	-	-	1	2	1	3	3
CO3	3	2	2	2	2	2	2	-	-	-	3	3	-	3	3
CO4	3	1	2	2	1	1	1	-	-	-	1	3	-	3	2
Average	3	1.75	2.5	2.25	1.5	1.25	1.5	-	-	-	1.5	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

3	0	0	3

Unit	Content & Competencies
1	Classification and Types of Boilers (C1): Provide an overview of boilers and their classification based on various criteria such as fuel type, construction, and application (C1). Describe different types of boilers including fire-tube boilers, water-tube boilers, package boilers, and electric boilers (C1). Arrangements of Main Boiler (C1): Explain the arrangement of major components in a boiler system, including the combustion chamber, heat exchanger, flue gas path, and boiler accessories (C1). Discuss the layout and positioning of these components to ensure efficient and safe boiler operation (C1). Fundamentals of Boiler Design (C2): Discuss the fundamental principles and considerations involved in boiler design, such as heat transfer, combustion efficiency, thermal insulation, and structural integrity (C2). Explain the factors that influence the design process, including load requirements, fuel characteristics, and safety regulations (C2). Location of Various Pressure Parts (C1): Describe the placement and positioning of different pressure parts within a boiler, such as the steam drum, water walls, superheaters, reheaters, economizers, and de-superheaters (C1). Discuss the importance of proper placement for efficient heat transfer, steam generation, and overall performance (C1). Boiler Circulation Theory (C2): Explain the principles of boiler circulation, including natural circulation, controlled circulation, and forced circulation (C2). Discuss the factors that affect circulation, such as water walls, boiling phenomena, nucleate and film boiling, and the role of pumps and fans in forced circulation (C2). Construction Details of Superheaters, Reheaters, and Economizers (C2): Provide an overview of the construction and design features of superheaters, reheaters, and economizers in a boiler system (C2). Discuss the purpose and functions of these components in enhancing heat transfer efficiency and maximizing energy utilization (C2). De-superheaters (C1): Explain the concept and operation of de-superheaters in a boiler system (C1). Discuss their role in controlling and reducing the temperature of superheated steam (C1). Steam Separation Theory: Boiler Drum & its Internals (C2):

	Describe the function and construction of the boiler drum and its internals, including steam separators, baffle plates, and steam outlets (C2). Explain the separation process of steam from water and the importance of proper steam quality in boiler operation (C2).
2	Water Supply System (C1): Explain the different types of water used in a water supply system, including soft water, circulated water, cooling water, and demineralized (D.M.) water (C1). Discuss the characteristics and purposes of each type of water in industrial applications (C1). Steam Cycle Theory (C2): Introduce the concept of steam cycles in power plants, including the Carnot cycle and Rankine cycle (C2). Discuss the specific application of the Rankine cycle in a 500/210 MW power unit and its steam properties (C2). Steam Turbines (C2): Provide an overview of steam turbines and their classification based on various criteria such as steam flow, expansion, and working principles (C2). Discuss the metallurgical considerations in turbine design and construction to withstand high temperatures and pressures (C2). Description of Main Components of Steam Turbines (C3): Describe the main components of steam turbines, including the turbine casing, rotor, blades, steam admission valves, couplings, and bearings (C3). Explain the functions and working principles of each component in converting steam energy into mechanical work (C3). Steam Condensation and Condensers (C2): Discuss the different modes of steam condensation, including film-wise and drop-wise condensation (C2). Explain the concepts of direct and indirect condensation and the creation of vacuum in steam condensers (C2).
3	Classification of Pumps (C1): Discuss the classification of pumps based on their operating principles, including centrifugal pumps and positive displacement pumps (C1). Explain the differences between these two types of pumps in terms of their working principles and applications (C1). Boiler Feed Pump (C2): Describe the function of a Boiler Feed Pump (BFP) in a steam power plant and its importance in supplying water to the boiler (C2). Discuss the constructional details of a Boiler Feed Pump, including its components and working principles (C2).

	Circulating Water System (C1): Explain the concept of a circulating water system in industrial applications, including open and closed systems (C1). Discuss the purpose and components of a circulating water system, such as CW pumps, cooling towers, and CT pumps (C1). Cooling Towers (C1): Describe the working principles of cooling towers in the process of heat dissipation and temperature reduction (C1). Discuss the types and constructional details of cooling towers used in industrial applications (C1). CT Pumps and CT Fans (C1): Explain the role of CT pumps in circulating water through the cooling towers to facilitate heat transfer (C1). Discuss the function and characteristics of CT fans in creating air movement within the cooling towers (C1).
4	Construction Details/Lubricating Oil System for PA Fan, FD Fan, ID Fan (C2): Discuss the construction details of the Primary Air (PA) Fan, Forced Draft (FD) Fan, and Induced Draft (ID) Fan in a boiler system, including their components and design features (C2). Explain the lubricating oil system used in these fans, including the oil reservoir, oil pumps, filters, coolers, and lubrication points (C2). Discuss the importance of proper lubrication and maintenance of the fan bearings and other moving parts (C2). Air Pre-heaters (C2): Describe the types and functions of air pre-heaters in a boiler system, such as recuperative and regenerative pre-heaters (C2). Explain the constructional details of air pre-heaters, including the arrangement of heating elements and the flow of flue gas and air (C2). Discuss the concept of Self-Cleaning Air Pre-heater (SCAPH) and its working principle (C2). Explain the use of soot blowers in air pre-heaters for removing ash and soot deposits (C2). Fuel Firing Arrangements and Burners (C3): Describe different fuel firing arrangements used in boilers, such as corner firing, front wall firing, and rear wall firing (C3). Explain the concepts of direct and indirect firing methods and their advantages in specific applications (C3). Provide details about coal and oil burners, including their construction, fuel atomization mechanisms, and ignition systems (C3). Discuss the burners' tilting mechanism and its role in optimizing combustion

	efficiency (C3). Explain the atomization process of fuel oil in oil burners and the role of igniters in initiating combustion (C3).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) P. K. Nag, (2014), Power Plant Engineering: Steam and Nuclear, Tata McGraw-Hill Publishing Company Ltd., 4th EditionISBN13 9789339204044. **ii)** Wood, A.J. and Wollen Berg, B.F. (2013), Power Generation and Control, John Wiley, 3rd Edition, ISBN: 978-0-471-79055-6

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Total Quality Management
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	To give the students an overview of quality and TQM and explaining the salient contributions of Quality Gurus like Deming, Juran and Crosby. General barriers in implementing TQM.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Need and steps of maintaining Quality environment of the organization.
CO2	The TQM approach for manufacturing/service organization at length
CO3	Quality terms like Tolerance and Variability PDCA cycle, Crosby's 10 points and Deming's 14 Points etc.
CO4	The international/national Quality Standards

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	-	2	-	2	2	2	2	2	3	2	3	2	1
CO2	3	2	-	2	-	1	1	1	1	1	2	3	3	1	-
CO3	3	1	-	2	-	2	2	2	2	2	3	3	3	2	1
CO4	3	1	-	1	-	2	2	2	2	2	2	3	3	1	-
Average	3	1.25	-	1.75	-	1.75	1.75	1.75	1.75	1.75	2.5	2.75	3	1.5	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Quality Management (C1): Provide an introduction to the concept of quality and its significance in organizations (C1). Explain the evolution of quality management and its importance in today's competitive business environment (C1). Define quality and discuss its various dimensions in relation to both products and services (C1). Total Quality Management (TQM) Basics (C2): Introduce the basic concepts of Total Quality Management (TQM) and its relevance in achieving organizational excellence (C2). Present the TQM framework, including its key principles and components (C2). Discuss the barriers and challenges commonly encountered in implementing TQM practices (C2). Explain the concept of quality statements and their role in setting quality objectives (C2). Customer Focus and Satisfaction (C3): Highlight the importance of customer focus in TQM and its impact on organizational success (C3). Discuss customer orientation and its role in understanding and meeting customer needs and expectations (C3). Explain the concepts of customer satisfaction, customer complaints, and customer retention and their significance in TQM (C3). Costs of Quality (C2): Explore the costs associated with quality management, including prevention costs, appraisal costs, and failure costs (C2). Discuss the impact of poor quality on organizational performance and the benefits of investing in quality improvement (C2). TQM Philosophy and Tools (C2): Introduce the TQM philosophy and its key principles, including leadership commitment, continuous improvement, and employee involvement (C2). Discuss lean and Just-in-Time (JIT) principles and their application in improving quality and efficiency (C2). Explain strategic quality planning and the role of quality councils in driving organizational improvement (C2). Describe the PDCA (Plan-Do-Check-Act) cycle as a systematic approach to problem-solving and continuous improvement (C2). Discuss the 5S methodology and Kaizen as tools for workplace organization and continuous improvement (C2).

	Contributions of Deming, Juran, and Crosby (C3): Highlight the significant contributions of W. Edwards Deming, Joseph M. Juran, and Philip B. Crosby to the field of quality management (C3). Discuss their respective philosophies and methodologies, including Deming's 14 Points, Juran's Quality Trilogy, and Crosby's Zero Defects (C3).
2	Introduction to Process Quality (C1): Provide an overview of process quality and its significance in achieving organizational goals (C1). Discuss the importance of process improvement in enhancing product/service quality and customer satisfaction (C1). Graphical and Statistical Techniques for Process Quality Improvement (C2): Introduce graphical tools used for data representation and analysis in process quality improvement, such as histograms, scatter plots, and Pareto charts (C2). Explain statistical techniques commonly employed in process quality improvement, including descriptive statistics, inferential statistics, and correlation analysis (C2). Discuss the use of graphical and statistical methods in identifying and prioritizing areas for improvement in a process (C2). Sampling, Sampling Distribution, and Hypothesis Testing (C3): Explain the concept of sampling and its importance in collecting data for process quality analysis (C3). Discuss sampling distribution and its role in making inferences about a population based on sample data (C3). Introduce hypothesis testing as a statistical technique for evaluating the validity of claims or hypotheses about a population (C3). Regression (C3): Present regression analysis as a tool for examining the relationship between a dependent variable and one or more independent variables (C3). Discuss the use of regression in predicting future values and identifying influential factors in a process (C3). Control Charts (C2): Explain the concept of control charts and their role in monitoring process stability and identifying process variations (C2). Introduce different types of control charts, such as X-bar and R charts, and discuss their interpretation (C2). Illustrate the use of control charts in detecting and addressing process deviations and out-of-control conditions (C2). Process Capability Analysis (C3): Describe process capability analysis as a method for assessing whether a process meets customer specifications and requirements (C3).

	Explain key process capability indices, such as Cp, Cpk, and Ppk, and their interpretation (C3). Discuss the application of process capability analysis in process improvement and setting realistic performance targets (C3). Measurement System Analysis (C2): Discuss the importance of measurement system analysis in ensuring reliable and accurate data for process quality evaluation (C2). Introduce techniques such as repeatability and reproducibility studies, gauge R&R (repeatability and reproducibility), and attribute agreement analysis (C2). Explain the interpretation of measurement system variation and its impact on process quality (C2). Analysis of Variance (ANOVA) (C3): Present ANOVA as a statistical technique for comparing means across multiple groups or factors (C3). Discuss the use of ANOVA in identifying sources of variation and evaluating the significance of different factors in a process (C3). Design and Analysis of Experiments (DOE) (C3): Introduce DOE as a systematic approach for optimizing process parameters and identifying the factors that most significantly impact process performance (C3). Explain the principles of experimental design, including factor selection, randomization, replication, and blocking (C3). Discuss the analysis and interpretation of experimental results to make informed decisions for process improvement (C3).
3	Six Sigma for Process Improvement: Explain the concept of Six Sigma and its application in process improvement (C2). Discuss the DMAIC (Define, Measure, Analyze, Improve, Control) methodology used in Six Sigma projects (C2). Present the roles and responsibilities of key personnel in a Six Sigma project, such as Champions, Black Belts, Green Belts, and Yellow Belts (C2). Quality Function Deployment (QFD): Introduce Quality Function Deployment as a method for translating customer requirements into specific design and process characteristics (C2). Explain the QFD process, which involves capturing customer needs, establishing design targets, and aligning the organization's resources and processes to meet those targets (C2). Failure Mode Effect Analysis (FMEA): Discuss the importance of reliability and failure prevention in ensuring product/service quality (C2). Explain the concept of Failure Mode Effect Analysis (FMEA) and its role in

	identifying and mitigating potential failures in design and process (C2). Present the stages of FMEA, including identification of failure modes, assessment of their effects, determination of their causes, and development of corrective actions (C2). Highlight the requirements for reliability, such as failure rate and mean time between failures (MTBF) (C2). Discuss the importance of documentation in FMEA, including maintaining a comprehensive record of identified failure modes, their effects, and corresponding preventive measures (C2). Seven Old (Statistical) Tools: Introduce the seven old (statistical) tools used in quality management and process improvement (C2). Explain the purpose and application of each tool, which includes Pareto charts, cause-and-effect diagrams, histograms, scatter plots, control charts, flowcharts, and check sheets (C2). Seven New Management Tools: Discuss the seven new management tools used in quality management and process improvement (C2). Explain the purpose and application of each tool, which includes affinity diagrams, interrelationship digraphs, tree diagrams, prioritization matrices, matrix diagrams, process decision program charts (PDPC), and activity network diagrams (C2). Benchmarking: Introduce benchmarking as a systematic process of comparing an organization's performance, products, or processes with those of industry leaders or best practices (C2). Discuss the benefits of benchmarking in identifying improvement opportunities and setting performance targets (C2). Poka Yoke: Explain the concept of Poka Yoke, also known as mistake-proofing or error-proofing (C2). Discuss the use of Poka Yoke techniques and devices to prevent or detect errors or defects in a process (C2).
4	IS/ISO 9004:2000 - Quality Management Systems - Guidelines for Performance Improvements: Introduce IS/ISO 9004:2000, which provides guidelines for organizations seeking to improve their performance through effective quality management systems (C2). Explain the key principles and concepts outlined in IS/ISO 9004:2000, such as

	customer focus, process approach, involvement of people, continuous improvement, and evidence-based decision making (C2). Discuss how IS/ISO 9004:2000 can be used to drive organizational performance improvements and enhance customer satisfaction (C2). Quality Audits: Explain the concept of quality audits and their role in evaluating the effectiveness of a quality management system (C2). Discuss the types of quality audits, including internal audits and external audits conducted by third-party certification bodies (C2). Highlight the importance of objective evidence, documentation review, interviews, and observations in conducting quality audits (C2). TQM Culture: Discuss the importance of building a Total Quality Management (TQM) culture within an organization (C2). Explain how a TQM culture promotes continuous improvement, customer focus, employee involvement, and a process-oriented mindset (C2). Leadership in Quality Management: Discuss the role of leadership in driving quality management initiatives (C2). Explain the concept of a quality council, which is a cross-functional team responsible for setting quality goals, defining strategies, and monitoring progress (C2). Discuss the importance of employee involvement, motivation, empowerment, recognition, and rewards in fostering a culture of quality within an organization (C2). Introduction to Software Quality: Explain the unique considerations and challenges related to software quality management (C2). Discuss the importance of software quality standards, such as ISO/IEC 25010, in ensuring the reliability, usability, efficiency, and security of software products (C2). Highlight the role of software testing, code reviews, and quality assurance processes in achieving software quality objectives (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2

Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 3rd Edition, ISBN- 978-0470169926. 2. Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson

	Education, ISBN- 9789332534452. 3. Shridhara Bhat K, Total Quality Management – Text and Cases, Himalaya Publishing House, ISBN- 978-8178662527.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Production Planning and Control
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	This course introduces students the dynamics of material flow through a manufacturing system, techniques of production planning and control. PPC is the process of production planning sets the objectives, goals, targets on the basis of available resources with their given constraints. Control is the integral part of effective planning. Similarly, control involves assessment of the performance; such assessment can be made effectively only when some standards are set in advance. Planning involves setting up to such standard. The controlling is made by comparing the actual performance with the present standard and deviations are ascertained and analysed.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Acquire Knowledge of type of production planning technique.
CO2	Acquire Knowledge of production planning.
CO3	Acquire Knowledge of Control and implement PPC methods in crucial areas of the industry.
CO4	Acquire Knowledge of Implementation of ERP systems and shop floor scheduling.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	2	2	2	3	2	3	3	1	-	-
CO2	3	-	-	-	2	2	2	2	3	2	3	3	1	-	-
CO3	3	-	-	-	2	2	2	2	3	2	3	3	1	2	-

CO4	3	-	-	-	2	2	2	2	3	2	3	3	1	2	-
Average	3	-	-	-	2	2	2	2	3	2	3	3	1	1	-

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Objectives and Benefits of Planning and Control: Explain the objectives of planning and control in a production environment, which include ensuring timely and efficient production, optimizing resource utilization, meeting customer demands, and minimizing costs (C2). Discuss the benefits of effective planning and control, such as improved productivity, reduced lead times, increased customer satisfaction, better resource allocation, and enhanced decision-making (C2). Functions of Production Control: Explain the key functions of production control, including demand forecasting, capacity planning, production scheduling, material planning, inventory control, and performance monitoring (C2). Discuss how each function contributes to ensuring smooth and efficient production operations and meeting customer requirements (C2). Factors Influencing MPC (Manufacturing Planning and Control) Performance: Discuss the factors that can influence the performance of manufacturing planning and control systems, such as accuracy of demand forecasting, availability and accuracy of data, production variability, supplier performance, and technological advancements (C2). Explain how these factors can impact the effectiveness and efficiency of planning and control processes (C2). Review of Fundamental Features of Material Requirements Planning (MRP) Systems: Provide an overview of Material Requirements Planning (MRP) systems and their fundamental features (C2). Discuss the key components of an MRP system, including the bill of materials, master production schedule, inventory records, and lead time data (C2). Explain how MRP systems use these components to calculate material requirements, plan production activities, and manage inventory levels (C2). MRP Systems Dynamics and System Nervousness: Discuss the dynamics of MRP systems and the concept of system nervousness

	(C2). Explain how changes in demand, lead times, or other variables can cause fluctuations and instability within an MRP system (C2). Highlight the importance of accurate data, effective forecasting, and appropriate system parameters in mitigating system nervousness and maintaining the stability of an MRP system (C2).
2	Sales and Operations Planning (S&OP): Explain the concept of Sales and Operations Planning (S&OP) and its importance in aligning sales forecasts with production capabilities (C2). Discuss the key steps involved in the S&OP process, including demand forecasting, production planning, inventory management, and financial analysis (C2). Highlight the benefits of effective S&OP, such as improved customer service, optimized inventory levels, reduced lead times, and enhanced decision-making (C2). Production Planning: Describe the process of production planning, which involves determining the production quantities, schedules, and resources required to meet the demand (C2). Explain how production planning considers factors such as available capacity, production constraints, material availability, and lead times (C2). Discuss different techniques and tools used in production planning, such as capacity planning, production levelling, and production control (C2). Master Scheduling and Order Promising: Define master scheduling and its role in translating the production plan into a detailed schedule (C2). Discuss the factors considered in master scheduling, including customer demand, production capacity, and inventory levels (C2). Explain how order promising is performed based on the master schedule, taking into account lead times, availability of materials, and production constraints (C2). Distribution Resource Planning (DRP): Introduce the concept of Distribution Resource Planning (DRP) and its role in managing the flow of goods from production to distribution (C2). Discuss the key components of DRP, including demand forecasting, inventory planning, order management, and transportation logistics (C2). Explain how DRP helps optimize distribution operations, minimize stockouts, and improve customer service (C2). Bills of Material Structuring, Master Scheduling, and Final Assembly Scheduling:

	Explain the concept of bills of material (BOM) and their role in defining the components and subassemblies required for final product assembly (C2). Discuss the structuring of BOMs, including the identification of parent items, subassemblies, and raw materials (C2). Describe the process of master scheduling; which involves determining the production quantities and schedules for finished products based on customer demand and production capabilities (C2). Discuss final assembly scheduling, which focuses on coordinating the production of finished products based on the master schedule and availability of components (C2).
3	Capacity Management using Planning Factors: Explain the concept of capacity management and its importance in ensuring that the production capacity meets the demand requirements (C2). Discuss the use of planning factors, such as lead time, setup time, and processing time, in estimating and planning the capacity needed for production (C2). Highlight the factors that influence capacity utilization, including machine availability, labor efficiency, and production variability (C2). Bills of Capacity: Describe the concept of bills of capacity and their role in defining the capacity requirements for each operation or work center (C2). Explain how bills of capacity are structured, including the identification of resource requirements, time standards, and skill levels (C2). Discuss how bills of capacity are used in capacity planning and scheduling to ensure that the required resources are available for production (C2). Capacity Requirements Planning (CRP) and I/O Control: Introduce Capacity Requirements Planning (CRP) as a technique for determining the capacity needed at each work center based on the production schedule (C2). Discuss how CRP considers factors such as routing, lead times, and resource availability to identify any capacity constraints or bottlenecks (C2). Explain the concept of I/O (Input/Output) control, which involves monitoring and controlling the flow of materials and resources on the shop floor to ensure efficient utilization of capacity (C2). Shop Floor Control/Operations Scheduling: Describe shop floor control as the process of managing and coordinating the activities on the shop floor to meet production schedules and optimize resource utilization (C2). Discuss the techniques and tools used in shop floor control, such as Gantt charts, dispatch lists, and visual management systems (C2).

	Explain how operations scheduling is performed to assign tasks to specific work centers and allocate resources based on priority, availability, and capacity constraints (C2). Inventory Models: Introduce different inventory models used in production and operations management, such as Economic Order Quantity (EOQ), Just-in-Time (JIT), and Material Requirements Planning (MRP) (C2). Discuss the principles and assumptions underlying each inventory model and their application in managing inventory levels (C2). Highlight the benefits of effective inventory management, including reduced carrying costs, minimized stockouts, and improved customer service (C2).
4	Shop Floor Control/Scheduling: Explain the concept of shop floor control and its role in managing and coordinating activities on the shop floor to meet production schedules and optimize resource utilization (C2). Discuss the use of scheduling techniques such as Gantt charts, dispatch lists, and visual management systems to schedule and monitor production operations (C2). Introduce Kanban and pull systems as effective methods for controlling production flow and ensuring a smooth and efficient production process (C2). Discuss the implementation and parameter settings of Kanban and pull systems, including determining the appropriate number of Kanban cards or setting reorder points (C2). Explain alternative pull systems, such as CONWIP (Constant Work in Progress) and DBR (Drum-Buffer-Rope), and their application in different production environments (C2). Discuss the concept of pull systems for suppliers, where suppliers produce and deliver materials based on customer demand signals, enabling a streamlined supply chain (C2). ERP Systems: Introduce ERP (Enterprise Resource Planning) systems as integrated software solutions that support various business functions, including manufacturing, finance, and supply chain management (C2). Focus on the technical aspects of SAP (Systems, Applications, and Products), one of the leading ERP software providers, including its architecture, modules, and database management (C2). Discuss the implementation of ERP systems, including the steps involved in system selection, data migration, customization, and training (C2). Highlight the importance of system fit, which refers to the alignment between the ERP system's functionalities and the specific needs and processes of the

	manufacturing firm (C2). Beyond ERP Software for Manufacturing Firms: Discuss the limitations of ERP systems in addressing all the needs and challenges of manufacturing firms (C2). Introduce the concept of Beyond ERP, which refers to complementary technologies and strategies that extend the capabilities of ERP systems (C2). Discuss different solutions beyond ERP, such as advanced analytics, IoT (Internet of Things), and cloud computing, and their role in improving manufacturing operations (C2). Supply Chain Management: Provide an overview of supply chain management and its importance in ensuring the smooth flow of materials, information, and services across the entire supply chain (C1). Discuss the key elements of supply chain management, including demand planning, inventory management, logistics, and supplier relationship management (C1). Highlight the role of technology, such as ERP systems and other supply chain management software, in enabling effective supply chain management (C1).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) S. K Mukhopadhyay (2009), Production Planning and Control: Text and Cases, 2nd Edition, Phi Learning. ISBN: 978-8-120-33118-1 **ii)** Stephen N. Chapman (2005), Fundamentals of Production Planning and Control, Prentice Hall. ISBN: 978-0-130-17615-8.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Mechanical Vibration
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Engineering Mechanics
Course Synopsis	A structure or a body is said to vibrate if it has a to and fro motion. A greater proportion of human activities involve vibration in one form or the other. We hear because our eardrums vibrate. The cause and effects of vibration must be clearly understood. The structures designed to support the high speed machines are subjected to inherent unbalance which causes problems. The unbalance may be due to faulty design or poor manufacture. Because of cyclic vibration, the material of the structure or the machine component may undergo fatigue failure. Vibration causes fasteners such as nuts of the machine to become loose. In metal machining processes, vibration may cause chatter, which results in poor surface finish. If the natural frequency of vibration of a machine or structure equals the forced frequency caused by external excitation, resonance occurs which causes dangerously large oscillations and the structure fails. A bridge can collapse due to wind-induced vibration. Critical instruments mounted on machines may lose their accuracy due to excessive vibrations. Vibrations can be used for useful works such as vibration testing equipments, vibratory conveyors, hoppers, sieves, compactors, washing machines.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understanding the fundamentals concepts of vibration.
CO2	To understand the free and forced vibrations with two-degree freedom system.
CO3	To learn the methods to solve vibration problems with multi-degree freedom system.
CO4	To understand the basics of vibration of continuous systems and experimental methods in vibration analysis and the working of vibration measuring instruments.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific

Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	1	2	3	3	3	2	1
CO2	3	1	2	3	1	1	1	1	2	1	2	2	3	2	2
CO3	3	2	2	2	2	1	2	1	2	1	2	2	3	1	2
CO4	3	2	1	1	2	2	1	2	3	2	3	3	3	2	1
Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Terminology: Define the terminology related to vibration analysis and single degree of freedom systems, such as displacement, velocity, acceleration, natural frequency, damping, resonance, and response (C1). Single Degree of Freedom Systems: Explain the concept of single degree of freedom systems and their relevance in vibration analysis (C1). Discuss the equation of motion for single degree of freedom systems and its derivation using Newton's second law of motion (C1). Introduce the concept of natural frequency and damping ratio and their influence on the dynamic behavior of the system (C1). Response to Arbitrary Periodic Excitations: Explain how single degree of freedom systems respond to arbitrary periodic excitations (C2). Introduce Duhamel's integral as a method for solving the equation of motion and obtaining the system response (C2). Discuss the impulse response function and its relationship to the system's response under arbitrary periodic excitations (C2). Virtual Work and Lagrange's Equation: Explain the principle of virtual work and its application in analyzing the dynamic behavior of mechanical systems (C2). Introduce Lagrange's equation as an alternative approach to deriving the

	equations of motion for single degree of freedom systems (C2). Forced Vibration with Elastically Coupled Viscous Dampers: Discuss the concept of elastically coupled viscous dampers and their role in controlling vibration in mechanical systems (C2). Analyze the forced vibration response of a single degree of freedom system with elastically coupled viscous dampers (C2). System Identification from Frequency Response: Explain the process of system identification using frequency response data (C2). Discuss the techniques for estimating system parameters, such as natural frequency and damping ratio, from the frequency response (C2). Transient Vibration and Laplace Transformation Formulation: Introduce the concept of transient vibration and its analysis in single degree of freedom systems (C2). Discuss the use of Laplace transformation and Laplace domain representation in analyzing transient vibration problems (C2).
2	Free Vibration of Spring-Coupled System: Explain the concept of a spring-coupled system and its relevance in vibration analysis (C1). Derive the equations of motion for a spring-coupled system with multiple degrees of freedom (C1). Analyze the free vibration response of a spring-coupled system and determine the natural frequencies and mode shapes (C2). Mass-Coupled System: Discuss the concept of a mass-coupled system and its significance in vibration analysis (C1). Derive the equations of motion for a mass-coupled system with multiple degrees of freedom (C1). Analyze the free vibration response of a mass-coupled system and determine the natural frequencies and mode shapes (C2). Bending Vibrations of Two Degree of Freedom System: Explain the concept of bending vibrations in a two-degree-of-freedom system (C1). Derive the equations of motion for a two-degree-of-freedom system undergoing bending vibrations (C1). Analyze the bending vibration response and determine the natural frequencies and mode shapes of the system (C2). Forced Vibration: Discuss forced vibrations and their occurrence in mechanical systems (C1). Analyze the forced vibration response of a system under external excitation (C2).

	Introduce the concept of resonance and discuss its effects on forced vibration (C2). Vibration Absorber: Explain the concept of a vibration absorber and its purpose in reducing vibration amplitudes (C1). Discuss the design and implementation of vibration absorbers to mitigate unwanted vibrations (C1). Vibration Isolation: Discuss the concept of vibration isolation and its importance in reducing transmitted vibrations (C1). Explain the techniques and methods used to isolate a vibrating system from its surroundings (C1). Force Transmissibility and Support Motion: Introduce the concept of force transmissibility and its relation to the input and output forces in a vibrating system (C1). Discuss the influence of support motion on the transmissibility of forces in a system (C1). Analyze the effect of different support conditions on the overall vibration response of a system (C2).
3	Normal Mode of Vibration: Define the concept of normal mode of vibration and its significance in vibration analysis (C1). Explain how a system can vibrate in its normal modes, which represent independent patterns of motion (C1). Discuss the characteristics of normal modes, including their natural frequencies and mode shapes (C2). Flexibility Matrix and Stiffness Matrix: Introduce the flexibility matrix and stiffness matrix as mathematical representations of the dynamic behavior of a system (C1). Explain how the flexibility matrix relates displacements to applied forces and the stiffness matrix relates forces to displacements (C1). Eigen value and Eigenvector: Define eigenvalues and eigenvectors and their importance in vibration analysis (C1). Discuss the eigen value problem and its solution, which involves finding the values and corresponding vectors that satisfy a specific equation (C2). Orthogonal Properties: Explain the concept of orthogonality and its relevance to vibration analysis (C1). Discuss the orthogonal properties of eigenvectors, including their independence

	and perpendicularity (C2). Modal Matrix: Define the modal matrix and its role in representing the mode shapes of a system (C1). Explain how the modal matrix is constructed using the eigenvectors of the system (C1). Modal Analysis: Describe the process of modal analysis, which involves determining the natural frequencies, mode shapes, and modal damping of a system (C1). Discuss the practical applications of modal analysis, such as in structural dynamics and vibration control (C1). Forced Vibration by Matrix Inversion: Explain the method of forced vibration analysis using matrix inversion (C2). Discuss how the modal matrix and modal coordinates can be used to solve the equations of motion for forced vibration (C2). Modal Damping in Forced Vibration: Discuss the concept of modal damping and its influence on the forced vibration response of a system (C2). Explain how modal damping ratios can be determined and their effects on the overall system response (C2). Numerical Methods for Fundamental Frequencies: Introduce numerical methods for calculating the fundamental frequencies of vibrating systems (C2). Discuss techniques such as the finite element method, finite difference method, and numerical eigen value solvers (C2).
4	System Governed by Wave Equations: Discuss systems that can be described by wave equations, such as vibrating strings, rods, beams, and plates (C1). Explain the wave equation and its significance in modeling the dynamic behavior of these systems (C1). Vibration of Strings: Discuss the vibration characteristics of strings, including their natural frequencies and mode shapes (C1). Explain the concepts of transverse vibration, standing waves, and harmonics in vibrating strings (C1). Vibration of Rods: Describe the vibration behavior of rods, including longitudinal and transverse vibrations (C1). Discuss the natural frequencies, mode shapes, and boundary conditions of vibrating rods (C1).

	Euler's Equation for Beams: Introduce Euler's equation for beams, which describes the bending vibration of beams (C1). Discuss the assumptions and boundary conditions associated with Euler's equation (C1). Effects of Rotary Inertia and Shear Deformation: Explain the effects of rotary inertia and shear deformation on the vibration characteristics of beams (C1). Discuss how these factors influence the natural frequencies and mode shapes of vibrating beams (C1). Vibration of Plates: Discuss the vibration behavior of plates, including their natural frequencies and mode shapes (C1). Explain the concepts of bending and membrane vibrations in plates (C1). Vibration Measuring Instruments: Introduce various instruments used for measuring vibrations, such as accelerometers, displacement transducers, and vibrometers (C1). Discuss the principles of operation and applications of these instruments (C1). Vibration Exciters: Explain the purpose and operation of vibration exciters, which are devices used to generate controlled vibrations in structures (C1). Discuss different types of vibration exciters, including electrodynamic shakers, hydraulic exciters, and modal exciters (C1). Vibration Tests - Free and Forced Vibration Tests: Explain the concept of vibration testing and its importance in analyzing the dynamic behavior of structures (C1). Discuss the difference between free vibration tests, which involve exciting a structure and measuring its response, and forced vibration tests, which apply known forces to the structure (C1). Examples of Vibration Tests - Industrial Case Studies: Provide examples of real-world vibration tests conducted in industrial settings (C2). Discuss the objectives, methodologies, and outcomes of these case studies, highlighting their relevance to industrial applications (C2). Current Industry Trends: Discuss current trends in the field of vibration analysis and testing, such as the use of advanced sensing technologies, data analytics, and automation (C2). Highlight the impact of these trends on improving the accuracy, efficiency, and reliability of vibration analysis in various industries (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) William T. Thomson (2005), Theory of vibration with applications, 5th Edition, Pearson Education India. ISBN: 978-8-131-70482-0. ii) R V Dukkipati (2008), Advanced Mechanical Vibrations, Alpha Science. ISBN: 978-1-842-65222-0.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Tool Design**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	**Engineering Workshop**
Course Synopsis	Tool design is a specialized area of manufacturing engineering comprising the analysis, planning, design, construction, and application of tools, methods, and procedures necessary to increase the manufacturing productivity.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand introduction, regulation of speed and feeds.
CO2	Learn the designing of machine tool structures and its constructional features.
CO3	Understand mechanical properties of materials and testing.
CO4	Learn about advance materials and its applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	-	-	-	-	-	1	2	2	3	1
CO2	3	2	3	2	-	-	-	-	-	-	1	3	1	3	3
CO3	3	2	2	2	2	-	-	-	-	-	1	2	-	3	3
CO4	3	2	3	3	2	-	-	-	-	-	2	3	-	3	2
Average	3	2	2.5	2.25	2	-	-	-	-	-	1.25	2.5	0.75	3	2.25

Course Content:				
L (Hours/Week)		**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Introduction to Machine Tool Drives and Mechanisms: Provide an overview of the course on machine tool drives and mechanisms, highlighting its importance in the field of machining (C1). Explain the concept of working and auxiliary motions in machine tools, including their roles and functions in the machining process (C1). Discuss the kinematics of machine tools, focusing on the study of motion and its transmission within the machine (C1). Explain the principles and mechanisms involved in motion transmission in machine tools, including gears, belts, and linkages (C1). Regulation of Speeds and Feeds: Discuss the aim and significance of speed and feed regulation in machine tools (C1). Explain the concept of stepped regulation of speeds, which involves using multiple speed settings to accommodate different machining operations (C1). Discuss the use of multiple speed motors in machine tools and their advantages (C1). Introduce ray diagrams and design considerations in the context of speed and feed regulation, emphasizing the importance of proper design for optimal performance (C1). Discuss the design aspects of speed gear boxes, feed drives, and feed box design, including considerations for efficiency, reliability, and ease of operation (C1).			
2	Design of Machine Tool Structures: Explain the functions and requirements of machine tool structures, emphasizing their role in providing stability, precision, and support for machining operations (C1). Discuss the design considerations for strength in machine tool structures, including factors such as static and dynamic loads, stress analysis, and safety margins (C1). Discuss the design considerations for rigidity in machine tool structures, focusing on minimizing deflections and vibrations to ensure accuracy and quality of machining (C1). Explain the selection of materials for machine tool structures, considering factors such as strength, stiffness, durability, and cost (C1). Describe the constructional features of machine tools, including beds and			

	housings, columns and tables, saddles and carriages (C1).
3	Design of Guideways, Power Screws, and Spindles: Guideways: Explain the functions and types of guideways in machine tools, including sliding guideways, rolling guideways, aerostatic slideways, and anti-friction guideways (C1). Discuss the design considerations for guideways, including factors such as load capacity, accuracy, friction, wear, and lubrication (C1). Explain the design principles for aerostatic slideways, including the use of air pressure to support the load and minimize friction (C1). Discuss the design considerations for anti-friction guideways, focusing on the selection and arrangement of bearings to provide smooth and precise motion (C1). Explain the concept of combination guideways, which combine different types of guideways to optimize performance in specific applications (C1). Power Screws: Describe the design considerations for power screws, including factors such as load capacity, pitch selection, efficiency, and backlash (C1). Discuss the calculation and selection of power screws based on the desired load, speed, and accuracy requirements (C1). Spindles and Spindle Supports: Explain the functions of spindles in machine tools, including providing rotational motion and supporting cutting tools (C1). Discuss the requirements for spindles in terms of accuracy, stiffness, damping, and thermal stability (C1). Explain the effect of machine tool compliance on machining accuracy and the design considerations for minimizing compliance (C1). Describe the design principles for spindles, including factors such as material selection, spindle configuration, and cooling methods (C1). Discuss the use of antifriction bearings in spindle design, considering factors such as load capacity, speed, and lubrication (C1).
4	Dynamics of Machine Tools: Machine Tool Elastic System Explain the concept of the machine tool elastic system, which includes the machine structure, guideways, spindles, and other components that exhibit elastic deformation during operation (C1). Discuss the importance of considering the elastic behavior of machine tools in terms of machining accuracy, stability, and vibration control (C1). Describe the methods for modeling and analyzing the elastic behavior of machine tool structures, including finite element analysis and experimental modal analysis (C1).

	Static and Dynamic Stiffness Acceptance Tests: Explain the significance of static and dynamic stiffness in machine tools and their impact on machining performance (C1). Discuss the acceptance tests for static stiffness, which involve measuring the machine tool's resistance to deformation under static loads (C1). Describe the acceptance tests for dynamic stiffness, which involve measuring the machine tool's response to dynamic excitations and analyzing its natural frequencies and mode shapes (C1). Discuss the criteria for evaluating the static and dynamic stiffness of machine tools and the implications for machine tool design and performance (C1). Current Industry Trends: Provide an overview of current trends in machine tool dynamics, such as the development of high-speed machining, precision machining, and advanced control systems (C2). Discuss the integration of advanced technologies, such as active vibration control, adaptive control, and intelligent monitoring systems, in machine tool design and operation (C2). Highlight the importance of addressing dynamic considerations in the design and development of machine tools to meet the evolving needs of modern manufacturing (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) Principles of Machine Tools/ G. C. Sen and A. Bhattacharyya / New Central Book Agency/ASINB01FIX1MKA. **ii)** Design of Machine Tools / D. K Pal, S. K. Basu / Oxford /ISBN: 9788120417779/Product Code-EBK0013309.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**SEC-II (ANSYS)**
Academic Year	II
Semester	IV
Number of Credits	2
Course Prerequisite	Engineering Graphics and Design, SolidWorks
Course Synopsis	This course introduces students to ANSYS, a powerful finite element analysis (FEA) software used for engineering simulations. Students will learn the fundamental concepts and skills necessary to perform structural and thermal analysis using ANSYS. The course focuses on pre-processing, solving, and post-processing of engineering problems using ANSYS.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Prepare and analyze finite element models for structural and thermal simulations in ANSYS.
CO2	Perform structural analysis and evaluate the structural behavior of components using ANSYS.
CO3	Conduct thermal analysis and evaluate heat transfer phenomena using ANSYS.
CO4	Interpret and communicate simulation results effectively using ANSYS post-processing tools.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	3	1	-	-	-	1	2	2	3	2	1
CO2	3	3	3	2	3	1	-	-	-	1	2	2	3	3	-
CO3	3	3	3	2	3	1	1	-	-	1	1	1	3	3	1
CO4	3	3	3	3	3	1	1	1	-	1	1	1	3	3	-

Average	3	2.75	2.75	2.25	3	1	0.5	0.25	-	1	1.5	1.5	3	2.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**4**	**4**

Sr. No.	Content & Competencies
1	Introduction to ANSYS (4 hours) Overview of ANSYS software and capabilities (C1: Remembering) ANSYS interface and workflow (C2: Understanding) Pre-processing steps: geometry import and cleanup (C3: Applying)
2	Structural Analysis in ANSYS (10 hours) Finite element method (FEM) and meshing techniques (C2: Understanding) Boundary conditions and loads (C3: Applying) Solving structural problems: static, modal, and transient analyses (C4: Analyzing)
3	Material Modeling and Simulation (8 hours) Material properties and material models in ANSYS (C2: Understanding) Nonlinear material behavior and plasticity (C4: Analyzing) Composite material analysis (C3: Applying)
4	Thermal Analysis in ANSYS (8 hours) Introduction to thermal analysis and heat transfer (C2: Understanding) Conduction, convection, and radiation heat transfer (C4: Analyzing) Solving thermal problems: steady-state and transient analyses (C3: Applying)
5	Fluid-Structure Interaction (FSI) Analysis (6 hours) Introduction to FSI analysis and coupling methods (C2: Understanding) Solving FSI problems: structural and fluid analyses (C4: Analyzing) Interpretation of FSI results (C3: Applying)
6	Optimization and Design Exploration (8 hours) Introduction to design optimization and parameterized modeling (C2: Understanding) Optimization methods and algorithms in ANSYS (C4: Analyzing) Design of Experiments (DoE) and sensitivity analysis (C3: Applying)
7	Post-Processing and Results Interpretation (8 hours) ANSYS post-processing tools and visualization (C2: Understanding) Extraction of simulation results and data analysis (C3: Applying) Creation of reports and presentations (C3: Applying)
8	Advanced Topics (6 hours) Nonlinear analysis and contact mechanics (C4: Analyzing) Dynamic analysis: modal, harmonic, and transient response (C4: Analyzing) Advanced meshing techniques (C3: Applying)
9	Case Studies and Projects (8 hours) Application of ANSYS in real-world engineering problems (C5: Creating)

	Project work involving structural or thermal analysis (C3: Applying) Documentation and presentation of project results (C3: Applying)

Teaching - Learning Strategies and Contact Hours

Teaching-Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	10
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	10
Revision	5
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
Problem Based Learning (PBL)	University Examination
Assignment	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Assignment	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps 1. Regular feedback through the Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of the semester.		
References:	(List of reference books)	
	1. "Engineering Analysis with ANSYS Workbench 19" by Guangming Zhang, College House Enterprises, Edition Year: 2019, ISBN: 978-1935673507 2. "Finite Element Simulations with ANSYS Workbench" by Huei-Huang Lee, SDC Publications, Edition Year: 2021, ISBN: 978-1630574567 3. "ANSYS Mechanical APDL for Finite Element Analysis" by Mary Kathryn Thompson and John Martin, Butterworth-Heinemann, Edition Year: 2017, ISBN: 978-0128129814 4. "Introduction to Finite Element Analysis Using SOLIDWORKS Simulation" by Randy H. Shih, SDC Publications, Edition Year: 2021, ISBN: 978-1630573874	

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Strength of Materials Lab
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	Engineering Mechanics
Course Synopsis	Strength of Materials (also known as Mechanics of Materials) is the study of the internal effect of external forces applied to structural member. Stress, strain, deformation deflection, torsion, flexure, shear diagram, and moment diagram are some of the topics covered by this subject.

Course Outcomes:

At the end of the course students will be able to:

CO1	To estimate and compare the strength of solid materials using Tension, shear and torsion test.
CO2	To determine and compare the Toughness of the materials using CHARPY and IZOD Test.
CO3	To determine and compare the Brinnell and Rockwell hardness number of the given specimen.
CO4	To determine the bending strength and fatigue strength of specimen using bending test.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	0	2	0	0	0	0	2	3	2	2
CO2	3	3	3	3	3	0	2	0	0	0	0	2	3	3	2
CO3	3	3	3	3	3	0	2	0	0	0	0	2	3	3	3
CO4	3	3	3	3	3	0	2	0	0	0	0	2	1	3	1
Average	3	3	3	3	3	0	2	0	0	0	0	2	2.5	2.75	2

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Unit	**Content & Competencies**
1	Evaluation of engineering stress-strain diagram on mild steel and cast iron rods under tension (C1)
2	Determine the mechanical Properties of material by bending test on mild steel using universal testing machine (C4)
3	Comparison of hardness values of steel, copper and aluminium using Brinell hardness testing machine (C3)
4	Comparison of hardness values of steel, copper and aluminium using Rockwell hardness testing machine (C3)
5	Determination of spring constant under tension and compression (C1)
6	Determination of impact strength for the given specimen using Charpy test (C2)
7	Determination of impact strength for the given specimen using Izod test (C2)
8	Determination of fatigue strength for the given specimen using Fatigue test (C4)
9	Determination of shear stress for the given specimen using Torsion test (C1)
10	Determination of shear strength for the given specimen using double shear test (C1)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	10
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination				
Feedback Process	1. Student's Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:				

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Material Engineering & Technology Lab**
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	+2 Physics and Chemistry
Course Synopsis	This introductory course combines the academic disciplines of chemistry, physics, and engineering to create a MST curriculum. The course covers the fundamentals of ceramics, glass, metals, polymers, and composites. Designed to appeal to a broad range of students, the course combines hands-on activities, demonstrations and long-term student project descriptions. The basic philosophy of the course is for students to observe, experiment, record, question, seek additional information, and, through creative and insightful thinking.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand how materials are formed and their classification based on atomic arrangement.
CO2	Describe the mechanical behavior of metallic systems and its importance.
CO3	Evaluate system for fatigue failures.
CO4	Gain knowledge on different classes of materials and their applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	-	1	1	2	-	-	1	-	2	3	3	2
CO2	3	2	2	-	3	-	-	-	-	-	-	2	3	3	2

CO3	3	2	2	3	2	-	2	-	-	-	-	2	3	3	3
CO4	3	2	2	2	1	2	2	-	-	1	-	3	2	2	1
Average	3	2	1.75	2.5	1.75	1.5	2	-	-	0.5	-	2.25	2.75	2.75	2

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sr. No.	**Content & Competencies**
1	Specimen preparation and micro-structural examination. C1, C2,C3,C4
2	Comparative study of microstructures of given specimens (mild steel, gray C.I., brass, copper etc.) C1, C2,C3,C4
3	Heat treatment experiments such as annealing, normalizing, quenching, case hardening and comparison of hardness before and after (C1, C2,C3,C4)
4	Making a plastic mould for small metallic specimen (C1, C2, C3, C4, C5,C6)
5	Study & working of simple measuring instruments- Verniercalipers, micrometer, tachometer (C1, C2)
6	Measurement of effective diameter of a screw thread (C1, C2,C3)
7	Measurement of angle using sine bar & slip gauges (C1, C2,C3)
8	Study & angular measurement using bevel protector (C1, C2,C3)
9	Study of undulation measurement using dial gauge (C1, C2,C3)
10	Study of corrosion in given sample (C1, C2,C3)
11	Measurement of gear dimensions using tool maker's microscope (C1, C2,C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10

Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--
	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination				

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) V. Raghavan. Materials Science and Engineering, PHI; Fifth edition (30 July 2011), ASIN: B00K7YGKWQ

ii) William D. Callister, David G. Rethwisch, Fundamentals of Materials Science And Engineering: An Integrated Approach, John Wiley & Sons; 4th Edition edition (8 December 2011), ISBN: 1118061608

iii) William F. Smith and Javad Hashemi (2004), Foundations of materials science and engineering 5th Edition, McGraw Hill, 2009, ISBN: 9780073529240

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Manufacturing Processes Lab**
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	Engineering Workshop
Course Synopsis	In this syllabus to introduce about manufacturing process, welding process and other important things which are very needful to a mechanical engineer. Students learn metal cutting operations like turning, milling, drilling, shaping, etc., Joining Processes, Metal Forming Processes, methods of measurements, Super Finishing Processes, Sheet Metal Developments.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Explain the mechanism of chip formation in machining.
CO2	Explain the various machining processes such as turning, drilling, boring, shaping, slotting,
CO3	Use the principles of machine tools.
CO4	Choose materials in a manufacturing process based on their properties.
CO5	Conduct experiments on various manufacturing processes.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	2	1	-	-	1	-	2	2	3	2	2
CO2	3	3	2	2	2	-	1	-	-	1	-	1	3	2	2
CO3	3	3	3	3	2	1	-	-	2	1	1	2	3	1	-
CO4	3	2	1	-	-	3	2	-	1	1	2	3	3	-	-

CO5	3	1	1	1	1	-	-	-	1	1	2	2	3	1	1
Average	3	2.4	2	1.6	1.4	1	0.6	-	1	0.8	1.4	2	3	1.2	1

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Sr. No.	Content & Competencies
1	Study and Practice of Orthogonal & Oblique Cutting on a Lathe (C1, C2,C3,C4)
2	Machining time calculation and comparison with actual machining time while cylindrical turning on a Lathe and finding out cutting efficiency (C1, C2,C3,C4,C5)
3	Study of Tool Life while Milling a component on the Milling Machine (C1, C2,C3,C4)
4	To establish the relationship between cutting speed, feed rate and depth of cut during forces generated in oblique cutting (C1, C2,C3,C4,C5)
5	Study of Tool Wear of a cutting tool while Drilling on a Drilling Machine (C1, C2,C3,C4)
6	Preparation of joint using spot welding (C1, C2,C3,C4,C5,C6)
7	Preparation of butt joint using arc welding (C1, C2,C3,C4,C5,C6)
8	Welding of stainless-steel specimen using MIG welding (C1, C2,C3,C4,C5,C6)
9	Experiment on sheet metal development: Preparation of models – tray, funnel, truncated cone, pyramid, transition piece (C1, C2,C3,C4,C5,C6)
10	Study of various super finishing operations-Lapping, honing, burnishing (C1,C2)
11	Study of divided head and generation of gear profile on milling machine (C1,C2)
12	To perform taper turning and thread cutting by different methods on lathe machine (C1, C2,C3,C4,C5,C6)
13	To select an appropriate grinding wheel to perform cylindrical & surface grinding operation (C1, C2,C3,C4)
14	Study and practice of Linear and angular measurement instruments (C1,C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**	
Quiz					
VIVA	✓	✓	✓	✓	
Assignment / Presentation					

Unit test					
Practical Log Book/ Record Book	✓	✓	✓	✓	
Mid Semester Examination 1					
Mid Semester Examination 2					
University Examination					

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) P N Rao, Vol. 1, Foundry, Forming and Welding, McGraw Hill, 5th Edition, ISBN-13: 978-93-5316-050-0. **ii)** Workshop Technology (Manufacturing Process) – S K Garg, Laxmi Publications; Fourth Edition (2018), ISBN-10: 8131806979

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Mobile Robots**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Robotics Engineering and Applications
Course Synopsis	This course introduces the fundamentals of robotics, emphasizing mobile robots, which are integrated mechanical, electrical and computational systems functioning in the physical world. Topics include state-of-the-art technologies in mobile robotics, such as locomotion, sensing, communication, localization and mapping, navigation, etc. Advanced topics such as coordination of multiple mobile robots will also be discussed. The course aims to provide both the students theoretical and practical experience lectures and hands-on experiments with real robots and simulation software.

Course Outcomes: At the end of the course, students will be able to:

CO1	Students will be able to define mobile robots and their fundamental technologies.
CO2	Develop a basic understanding of mobile robot control systems.
CO3	Understand the localization of Robots.
CO4	Understand basics of image processing and its use in the designing of mobile robots.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	-	-	-	-	0	3	3	2	2
CO2	3	3	2	2	2	2	-	-	-	-	0	1	3	2	1
CO3	3	2	3	3	3	2	-	-	-	-	1	1	3	2	2
CO4	3	2	3	3	3	2	-	-	-	-	3	1	3	2	2

Average	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	3	2	1.75

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	A Brief History of Mobile Robotics (C1) Exploring the historical development of mobile robotics (C1) Understanding the market and applications of mobile robotics (C1) Recent Advances in Mobile Robotics for RISE Applications (C3) Examining the latest advancements in mobile robotics for risky intervention and surveillance environments (C3) Analyzing real-world applications of mobile robots in such environments (C3) Locomotion Principles (C2) Understanding the key principles of locomotion in mobile robotics (C2) Examining different locomotion mechanisms, including legged, wheeled, and aerial robots (C2) Key Issues in Locomotion (C3) Investigating the challenges and issues related to locomotion in mobile robotics (C3) Analyzing factors such as stability, adaptability, terrain traversal, and energy efficiency (C3) Mobile Robot Kinematics: Introduction (C2) Introducing the concept of mobile robot kinematics (C2) Understanding the relationship between robot motion and its kinematic models (C2) Kinematic Models and Constraints (C3) Exploring different kinematic models for mobile robots (C3) Analyzing constraints imposed on robot motion and maneuverability (C3) Mobile Robot Workspace (C3) Examining the workspace of mobile robots and its impact on robot mobility (C3) Assessing the reachable and unobstructed regions for mobile robot operations (C3) Beyond Basic Kinematics (C4) Delving into advanced topics in mobile robot kinematics (C4) Exploring motion planning, obstacle avoidance, and sensor integration (C4) Motion Control (Kinematic Control) (C4)

	Studying motion control strategies for mobile robots (C4) Analyzing kinematic control techniques for precise robot motion (C4)
2	Sensors Classification (C1) Introduction to sensor classification in robotics (C1) Understanding the different types and functionalities of sensors (C1) Sensor Characterization (C2) Techniques for characterizing and calibrating sensors (C2) Evaluating sensor performance and accuracy (C2) Wheel/Motor Encoders (C2) Exploring the use of wheel/motor encoders for robot control (C2) Understanding how encoders provide information about robot speed and distance traveled (C2) Heading/Orientation Sensors (C2) Examining sensors used to measure robot heading and orientation (C2) Analyzing the role of these sensors in robot navigation and control (C2) Ground-based Beacons (C2) Understanding the use of ground-based beacons for robot localization and positioning (C2) Exploring the principles and techniques behind beacon-based sensing (C2) Active Ranging Sensors (C2) Investigating active ranging sensors, such as lidar and ultrasonic sensors (C2) Analyzing their capabilities for environment perception and obstacle avoidance (C2) Motion/Speed Sensors (C2) Exploring sensors used to measure robot motion and speed (C2) Understanding their applications in robot control and feedback (C2) Vision-based Sensors (C3) Studying vision-based sensors, including cameras and depth sensors (C3) Analyzing computer vision techniques for object recognition, tracking, and mapping (C3) Low-Level Control (C3) Introduction to low-level control techniques in robotics (C3) Exploring motor control, PID control, and feedback control (C3) Control Architectures and Software Frameworks (C4) Understanding different control architectures, such as hierarchical and behavior-based architectures (C4) Exploring software frameworks for robot control, such as ROS (Robot Operating System) (C4) Robot Learning (C4)

	Overview of robot learning techniques, including supervised, unsupervised, and reinforcement learning (C4) Analyzing the role of learning algorithms in adapting robot behavior and control (C4) Case Studies of Learning Robots (C5) Examining real-world case studies of robots that employ learning algorithms (C5) Analyzing the challenges, benefits, and limitations of learning-based robot control (C5)
3	Introduction (C1) Overview of the course objectives and topics (C1) Introduction to the challenges and importance of localization, mapping, and navigation in robotics (C1) The Challenge of Localization: Noise and Aliasing (C2) Understanding the impact of noise and aliasing on robot localization (C2) Exploring techniques to mitigate noise and aliasing effects in localization (C2) To Localize or Not to Localize: Localization-based Navigation versus Programmed Solutions (C2) Analyzing the advantages and limitations of localization-based navigation (C2) Comparing localization-based navigation with pre-programmed solutions (C2) Map Representation (C2) Overview of map representation techniques in robotics (C2) Understanding the different types of maps, such as grid maps and feature-based maps (C2) Probabilistic Mapping (C3) Exploring probabilistic mapping techniques, such as occupancy grids and Bayesian filters (C3) Understanding the probabilistic nature of mapping and its impact on robot localization (C3) Map-based Localization (C3) Understanding map-based localization methods, such as scan matching and particle filters (C3) Analyzing the strengths and weaknesses of map-based localization techniques (C3) Autonomous Map Building (C4) Exploring techniques for autonomous map building in robotics (C4) Analyzing simultaneous localization and mapping (SLAM) algorithms (C4) Planning and Navigation (C4) Overview of planning and navigation techniques in robotics (C4)

	Understanding the role of path planning and obstacle avoidance in robot navigation (C4) Obstacle Avoidance (C4) Exploring obstacle avoidance algorithms and techniques (C4) Analyzing reactive approaches and behavior-based navigation (C4) D* Algorithm (C4) Introduction to the D* algorithm for dynamic path planning (C4) Understanding the principles and implementation of the D* algorithm (C4) Navigation Architecture (C5) Overview of navigation architectures in robotics (C5) Analyzing layered architectures and deliberative/reactive approaches (C5) Case Studies (C5) Examining real-world case studies of navigation architectures in robotics (C5) Analyzing the challenges, benefits, and limitations of different navigation approaches (C5)
4	Introduction to Computer Vision (C1) Overview of computer vision and its applications (C1) Introduction to the fundamental concepts and challenges in computer vision (C1) Image Processing: Point Operators (C2) Understanding point operators for image enhancement and manipulation (C2) Applying point operators for image contrast adjustment, brightness correction, and thresholding (C2) Image Processing: Linear Filters (C2) Introduction to linear filters for image smoothing, sharpening, and noise reduction (C2) Understanding different types of linear filters, such as Gaussian, mean, and median filters (C2) Image Processing: More Neighborhood Operators (C2) Exploring neighborhood operators, including edge detection and gradient-based operators (C2) Analyzing techniques such as Sobel, Prewitt, and Laplacian operators (C2) Fourier Transforms (C3) Understanding Fourier transforms for image frequency analysis and filtering (C3) Applying Fourier transforms for image compression and feature extraction (C3) Pyramids and Wavelets (C3) Introduction to image pyramids for multi-resolution analysis and image scaling (C3)

	Exploring wavelet transforms for image compression, denoising, and edge detection (C3) Geometric Transformations (C3) Understanding geometric transformations, including translation, rotation, scaling, and affine transformations (C3) Applying geometric transformations for image registration, alignment, and perspective correction (C3) Camera Technology: History in Brief (C1) Exploring the historical development of camera technology (C1) Understanding the key milestones and advancements in camera systems (C1) Machine Vision vs. Closed Circuit Television (CCTV) (C2) Comparing machine vision systems with closed circuit television (CCTV) systems (C2) Analyzing the differences, applications, and requirements of machine vision in industrial settings (C2) Sensor Technologies (C3) Overview of sensor technologies used in camera systems (C3) Understanding the principles of image sensors, including CCD and CMOS technologies (C3) Spatial Differentiation: 1D and 2D (C3) Exploring spatial differentiation techniques for image edge detection and feature extraction (C3) Understanding the concepts of gradient and Laplacian operators (C3) CCD Technology and Frame Readout (C4) In-depth study of CCD (charge-coupled device) technology in camera systems (C4) Understanding different frame readout principles, including full frame, frame transfer, and interline transfer

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	3
Small Group Discussion (SGD)	3
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5

Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid-Semester Examination 1	✓	✓	✓	✓
Mid-Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

<table>
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iii) George A. Bekey “Autonomous Robots” MIT Press.
iv) Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A. Kantor, Wolfram Burgard, Lydia E. Kavrakiand Sebastian Thrun, "Principles of Robot motion: Theory, Algorithm and Implementations", MIT Press.</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Mobile Robots Lab**
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	Robotics Engineering and Applications
Course Synopsis	A mobile robot lab is a specialized facility equipped with resources and tools for conducting experiments and research related to mobile robotics. It provides an environment to study the design, control, navigation, and sensing capabilities of mobile robots.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Students will start analyzing, developing and presenting control & navigation systems for applications that span multiple disciplines through laboratory exercises.
CO2	Develop an understanding of factors that affect system performance and stability.
CO3	Students will be able to define sensing and controller requirements for unmanned vehicles that operate in different conditions.
CO4	Understand the localization of Robots.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	-	-	-	-	0	3	3	1	0
CO2	3	3	2	2	2	2	-	-	-	-	0	1	3	2	2
CO3	3	2	3	3	3	2	-	-	-	-	1	1	3	1	2
CO4	3	2	3	3	3	2	-	-	-	-	3	1	3	2	2
Average	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	3	1.5	1.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Sr. No.	Content & Competencies
1	Introduction to Mobile Robots (C1) Overview of mobile robotics and its applications (C1) Introduction to the fundamental concepts and challenges in mobile robotics (C1)
2	Mobile Robot Hardware: Locomotion (C2) Study of different locomotion mechanisms used in mobile robots, such as wheeled, legged, and aerial (C2) Understanding the advantages, limitations, and applications of each locomotion type (C2)
3	Mobile Robot Hardware: Sensors (C2) Overview of sensors used in mobile robots, including proximity sensors, vision systems, IMU, and GPS (C2) Understanding the principles of operation, data acquisition, and integration of sensors in mobile robot systems (C2)
4	Mobile Robot Control System: Hardware and Software (C3) Study of the hardware components, such as microcontrollers and motor drivers, used in mobile robot control systems (C3) Introduction to software frameworks and programming languages for mobile robot control (C3)
5	Navigation I: Localization and Mapping (C3) Understanding the concepts of localization and mapping in mobile robots (C3) Exploring techniques such as odometry, landmark-based localization, and simultaneous localization and mapping (SLAM) (C3)
6	Navigation II: Reasoning and Motion Planning (C3) Introduction to reasoning and decision-making algorithms for mobile robot navigation (C3) Study of motion planning techniques, including potential fields, A*, and RRT-based algorithms (C3)
7	Wireless Communication for Mobile Robots (C2) Overview of wireless communication technologies used in mobile robot systems (C2) Understanding communication protocols, networking, and data exchange

	between robots and remote stations (C2)
8	Advanced Topics: Multiple Robots' Coordination (C4) Exploring advanced concepts and techniques for coordinating multiple mobile robots (C4) Studying approaches to collaboration, task allocation, and communication in multi-robot systems (C4)
Note:	1. At least 08 experiments/ jobs are to be performed/ prepared by students in the semester. 2. At least 06 experiments/ jobs should be performed/prepared from the above list; the remaining two may either be performed/prepared from the above list or designed and set as per the scope of the syllabus of the Engineering Workshop.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	05
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	05
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--

Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

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Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Battery Management System
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Introduction to Electric and Hybrid Vehicles
Course Synopsis	The outline of this course is to introduce learner to batteries, its parameters, modelling and charging requirements. The course will help learner to develop battery management algorithms for batteries.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Interpret the role of battery management system
CO2	Interpret the concept associated with battery charging / discharging process
CO3	Calculate the various parameters of battery and battery pack
CO4	Design the model of battery pack

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	2	1	2	-	-	-	-	-	2	3	1	1
CO2	3	2	2	2	1	2	-	-	-	-	-	2	3	2	-
CO3	3	2	2	2	2	2	-	-	-	-	-	2	3	2	-
CO4	3	2	2	2	2	2	-	-	-	-	-	2	3	2	1
Average	3	1.75	2	2	1.5	2	0	0	0	0	0	2	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Battery Management System (BMS): Define a Battery Management System (BMS) as an electronic system that manages and monitors the performance, health, and safety of rechargeable batteries (C1). Explain the importance of a BMS in ensuring the efficient and safe operation of batteries in various applications, such as electric vehicles, renewable energy systems, and portable electronics (C1). Cells & Batteries: Define a cell as the basic unit of a battery that converts chemical energy into electrical energy (C1). Explain the concept of a battery as a collection of interconnected cells that work together to provide a higher voltage and capacity (C1). Discuss the common types of batteries, including primary and secondary batteries, and their respective characteristics and applications (C1). Nominal Voltage and Capacity: Define the nominal voltage as the average voltage output of a fully charged battery under normal operating conditions (C1). Explain the concept of capacity as the amount of charge a battery can store and deliver over a specific period of time (C1). Discuss the relationship between the nominal voltage and capacity of a battery and their significance in determining the battery's performance and runtime (C1). C Rate, Energy, and Power: Define the C rate as a measure of the battery's charging or discharging current in relation to its capacity (C1). Explain the concepts of energy and power in relation to batteries, where energy represents the total amount of charge stored in the battery, and power represents the rate at which energy is delivered or received (C1). Cells Connected in Series and Parallel: Explain the concept of connecting cells in series, where the positive terminal of one cell is connected to the negative terminal of another cell, resulting in an increased voltage (C1). Explain the concept of connecting cells in parallel, where the positive terminals of multiple cells are connected together, and the negative terminals are connected together, resulting in an increased capacity (C1). Electrochemical and Lithium-ion Cells:

	Explain the basic principles of electrochemical cells, where chemical reactions occur at the electrodes to generate electrical energy (C1). Discuss the characteristics and advantages of lithium-ion cells, which are widely used in rechargeable batteries due to their high energy density, long cycle life, and low self-discharge (C1). Rechargeable Cell, Charging, and Discharging Process: Explain the concept of a rechargeable cell, which can be charged and discharged multiple times (C1). Discuss the process of charging a battery, where electrical energy is applied to the cell to store energy through the electrochemical reactions (C1). Discuss the process of discharging a battery, where the stored energy is released as electrical energy for powering devices (C1). Overcharge and Undercharge: Define overcharge as a condition where a battery is charged beyond its recommended voltage or capacity limits, which can lead to reduced battery life, performance degradation, or even safety hazards (C1). Define undercharge as a condition where a battery is discharged below its recommended voltage or capacity limits, which can lead to reduced battery runtime and potential damage (C1). Modes of Charging: Discuss the different modes of charging batteries, such as constant current (CC), constant voltage (CV), and trickle charging, and their respective applications (C1).
2	Introduction to Battery Management System (BMS): Provide an introduction to the Battery Management System (BMS) as an essential component in managing and monitoring the performance, health, and safety of rechargeable battery packs (C1). Explain the importance of a BMS in optimizing battery pack operation, ensuring balanced charging and discharging, protecting against overcharging and over-discharging, and extending battery life (C1). Battery Pack Topology: Discuss different battery pack topologies, such as series-connected, parallel-connected, and hybrid configurations (C1). Explain the advantages and considerations of each topology in terms of voltage, capacity, power output, and system reliability (C1). BMS Functionality: Provide an overview of the key functionalities of a BMS in a battery pack system (C1). Discuss the primary functions, including voltage sensing, temperature sensing, current sensing, high-voltage contactor control, isolation sensing, thermal

	control, protection, communication interface, range estimation, state-of-charge estimation, and cell total energy and power calculation (C1). Voltage Sensing: Explain the voltage sensing function of the BMS, which involves measuring the voltage of individual battery cells or modules within the pack (C1). Discuss the importance of voltage sensing for monitoring cell balancing, detecting abnormal voltage levels, and ensuring the overall pack voltage remains within safe operating limits (C1). Temperature Sensing: Discuss the temperature sensing function of the BMS, which involves measuring the temperature of battery cells, modules, or the surrounding environment (C1). Explain the significance of temperature sensing for monitoring thermal conditions, detecting overheating or excessive cooling, and implementing temperature-based safety measures (C1). Current Sensing: Explain the current sensing function of the BMS, which involves measuring the current flowing into or out of the battery pack (C1). Discuss the importance of current sensing for monitoring charging and discharging rates, detecting abnormal current levels, and implementing current-based safety protections (C1). High-voltage Contactor Control: Discuss the high-voltage contactor control function of the BMS, which involves managing the connection and disconnection of the battery pack to the external load or charging source (C1). Explain the role of high-voltage contactors in ensuring safe and controlled power delivery and isolation during various operating modes (C1). Isolation Sensing: Explain the isolation sensing function of the BMS, which involves monitoring the electrical isolation between the battery pack and the system or chassis (C1). Discuss the importance of isolation sensing for detecting potential faults or leakage currents that may compromise safety (C1). Thermal Control: Discuss the thermal control function of the BMS, which involves managing the temperature of the battery pack through active cooling or heating methods (C1). Explain the significance of thermal control in maintaining optimal battery performance, preventing overheating or freezing, and enhancing overall system reliability (C1). Protection:

	Explain the protection function of the BMS, which involves implementing safety measures to protect the battery pack from overcharging, over-discharging, overcurrent, short circuits, and other abnormal conditions (C1). Discuss the importance of protection mechanisms in ensuring the longevity and safety of the battery pack (C1). Communication Interface: Discuss the communication interface function of the BMS, which involves providing data exchange capabilities between the BMS and external systems, such as vehicle control units or monitoring systems (C1). Explain the role of communication interfaces in transmitting vital battery information, status updates, and diagnostic data (C1). Range Estimation: Explain the range estimation function of the BMS, which involves estimating the remaining driving range or operating time based on battery capacity, current consumption, and other factors (C1). Discuss the significance of accurate range estimation for providing users with real-time information and optimizing battery utilization (C1). State-of-Charge Estimation: Explain the state-of-charge estimation function of the BMS, which involves estimating the remaining capacity or energy level of the battery pack (C1). Discuss the importance of accurate state-of-charge estimation for battery management, user convenience, and preventing over-discharging or premature charging (C1). Cell Total Energy and Cell Total Power: Explain the cell total energy and cell total power calculation functions of the BMS, which involve aggregating and monitoring the energy and power levels of individual battery cells or modules within the pack (C1). Discuss the significance of calculating total energy and power for capacity planning, load management, and overall pack performance monitoring (C1).
3	Battery State of Charge Estimation (SOC): Explain the concept of State of Charge (SOC), which represents the remaining capacity or energy level of a battery (C1). Discuss the importance of accurate SOC estimation for battery management, performance optimization, and user convenience (C1). Voltage-Based Methods to Estimate SOC: Discuss voltage-based methods commonly used to estimate SOC, such as the Open Circuit Voltage (OCV) method and the Coulomb Counting method (C1). Explain how these methods utilize the relationship between battery voltage and SOC to estimate the state of charge (C1). Model-Based State Estimation:

	Introduce model-based state estimation techniques used to estimate SOC, such as the Kalman Filter and the Extended Kalman Filter (C2). Explain how these methods utilize battery models, incorporating voltage, current, and other factors, to estimate the state of charge more accurately (C2). Battery Health Estimation: Discuss the concept of battery health estimation, which involves assessing the overall condition, degradation, and remaining useful life of a battery (C1). Explain the importance of battery health estimation for predicting battery performance, optimizing maintenance strategies, and ensuring reliable operation (C1). Lithium-Ion Aging: Negative Electrode: Explain the aging mechanisms specific to the negative electrode (anode) in lithium-ion batteries, such as lithiation and delithiation processes, solid-electrolyte interphase (SEI) formation, and structural degradation (C2). Discuss the factors influencing negative electrode aging and its impact on battery performance and capacity fade (C2). Lithium-Ion Aging: Positive Electrode: Explain the aging mechanisms specific to the positive electrode (cathode) in lithium-ion batteries, such as phase transitions, side reactions, particle cracking, and electrode/electrolyte interface degradation (C2). Discuss the factors influencing positive electrode aging and its impact on battery performance and capacity fade (C2). Cell Balancing: Discuss the concept of cell balancing in multi-cell battery packs, which involves equalizing the voltage or state of charge among individual cells (C1). Explain the importance of cell balancing for improving pack efficiency, extending battery life, and preventing overcharging or over-discharging (C1). Causes of Imbalance: Discuss the various factors that can lead to cell imbalance in a battery pack, such as manufacturing variations, cell aging, temperature effects, and operational conditions (C1). Explain how these factors contribute to voltage variations and capacity imbalances among cells (C1). Circuits for Balancing: Explain different circuit topologies and techniques used for cell balancing in battery packs, such as passive balancing, active balancing, and hybrid balancing (C1). Discuss the operation principles, advantages, and limitations of each balancing circuit approach (C1)
4	Design Principles of Battery BMS:

	Discuss the key design principles of a Battery Management System (BMS), which is responsible for monitoring, controlling, and protecting batteries in various applications (C2). Explain the importance of safety, reliability, accuracy, and efficiency in BMS design (C2). Discuss the need for voltage, temperature, and current sensing, as well as state estimation algorithms, protection circuits, communication interfaces, and diagnostic capabilities in a BMS (C2). Effect of Distance, Load, and Force on Battery Life and BMS: Explain how the physical characteristics of a battery system, such as the distance between cells/modules, the applied load, and external forces, can impact battery life and BMS performance (C2). Discuss the influence of distance on the resistance and impedance of interconnecting cables and their effect on the overall system efficiency and performance (C2). Explain how excessive loads, both electrical and mechanical, can cause stress, degradation, and premature failure of batteries and BMS components (C2). Energy Balancing with Multi-Battery System: Discuss the challenges associated with energy balancing in a multi-battery system, where multiple batteries are connected in parallel or series (C2). Explain the importance of energy balancing for maximizing battery pack performance, extending overall system life, and ensuring consistent operation (C2). Discuss different approaches to energy balancing, such as passive balancing, active balancing, and hybrid balancing, and their applicability in multi-battery systems (C2). Explain how balancing algorithms and control strategies can be implemented within the BMS to distribute energy evenly among batteries and maintain optimal performance (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	4
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	7

Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley& Sons Ltd., 2016. 2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003. 3. Chris Mi, AbulMasrur& David WenzhongGao, "Hybrid electric

	Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Battery Management System Lab
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	Introduction to Electric and Hybrid Vehicles
Course Synopsis	The outline of this Lab course is to analyze batteries, its parameters, modelling and charging requirements. The Lab work will help learner to develop battery management algorithms for batteries.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Interpret the role of battery management system
CO2	Interpret the concept associated with battery charging / discharging process
CO3	Calculate the various parameters of battery and battery pack
CO4	Design the model of battery pack

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	2	-	-	-	-	-	2	3	1	1
CO2	3	2	2	2	1	2	-	-	-	-	-	2	3	2	-
CO3	3	2	2	2	2	2	-	-	-	-	-	2	3	2	-
CO4	3	2	2	2	2	2	-	-	-	-	-	2	3	2	1
Average	3	1.75	2	2	1.5	2	0	0	0	0	0	2	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Unit	**Content & Competencies**
1	To Study of different types of batteries. C1, C2
2	To Study Battery monitoring System for Lead acid battery. C1, C2
3	To study for passive cell balancing for Li-Ion battery. C1, C2
4	Analysis of Electric vehicle power system. C1, C2, C3, C4
5	To Perform Short Circuit Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard. C1, C2, C3, C4
6	To Perform Overcharge Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard. C1, C2, C3, C4
7	To study Coulomb counting method for Lead-Acid battery and Li-ion battery. C1, C2, C3
8	To Study of different types of batteries with their characteristics & detailed specifications. C1, C2, C3

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4	
VIVA	✓	✓	✓	✓	
Practical Log Book/ Record Book	✓	✓	✓	✓	
University Examination	✓	✓	✓	✓	

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

1. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley& Sons Ltd., 2016.
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.
3. Chris Mi, AbulMasrur& David WenzhongGao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	**Database Management Systems**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	A course on "Data Structures"
Course Synopsis	Gain knowledge of fundamentals of DBMS, database design and normal form.

Course Outcomes:

At the end of the course students will be able to:

CO1	Define the basic concepts of database management systems
CO2	Ability to design entity relationship model and convert entity relationship diagrams into RDBMS and formulate SQL queries on the data
CO3	Able to demonstrate transaction processing and concurrency control
CO4	Able to apply normalization technique for schema refinement. Ability to compare different storage structures.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

Cos	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	**3**	**3**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**
CO3	**3**	**3**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO4	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**
Average	**3**	**3**	**0.5**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.5**	**0.5**	**-**	**-**

Course Content:

L (Hours/ Week)	**T (Hours/Week)**	**P (Hours/Week)**	**CL (Hours/Week)**	**Total Hour/Week**

3	**0**	**0**	**0**	**3**

Unit	**Content and Competency**
1	1. Define Database System Applications: A Historical Perspective, File Systems versus a DBMS, the Data Model, Levels of Abstraction in a DBMS. (C1: Knowledge) 2. Demonstrate Data Independence, and Structure of a DBMS. (C3: Application) 3. Create Database: Database Design and ER Diagrams, Entities, Attributes, and Entity Sets, Relationships and Relationship Sets. (C5: Synthesis) 4. Design with the ER Model, Additional Faculty of Engineering and Technologies of the ER Model, Conceptual. (C5: Synthesis)
2	1. Define Relational Model: Integrity constraint over relations, enforcing integrity constraints, querying relational data, logical data base design. (C1: Knowledge) 2. Create views, destroying/altering tables and views. (C5: Synthesis) 3. Explain Relational Algebra, Tuple relational Calculus, Domain relational calculus. (C2: Comprehension)
3	1.Demonstrate SQL: QUERIES, CONSTRAINTS, TRIGGERS: form of basic SQL query, UNION, INTERSECT, and EXCEPT, Nested Queries, aggregation operators, NULL values, complex integrity constraints in SQL, triggers and active data bases. (C3: Application) 2. Explain Schema Refinement: Problems caused by redundancy, decompositions, problems related to decomposition, reasoning about functional dependencies, FIRST, SECOND, THIRD normal forms, BCNF, lossless join decomposition, multi-valued dependencies, FOURTH normal form, FIFTH normal form. (C2: Comprehension, C6: Evaluation)
4	1. Explain Transaction Concept, Transaction State, Implementation of Atomicity and Durability, Concurrent Executions, Serializability, Recoverability. (C2: Comprehension) 2. Implementation of Isolation, Testing for serializability, Lock Based Protocols, Timestamp Based Protocols. (C6: Evaluation) 3. Describe Validation- Based Protocols, Multiple Granularity, Recovery and Atomicity, Log–Based Recovery, Recovery with Concurrent Transactions. (C2: Comprehension) 4. Explain Data on External Storage. (C2: Comprehension) 5. Define File Organization and Indexing, Cluster Indexes, Primary and Secondary Indexes, Index data Structures, Hash Based Indexing, Tree base Indexing, Comparison of File Organizations, Indexes and Performance Tuning, Intuitions for tree Indexes. (C2: Comprehension)

Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	30

Practical	-
Seminar/Journal Club	2
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	2
Problem Based Learning (PBL)	4
Case/Project Based Learning (CBL)	2
Revision	4
Others If any:	-
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2
Objective Structured Clinical Examination (OSCE)	University Examination
Objective Structured Practical Examination (OSPE)	Dissertation
Quiz	Multiple Choice Questions (MCQ)
Seminars	Short Answer Questions (SAQ)
Problem Based Learning (PBL)	Long Answer Question (LAQ)
Journal Club	Practical Examination & Viva-voce
	Objective Structured Clinical Examination (OSCE)
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz	✓	✓	✓	✓
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Clinical assessment				

Clinical/Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback			

References:	Textbooks: 1.Database Management Systems, Raghurama Krishnan, Johannes Gehrke, Tata McGraw Hill 3rd Edition 2. Database System Concepts, Silberschatz, Korth, McGraw hill, V edition.
	References: 1.Database Systems design, Implementation, and Management, Peter Rob & Carlos Coronel 7th Edition. 2. Fundamentals of Database Systems, Elmasri Navrate, Pearson Education 3. Introduction to Database Systems, C. J. Date, Pearson Education 4. Oracle for Professionals, The X Team, S.Shah and V. Shah, SPD. 5. Database Systems Using Oracle: A Simplified guide to SQL and PL/SQL,Shah, PHI. 6. Fundamentals of Database Management Systems, M. L. Gillenson, Wiley Student Edition

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Database Management Systems lab**
Academic Year	II
Semester	IV
Number of Credits	1
Course Prerequisite	Database Management Systems
Course Synopsis	Design database schema for a given application and apply normalization. Acquire skills in using SQL commands for data definition and data manipulation. Develop solutions for database applications using procedures, cursors and triggers

Course Outcomes:

At the end of the course, students will be able to:

CO1	Able to choose appropriate database schema for a given problem
CO2	Able to design an E-R model for real world problem
CO3	Able to develop relational model for schema refinement
CO4	Able to build a database for roadway travels and formulate quires using DDL, DML, DCL commands

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	-	-	-	-	-	-	-	-	-	3	2	1
CO2	3	3	3	-	-	-	-	-	-	-	-	-	3	2	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	2	-
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2	1
Average	3	3	3	1.5	1.5	-	-	-	-	-	-	-	3	2	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Content & Competencies	
Sr. No.	**Title**
1	Demonstrate Concept design with E-R Model. (C3: Application)
2	Demonstrate Relational Model. (C3: Application)
3	Demonstrate Normalization. (C3: Application)
4	Practicing DDL commands. (C3: Application)
5	Practicing DML commands. (C3: Application)
6	Querying (using ANY, ALL, IN, Exists, NOT EXISTS, UNION, INTERSECT, Constraints etc.) (C3: Application)
7	Queries using Aggregate functions, GROUP BY, HAVING and Creation and dropping of Views. (C3: Application)
8	Triggers (Creation of insert trigger, delete trigger, update trigger) (C3: Application)
9	Procedures (C3: Application)
10	Usage of Cursor (C3: Application)
Note:	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	Textbooks: 1.Database Management Systems, Raghurama Krishnan, Johannes Gehrke, Tata McGraw Hill 3rd Edition 2. Database System Concepts, Silberschatz, Korth, McGraw hill, V edition.

	References: 1.Database Systems design, Implementation, and Management, Peter Rob & Carlos Coronel 7th Edition. 2. Fundamentals of Database Systems, ElmasriNavrate, Pearson Education 3. Introduction to Database Systems, C. J. Date, Pearson Education 4. Oracle for Professionals, The X Team, S.Shah and V. Shah, SPD. 5. Database Systems Using Oracle: A Simplified guide to SQL and PL/SQL,Shah, PHI. 6. Fundamentals of Database Management Systems, M. L. Gillenson, Wiley Student Edition

SEMESTER - V

Course Code	Course Title
	Kinematics of Machines
	Fluid Mechanics
	Applied Thermodynamics
	Biology for Engineers
Program Electives Course - III	
	Power Plant Engineering
	Hydrogen and Fuel Cells
	Non-Conventional Machining
	Plant Layout and Material Handling
	Industrial Safety Engineering
	SEC-III (MATLAB)
	Kinematics of Machines Lab
	Fluid Mechanics Lab
	Applied Thermodynamics Lab
	Industrial Training - I
Minor Elective Course-III (Robotics)	
	Mechanics of Robot
	Mechanics of Robot Lab
Minor Elective Course-III (Electric Vehicles)	
	Power train Design
	Power train Design Lab

Minor Elective Course-III (Computer Science Engineering)	
	Data Structure & Algorithm
	Data Structure & Algorithm Lab

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Kinematics of Machines**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Mechanics
Course Synopsis	The analysis of a machine requires the determination of the movement or kinematics of its component parts, known as kinematic analysis. The assumption that the system is an assembly of rigid components allows rotational and translational movement to be modelled mathematically. This allows the position, velocity and acceleration of all points in a component to determine from these properties for a reference point and the angular position, angular velocity and angular acceleration of the component. Students learn Basics of Mechanisms, kinematic analysis of simple mechanisms, synthesis of simple mechanisms, kinematics of CAMS and kinematics of gears and gear train.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Demonstrate an understanding of the concepts of various mechanisms and pairs.
CO2	Conduct velocity and acceleration analysis of simple mechanisms.
CO3	Synthesize simple mechanisms for function, path generation and body guidance.
CO4	Design a layout of cam for specified motion and demonstrate an understanding of principles of operation of gears.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	-	-	-	1	-	1	3	3	2	3
CO2	3	3	3	3	2	1	-	-	1	1	-	2	3	3	3
CO3	3	2	2	2	3	1	-	-	-	-	1	2	3	2	2

CO4	3	2	2	2	2	-	1	-	-	-	1	2	3	2	2
Average	3	2.4	2.6	2.4	2.2	0.6	0.4	0.2	0.4	0.2	0.6	2.4	3	2.4	2.6

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Mechanisms and Grashoff's Law: Provide an overview of mechanisms and their importance in engineering systems (C1). Explain the concept of kinematic chains and the role of joints in connecting links (C1). Introduce Grashoff's law, which states the conditions for the existence of a crank-rocker mechanism, double rocker mechanism, and double-crank mechanism (C1). Kinematic Inversions of 4-Bar Chain: Discuss the concept of kinematic inversions, which refer to different arrangements of links in a mechanism while preserving the same relative motion (C1). Focus on the 4-bar chain, a widely used mechanism, and explain its different kinematic inversions, including crank-rocker, double-rocker, and double-crank configurations (C1). Single Slider and Double Slider Crank Chains: Introduce the single slider crank chain and double slider crank chain, which are mechanisms that involve a sliding or translating motion (C1). Explain the working principles and applications of these chains in various mechanical systems (C1). Quick Return and Its Terminologies: Discuss the concept of quick return in mechanisms, where the return stroke is faster than the forward stroke (C1). Introduce terminologies associated with quick return mechanisms, such as cutting speed, cutting stroke, return stroke, and dwell (C1). Degree of Freedom, Mobility, Kutzbach Criterion, Grubler's Criterion: Define the degree of freedom and mobility of a mechanism, which represent the number of independent motions it can exhibit (C1). Explain Kutzbach's criterion, which determines the mobility of planar mechanisms based on the number of links, joints, and higher pairs (C1).

	Introduce Grubler's criterion, which determines the degree of freedom of planar mechanisms based on the number of links, joints, and constraints (C1). Limiting Positions, Mechanical Advantage, Transmission Angle: Discuss limiting positions in mechanisms, which refer to extreme positions where certain motions or configurations are constrained (C1). Explain the concept of mechanical advantage, which quantifies the amplification of force or speed in a mechanism (C1). Introduce the transmission angle, which represents the angle between the input and output links in a mechanism (C1).
2	Displacement, Velocity, and Acceleration Analysis in Simple Mechanisms: Explain the concept of displacement, velocity, and acceleration analysis in mechanisms (C1). Discuss turning pairs, sliding pairs, and rolling pairs as the basic types of joints in mechanisms (C1). Illustrate the use of graphical and analytical methods to analyze the displacement, velocity, and acceleration of simple mechanisms (C1). Coriolis Acceleration using Graphical Relative Motion Method: Introduce the concept of Coriolis acceleration, which is the apparent acceleration experienced by a point on a moving link due to the rotation of the frame of reference (C1). Explain the graphical relative motion method to determine the Coriolis acceleration in mechanisms (C1). Instantaneous Center Method: Describe the instantaneous center method, also known as the Kennedy's theorem, which is used to analyze the velocity and acceleration of points in mechanisms (C1). Demonstrate how to find the instantaneous center of rotation for different types of motion in mechanisms (C1). Four-Bar and Slider-Crank Mechanisms: Discuss the kinematic analysis of the four-bar mechanism, which consists of four links connected by revolute joints (C1). Explain the analysis of the slider-crank mechanism, which includes a slider connected to a crank and a connecting rod (C1). Illustrate the displacement, velocity, and acceleration analysis of these mechanisms using graphical and analytical methods (C1). Analytical Method for Four-Bar and Slider-Crank Mechanisms: Present the analytical methods, such as vector algebra and complex number representation, for analyzing the kinematics of four-bar and slider-crank mechanisms (C2). Demonstrate the use of vector loop equations and vector algebra to derive

	equations for displacement, velocity, and acceleration (C2)
3	Classification of Kinematic Synthesis Problems: Explain the concept of kinematic synthesis, which involves designing mechanisms to perform specific motion tasks (C1). Discuss the classification of kinematic synthesis problems based on the type of motion desired, such as path generation, function generation, and motion transmission (C1). Two-Position Synthesis of Slider-Crank and Crank-Rocker Mechanisms: Describe the two-position synthesis, which involves designing a mechanism to achieve desired positions of the links (C1). Explain the procedure for synthesizing the slider-crank and crank-rocker mechanisms to achieve specific positions of the slider or rocker (C1). Illustrate the use of graphical and analytical methods, such as the graphical method of inversion and algebraic equations, for the synthesis process (C1). Three-Position Synthesis of Double Rocker Mechanism: Discuss the three-position synthesis, which involves designing a mechanism to achieve desired positions of multiple links (C1). Explain the procedure for synthesizing the double rocker mechanism to achieve specific positions of the rockers (C1). Demonstrate the use of graphical methods, such as the graphical method of position synthesis, for determining the dimensions and locations of the mechanism components (C1). Chebyshev Spacing and Freudenstein Analytical Method: Introduce Chebyshev spacing, which is a method for distributing precision points along a prescribed path to minimize errors (C2). Explain the Freudenstein analytical method, which is used for the synthesis of four-bar linkages with specific position requirements (C2). Discuss how these techniques can be applied to improve the accuracy and precision of mechanism designs (C2). Synthesis of Function Generator using Three Precision Positions: Describe the synthesis of a function generator, which is a mechanism that produces a specific output function based on the input motion (C2). Explain the process of designing a function generator by specifying three precision positions and determining the linkage dimensions (C2). Discuss the graphical and analytical methods that can be used for this synthesis problem (C2). Graphical and Analytical Design of a Four-Bar Linkage for Body Guidance: Present the design process of a four-bar linkage for body guidance, which involves designing a mechanism to guide a specific body through a desired path (C2).

	Discuss the graphical method, such as the use of a motion diagram or a position diagram, to determine the linkage dimensions (C2). Explain how analytical methods, such as vector loop equations or vector algebra, can be employed to solve for the dimensions and angles of the linkage (C2). Path Generation by Graphical Method: Explain the graphical method for path generation, which involves designing a mechanism to trace a specific path (C1). Describe the use of a template or tracing paper to construct the desired path and determine the corresponding linkage dimensions (C1). Illustrate the application of the graphical method to design mechanisms that generate complex paths (C1).
4	Types of cams and followers: (C2) Recognizing and distinguishing different types of cams and followers used in mechanical systems. (C2) Describing the characteristics and applications of plate or disk cams, cylindrical cams, conjugate cams, and globoidal cams. (C2) Differentiating between knife-edge followers, roller followers, and flat-faced followers. (C2) Definitions related to cam profiles: (C1) Defining and explaining terms such as base circle, pitch curve, pressure angle, and dwell in the context of cam profiles. (C1) Motion profiles for cams and followers: (C2) Understanding and analyzing the concepts of simple harmonic motion, constant acceleration and deceleration, constant velocity, and cycloidal motion. (C2) Describing the characteristics and applications of each type of motion in relation to cams and followers. (C2) Spur gear terminology and definitions: (C2) Familiarizing with and utilizing the terminology used in spur gears, such as gear pitch, gear module, gear pressure angle, gear addendum, and gear dedendum. (C2) Explaining the significance of each parameter in gear design and operation. (C2) Law of toothed and involute gearing: (C2) Understanding and applying the fundamental principle of the law of toothed gearing, which states the relationship between gear velocity ratio and the number of teeth. (C2) Explaining the concept of involute tooth profile and its advantages in gear meshing. (C2) Interchangeable gears: (C1) Understanding the concept of interchangeable gears and their role in standardization. (C1) Recognizing the importance of manufacturing gears to specific standards for compatibility and interchangeability. (C1) Gear tooth action, interference, and undercutting: (C2) Describing and analyzing the interaction and motion between gear teeth during meshing. (C2)

	Identifying the conditions of interference and undercutting in gear teeth and evaluating their impact on gear performance. (C2) Basics of nonstandard gear teeth: (C2) Understanding and applying the concept of nonstandard gear teeth and their deviation from standard involute profiles. (C2) Exploring different types of nonstandard gear teeth and evaluating their applications. (C2) Helical, Bevel, Worm, Rack and pinion gears: (C2) Distinguishing and classifying helical gears, bevel gears, worm gears, and rack and pinion gears. (C2) Describing the principles, advantages, and applications of each type of gear system. (C2) Cycloidal tooth properties: (C3) Understanding and analyzing the unique properties and advantages of cycloidal tooth profiles in gear systems. (C3) Evaluating the characteristics and benefits of cycloidal gears, such as higher tooth contact ratio and smoother operation. (C3) Comparison of involute and cycloidal tooth forms: (C3) Analyzing and evaluating the characteristics, advantages, and disadvantages of involute and cycloidal tooth forms in gear design and performance. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term

Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) A. Ghosh (2009), Theory of Mechanisms and Machines, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, ISBN: 978-8-185-93893-6. **ii)** Thomas Bevan (2009), Theory of Machines, 3rd Edition, Pearson Education, ISBN: 978-8-131-72965-6.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Fluid Mechanics**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Maths & Engineering Mechanics
Course Synopsis	Fluid mechanics and machinery is a branch of continuum mechanics that deals with the behavior of fluids (gases or liquids) either in motion or at rest and the subsequent effects of fluids upon boundaries, which may be either solid surfaces or interfaces with other fluids. This course deals fluids and their properties, and the kinematics and dynamics of fluid flow. After that students learn the fundamentals of flow through pipes, turbulent flow, dimensional analysis and boundary layers and their applications in engineering.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the fundamental models for analyzing a fluid flow and fluid at rest both.
CO2	Find the dependent and independent parameters for a fluid flow.
CO3	Explain various methods available for boundary layer separation and analyze the model and prototype.
CO4	Understand the working principles of turbines and pumps.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	1	1	1	1	3	2	3	1

CO2	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3
CO3	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3
CO4	3	3	3	3	3	1	1	1	1	1	1	3	1	3	2
Average	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Introduction to Fluid Mechanics: Provide an overview of fluid mechanics as a branch of physics that deals with the study of fluids (liquids and gases) and their behavior under various conditions (C1). Explain the importance of fluid mechanics in understanding and analyzing fluid flow in engineering applications (C1). Fluid Types and Properties: Define fluid properties such as density, viscosity, surface tension, compressibility, and capillarity (C1). Discuss the significance of these properties in characterizing and describing fluid behavior (C1). Differentiate between different types of fluids, including liquids and gases (C1). Fluid Statics: Introduce fluid statics, which deals with the equilibrium of fluids at rest (C1). Discuss hydrostatic forces exerted by fluids on various surfaces, including plane, inclined, and curved surfaces (C1). Explain concepts such as pressure, buoyancy, center of buoyancy, and metacenter (C1). Fluid Kinematics: Explain fluid kinematics, which focuses on the study of fluid motion without considering the forces acting on it (C1). Define streamline and velocity potential lines as visualization tools to represent fluid flow patterns (C1). Introduce stream function and potential function as mathematical representations of fluid motion (C1). Types of Flows: Discuss different types of fluid flows based on various characteristics (C1).

	Define steady flow as flow in which the fluid properties do not change with time, and unsteady flow as flow in which the fluid properties vary with time (C1). Differentiate between uniform and non-uniform flow based on the constancy of fluid velocity (C1). Introduce rotational flow, characterized by the presence of vortices or rotating motion in the fluid (C1). Define irrotational flow as flow without any rotation (C1). Explain the concepts of 1-D (one-dimensional), 2-D (two-dimensional), and 3-D (three-dimensional) flows based on the spatial dimensions involved in the flow (C1)
2	Surface and Body Forces: Explain the concept of surface forces, which act on the boundary of a fluid, and body forces, which act throughout the volume of a fluid (C1). Provide examples of surface forces (e.g., pressure forces, shear forces) and body forces (e.g., gravitational force, electromagnetic force) (C1). Euler and Bernoulli's Equations: Introduce Euler's equation, which describes the relationship between pressure, velocity, and elevation in a fluid (C2). Explain Bernoulli's equation, which relates the pressure, velocity, and elevation of a fluid along a streamline (C2). Discuss the assumptions and applications of these equations, such as in analyzing flow in pipes, nozzles, and other fluid flow devices (C2). Momentum Equation: Present the momentum equation, which relates the rate of change of momentum to the forces acting on a fluid (C2). Discuss the conservation of momentum principle and its applications in fluid dynamics (C2). Navier-Stokes Equations: Introduce the Navier-Stokes equations, which describe the motion of viscous fluids (C2). Explain the terms in the equations, including the convective term, pressure gradient term, and viscous term (C2). Discuss the importance of the Navier-Stokes equations in solving complex fluid flow problems (C2). Closed Conduit Flow: Describe Reynolds' experiment, which demonstrated the transition from laminar to turbulent flow in pipes (C2). Introduce the Darcy-Weisbach equation, which relates the frictional losses in a pipe to the flow rate and pipe characteristics (C2).

	Discuss minor losses in pipes, such as those caused by bends, fittings, and valves (C2). Explain the concept of pipes in series and parallel and how it affects the total flow rate and pressure (C2). Introduce the concepts of the total energy line and hydraulic gradient line in pipe flow analysis (C2). Measurement of Flow: Discuss different methods for measuring flow rate, including the Venturi meter, orifice meter, and Pitot tube (C2). Explain the operating principles and applications of these flow measurement devices (C2).
3	Compressible Flows: Provide an introduction to compressible flows, which occur when the density changes significantly due to changes in pressure and temperature (C1). Discuss the thermodynamic relations of perfect gases, including equations relating pressure, density, temperature, and specific heat (C1). Explain concepts such as internal energy and enthalpy in relation to compressible flows (C1). Introduce the speed of sound, which represents the maximum velocity at which disturbances can propagate through a compressible fluid (C1). Discuss the pressure field created by a moving source in a compressible fluid (C1). Present the basic equations for one-dimensional flow, including the continuity equation, momentum equation, and energy equation (C2). Explain the concepts of stagnation properties and sonic properties in compressible flows (C2). Introduce normal and oblique shocks, which are abrupt changes in flow properties caused by compression waves (C2). Introduction to CFD: Discuss the necessity of Computational Fluid Dynamics (CFD) as a numerical tool for solving fluid flow problems (C2). Explain the limitations of CFD, such as assumptions and simplifications made in the numerical models (C2). Present the philosophy behind CFD, including the discretization of equations, mesh generation, and solution algorithms (C2). Provide examples of applications of CFD in various fields, such as aerospace, automotive, and environmental engineering (C2)
4	Boundary Layers: Explain the concept of boundary layers, which are thin layers of fluid that form near solid boundaries due to the effects of viscosity (C1).

	Discuss the differences between laminar flow and turbulent flow within boundary layers (C1). Describe the boundary layer thickness and its variation along a surface (C1). Introduce the momentum integral equation, which relates the momentum thickness and the boundary layer displacement thickness (C2). Discuss the drag and lift forces acting on bodies in a flow, which are influenced by the properties of the boundary layer (C2). Explain the phenomenon of boundary layer separation, where the flow separates from the surface and leads to changes in flow behavior (C2). Present methods used to control or delay boundary layer separation, such as using boundary layer control devices (C2). Dimensional Analysis and Model Laws: Introduce the concept of dimensional homogeneity, which states that equations must have consistent dimensions on both sides (C1). Explain the Raleigh and Buckingham pi theorems, which are used in dimensional analysis to reduce the number of variables in a problem (C2). Discuss non-dimensional numbers, such as Reynolds number, Froude number, and Mach number, which provide information about the flow characteristics (C2). Explain the concept of model laws and distorted models, which are used to study fluid flow phenomena in a scaled-down or distorted form (C2). Discuss the use of module quantities, which are non-dimensional ratios used to compare different physical systems (C2). Explain specific quantities, which are non-dimensional ratios used to compare properties of fluids, such as specific heat and viscosity (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5

Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

<table>
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<tr><td></td><td colspan="2">i) R. K. Bansal (2010), A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Edition, Laxmi Publication (P) Ltd. New Delhi. ISBN- 978-8-131-80815-3.
ii) Yunus A. Çengel (2010), Fluid Mechanics, Tata McGraw Hill, ISBN: 978-0-070-70034-5.
iii) Frank M. White (2011), Fluid Mechanics, 7th edition, Tata McGraw-Hill Education, ISBN-978-0-071-33312-2.</td></tr>
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Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Applied Thermodynamics**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	**Engineering Thermodynamics**
Course Synopsis	Thermodynamics is a subject of fundamental interest to Mechanical engineers and therefore is always taught in the 2nd or 3rd semester. Present course can be viewed as the next step, where the thermodynamic principles will be employed to discuss about different power producing & absorbing cycles. Properties of pure substance will be discussed, along with the thermodynamic property relations, thereby enabling the participants to estimate all relevant thermodynamic properties at any particular state of point. Subsequently the gas & vapor power cycles will be analyzed, followed by the principles of cogeneration & combined cycles. Then the refrigeration cycles will be introduced, followed by a discussion on the selection of refrigerants. The properties of gas mixtures and gas vapour mixtures will also be discussed, leading to psychrometry & psychrometric processes. The course will be completed with a brief introduction to the chemical equilibrium.

Course Outcomes:

At the end of the course students will be able to:

CO1	To understand the working of compressors and power cycles.
CO2	To learn the basics of reciprocating engines and combustion cycles.
CO3	To understand vapor absorption and compression refrigeration cycle.
CO4	To learn the fundamentals of turbomachinery.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	1	1	0	0	0	0	2	0	3	3
CO2	3	2	3	3	2	2	2	1	0	0	0	3	1	3	2
CO3	3	3	3	2	2	1	2	0	0	1	0	2	1	3	3
CO4	3	2	2	2	2	1	0	0	0	0	1	3	2	3	2
Average	3	2.25	2.75	2.25	1.75	1.25	1.25	0.25	0	0.25	0.25	2.5	1	3	2.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Review of basic Thermodynamics: (C1) Refreshing and reviewing the fundamental concepts of thermodynamics, including the laws of thermodynamics and basic thermodynamic properties. (C1) Air standard cycles: (C2) Understanding and analyzing the characteristics and operation of air standard cycles, including the Carnot, Otto, Diesel, Dual, and Stirling cycles. (C2) Constructing p-v (pressure-volume) and T-s (temperature-entropy) diagrams for each cycle. (C2) Evaluating the efficiencies and mean effective pressures of the air standard cycles. (C2) Comparison of Otto and Diesel cycles: (C3) Comparing and contrasting the Otto and Diesel cycles in terms of their working principles, fuel combustion processes, and efficiency. (C3) Analyzing the differences in p-v and T-s diagrams, as well as the effects on mean effective pressures. (C3) Gas turbine (Brayton) cycle: (C2) Describing and analyzing the Brayton cycle, which is the idealized thermodynamic cycle for gas turbines. (C2) Explaining the components and processes involved in the gas turbine cycle, including compression, combustion, expansion, and exhaust. (C2) Evaluating the efficiency and performance of the Brayton cycle. (C2) Regenerative gas turbine cycle: (C3) Understanding and explaining the concept and implementation of regenerative heat exchange in gas turbine cycles. (C3) Analyzing the benefits and effects of regenerative heating on cycle efficiency and performance. (C3) Inter-cooling and reheating in gas turbine cycles: (C3)

	Describing the concepts and applications of inter-cooling and reheating in gas turbine cycles. (C3) Analyzing the effects of inter-cooling and reheating on cycle efficiency, temperature, and specific work output. (C3) Jet propulsion: (C1) Introducing the principles and fundamentals of jet propulsion systems. (C1) Exploring the basic operation and components of jet engines, including air intake, compression, combustion, and exhaust. (C1) Understanding the principles of thrust generation and the basic performance parameters of jet engines. (C1)
2	Vapour Power Cycles: (C2) Studying the Carnot vapour power cycle and its limitations as a reference cycle for practical applications. (C2) Analyzing the Simple Rankine cycle, including its description, T-s diagram, and performance analysis. (C2) Comparing and contrasting the Carnot and Rankine cycles in terms of their efficiencies and characteristics. (C2) Investigating the effects of pressure and temperature variations on the performance of the Rankine cycle. (C2) Actual vapour power cycles: (C3) Examining the characteristics and performance of actual vapour power cycles, taking into account real-world considerations and limitations. (C3) Ideal and practical regenerative Rankine cycles: (C3) Understanding the principles and characteristics of ideal and practical regenerative Rankine cycles. (C3) Analyzing the impact of open and closed feed water heaters on the efficiency and performance of the Rankine cycle. (C3) Reheat Rankine cycle: (C3) Exploring the concept and implementation of the reheat Rankine cycle, which involves multiple stages of expansion and reheat. (C3) Analyzing the advantages and effects of the reheat process on cycle efficiency. (C3) Characteristics of an Ideal working fluid in Vapour power cycles: (C2) Identifying and discussing the desirable characteristics of an ideal working fluid for vapour power cycles. (C2) Evaluating the performance and efficiency implications of different working fluids. (C2) Binary Vapour cycles: (C3) Understanding the concept of binary vapour cycles, which involve the use of two different working fluids in the power cycle. (C3) Analyzing the advantages and applications of binary vapour cycles. (C3)
3	Combustion Thermodynamics: (C3) Understanding the concept of theoretical (stoichiometric) air for the combustion of fuels and its significance in the combustion process. (C3) Analyzing the concept of excess air and its impact on combustion efficiency. (C3)

	Exploring the mass balance and exhaust gas analysis in combustion processes, including the determination of air-fuel ratio. (C3) Investigating the energy balance for chemical reactions, including the calculation of enthalpy of formation, enthalpy, and internal energy of combustion. (C3) Evaluating the combustion efficiency and its relation to the overall performance of combustion systems. (C3) Examining the concepts of dissociation and equilibrium in combustion processes and their effects on emissions. (C3) I.C. Engines: (C3) Classifying internal combustion (IC) engines based on their operating principles and characteristics. (C3) Understanding the combustion process in spark ignition (SI) engines and compression ignition (CI) engines. (C3) Analyzing the factors affecting detonation in SI engines and its impact on engine performance. (C3) Conducting performance analysis of IC engines, including heat balance calculations and Morse test evaluations. (C3) Exploring IC engine fuels, their ratings, and the use of alternate fuels in IC engines. (C3)
4	Refrigeration Cycles: (C3) Understanding the working principles of vapor compression refrigeration systems, including the description, analysis, and refrigerating effect. (C3) Analyzing the performance parameters of refrigeration systems such as capacity, power required, units of refrigeration, and coefficient of performance (COP). (C3) Examining different refrigerants and their desirable properties, as well as alternative refrigerants. (C3) Conducting a case study on a cold storage or industrial refrigerator to understand the practical application of refrigeration systems. (C4) Exploring air cycle refrigeration systems, including the reversed Carnot cycle, reversed Brayton cycle, and vapor absorption refrigeration system. (C3) Investigating steam jet refrigeration and its operation in cooling applications. (C3) Psychrometrics and Air-conditioning Systems: (C3) Understanding the properties of atmospheric air and the psychometric properties of air, including temperature, humidity, and specific volume. (C3) Analyzing air-conditioning processes such as heating, cooling, dehumidification, humidification, and evaporative cooling using psychrometric charts. (C3) Examining the concept of adiabatic mixing of two moist air streams and its impact on air-conditioning systems. (C3) Exploring the operation and function of cooling towers in air-conditioning systems. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4

Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:				
i) R.K Rajput, Applied Thermodynamics, Laxmi Publications; Second edition (1 January 2016), ISBN-13: 978-8131805831 **ii)** Moran, Shapiro, Boettner, Bailey, Fundamentals of Engineering Thermodynamics, Wiley Publication, ISBN 978-1118412930				

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Biology for Engineers
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	It is well known that this is the century of biology in which significant advances in the understanding and application of biological systems are expected. The significant impact on the world is expected in terms of better healthcare, better processes, better products and an overall better quality of life. Thus, any person can be interested in knowing the fundamentals of biology to be able to understand, or participate in the biological revolution. For example, any engineer, irrespective of the parent discipline (mechanical, electrical, civil, chemical, metallurgical, etc.,) has a high probability of using the disciplinary skills toward designing/improving biological systems in the future. This course is designed to convey the essentials of cell and molecular biology to provide a frame-work for more specific understanding, and contribution by any interested person.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the biological concepts from an engineering perspective
CO2	Understand the concepts of biological sensing and its challenges
CO3	Understand development of artificial systems mimicking human action
CO4	Integrate biological principles for developing next generation technologies

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	2	1	1	1	1	1	1	1	3	1	3	1

CO2	3	2	3	2	1	1	1	1	1	1	1	2	1	3	3
CO3	3	2	2	2	1	1	1	1	1	1	1	2	2	3	3
CO4	3	3	3	3	3	1	1	1	1	1	1	3	1	3	2
Average	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Life Science Studies Significance: (C1) Understanding the importance and relevance of life science studies in various fields such as medicine, agriculture, environmental science, and biotechnology. (C1) Recognizing the impact of life science research on human health, food production, ecosystem preservation, and technological advancements. (C1) Bio-Inspired Inventions: (C2) Exploring the concept of bio-inspired inventions, which involve taking inspiration from biological systems and applying it to the development of new technologies or products. (C2) Understanding examples of bio-inspired inventions, such as Velcro (inspired by burrs), solar panels (inspired by photosynthesis), and artificial limbs (inspired by human anatomy). (C2) Role of Biology in Next Generation Technology Development: (C2) Recognizing the significant role of biology in shaping the future of technology and innovation. (C2) Understanding how biological principles and processes can be harnessed to develop advanced technologies, such as bioinformatics, genetic engineering, and biomimicry. (C2) Cell Structure: (C1) Understanding the basic structure and components of a cell, including the cell membrane, cytoplasm, nucleus, and organelles. (C1) Recognizing the different types of cells (e.g., prokaryotic and eukaryotic cells) and their distinguishing features. (C1) Cell Potential and Action Potential: (C2) Exploring the concept of cell potential, which refers to the electrical potential difference across a cell membrane. (C2) Understanding the generation and propagation of action potentials in excitable cells, such as neurons and muscle cells. (C2) Recognizing the role of ion channels and membrane proteins in the generation and regulation of action potentials. (C2) ECG and Other Common Signals - Sodium: (C1, C2)

	Understanding the electrocardiogram (ECG) as a common diagnostic tool used to measure the electrical activity of the heart. (C1) Recognizing the role of sodium ions in generating action potentials in cardiac muscle cells, as well as their involvement in nerve cell signaling and other physiological processes. (C2)
2	Potassium Channels: (C2) Understanding the role of potassium channels in regulating the flow of potassium ions across the cell membrane. (C2) Recognizing the importance of potassium channels in maintaining the resting membrane potential and contributing to the repolarization phase of action potentials. (C2) Neuron Function: (C1) Understanding the basic structure and function of neurons, which are specialized cells responsible for transmitting electrical signals in the nervous system. (C1) Recognizing the different components of a neuron, including the dendrites, cell body, axon, and synapses. (C1) Central Nervous System: (C1) Understanding the central nervous system (CNS) as the part of the nervous system that includes the brain and spinal cord. (C1) Recognizing the role of the CNS in processing and integrating sensory information, coordinating motor responses, and regulating various bodily functions. (C1) Evolution of Artificial Neural Networks: (C2) Exploring the historical development and evolution of artificial neural networks (ANNs) as computational models inspired by biological neural networks. (C2) Understanding how ANNs are designed to mimic the structure and function of biological neurons to perform tasks such as pattern recognition, prediction, and decision-making. (C2) Machine Learning Techniques: (C1, C2) Understanding the basic concepts and techniques of machine learning, which is a field of study focused on developing algorithms that enable computers to learn and make predictions or decisions without explicit programming. (C1, C2) Recognizing common machine learning techniques such as supervised learning, unsupervised learning, and reinforcement learning, as well as their applications in various domains. (C1, C2)
3	Sense Organs Working: (C1) Understanding the basic functioning of sense organs such as the eyes, ears, nose, tongue, and skin. (C1) Recognizing how these sense organs receive and process sensory information from the environment. (C1) Sensing Mechanisms: (C1) Understanding the different mechanisms by which sensory organs detect and convert various stimuli into electrical signals. (C1) Recognizing the role of specialized cells, receptors, and neural pathways in the sensing process. (C1)

	Sensor Development Issues: (C2) Exploring the challenges and considerations involved in developing sensors for different applications. (C2) Understanding factors such as sensitivity, selectivity, response time, and reliability that impact sensor performance. (C2) Digital Camera and Eye Comparison: (C2) Comparing the functioning of a digital camera with the human eye in terms of capturing and processing visual information. (C2) Understanding the similarities and differences between the mechanisms of image formation and processing in cameras and the human visual system. (C2) Electronic Nose: (C2) Understanding the concept of an electronic nose, which is a device designed to mimic the sense of smell by detecting and analyzing odorant molecules. (C2) Recognizing the applications of electronic noses in areas such as food quality control, environmental monitoring, and medical diagnostics. (C2) Electronic Tongue: (C2) Understanding the concept of an electronic tongue, which is a device designed to mimic the sense of taste by analyzing the chemical composition of substances. (C2) Recognizing the applications of electronic tongues in fields such as food and beverage industry, pharmaceuticals, and environmental analysis. (C2) Electronic Skin: (C2) Understanding the concept of electronic skin or e-skin, which is a flexible and stretchable sensor system designed to mimic the sense of touch. (C2) Recognizing the potential applications of electronic skin in fields such as robotics, prosthetics, and human-machine interfaces. (C2)
4	Physiological Assist Device: Artificial Organ Development (C3) Understanding the concept of physiological assist devices, which are artificial devices designed to support or replace the function of specific organs in the human body. (C3) Recognizing the significance of artificial organ development in improving the quality of life and survival rates for patients with organ failure. (C3) Kidney, Liver, Pancreas, and Heart Valve Development: (C3) Exploring the challenges and complexities involved in the design and development of artificial kidneys, livers, pancreas, and heart valves. (C3) Understanding the anatomical and physiological considerations specific to each organ and the unique design requirements for their artificial counterparts. (C3) Design Challenges: (C4) Identifying the key design challenges associated with developing artificial organs, such as biocompatibility, functionality, durability, and long-term reliability. (C4) Understanding the importance of integrating the artificial organ seamlessly into the recipient's body to ensure proper functioning and minimize complications. (C4) Technological Developments: (C4) Exploring the latest technological advancements in the field of artificial organ

	development, such as tissue engineering, biomaterials, 3D printing, and regenerative medicine. (C4) Recognizing how these advancements are improving the performance, functionality, and compatibility of artificial organs, leading to better patient outcomes. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Biology for Engineers by Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, ISBN: 1121439934 ii) Biology for Engineers, by Wiley Editorial (Author), January 2018, ISBN: 8126576340. iii) Biology for Engineers by G. K. Suraishkumar, Oxford University Press; First edition, May 2019, ISBN: 0199498741

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Power Plant Engineering**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Thermodynamics
Course Synopsis	Power Plant Engineering course is concerned with the types, construction, working principles and performance of various conventional and non-conventional power plants. This course covers the design, construction, operations and performance of various components of steam, gas turbine, nuclear, hydra and diesel power plants. The course also focuses on various sub components of power plants, such as steam generators, condensers, cooling towers, fuel and air handling system, super-heaters, inter-coolers, re-heaters and waste handling systems; to have a proper understanding. This course also discusses the Steam power plant in detail as 60% of total energy produced in world are generated by thermal power plants. The syllabus also covers nuclear power plant in detail which is a need of current scenario..

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand basic power generation types and steam cycles.
CO2	Know about the kind of boilers being used in various industries and their applicability.
CO3	Solve problems related to gas turbines and Rankine cycles.
CO4	Distinguish between various power generation Modules and choose one that meets desired economic,

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO2	PSO3
CO1	3	1	2	2	1	2	2	-	-	-	-	3	2	3	1
CO2	3	2	2	2	2	2	2	-	-	-	1	2	1	3	3
CO3	3	3	2	3	1	1	1	-	-	-	-	2	-	3	3

CO4	3	1	2	2	2	3	3	-	-	-	3	2	-	3	2
Average	3	1.75	2	2.25	1.5	2	2	-	-	-	2	2.25	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	**Power Plants:** Provide an overview of power plants as facilities that generate electricity on a large scale (C1). Discuss the importance of power plants in meeting the energy demands of industries, residential areas, and commercial sectors (C1). Explain the various types of power plants, including steam, hydroelectric, nuclear, gas turbine, and diesel power plants (C1). Components and Layouts: Describe the major components found in power plants, such as boilers, turbines, generators, condensers, pumps, and cooling systems (C1). Discuss the layout and arrangement of these components in different types of power plants (C1). Highlight the significance of auxiliary systems, such as fuel storage, water treatment, and control systems, in the overall operation of power plants (C1). Working Principle of Steam Power Plants: Explain the working principle of steam power plants based on the Rankine cycle (C1). Discuss the key components and processes involved, including the boiler, turbine, condenser, and heat exchange (C1). Describe the role of steam in driving the turbine and generating electricity (C1). Hydroelectric Power Plants: Discuss the working principle of hydroelectric power plants, which utilize the potential energy of water to generate electricity (C1). Explain the process of water flow, dam construction, and turbine operation in hydroelectric power plants (C1). Highlight the advantages of hydroelectric power plants in terms of renewable energy and environmental sustainability (C1). Nuclear Power Plants: Provide an overview of nuclear power plants, which generate electricity through nuclear reactions (C1). Explain the concept of nuclear fission and the role of nuclear reactors in generating heat (C1).

	Discuss the safety measures and waste management associated with nuclear power plants (C1). Gas Turbine Power Plants: Describe the working principle of gas turbine power plants, which utilize the combustion of natural gas or liquid fuel to drive the turbine (C1). Explain the Brayton cycle and the role of the compressor, combustor, and turbine in gas turbine power plants (C1). Discuss the advantages of gas turbine power plants, such as high efficiency and quick start-up time (C1). Diesel Power Plants: Explain the working principle of diesel power plants, which use diesel engines to generate electricity (C1). Discuss the combustion process in diesel engines and the conversion of chemical energy into mechanical energy (C1). Highlight the applications of diesel power plants, particularly in remote areas and as backup power sources (C1). Selection of Site: Discuss the factors considered in selecting the site for power plants, such as proximity to fuel sources, water availability, environmental impact, and transmission infrastructure (C2). Explain the importance of site evaluation studies, environmental assessments, and regulatory compliance in the site selection process (C2). Analysis of Steam Cycles: Explain the analysis of steam cycles in power plants to assess their efficiency and performance (C2). Discuss parameters such as pressure, temperature, enthalpy, entropy, and quality of steam in the analysis (C2). Describe the different variations of the Rankine cycle, including reheating and regenerative cycles, and their impact on power plant efficiency (C2).
2	**Boiler Classification:** Provide an overview of boiler classification based on different criteria, such as pressure, usage, and fuel type (C1). Discuss the main types of boilers, including fire tube and water tube boilers (C1). Explain the differences between high-pressure boilers and supercritical boilers (C1). Describe positive circulation boilers, which ensure the continuous flow of water and steam (C1). Discuss fluidized bed boilers, which use a bed of solid particles to efficiently burn fuel (C1).

	Explain waste heat recovery boilers, which utilize the waste heat from other processes to generate steam (C1). Boiler Components: Describe the various components of boilers, including feed water heaters, superheaters, reheaters, economizers, condensers, cooling towers, feed water treatment systems, and air heaters (C1). Explain the purpose and functioning of each component in the boiler system (C1). Coal Handling and Preparation: Discuss the process of coal handling and preparation in power plants (C1). Explain the steps involved in storing, crushing, and conveying coal to the boiler (C1). Combustion Equipment and Firing Methods: Describe the combustion equipment used in boilers, such as burners and fuel injectors (C1). Explain different firing methods, including mechanical stokers, pulverized coal firing systems, and cyclone furnaces (C1). Ash Handling Systems: Discuss the importance of ash handling systems in power plants to handle and dispose of the ash generated during combustion (C1). Explain different ash handling techniques, such as electrostatic precipitators, fabric filters, and bag houses (C1). Forced Draft and Induced Draft Fans: Explain the role of forced draft fans in supplying air to the combustion process (C1). Discuss the function of induced draft fans in creating a negative pressure to remove flue gases from the boiler (C1). Chimney: Describe the purpose of a chimney in a power plant, which is to discharge the flue gases into the atmosphere (C1).
3	**Boiling Water Reactor (BWR):** Explain the working principle and key features of a boiling water reactor, where the reactor coolant also serves as the steam source for the turbine (C1). Discuss the main components and systems of a BWR, including the reactor core, steam generators, and reactor coolant pumps (C1). Pressurized Water Reactor (PWR): Describe the operation of a pressurized water reactor, where the reactor coolant remains at high pressure to prevent boiling (C1). Explain the primary and secondary coolant loops, as well as the steam generator and reactor coolant pumps in a PWR (C1).

	Pressurized Heavy Water Reactor (PHWR): Discuss the features and working principle of a pressurized heavy water reactor, which uses heavy water as both the moderator and coolant (C1). Explain the role of the fuel channels, calandria, and moderator in a PHWR (C1). Gas-Cooled Reactor (GCR): Explain the concept and functioning of a gas-cooled reactor, where a gas such as helium is used as the coolant (C1). Discuss the primary and secondary cooling systems, as well as the graphite moderator used in GCRs (C1). High-Temperature Gas-Cooled Reactor (HTGR): Describe the features and operation of a high-temperature gas-cooled reactor, capable of operating at higher temperatures than conventional reactors (C1). Explain the use of ceramic-coated fuel particles and helium as the coolant in HTGRs (C1). Pebble Bed Reactor (PBR): Discuss the design and working principle of a pebble bed reactor, which utilizes small fuel pebbles to achieve high thermal efficiency (C1). Explain the concept of random packing of pebbles and the use of helium as the coolant in PBRs (C1). Fast Breeder Reactor (FBR): Explain the working principle of a fast breeder reactor, which uses fast neutrons to sustain a chain reaction and produce more fissile material than it consumes (C1). Discuss the use of liquid metal, such as sodium, as the coolant in FBRs (C1). Liquid Metal Fast Breeder Reactor (LMFBR): Discuss the features and materials used in liquid metal fast breeder reactors, which utilize liquid sodium or another liquid metal as the coolant (C1). Radiation Shielding: Explain the importance of radiation shielding in nuclear power plants to protect personnel and the environment from radiation exposure (C1). Discuss various materials and design considerations for effective radiation shielding (C1). Waste Disposal: Discuss the challenges and methods associated with the disposal of nuclear waste generated by nuclear power plants (C1). Explain concepts such as deep geological repositories and long-term storage of nuclear waste (C1). Gas Turbine Power Plant: Explain the basic working principle of a gas turbine power plant, where the combustion of a fuel drives a gas turbine to generate electricity (C1).

	Discuss the components of a gas turbine power plant, including the compressor, combustor, and turbine (C1). Open and Closed Cycles: Explain the differences between open and closed cycles in gas turbine power plants (C1). Discuss the advantages and disadvantages of each cycle configuration (C1). Intercooling, Reheating, and Regenerating: Explain the concepts of intercooling, reheating, and regenerating in gas turbine power plants to improve efficiency (C1). Discuss how these processes impact the thermodynamic cycle and power output (C1). Combined Cycle Power Plant: Describe the working principle of a combined cycle power plant, which combines a gas turbine cycle with a steam turbine cycle for increased efficiency (C1). Discuss the configuration and operation of combined cycle power plants (C1).
4	**Classification of Hydroelectric Power Plants:** Discuss the classification of hydroelectric power plants based on various criteria such as the head, water flow, and layout (C1). Explain the differences between low-head, medium-head, and high-head hydroelectric power plants (C1). Discuss the applications and advantages of different types of hydroelectric power plants (C1). Selection of Prime Movers: Explain the factors and considerations involved in selecting prime movers for power plants, including hydroelectric and thermal power plants (C1). Discuss the criteria for selecting turbines and generators based on power plant requirements (C1). Governing of Turbine: Explain the concept of turbine governing in hydroelectric power plants and its importance in maintaining a constant and stable power output (C1). Discuss different governing mechanisms and control systems used in turbines (C1). Diesel Power Plant: Describe the basic components and subsystems of a diesel power plant, including the diesel engine, fuel system, cooling system, and electrical system (C1). Discuss the working principle of a diesel engine and its application in power generation (C1). Subsystems in Diesel Power Plants:

	Explain the subsystems involved in a diesel power plant, such as the lubrication system, starting system, and exhaust system (C1). Discuss the functions and components of each subsystem (C1). Starting and Stopping of Diesel Engines: Explain the procedures and methods for starting and stopping diesel engines in power plants (C1). Discuss the importance of proper starting and stopping sequences for engine efficiency and longevity (C1). Heat Balance in Diesel Power Plants: Explain the concept of heat balance in diesel power plants and its significance in evaluating plant performance and efficiency (C1). Discuss the calculation and optimization of heat balance components, such as fuel input, heat output, and losses (C1). Supercharging of Diesel Engines: Explain the concept of supercharging in diesel engines and its purpose in increasing power output and efficiency (C1). Discuss different methods of supercharging, such as turbocharging and supercharging using external compressors (C1).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

	i) P. K. Nag, (2014), Power Plant Engineering: Steam and Nuclear, Tata McGraw-Hill Publishing Company Ltd., 4th EditionISBN13 9789339204044. ii) M.M. El- Wakil, (2010), Power Plant Technology, Tata McGraw-Hill Education, 1st Edition, ISBN 13: 9780072871029 iii) P C Sharma (2013), Power Plant Engineering, S.K. Kataria& Sons; 2013 edition, ISBN-13: 978-9350143841 (iii)P.K. Nag, Basic and Applied Thermodynamics, Tata McGraw-Hill Publishing Company Ltd., ISBN-978-0-070-15131-4 iv)Yunus A. Cengel, Thermodynamics: An Engineering Approach, Tata McGraw-Hill Publishing Company Ltd.,ISBN978-0-073-30537-0vi) C.P. Arora, Thermodynamics, Tata McGraw Hill Publishing Company Ltd., ISBN-978-0-074-62014-4

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Hydrogen and Fuel Cells
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Thermodynamics
Course Synopsis	To impart knowledge on use of hydrogen for achieving sustainable growth and facilitate analysis of the challenges in transition to hydrogen economy

Course Outcomes:

At the end of the course, students will be able to:

CO1	Students able to understand and demonstrate the hydrogen production technologies, storage methods and strategies for transition to hydrogen economy
CO2	Students able to know the concepts and characteristics of various types of fuel cell
CO3	Students able to consist and demonstrate the working of fuel cells
CO4	Students able to know the application of fuel cells with economic and environment analysis

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	3	3	1	-	-	-	3	3	2	1
CO2	3	2	1	2	2	3	3	2	-	-	-	2	3	1	-
CO3	3	2	3	3	3	2	2	1	-	-	-	2	3	2	1
CO4	3	1	1	1	2	3	3	1	-	-	-	3	3	1	-
Average	3	1	2	3	2	3	3	1	-	-	-	3	3	1.5	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	**Introduction to Hydrogen Economy:** Provide an overview of the concept of a hydrogen economy and its potential role in the future energy landscape (C1). Explain the benefits and challenges associated with transitioning to a hydrogen-based energy system (C1). Production of Hydrogen: Discuss various methods of hydrogen production, including steam methane reforming, coal gasification, electrolysis, and thermochemical cycles (C1). Explain the principles and processes involved in each method (C1). Storage and Transportation of Hydrogen: Discuss different methods of hydrogen storage, such as compressed gas, liquid hydrogen, and solid-state storage (C1). Explain the challenges and considerations for safe and efficient hydrogen transportation (C1). Hydrogen from Fossil Fuels: Explain the process of hydrogen production from fossil fuels, such as natural gas and coal (C1). Discuss the technologies and environmental considerations associated with fossil fuel-based hydrogen production (C1). Electrolysis of Water: Explain the electrolysis process for hydrogen production, including both alkaline and proton exchange membrane (PEM) electrolysis (C1). Discuss the efficiency, advantages, and limitations of electrolysis (C1). Thermochemical Cycles: Explain the concept of thermochemical cycles for hydrogen production, such as the sulfur-iodine and hybrid sulfur cycles (C1). Discuss the key reactions and processes involved in these cycles (C1). Transmission and Infrastructure Requirements: Discuss the infrastructure requirements for hydrogen transmission, distribution, and refueling stations (C1). Explain the challenges and considerations for integrating hydrogen into existing energy systems (C1). Safety and Environmental Impacts: Discuss the safety considerations and measures associated with handling, storing, and using hydrogen (C1). Explain the environmental impacts of hydrogen production, storage, and utilization (C1). Economics of Transition to Hydrogen Systems:

	Discuss the economic factors and considerations involved in transitioning to hydrogen-based energy systems (C1). Explain the cost competitiveness and potential market trends for hydrogen technologies (C1).
2	**Fuel Cells:** Introduce the concept and working principle of fuel cells as electrochemical devices that convert chemical energy directly into electrical energy (C1). Explain the key components of a fuel cell, including the anode, cathode, electrolyte, and catalyst (C1). Discuss the physical and chemical phenomena that occur within a fuel cell, such as electrochemical reactions and ion transport (C1). Advantages and Disadvantages of Fuel Cells: Outline the advantages of fuel cells, such as high energy efficiency, low emissions, and versatility in fuel sources (C1). Discuss the challenges and disadvantages associated with fuel cells, including cost, durability, and infrastructure requirements (C1). Types of Fuel Cells and Applications: Provide an overview of different types of fuel cells, including proton exchange membrane (PEM) fuel cells, solid oxide fuel cells (SOFCs), and molten carbonate fuel cells (MCFCs) (C1). Explain the characteristics and working principles of each type of fuel cell (C1). Discuss the applications of fuel cells in various sectors, such as transportation, stationary power generation, and portable electronics (C1). Nernst Equation: Explain the Nernst equation and its relevance to fuel cell operation (C1). Discuss how the Nernst equation relates the fuel consumption to the current output in a fuel cell (C1). Relation of Fuel Consumption versus Current Output: Explain the relationship between fuel consumption and current output in a fuel cell system (C1). Discuss factors that influence the fuel consumption rate, such as cell voltage, cell temperature, and fuel utilization (C1).
3	**Fuel Cell Design and Performance:** Explain stoichiometric coefficients and utilization percentages of fuels (hydrogen, methanol, etc.) and oxygen in fuel cell reactions (C2). Discuss the calculation of mass flow rates for fuel and oxygen in a single fuel cell and a fuel cell stack (C2). Explain how the total voltage and current are determined for fuel cells connected in parallel and series (C2). Discuss over-potential and the different types of polarization (activation, ohmic,

	and concentration) that affect fuel cell performance (C2). Direct Methanol Fuel Cell (DMFC) Operation: Explain the operating scheme of a Direct Methanol Fuel Cell (DMFC), which utilizes methanol as the fuel (C2). Discuss the advantages and challenges associated with DMFC operation (C2). Water Flooding and Water Management: Discuss the issue of water flooding in fuel cells and its impact on performance (C2). Explain strategies for effective water management in fuel cells, such as the use of humidification and water removal techniques (C2). Polarization in Proton Exchange Membrane Fuel Cells (PEMFC): Explain the sources of polarization in PEMFCs, including activation, ohmic, and concentration polarizations (C2). Discuss techniques to mitigate polarization effects and improve the performance of PEMFCs (C2).
4	**Fuel Cell Applications:** Discuss the application of fuel cells in domestic power systems, where they can provide reliable and clean electricity for residential use (C2). Explain the use of fuel cells for large-scale power generation, where they can be integrated into grid systems to provide sustainable electricity (C2). Discuss the application of fuel cells in automobiles as a potential alternative to internal combustion engines, offering zero-emission transportation (C2). Explain the use of fuel cells in space applications, where they provide power for satellites and space exploration missions (C2). Economic and Environmental Analysis: Conduct an economic analysis of fuel cell systems, considering factors such as capital costs, operational costs, and the potential for cost reduction through technological advancements (C3). Conduct an environmental analysis comparing the emissions and environmental impact of fuel cells with conventional energy systems (C3). Discuss the overall economic and environmental benefits of adopting fuel cell technology in various sectors (C2). Future Trends: Discuss emerging trends in fuel cell technology, such as advancements in materials, system efficiency, and durability (C2). Explore potential future applications for fuel cells, such as portable devices, backup power systems, and integration with renewable energy sources (C2). Discuss ongoing research and development efforts aimed at improving the performance and reducing the cost of fuel cell systems (C2).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	34
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	4
Case/Project Based Learning (CBL)	--
Revision	3
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Assignments	Mid Semester Examination 2 (Mid Term 3 is optional)
Student Seminar	University End Term Examination
Problem Based Learning (PBL)	Project

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms.	

3. Course Exit Survey will be taken at the end of semester.	
References:	(List of reference books)
	1. Fuel cell Fundamentals, John Wiley and sons, Willey 2. Fuel cells: Principles and Applications, Viswanathan B and AuliceScibioh, University Press 3. Hydrogen – A fuel for Automatic Engines, Prashukumar G P, ISTE 4. Fuel Cells: Theory and Applications, Hart A B and Womack G J, Chapman and Hall 5. Tomorrow's Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet, Peter Hoffman, MIT

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Non-Conventional Machining
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Manufacturing Process and Technology
Course Synopsis	This course is designed to understand advance manufacturing process within the Mechanical Engineering curriculum. Students will explore advance manufacturing process over conventional manufacturing process known as non-conventional manufacturing. The nonconventional manufacturing is designed to prepare interested students for future careers manufacturing industry where non-conventional machines are used.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To understand the need of Non-Traditional Machining Processes and able to Classify various processes.
CO2	To recognize the CNC and thermal energy based nontraditional machining processes.
CO3	To apply the knowledge of process parameters to calculate the performance of nontraditional machining processes.
CO4	To understand the concept of machining the hard material using chemical energy and Electrochemical energy.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	1	-	-	-	-	-	3	1	-	-
CO2	3	2	2	2	2	2	-	-	-	-	-	2	2	2	-
CO3	3	2	3	3	3	1	-	-	-	-	-	3	3	3	-
CO4	3	3	3	3	2	1	-	-	-	-	-	2	1	-	-

Average	3	2.25	2.5	2.5	2.25	1.25	-	-	-	-	-	2.5	1.75	1.25	-

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	Content & Competencies
1	**Non-Conventional Machining Methods:** Provide an introduction to non-traditional machining processes, highlighting their significance in modern manufacturing (C1). Compare and contrast non-traditional machining methods with traditional machining processes, emphasizing their unique characteristics and advantages (C2). Discuss the economic considerations of using non-conventional machining methods, including cost-effectiveness and application suitability (C2). Abrasive Jet Machining (AJM): Explain the principle of abrasive jet machining, which involves the use of high-velocity abrasive particles for material removal (C2). Discuss the process parameters involved in AJM, such as abrasive particle size, velocity, and standoff distance (C2). Classify different types of AJM based on variations in the process setup, nozzle design, and abrasive media (C2). Evaluate and determine the material removal rate (MRR) in AJM and discuss its applications and limitations (C3). Water Jet Machining: Explain the principle of water jet machining, which utilizes a high-velocity stream of water for cutting or machining purposes (C2). Discuss the process parameters in water jet machining, including water pressure, nozzle design, and abrasive addition (C2). Evaluate and determine the material removal rate (MRR) in water jet machining and discuss its applications and limitations (C3).
2	**Numerical Control (NC) and Thermal-based Processes:** Introduce the concept and types of numerical control, highlighting its role in automated machining (C1). Discuss the constructional features of NC machines, including position and motion control systems (C2). Explain the difference between Computer Numerical Control (CNC) and Direct Numerical Control (DNC) systems (C2). Ultrasonic Machining: Explain the principle of ultrasonic machining, which uses high-frequency

	vibrations to remove material (C2). Discuss the applications of ultrasonic machining in industries such as aerospace, electronics, and medical (C2). Describe the process parameters involved in ultrasonic machining, including vibration frequency, amplitude, and tool materials (C2). Discuss the purpose of slurry selection in ultrasonic machining and its impact on material removal rate and surface finish (C2). Plasma Arc Machining: Explain the principle of plasma arc machining, which utilizes a high-temperature plasma arc for material removal (C2). Discuss the applications of plasma arc machining in cutting, welding, and surface modification processes (C2). Electron Beam Machining: Explain the principle of electron beam machining, which uses a high-velocity electron beam for material removal (C2). Discuss the advantages of electron beam machining, such as high precision, minimal heat-affected zone, and suitability for non-conductive materials (C2). Highlight the limitations of electron beam machining, including vacuum requirements and limited material thickness (C2).
3	**Electric Discharge Machining (EDM):** Explain the principle of Electric Discharge Machining (EDM), which uses electrical sparks to erode and remove material from the workpiece (C2). Describe the mechanism of metal removal in EDM, including the formation of plasma channel and thermal energy generation (C2). Process Parameters and Basic Circuits: Discuss the important process parameters in EDM, such as current, voltage, pulse duration, pulse frequency, and electrode material (C2). Explain the role of the power supply circuit, including the generator, control unit, and servo system, in controlling the EDM process (C2). Metal Removal Evaluation and Optimization: Describe the methods for evaluating metal removal in EDM, including measurement of material removal rate (MRR) and electrode wear (C2). Discuss the factors affecting MRR in EDM and the strategies for optimizing it, such as adjusting process parameters and tool electrode design (C2). Tool Material and Dielectric Selection: Explain the considerations in selecting the tool electrode material for EDM, such as conductivity, wear resistance, and thermal stability (C2). Discuss the role of dielectric fluids in EDM, including their functions in cooling, flushing, and preventing electrode wear (C2).

	Highlight the criteria for selecting suitable dielectric fluids, such as dielectric strength, viscosity, and compatibility with the workpiece material (C2). Applications: Discuss the applications of EDM in various industries, such as aerospace, automotive, mold making, and electronics (C2). Explain the advantages of EDM in machining complex shapes, hard materials, and heat-sensitive materials (C2).
4	**Electrochemical Machining (ECM):** Explain the principle of Electrochemical Machining (ECM), which utilizes the controlled dissolution of the workpiece material through an electrochemical process (C2). Discuss the classification of ECM based on the electrolyte used, such as ECM using aqueous electrolytes, salt electrolytes, or organic electrolytes (C2). Chemical Machining and Electrochemical Machining: Differentiate between Chemical Machining (CM) and Electrochemical Machining (ECM), highlighting the role of electrochemical reactions in ECM (C2). Etchants and Maskants: Describe the role of etchants in ECM, which selectively dissolve the workpiece material (C2). Discuss the use of maskants in ECM to protect specific areas of the workpiece from the electrochemical dissolution (C2). Explain the techniques of applying maskants, such as spraying, brushing, or stenciling (C2). Process Parameters, Surface Finish, and MRR: Discuss the important process parameters in ECM, including current density, electrolyte flow rate, gap voltage, and electrolyte composition (C2). Explain the relationship between process parameters and surface finish in ECM, including the effect of current density on surface roughness (C2). Describe the methods for determining and evaluating Material Removal Rate (MRR) in ECM (C2). Applications and Principles of ECM Equipment: Highlight the applications of ECM in industries such as aerospace, automotive, medical, and electronics (C2). Explain the principles of ECM equipment, including the power supply, tool electrode, workpiece holder, and electrolyte delivery system (C2). Discuss the importance of surface roughness in ECM and the techniques for achieving desired surface finishes (C2). Electrochemistry of ECM and Selection of Electrolytes: Provide an overview of the electrochemical reactions involved in ECM and the

	role of electrolytes in facilitating these reactions (C2). Discuss the selection criteria for electrolytes in ECM, including conductivity, compatibility with the workpiece material, and environmental considerations (C2). Explain the analysis techniques used to monitor and control the ECM process, such as pH measurement and analysis of dissolved material (C2). Electrochemical Grinding: Briefly introduce Electrochemical Grinding (ECG), which combines ECM with conventional grinding for enhanced material removal and surface finish (C1).

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)

Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.	
References:	(List of reference books)
	i) Pandey, P.C., Shan, H.S. (1980),"Modern Machining Processes", India:McGraw-Hill,ISBN:9780070965539, 0070965536 **ii)** Paulo Davim J. (2013), "Non-traditional Machining Processes: Research Advances", Netherlands: Springer London, ISBN:9781447151791, 1447151798

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Plant layout & Material Handling
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Workshop
Course Synopsis	Plant layout & Material Handling is basically focused on application of Material handling systems for real world applications. More specifically this course is focused on application of material handling methods, paths, methods to minimize cost of material handling energy. The main purpose of implementing this course in curriculum is to learn about material handling layout plants.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To identify the various factors affecting the Plant Layout.
CO2	To visualize plant layout and material handling in industries.
CO3	To identify and select various types of material handling equipment
CO4	To device the planning strategies for various divisions of plant.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	1	1	1	1	2	2	3	3	3	2	1
CO2	3	1	2	3	2	1	1	1	2	1	2	2	3	1	2
CO3	3	2	2	2	2	1	1	1	1	1	2	2	3	2	2
CO4	3	2	1	1	2	2	2	2	3	2	3	3	3	2	1
Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	**Factors to be Considered in Plant Layout and Site Selection: Influence of Location on Plant Layout:** Analyze the geographical location of the plant, considering factors such as proximity to raw materials, suppliers, and customers (C3). Evaluate the availability and cost of utilities such as water, electricity, and transportation infrastructure (C3). Consider environmental factors, including zoning regulations, waste disposal, and potential hazards (C3). Assess the local labor market and availability of skilled workers (C3). Selection of Plant Site: Evaluate the suitability of potential sites based on land availability, topography, and soil conditions (C3). Consider the legal and regulatory requirements for site acquisition and construction (C3). Assess the potential for future expansion and the availability of nearby support services (C3). Consider the cost implications, including land prices, taxes, and infrastructure development (C3). Considerations in Facilities Planning and Layout: Determine the optimal layout of various functional areas within the plant, including production, storage, offices, and support services (C3). Analyze workflow patterns, material handling requirements, and safety considerations (C3). Incorporate ergonomic principles in the design of workstations and equipment placement (C3). Consider the flexibility to accommodate changes in production processes or future technological advancements (C3). Equipment Required for Plant Operation: Identify the specific equipment and machinery required for the plant's production processes (C3). Analyze the technical specifications, performance capabilities, and compatibility of different equipment options (C3). Consider the availability of spare parts, maintenance requirements, and the reputation of equipment suppliers (C3). Assess the cost-effectiveness and efficiency of equipment in relation to the			

	desired production capacity (C3). Capacity, Serviceability, and Flexibility: Determine the desired production capacity based on market demand and business projections (C3). Consider the serviceability and maintenance requirements of the equipment, including accessibility for repairs and preventive maintenance (C3). Evaluate the flexibility of the equipment to handle variations in product specifications or changes in production volumes (C3). Assess the potential for future upgrades or modifications to meet evolving business needs (C3). Space Requirements and Manpower Requirements: Estimate the space requirements for each functional area within the plant, considering factors such as equipment layout, storage needs, and circulation paths (C3). Determine the optimal allocation of space to ensure efficient workflow and minimize material handling distances (C3). Analyze the manpower requirements based on production volume, shift patterns, and skill levels (C3). Consider ergonomic factors and the provision of appropriate facilities for employee well-being (C3).
2	**Need for Layout** Understanding the importance and purpose of layout in manufacturing operations. (C1) Types of Layouts Familiarity with different types of layouts such as process layout, product layout, cellular layout, and fixed-position layout. (C1) Factors Influencing Product Layout Understanding the factors that influence the design of a product layout, such as product characteristics, production volume, and required equipment. (C2) Factors Influencing Process Layout Understanding the factors that influence the design of a process layout, such as workflow, interdepartmental relationships, and flexibility requirements. (C2) Fixed and Combination Layout Knowledge of fixed layout where the position of equipment and workstations is predetermined. Knowledge of combination layout where a combination of process and product layouts is used. (C2) Tools and Techniques for Developing Layouts Understanding and application of various tools and techniques for developing layouts, such as:

	Process chart: Representing the sequence of operations in a graphical format. Flow diagram: Illustrating the flow of materials and information in a layout. String diagram: Visualizing the movement of materials, workers, or equipment within a layout. Template and scale models: Creating physical representations of the layout design. Machine data: Considering equipment specifications and requirements during layout design. (C3) Layout Planning Procedure Understanding the systematic approach to layout planning, including data collection, analysis, design, and evaluation. (C3) Visualization of Layout Ability to create visual representations, such as 2D or 3D drawings or computer-aided design (CAD) models, to visualize the layout design. (C4) Revision and Improvement of Existing Layout Skill to analyze and identify areas for improvement in an existing layout design, and propose modifications or enhancements. (C4) Balancing of Fabrication and Assembly Lines Understanding the concept of balancing production lines to optimize workflow, minimize bottlenecks, and improve efficiency. (C5)
3	**Importance and Scope of Material Handling:** Understanding the significance of efficient material handling in manufacturing and logistics operations. (C1) Recognizing the impact of material handling on productivity, cost, and overall operational performance. (C1) Principles of Material Handling (C1): Familiarity with the fundamental principles and concepts of material handling, including safety, efficiency, and ergonomics. (C1) Understanding the importance of proper planning, organization, and coordination in material handling activities. (C1) Planning, Operating, and Costing Principles (C2): Understanding the process of planning material handling systems, considering factors such as product characteristics, production volume, layout constraints, and safety requirements. (C2) Knowledge of operating principles, including equipment selection, workflow optimization, and maintenance considerations. (C2) Understanding cost estimation and cost analysis techniques for material handling operations. (C2) Types of Material Handling Systems (C2): Knowledge of various types of material handling systems, including manual

	handling, mechanized handling, automated systems, and robotics. (C2) Understanding the characteristics, advantages, and limitations of each system type. (C2) Factors Influencing System Choice (C2): Understanding the factors that influence the selection of a material handling system, such as product characteristics, volume, weight, fragility, facility layout, available space, and budget constraints. (C2) Motion Analysis, Flow Analysis, Graphic Analysis, and Safety Analysis (C3): Ability to perform motion analysis to optimize movement and minimize ergonomic issues in material handling. (C3) Conducting flow analysis to evaluate the efficiency of material flow within a facility. (C3) Utilizing graphic analysis techniques, such as flowcharts and diagrams, to visualize material handling processes. (C3) Identifying and mitigating safety risks associated with material handling operations. (C3) Equipment Cost Analysis and Palletization Analysis (C4): Ability to analyze the costs associated with material handling equipment, including acquisition costs, maintenance costs, and operating costs. (C4) Understanding the principles of palletization and its benefits in improving efficiency, storage, and transportation. (C4) Analysis of Operation and Material Handling Surveys (C5): Conducting operational analysis to identify areas of improvement in material handling processes and systems. (C5) Performing material handling surveys to assess current practices, identify bottlenecks, and propose optimization strategies. (C5)
4	**Centralized Electrical, Pneumatic, and Water Line Systems :** Understanding the concept and benefits of centralized systems for electrical, pneumatic, and water supply in buildings and industrial facilities. (C2) Knowledge of the design, installation, and maintenance considerations for centralized systems. (C2) Types of Buildings (C1): Familiarity with different types of buildings, such as residential, commercial, industrial, and institutional structures. (C1) Understanding the specific requirements and considerations for each building type. (C1) Lighting, Heating, Air Conditioning, and Ventilation Utilities - Planning and Maintenance (C2): Understanding the principles and practices of lighting design, heating system selection, air conditioning, and ventilation planning in buildings. (C2)

	Knowledge of energy efficiency considerations and maintenance requirements for these utilities. (C2) Waste Handling (C1): Understanding the importance of proper waste handling and disposal in maintaining cleanliness, hygiene, and environmental sustainability. (C1) Knowledge of waste segregation, recycling, and waste management techniques. (C1) Statutory Requirements (C2): Familiarity with the legal and regulatory requirements related to building utilities, safety standards, waste management, and environmental regulations. (C2) Understanding the importance of compliance with statutory requirements for building operations. (C2) Importance of Packaging (C1): Recognizing the significance of packaging in protecting products during storage, transportation, and distribution. (C1) Understanding the role of packaging in branding, marketing, and consumer satisfaction. (C1) Layout for Packaging (C2): Ability to plan and design an efficient layout for packaging operations, considering factors such as workflow, space utilization, and safety. (C2) Knowledge of best practices in packaging layout design to optimize productivity and minimize errors. (C2) Packaging Machinery (C2): Familiarity with different types of packaging machinery and equipment, such as fillers, sealers, labelers, and wrappers. (C2) Understanding the principles of operation, selection criteria, and maintenance requirements for packaging machinery. (C2) Wrapping and Packing Materials, Cushion Materials (C2): Knowledge of various wrapping and packing materials, including boxes, containers, films, foams, and protective cushioning materials. (C2) Understanding the characteristics, suitability, and cost-effectiveness of different packaging materials. (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--

Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				

Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:	(List of reference books)			
	i) Sharma, S. C. (2001), “Plant Layout and Materials Handling”, India: Khanna Publishers, ISBN: 9788174090980, 8174090983. **ii)** Aggarwal G.K (2007), “Plant Layout & Material Handling”, India: Jain Brothers, ISBN: 9788186321782, 8186321780			

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Industrial Safety Engineering**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Workshop
Course Synopsis	This course provides students a brief overview on Industrial Safety. This includes understanding the safety precautions in various manufacturing processes. Also give overview on safety in finishing and testing.

Course Outcomes:

At the end of the course students will be able to:

CO1	Apply operations research techniques in industrial Safety in metal working and wood working machines
CO2	Understanding the concept of Principles of Machine Guarding
CO3	Understanding the concept of Safety in Welding and Gas Cutting
CO4	Understanding the concept of Safety in Finishing, Inspection and Testing

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	-	-	-	-	2	2	2	3	3	2	3	2	3	1
CO2	3	-	-	-	-	2	2	3	3	3	2	3	1	3	3
CO3	3	-	-	-	-	2	2	2	2	2	3	2	-	3	3
CO4	3	-	-	-	-	2	2	2	2	2	2	2	-	3	2
Average	3	-	-	-	-	2	2	2.25	2.5	2.5	2.25	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	Content & Competencies
1	**General Safety Rules :** Understanding and following general safety rules and regulations in a manufacturing or workshop environment. (C1) Awareness of personal protective equipment (PPE), safe work practices, and emergency procedures. (C1) Turning Machines (C2): Knowledge of specific safety considerations and precautions when operating turning machines. (C2) Understanding the safe setup, tooling, and operation of turning machines to prevent accidents. (C2) Boring Machines (C2): Understanding the safety measures and procedures for operating boring machines. (C2) Knowledge of proper tooling, workpiece clamping, and machine guarding for safe boring operations. (C2) Milling, Planning, and Grinding Machines (C2): Familiarity with the safety guidelines and precautions for milling, planning, and grinding machines. (C2) Understanding the safe use of cutting tools, workpiece holding methods, and machine adjustments. (C2) Safety Principles (C1): Awareness of general safety principles and their application in machine operations. (C1) Understanding the importance of risk assessment, hazard identification, and implementing safety measures. (C1) Safety in the Use of Sawing Machines (C2): Knowledge of the safety considerations and precautions when using sawing machines. (C2) Understanding the safe work procedures, blade selection, and machine guarding for sawing operations. (C2) Woodworking Equipment (C2): Familiarity with the safety guidelines and precautions specific to woodworking equipment. (C2) Knowledge of safe operation, tool handling, dust control, and machine maintenance in woodworking operations. (C2) CNC Machines (C2): Understanding the safety requirements and precautions for operating CNC machines. (C2) Knowledge of safe programming, tooling, machine setup, and emergency stop

	procedures for CNC operations. (C2) Selection and Care of Cutting Tools (C2): Understanding the importance of selecting appropriate cutting tools for specific machining operations. (C2) Knowledge of tool materials, geometry, tool wear, and proper tool maintenance for optimal performance and safety. (C2) Preventive Maintenance and Periodical Checks (C2): Awareness of the need for regular preventive maintenance and inspection of machines and equipment. (C2) Understanding the importance of lubrication, calibration, and safety checks to ensure safe machine operation. (C2) Associated Hazards and Prevention (C2): Knowledge of the potential hazards associated with machining operations and the necessary preventive measures. (C2) Understanding machine guarding, proper handling of hazardous materials, and safe work practices to mitigate risks. (C2)
2	**Guarding During Maintenance:** Understanding the importance of guarding during maintenance activities to ensure safety. (C2) Knowledge of the procedures and practices for implementing effective guarding measures during maintenance tasks. (C2) Zero Mechanical State (ZMS) (C3): Understanding the concept of Zero Mechanical State (ZMS) and its significance in ensuring safety during maintenance. (C3) Knowledge of the policy and guidelines for achieving and maintaining ZMS during maintenance operations. (C3) Guarding of Hazards Point of Operation (C2): Familiarity with the guarding requirements and techniques for hazards at the point of operation. (C2) Understanding the importance of machine guarding to prevent accidents and injuries at the point of operation. (C2) Protective Devices (C2): Knowledge of various protective devices used for machine guarding. (C2) Understanding the principles and functions of fixed guards, interlock guards, automatic guards, trip guards, electron eye, and positional control guards. (C2) Fixed Guard Fencing (C2): Understanding the concept and purpose of fixed guard fencing for machine safety. (C2) Knowledge of the selection, installation, and maintenance of fixed guard

	fencing systems. (C2) Selection and Suitability (C2): Understanding the factors influencing the selection and suitability of machine guarding methods. (C2) Knowledge of specific guarding requirements and considerations for different machines, such as lathes, drills, boring machines, milling machines, grinding machines, shaping machines, sawing machines, shearing machines, presses, forge hammers, flywheels, shafts, couplings, gears, sprockets, wheels and chains, pulleys and belts. (C2) Authorized Entry to Hazardous Installations (C2): Understanding the procedures and requirements for authorized entry to hazardous installations. (C2) Knowledge of the benefits of controlled and authorized access to hazardous areas for maintenance and servicing purposes. (C2) Benefits of Good Guarding Systems (C2): Awareness of the advantages and benefits of implementing effective guarding systems. (C2) Understanding how proper machine guarding contributes to a safe working environment, reduces accidents, and protects personnel and equipment. (C2)
3	**Gas Welding and Oxygen Cutting :** Understanding the principles and techniques of gas welding and oxygen cutting. (C3) Knowledge of the equipment and materials used in gas welding and oxygen cutting processes. (C3) Resistance Welding and Arc Welding/Cutting (C3): Familiarity with the concepts and methods of resistance welding and arc welding/cutting. (C3) Understanding the different types of equipment and their applications in resistance welding and arc welding/cutting. (C3) Common Hazards (C2): Knowledge of the common hazards associated with welding and cutting processes. (C2) Understanding the risks of fire, electrical shock, toxic fumes, and personal injuries during welding and cutting operations. (C2) Personal Protective Equipment (C2): Understanding the importance of personal protective equipment (PPE) in welding and cutting operations. (C2) Knowledge of the appropriate PPE, such as welding helmets, gloves, protective clothing, and respiratory protection. (C2) Training and Safety Precautions (C2):

	Familiarity with the importance of training and proper safety precautions in welding, brazing, soldering, and metalizing. (C2) Understanding the safe handling of equipment, controlling heat, and preventing accidents during these processes. (C2) Explosive Welding (C3): Knowledge of the principles and applications of explosive welding. (C3) Understanding the safety considerations and precautions associated with explosive welding. (C3) Selection, Care, and Maintenance of Equipment (C2): Understanding the criteria for selecting, caring for, and maintaining equipment and instruments used in welding and cutting processes. (C2) Knowledge of equipment inspection, maintenance procedures, and calibration requirements. (C2) Safety in Gas Generation, Distribution, and Handling (C2): Awareness of safety protocols for the generation, distribution, and handling of industrial gases used in welding and cutting processes. (C2) Understanding the color coding systems, flashback arrestors, and leak detection methods for ensuring safe gas handling. (C2) Pipe Line Safety (C2): Familiarity with safety practices related to pipe lines used in gas distribution for welding and cutting processes. (C2) Knowledge of pipe line inspection, maintenance, and safety measures to prevent accidents and leaks. (C2) Storage and Handling of Gas Cylinders (C2): Understanding the proper storage and handling procedures for gas cylinders used in welding and cutting operations. (C2) Knowledge of cylinder storage requirements, handling techniques, and precautions for transportation and storage areas. (C2)
4	**Safety in Grinding:** Understanding the safety precautions and guidelines for grinding operations. (C2) Knowledge of proper use of grinding equipment, personal protective equipment (PPE), and safe work practices. (C2) Safety in Heat Treatment Operations (C2): Familiarity with the safety measures and guidelines for heat treatment processes. (C2) Understanding the hazards associated with high temperatures, handling of hot materials, and proper use of heat treatment equipment. (C2) Safety in Electroplating (C2): Knowledge of safety procedures and precautions for electroplating processes.

	(C2) Understanding the hazards of chemical exposure, electrical hazards, and proper handling of plating equipment and chemicals. (C2) Safety in Paint Shops (C2): Awareness of safety protocols in paint shops, including proper ventilation, use of personal protective equipment, and safe handling of paints and solvents. (C2) Knowledge of fire prevention measures and safe disposal of paint-related waste materials. (C2) Safety in Sand and Shot Blasting (C2): Understanding the safety precautions and guidelines for sand and shot blasting operations. (C2) Knowledge of proper equipment operation, personal protective equipment, and safe work practices to prevent injuries and exposure to airborne particles. (C2) Safety in Inspection and Testing (C2): Familiarity with safety procedures for inspection and testing activities. (C2) Understanding the importance of following safety guidelines, using appropriate equipment, and ensuring a safe work environment during inspections and testing. (C2) Dynamic Balancing (C3): Knowledge of the principles and techniques of dynamic balancing. (C3) Understanding the safety considerations and precautions associated with dynamic balancing processes. (C3) Safety in Hydro Testing (C2): Awareness of safety protocols for hydrostatic testing of pressure vessels and pipelines. (C2) Understanding the hazards associated with high-pressure testing and the importance of following proper procedures and safety precautions. (C2) Safety in Valve, Boiler Drums, and Pressure Vessel Operations (C2): Knowledge of safety measures and guidelines for working with valves, boiler drums, and pressure vessels. (C2) Understanding the risks involved, proper handling techniques, and compliance with Indian Boilers Regulation. (C2) Air Leak Testing and Steam Testing Safety (C2): Familiarity with safety precautions for air leak testing and steam testing processes. (C2) Knowledge of the hazards associated with high-pressure systems, proper equipment usage, and safety protocols. (C2) Safety in Radiography (C2): Understanding the safety procedures and precautions for radiography operations. (C2)

	Knowledge of radiation hazards, personal monitoring devices, and the use of engineering and administrative controls to ensure safety. (C2) Health and Welfare Measures in the Engineering Industry (C2): Awareness of health and welfare measures implemented in the engineering industry to promote employee well-being. (C2) Understanding the importance of providing a safe and healthy work environment, including measures such as ergonomic design, medical facilities, and employee welfare programs. (C2) Pollution Control in the Engineering Industry (C2): Familiarity with pollution control measures and regulations in the engineering industry. (C2) Knowledge of waste management practices, environmental regulations, and the importance of minimizing environmental impact in engineering operations. (C2) Industrial Waste Disposal (C2): Understanding the proper methods and regulations for the disposal of industrial waste materials. (C2) Knowledge of waste segregation, treatment options, and compliance with applicable environmental guidelines. (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term

Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:				
i) Safety Management by John V. Grimaldi and Rollin H. Simonds, All India Travelers Book seller, New Delhi, 5th Edition. ISBN:0939874989 **ii)** Health and Safety in welding and Allied Processes, welding Institute, UK, High Tech. Publishing Ltd., London, 2002 5th Edition. ISBN: 9781855735385				

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**SEC-III (MATLAB)**
Academic Year	III
Semester	V
Number of Credits	2
Course Prerequisite	Programming for Problem Solving, Engineering Maths
Course Synopsis	This course introduces students to MATLAB, a high-level programming language and environment widely used in scientific and engineering applications. Students will learn the fundamentals of MATLAB programming, including data types, control flow, functions, and numerical computations. The course focuses on problem-solving and algorithm development using MATLAB.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Write MATLAB code to solve mathematical and engineering problems.
CO2	Develop algorithms and implement them using MATLAB programming constructs.
CO3	Analyze and visualize data using MATLAB's built-in functions and plotting capabilities.
CO4	Utilize MATLAB for numerical computations, optimization, and simulations.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	3	1	-	-	-	1	1	1	3	2	1
CO2	3	3	3	2	3	1	-	-	-	1	1	1	3	3	-
CO3	3	3	3	2	3	-	-	-	-	1	2	2	3	3	-
CO4	3	3	3	3	3	-	-	1	-	1	2	2	3	3	-

Average	3	2.75	2.75	2.25	3	0.5	-	0.25	-	1	1.5	1.5	3	2.75	0.25

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
0	**0**	**4**	**4**

Sr. No.	**Content & Competencies**
1	Introduction to MATLAB (4 hours) MATLAB environment and basic operations (C1: Remembering) MATLAB data types and variables (C2: Understanding) Basic arithmetic and mathematical functions (C3: Applying)
2	Control Flow and Decision Making (8 hours) Conditional statements and logical operations (C2: Understanding) Loops and iterative structures (C3: Applying) Vectorization and array operations (C3: Applying)
3	MATLAB Functions and Scripting (8 hours) Creating and using MATLAB functions (C3: Applying) Input and output parameters (C2: Understanding) Scripting and automation (C3: Applying)
4	Data Manipulation and Analysis (8 hours) Importing and exporting data (C2: Understanding) Data structures: arrays, matrices, and cell arrays (C3: Applying) Data indexing and manipulation (C3: Applying)
5	Plotting and Data Visualization (6 hours) 2D and 3D plotting (C3: Applying) Customizing plots and annotations (C4: Analyzing) Creating subplots and multiple plots (C3: Applying)
6	Numerical Computations (8 hours) Numerical methods and algorithms (C4: Analyzing) Solving linear and nonlinear equations (C3: Applying) Numerical integration and differentiation (C3: Applying)
7	Symbolic Math Toolbox (6 hours) Symbolic variables and expressions (C2: Understanding) Symbolic equations and algebraic manipulations (C3: Applying) Symbolic calculus and differential equations (C4: Analyzing)
8	Advanced Topics (6 hours) File input/output operations (C3: Applying) Performance optimization techniques (C4: Analyzing) Introduction to MATLAB toolboxes and extensions (C2: Understanding)
9	MATLAB Applications (8 hours) Image and signal processing (C3: Applying) Control systems and simulations (C3: Applying) Optimization and curve fitting (C4: Analyzing)

10	Project Work (8 hours) Application of MATLAB in a project of choice (C5: Creating) Problem-solving and algorithm development (C4: Analyzing) Documentation and presentation of the project (C3: Applying)

Teaching - Learning Strategies and Contact Hours

Teaching-Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	10
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	10
Revision	5
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
Problem Based Learning (PBL)	University Examination
Assignment	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Assignment	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

<table>
<tr><td colspan="2">Feedback Process</td><td>1. Student’s Feedback
2. Course Exit Survey</td></tr>
<tr><td colspan="3">Students Feedback is taken through various steps
1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.</td></tr>
<tr><td>References:</td><td colspan="2">(List of reference books)</td></tr>
<tr><td></td><td colspan="2">1. "MATLAB: An Introduction with Applications" by Amos Gilat, Wiley, Edition Year: 2012, ISBN: 978-8126537204
2. "MATLAB Programming for Engineers" by Stephen J. Chapman, Cengage Learning, Edition Year: 2012, ISBN: 978-8131518656
3. "MATLAB for Engineers" by Holly Moore, Pearson, Edition Year: 2017, ISBN: 978-0134589640
4. "Essential MATLAB for Engineers and Scientists" by Brian Hahn and Daniel Valentine, Academic Press, Edition Year: 2019, ISBN: 978-0081029978</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Title	Kinematics of Machines Lab
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	NIL
Course Synopsis	This practical lab work will give students an insight about the basics of applied engineering mechanics.

Course Outcomes:

At the end of the course students will be able to:

CO1	Demonstrate an understanding of the concepts of various mechanisms and pairs.
CO2	Conduct velocity and acceleration analysis of simple mechanisms.
CO3	Calculate gyroscopic couple find its effect on various vehicles.
CO4	Apply concept of governors for speed control.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	1	-	-	-	1	-	1	3	3	3	1
CO2	3	3	3	3	2	1	-	-	1	1	-	2	3	3	2
CO3	3	2	2	2	3	1	-	-	-	-	1	2	1	3	2
CO4	3	2	2	2	2	-	1	-	-	-	1	2	2	2	1
Average	3	2.4	2.6	2.4	2.2	0.6	0.4	0.2	0.4	0.2	0.6	2.4	2.25	2.75	1.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Unit	Content & Competencies
1	To study various types of Kinematic links, pairs, chains and Mechanisms (C1)
2	To study inversions of 4 Bar Mechanisms, Single and double slider crank mechanisms (C1)
3	To plot slider displacement, velocity and acceleration against crank rotation for single slider crank mechanism (C1)
4	To determine the radius of gyration 'k' of the given compound pendulum (C2)
5	Comparative study of static and dynamic balancing in rotors (C5)
6	To study TRI –FILAR / BI-FILAR System (C5)
7	To determine gyroscopic couple on motorized gyroscope (C4)
8	To perform experiment on Watt and Porter governors to determine performance characteristic curves, and to find stability & sensitivity (C5)
9	To perform experiment on Hartnell governor to determine performance characteristic curves, and to find stability & sensitivity (C4)
10	To perform experiment on Proell governor to determine performance characteristic curves, and to find stability & sensitivity (C4)
11	Create various types of linkage mechanism in CAD and simulate for motion outputs and study the relevant effects (C1, C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative

Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination				
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) A. Ghosh (2009), Theory of Mechanisms and Machines, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, ISBN: 978-8-185-93893-6.

ii) Thomas Bevan (2009), Theory of Machines, 3rd Edition, Pearson Education, ISBN: 978-8-131-72965-6.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Fluid Mechanics Lab**
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	Engineering Maths and Engineering Mechanics
Course Synopsis	Fluid mechanics and machinery is a branch of continuum mechanics that deals with the behavior of fluids (gases or liquids) either in motion or at rest and the subsequent effects of fluids upon boundaries, which may be either solid surfaces or interfaces with other fluids. This course deals fluids and their properties, and the kinematics and dynamics of fluid flow. After that students learn the fundamentals of flow through pipes, turbulent flow, dimensional analysis and boundary layers and their applications in engineering.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the fundamental models for analyzing a fluid flow and fluid at rest both.
CO2	Find the dependent and independent parameters for a fluid flow.
CO3	Explain various methods available for boundary layer separation and analyze the model and prototype.
CO4	Understand the working principles of turbines and pumps.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	1	1	1	1	1	1	1	3	2	3	1
CO2	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3
CO3	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3
CO4	3	3	3	3	3	1	1	1	1	1	1	3	1	3	2

Average	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

S. No.	Content & Competencies
1	Conducting experiments to verify Bernoulli's theorem (C1, C2)
2	Determination of the Coefficient of discharge and coefficient of velocity for the given Orifice meter (C1, C2)
3	Determination of the Coefficient of discharge of given Venturi-meter (C1, C2,C3)
4	Determination of the Coefficient of discharge of given of Notch (V and Rectangular types) (C1, C2, C3)
5	Comparative study of head loss in pipes connected series and parallel (C1, C2)
6	Study of fluid flow types using Reynolds apparatus (C1, C2)
7	To determine the coefficient of impact for vanes (C1, C2,C3)
8	To determine the meta-centric height of a floating body (C1, C2, C3)
9	To determine the coefficient of discharge of an orifice of a given shape. Also, to determine the coefficient of velocity and the coefficient of (C1, C2,C3)
10	To calibrate an orifice meter and study the variation of the co-efficient of discharge with the Reynolds number (C1, C2, C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	20
Seminar/Journal Club	4
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	3
Case/Project Based Learning (CBL)	--
Revision	3

Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system.	

2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.	
References:	(List of reference books)
	i)R. K. Bansal (2010), A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Edition, Laxmi Publication (P) Ltd. New Delhi. ISBN- 978-8-131-80815-3. ii)Yunus A. Çengel (2010), Fluid Mechanics, Tata McGraw Hill, ISBN: 978-0-070-70034-5. iii) Frank M. White (2011), Fluid Mechanics, 7th edition, Tata McGraw-Hill Education, ISBN-978-0-071-33312-2.

Faculty of engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Applied Thermodynamics Lab**
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	**Engineering Thermodynamics**
Course Synopsis	Thermodynamics is a subject of fundamental interest to Mechanical engineers and therefore is always taught in the 2nd or 3rd semester. Present course can be viewed as the next step, where the thermodynamic principles will be employed to discuss about different power producing & absorbing cycles. Properties of pure substance will be discussed, along with the thermodynamic property relations, thereby enabling the participants to estimate all relevant thermodynamic properties at any particular state of point. Subsequently the gas &vapor power cycles will be analyzed, followed by the principles of cogeneration & combined cycles. Then the refrigeration cycles will be introduced, followed by a discussion on the selection of refrigerants. The properties of gas mixtures and gas vapour mixtures will also be discussed, leading to psychrometry&psychrometric processes. The course will be completed with a brief introduction to the chemical equilibrium.

Course Outcomes:

At the end of the course students will be able to:

CO1	To understand the working of compressors and power cycles.
CO2	To learn the basics of reciprocating engines and combustion cycles.
CO3	To understand vapor absorption and compression refrigeration cycle.
CO4	To learn the fundamentals of turbomachinery.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific

Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	1	1	0	0	0	0	2	0	3	3
CO2	3	2	3	3	2	2	2	1	0	0	0	3	1	3	2
CO3	3	3	3	2	2	1	2	0	0	1	0	2	1	3	3
CO4	3	2	2	2	2	1	0	0	0	0	1	3	2	3	2
Average	3	2.25	2.75	2.25	1.75	1.25	1.25	0.25	0	0.25	0.25	2.5	1	3	2.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	0	2	2

Sr. No.	Content & Competencies
1	Model of 2 stroke and 4 stroke petrol and diesel engine, (C1, C2, C3,C4)
2	Model of Lancashire (C1, C2, C3,C4)
3	Model of Babcock Wilcox (C1, C2, C3,C4)
4	Model of Locomotive boiler (C1, C2, C3,C4)
5	Fuel Supply system (C1, C2, C3,C4)
6	Model of steam engine with boiler (C1, C2, C3,C4)
7	Model of air steam pressure turbine (C1, C2, C3,C4)
8	Turbojet engine Model (C1, C2, C3,C4)
9	Engine indicating system (C1, C2, C3,C4)
10	Exhaust gas calorimeter (C1, C2, C3,C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	15
Seminar/Journal Club	--

Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid Semester Examination 1				
Mid Semester Examination 2				
University Examination				

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.	
References:	
i) R.K Rajput, Applied Thermodynamics, Laxmi Publications; Second edition (1 January 2016), ISBN-13: 978-8131805831 **ii)** Moran, Shapiro, Boettner, Bailey, Fundamentals of Engineering Thermodynamics, Wiley Publication, ISBN 978-1118412930	

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Mechanics of Robot**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Robotics Engineering and Applications
Course Synopsis	The mechanics of a robot refer to the physical aspects and principles that govern its movement, manipulation, and overall mechanical functionality. It involves understanding the structural components, joints, actuators, and mechanisms that enable the robot to perform its intended tasks.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the basic components of robots.
CO2	Differentiate types of robots and robot grippers.
CO3	Model forward and inverse kinematics of robot manipulators.
CO4	Analyze forces in links and joints of a robot.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	1	0	1	1	2	-	-	-	-	2	3	3	1
CO2	3	2	2	0	3	0	0	-	-	-	-	2	3	1	1
CO3	3	2	2	3	2	0	2		-	-	-	2	3	2	1
CO4	3	2	2	2	1	2	2	-	-	-	-	3	3	2	1
Average	3	1.5	1.75	1.25	1.75	0.75	1.5	-	-	-	-	2.25	3.0	2.0	1

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Introduction to Spatial Descriptions (C1) Understanding positions and orientations in 3D space (C1) Overview of frames and their importance in spatial descriptions (C1) Spatial Transformations and Mappings (C2) Exploring different types of spatial transformations (C2) Understanding mappings and their role in changing descriptions between frames (C2) Operators for Translations, Rotations, and Transformations (C2-C3) Performing translations in 3D space (C2) Rotating objects around different axes (C3) Applying and combining transformations (C3) Transformation Arithmetic (C3-C4) Performing arithmetic operations with transformations (C3) Understanding the order of operations and their impact on the final result (C3) Solving problems involving compound transformations (C4) Inverting a Transform (C4) Understanding the concept of inverting a transformation (C4) Applying inverse transformations to reverse the effect of a given transformation (C4) Transform Equations (C3-C4) Working with transform equations to represent spatial relationships (C3) Solving equations involving transformations (C4) Applying transform equations to real-world scenarios (C4) Euler Angles (C3) Introduction to Euler angles as a representation of spatial orientations (C3) Understanding the different rotation sequences and their effects on Euler angles (C3) Fixed Angles (C3) Exploring fixed angles as an alternative method for representing spatial orientations (C3) Understanding the limitations and advantages of fixed angles (C3) Euler Parameters (C3) Understanding Euler parameters (quaternions) as a mathematical representation of orientations (C3) Applying Euler parameters in spatial transformations (C3)				

2	Link Description and Reference Frame Connections (C1) Understanding link descriptions and their role in manipulator kinematics (C1) Establishing connections between links and reference frames (C1) Denavit-Hartenberg Approach and D-H Parameters (C2) Introducing the Denavit-Hartenberg approach for link parameterization (C2) Understanding D-H parameters and their use in kinematic analysis (C2) Position Representations (C2-C3) Exploring different position representations in manipulator kinematics (C2) Analyzing the advantages and limitations of each representation (C3) Homogeneous Transformation Matrix (C3) Understanding the concept of homogeneous transformation matrices (C3) Applying homogeneous transformations for position and orientation calculations (C3) Forward Kinematics (C3-C4) Solving forward kinematics problems using the D-H parameters and homogeneous transformations (C3) Calculating end-effector positions and orientations based on joint variables (C4) Inverse Kinematics (C4) Introducing inverse kinematics as the process of determining joint variables from desired end-effector positions (C4) Applying geometric and analytical approaches for solving inverse kinematics problems (C4) Geometric Approach for Inverse Kinematics (C4) Exploring geometric methods, such as the geometric Jacobian and geometric interpretations, for solving inverse kinematics problems (C4) Analytical Approach for Inverse Kinematics (C4) Understanding analytical methods, such as closed-form solutions and numerical methods, for solving inverse kinematics problems (C4)
3	Cross Product Operator for Kinematics (C2) Introduction to the cross product operator and its role in robot kinematics (C2) Understanding the mathematical properties and applications of the cross product operator (C2) Jacobians and Direct Differentiation (C3) Introduction to Jacobians for robot manipulators (C3) Understanding direct differentiation and its use in calculating Jacobians (C3) Basic Jacobian and Jacobian Jv / Jw (C3) Exploring the basic Jacobian and its components for velocity analysis (C3) Analyzing the Jacobian matrix for linear and angular velocity (C3)

	Jacobian in a Frame and Jacobian in Frame {0} (C3) Understanding the concept of the Jacobian in a specific frame and in the reference frame (C3) Applying the Jacobian transformation for different coordinate systems (C3) Kinematic Singularity and Kinematic Redundancy (C4) Identifying kinematic singularities and their impact on robot motion (C4) Exploring the concept of kinematic redundancy and its advantages and challenges (C4) Force Balance Equation and Forces (C3) Understanding the force balance equation and its role in robot dynamics (C3) Analyzing the forces acting on robot manipulators and their effects (C3) Velocity/Force Duality and Virtual Work (C4) Exploring the concept of velocity/force duality and its applications in robot dynamics (C4) Understanding virtual work and its relation to robot motion and forces (C4) Force Ellipsoid and Jacobian (C4) Introduction to the force ellipsoid and its significance in force analysis (C4) Analyzing the relationship between the force ellipsoid and the Jacobian matrix (C4) Kinematic Singularity and Kinematic Redundancy (C4) Identifying kinematic singularities and their impact on robot motion (C4) Exploring the concept of kinematic redundancy and its advantages and challenges (C4) Mechanical Design of Robot Linkages (C4) Integrating mechanical design principles with kinematics analysis (C4) Understanding the considerations for designing robot linkages for optimal performance (C4)
4	Introduction to Dynamics (C1) Overview of dynamics and its importance in robotics (C1) Introduction to key concepts and principles in robot dynamics (C1) Velocity Kinematics (C2) Understanding velocity kinematics for robotic systems (C2) Calculating the linear and angular velocities of rigid bodies (C2) Acceleration of Rigid Body and Mass Distribution (C2) Analyzing the acceleration of rigid bodies in robotic systems (C2) Understanding mass distribution and its impact on dynamics (C2) Newton's Equation and Euler's Equation (C3) Exploring Newton's equation for motion and forces in robotic systems (C3) Understanding Euler's equation and its application to rotating bodies (C3)

	Iterative Newton-Euler's Dynamic Formulation (C4) Introduction to the iterative Newton-Euler's dynamic formulation (C4) Applying iterative methods to calculate dynamic quantities (C4) Closed Dynamic and Lagrangian Formulation of Manipulator Dynamics (C4) Understanding closed dynamic formulations for robotic manipulators (C4) Exploring the Lagrangian formulation of manipulator dynamics (C4) Dynamic Simulation (C4) Introduction to dynamic simulation techniques for robotic systems (C4) Implementing numerical methods to simulate robot dynamics (C4) Computational Considerations (C3) Analyzing computational aspects in robot dynamics (C3) Understanding numerical stability and efficiency in dynamic simulations (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	3
Small Group Discussion (SGD)	3
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)

Seminars	Multiple Choice Questions (MCQ)
Problem-Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid-Semester Examination 1	✓	✓	✓	✓
Mid-Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Industrial Robotics / Groover M P /McGraw Hill. (ISBN-10: 0071004424, ISBN-13: 978-0071004428) **ii)** John J. Craig (2008), Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson Education. ISBN: 978-8-131-71836-0. **iii)** Theory of Applied Robotics /Jazar/Springer. (ISBN- 978-1-4419-1750-8) **iv)** Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, (2010), Robotic Engineering an Integrated Approach, 1st Edition, Prentice-hall of India. ISBN: 978-8-120-30842-8.

	v)	S. R. Deb and Sankha Deb (2009), Robotics Technology and Flexible Automation, 2nd Edition, Tata McGraw-Hill Edu-cation. ISBN: 978-0-070-07791-1.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Mechanics of Robot Lab**
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	Robotics Engineering and Applications
Course Synopsis	A robotics lab dedicated to the study of robot mechanics is a facility equipped with specialized tools, equipment, and resources for conducting experiments and research related to the mechanical aspects of robots.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.
CO2	Fabricate components with their own hands.
CO3	Get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes. Also, able to study and analyse different electrical signals.
CO4	Gain Knowledge of the basics of electrical & electronics circuits and able to design their own components.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	1	-	1	3	1	-	-	3	3	3	2	1
CO2	3	2	3	2	1	1	-	-	-	-	2	3	3	2	-
CO3	3	1	2	2	3	2	-	-	-	-	-	2	3	2	-
CO4	3	1	1	1	1	1	2	3	-	-	-	2	3	2	1
Average	3	2	2	2	1	1	1	1	-	-	1	3	3.0	2.0	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	0	2	1

Sr. No.	Content & Competencies
1	Robot Arm Kinematics (C2) Investigating the relationship between joint angles and end effector position/orientation (C2) Recording changes in the end effector using position sensors (C2)
2	Workspace Analysis (C3) Determining the reachable workspace of the robot (C3) Analyzing limitations, constraints, and singularities within the workspace (C3)
3	Inverse Kinematics (C4) Calculating joint angles to achieve a desired end effector position/orientation (C4) Validating inverse kinematic equations by comparing calculated joint angles with actual robot movements (C4)
4	Forward Dynamics (C4) Studying the dynamics of the robot arm by applying forces/torques to the joints (C4) Analyzing the relationship between applied forces/torques and resulting joint accelerations (C4)
5	End Effector Manipulation (C3) Investigating the capabilities of the robot's end effector for object grasping, lifting, and placing (C3) Measuring forces exerted by the end effector during manipulation (C3)
6	Mobile Robot Kinematics (C3) Analyzing the kinematics of mobile robots (e.g., differential drive, holonomic drive) (C3) Relating wheel velocities to robot position and orientation changes (C3)
7	Path Planning (C3) Developing and testing algorithms for robot path planning (C3) Evaluating efficiency and optimality of generated paths (C3)
8	Sensor Integration (C4) Integrating different sensors into the robot system (C4) Assessing the impact of sensors on robot mechanics and control (C4)
9	Collaborative Robots (C3) Investigating the mechanics and control of collaborative robots (cobots) (C3) Studying safety features, interaction with human operators, and tasks performed in a shared workspace (C3)
10	Control System Evaluation (C4) Implementing and testing different control algorithms for regulating robot arm

	position or trajectory (C4) Evaluating accuracy, stability, and response time of the control system (C4)
Note:	1. At least ten experiments/ jobs are to be performed/ prepared by students in the semester. 2. At least 8 experiments/ jobs should be performed/prepared from the above list, the remaining two may either be performed/prepared from the above list or designed and set as per the scope of the syllabus of the Engineering Workshop.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	05
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	05
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References: (List of reference books)

i) Industrial Robotics / Groover M P /McGraw Hill. (ISBN-10: 0071004424, ISBN-13: 978-0071004428)

ii) John J. Craig (2008), Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson Education. ISBN: 978-8-131-71836-0.

iii) Theory of Applied Robotics /Jazar/Springer. (ISBN- 978-1-4419-1750-8)

iv) Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, (2010), Robotic Engineering an Integrated Approach, 1st Edition, Prentice-hall of India. ISBN: 978-8-120-30842-8.

v) S. R. Deb and Sankha Deb (2009), Robotics Technology and Flexible Automation, 2nd Edition, Tata McGraw-Hill Edu-cation. ISBN: 978-0-070-07791-1.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Power Train Design
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Engineering Graphics and Design, Strength of Materials
Course Synopsis	This course introduces students to the concept of Electric power train in Electric vehicles, its design modeling and analysis. It covers all the aspect of force capacity, transmission and generating source. Electric motors are an integral part of any electric vehicle and are the main power source. So modeling the motor characteristics is very important while designing an EV.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Calculate the power required at the wheels of an EV based on the power train topology used.
CO2	Calculate the torque developed by a particular type of motor.
CO3	Select proper size of different components of an electric power train based on the size of vehicle.
CO4	Model and analyze the performance of an electric vehicle.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	-	-	-	-	-	1	2	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	2	3	3	2	-
CO3	3	1	3	3	3	-	1	-	-	-	-	2	3	2	1
CO4	3	3	3	3	3	-	2	-	-	-	-	2	3	2	-
Average	3	1.75	2.5	2.5	2.5	-	1.5	-	-	-	1.5	2.25	3	2	0.25

Course Content:				
L (Hours/Week)		T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3		0	0	3
Unit	Content & Competencies			
1	**Basic Concept of Electric Traction:** Understanding the principles and advantages of electric traction in transportation systems. (C1) Knowledge of the role of electric traction in reducing emissions and improving energy efficiency. (C1) Introduction to Various Electric Drive-Train Topologies (C2): Familiarity with different electric drive-train configurations, such as series, parallel, and hybrid systems. (C2) Understanding the characteristics, advantages, and limitations of each topology. (C2) Power Flow Control in Electric Drive-Train Topologies (C3): Knowledge of power electronics and control strategies used in electric drive-train systems to regulate power flow. (C3) Understanding the principles of power flow control, including speed control, regenerative braking, and energy storage. (C3) Fuel Efficiency Analysis (C3): Ability to analyze and evaluate the fuel efficiency of electric drive-train systems. (C3) Understanding the factors influencing fuel efficiency, such as energy conversion efficiency, vehicle weight, aerodynamics, and driving conditions. (C3) Calculating Rolling Resistance (C2): Proficiency in calculating the rolling resistance of a vehicle using relevant equations and parameters. (C2) Understanding the factors affecting rolling resistance, such as tire characteristics, vehicle weight, and road surface conditions. (C2) Calculating Grade Resistance (C2): Ability to calculate the grade resistance encountered by a vehicle when driving uphill or downhill. (C2) Understanding the relationship between grade, vehicle weight, and the inclination of the road. (C2) Calculating Acceleration Force (C2): Proficiency in determining the required acceleration force for a vehicle based on its mass and desired acceleration. (C2) Knowledge of the equations and principles of Newton's laws of motion applied to vehicle dynamics. (C2)			

	Finding the Total Tractive Effort (C2): Ability to calculate the total tractive effort required to propel a vehicle, considering factors such as rolling resistance, grade resistance, and acceleration force. (C2) Understanding the relationship between tractive effort, vehicle weight, and driving conditions. (C2) Torque Required on the Drive Wheel (C2): Proficiency in determining the torque required on the drive wheel of a vehicle to achieve the desired acceleration and overcome resistance. (C2) Knowledge of the relationship between torque, wheel radius, vehicle weight, and driving conditions. (C2)
2	Introduction to Electric Components Used in Electric Vehicles (C1): Understanding the basic electric components used in electric vehicles, such as batteries, power electronics, electric motors, and control systems. (C1) Familiarity with the functions and characteristics of each component in the context of electric vehicle propulsion. (C1) Configuration and Control of DC Motor Drives (C2): Knowledge of the configuration and control strategies employed in DC motor drives for electric vehicles. (C2) Understanding the principles of speed control, torque control, and regenerative braking in DC motor drives. (C2) Configuration and Control of Induction Motor Drives (C2): Familiarity with the configuration and control techniques used in induction motor drives for electric vehicles. (C2) Understanding the concepts of vector control, field-oriented control, and direct torque control in induction motor drives. (C2) Types of Motors (C1): Knowledge of different types of electric motors used in electric vehicles, such as DC motors, induction motors, and permanent magnet motors. (C1) Understanding the characteristics, advantages, and limitations of each motor type in the context of electric vehicle applications. (C1) RPM and Torque Calculation of Motor (C2): Proficiency in calculating the rotational speed (RPM) and torque requirements of electric motors based on the vehicle's performance specifications. (C2) Understanding the relationship between motor speed, torque, power, and mechanical load. (C2) Motor Controllers (C2): Knowledge of motor controllers used in electric vehicles to regulate motor speed, torque, and direction. (C2) Understanding the functions and features of motor controllers, such as pulse

	width modulation (PWM) control, current sensing, and fault protection. (C2) Mechanical Connection of Motor (C1): Familiarity with the mechanical aspects of connecting electric motors to the vehicle's drivetrain, including mounting, coupling, and alignment. (C1) Understanding the importance of proper mechanical connections for efficient power transmission and vibration reduction. (C1) Electrical Connection of Motor (C1): Understanding the electrical connections required for integrating electric motors into the vehicle's power system, including wiring, connectors, and insulation. (C1) Knowledge of the safety considerations and industry standards related to electrical connections in electric vehicles. (C1)
3	Matching the Electric Machine and the Internal Combustion Engine (ICE) (C3): Understanding the criteria and considerations for matching the electric machine and the internal combustion engine in hybrid electric vehicles. (C3) Knowledge of the powertrain architecture and control strategies for achieving optimal power distribution between the electric machine and the ICE. (C3) Selection and Sizing of Propulsion Motor (C4): Ability to select the appropriate electric propulsion motor based on the vehicle's performance requirements, such as power, torque, and speed. (C4) Understanding the factors influencing motor selection, including efficiency, weight, size, and cost. (C4) Component Sizing (C4): Proficiency in sizing various components of the electric drivetrain system, including the motor, gearbox, and drivetrain components, based on the vehicle's specifications and operating conditions. (C4) Knowledge of the trade-offs between component size, efficiency, and performance. (C4) Sizing the Power Electronics (C4): Understanding the principles and techniques for sizing the power electronics components, such as inverters, converters, and motor controllers, in the electric drivetrain system. (C4) Ability to determine the power rating, current handling capacity, and thermal management requirements of the power electronics components. (C4) Selecting the Energy Storage Technology (C5): Familiarity with various energy storage technologies used in electric vehicles, such as batteries, fuel cells, and ultracapacitors. (C5) Understanding the factors influencing the selection of energy storage technology, including energy density, power density, cycle life, cost, and environmental impact. (C5)

4	Modeling and Characteristics of EV Powertrain Components (C4): Understanding the modeling techniques and principles for various components of electric vehicle powertrains, including internal combustion engines (ICE), electric motors, batteries, transmissions, and drivetrains. (C4) Ability to analyze the performance characteristics of each component and their interactions within the powertrain system. (C4) ICE Performance Characteristics (C4): Knowledge of the performance characteristics of internal combustion engines used in hybrid electric vehicles, including power output, torque curve, fuel efficiency, and emissions. (C4) Understanding the factors influencing ICE performance, such as engine displacement, compression ratio, and fuel injection system. (C4) Electric Motor Performance Characteristics (C4): Understanding the performance characteristics of electric motors, including torque-speed characteristics, efficiency, power rating, and thermal limits. (C4) Ability to analyze motor performance under various operating conditions and control strategies. (C4) Battery Performance Characteristics (C4): Familiarity with the performance characteristics of batteries used in electric vehicles, including energy capacity, power output, charging/discharging rates, voltage profiles, and cycle life. (C4) Understanding the impact of battery characteristics on vehicle range, acceleration, and overall performance. (C4) Transmission and Drivetrain Characteristics (C3): Knowledge of the transmission and drivetrain systems used in electric vehicles, including single-speed, multi-speed, and direct-drive systems. (C3) Understanding the role of transmissions in optimizing torque delivery and efficiency in electric vehicle powertrains. (C3) Regenerative Braking Characteristics (C3): Understanding the principles and benefits of regenerative braking in electric vehicles, including energy recovery, improved efficiency, and extended range. (C3) Ability to analyze the regenerative braking system's characteristics, such as braking force, energy conversion efficiency, and integration with the overall vehicle control system. (C3) Driving Cycles Modeling and Analysis (C4): Proficiency in modeling and analyzing driving cycles to understand the energy consumption, power demand, and performance requirements of electric vehicles under different driving conditions. (C4) Ability to use simulation tools and techniques to evaluate the impact of driving

	cycles on vehicle range, energy efficiency, and battery life. (C4) Vehicle Propulsion Modeling and Analysis (C4): Ability to model and analyze the propulsion system of electric vehicles, considering the interactions between the electric motor, transmission, drivetrain, and energy source (ICE or battery). (C4) Understanding the factors influencing vehicle propulsion performance, such as powertrain efficiency, torque distribution, and control strategies. (C4) Vehicle Braking Modeling and Analysis (C4): Proficiency in modeling and analyzing the braking system of electric vehicles, including traditional friction brakes and regenerative braking. (C4) Ability to evaluate the braking performance, energy recovery, and integration of braking systems with vehicle dynamics and control. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	23
Practical	--
Seminar/Journal Club	4
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References: (List of reference books)

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003. ISBN 9780367693930.
2. James Larminie and John Lowry,"Electric Vehicle Technology Explained", Wiley, 2003.ISBN: 978-1-119-94273-3
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004. ISBN 13: 978-0849331541

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Power Train Design Lab
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	Engineering Graphics and Design, Strength of Materials
Course Synopsis	This course introduces students to the concept of Electric power train in Electric vehicles, its design modeling and analysis. It covers all the aspect of force capacity, transmission and generating source. Electric motors are an integral part of any electric vehicle and are the main power source. So modeling the motor characteristics is very important while designing an EV.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Calculate the power required at the wheels of an EV based on the power train topology used.
CO2	Calculate the torque developed by a particular type of motor.
CO3	Select proper size of different components of an electric power train based on the size of vehicle.
CO4	Model and analyze the performance of an electric vehicle.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	-	2	2	2	1	1	-	-	-	2	2	3	2	-
CO2	3	2	2	2	2	1	1	-	-	-	2	3	3	2	-
CO3	3	3	3	3	3	1	2	-	-	-	-	2	3	2	1
CO4	3	3	3	3	3	1	3	-	-	-	-	2	3	2	-
Average	3.00	2.67	2.50	2.50	2.50	1.00	1.75	-	-	-	1.00	2.25	3	2	0.25

Course Content:			
L (**Hours/Week**)	**T** (**Hours/Week**)	**P** (**Hours/Week**)	**Total Hour/Week**
0	**0**	**2**	**2**

Unit	**Content & Competencies**
1	Power calculation based on power train used. (C1, C2, C3, C4)
2	Motor torque calculation. (C1, C2, C3, C4)
3	Tractive effort calculation (C1, C2, C3, C4)
4	Selection of Components for EV. (C1, C2, C3, C4, C5)
5	Selection of Energy Storage (C1, C2, C3, C4, C5)
6	Model the Electric Vehicle. (C1, C2, C3, C4, C5)
7	Model the Electric Vehicle Propulsion (C1, C2, C3, C4, C5)
8	Analyze the EV for different characteristics (C1, C2, C3, C4, C5)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	8
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps
1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003. ISBN 9780367693930.
2. James Larminie and John Lowry,"Electric Vehicle Technology Explained", Wiley, 2003.ISBN: 978-1-119-94273-3.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004. ISBN 13: 978-0849331541

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	**Data Structure and Algorithms**
Academic Year	III
Semester	V
Number of Credits	3
Course Prerequisite	Programming for Problem Solving
Course Synopsis	Exploring basic data structures such as stacks and queues. Introduces a variety of data structures such as hash tables, search trees, tries, heaps, graphs. Introduces sorting and pattern matching algorithms

Course Outcomes:

At the end of the course students will be able to:

CO1	Ability to select the data structures that efficiently model the information in a problem
CO2	Ability to assess efficiency trade-offs among different data structure implementations or combinations.
CO3	Implement and know the application of algorithms for sorting and pattern matching.
CO4	Design programs using a variety of data structures, including hash tables, binary and general tree structures, search trees, tries, heaps, graphs, and AVL-trees

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

Cos	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PS O4**
CO1	3	3	1	3	3	-	-	1	3	3	1	1	3	2	1	1
CO2	3	3	1	2	2	-	-	1	2	2	1	1	3	2	1	1
CO3	3	3	1	2	2	-	-	1	2	2	1	1	3	2	1	1
CO4	3	3	1	2	2	-	-	1	2	2	1	1	3	2	1	1
Average	3	3	1	2.25	2.25	-	-	1	2.25	2.25	1	1	3	2	1	1

Course Content:

L (Hours/ Week)	**T (Hours/Week)**	**P (Hours/Week)**	**CL (Hours/Week)**	**Total Hour/Week**

3	-	-	3	3

Unit	Content and Competencies
1	1. Explain Data Structures. (C2: Comprehension) 2. Define abstract data types. (C1: Knowledge) 3. Describe linked list using singly linked list operation insertion, deletion and searching on linear list. (C2: Comprehension) 4. Explain Stacks-Operations. (C2: Comprehension) 5. Define array and linked representations of stacks, Queues-operations, array &linked representations, and applications. (C1: Knowledge)
2	1. Explain Dictionaries by using linear list representation. (C2: Comprehension) 2. Define skip list representation operations - insertion, deletion and searching. (C2: Comprehension) 3. Describe Hash Table Representation: hash functions, collision resolution-separate chaining, open addressing-linear probing, quadratic probing, double hashing, rehashing, and extendible hashing. (C2: Comprehension)
3	1. Define and Implementation Search Trees: Binary Search Trees, and Searching Operations like Insertion and Deletion. (C1: Knowledge) 2. Implement AVL Trees, and Height of an AVL Tree with Operations – Insertion, Deletion and Searching. (C6: Evaluation) 3. Explain Red –Black.(C2: Comprehension) 4. Explain Splay Trees. (C2: Comprehension)
4	1. Explain Graph Traversal Methods and Graph Implementation Methods. (C2: Comprehension) 2. Demonstrate Sorting: Heap Sort, External Sorting- Model for external sorting, Merge Sort. (C3: Application)

Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	30
Practical	
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	4
Case/Project Based Learning (CBL)	2

Revision	4
Others If any:	-
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2
Objective Structured Clinical Examination (OSCE)	University Examination
Objective Structured Practical Examination (OSPE)	Dissertation
Quiz	Multiple Choice Questions (MCQ)
Seminars	Short Answer Questions (SAQ)
Problem Based Learning (PBL)	Long Answer Question (LAQ)
Journal Club	Practical Examination & Viva-voce
	Objective Structured Clinical Examination (OSCE)
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Clinical assessment				
Clinical/Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓

University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback			

References:	Textbooks: 1. Fundamentals of Data Structures in C, 2nd Edition, E. Horowitz, S. Sahni and Susan Anderson Freed, Universities Press. 2. Data Structures using C – A. S. Tanenbaum, Y. Langsam, and M.J. Augenstein, PHI/Pearson Education
	References: 1. Data Structures: A Pseudocode Approach with C, 2nd Edition, R. F. Gilberg and B.A. Forouzan, Cengage Learning

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Data Structure and Algorithms lab**
Academic Year	III
Semester	V
Number of Credits	1
Course Prerequisite	Programming for Problem Solving
Course Synopsis	It covers various concepts of C programming language

Course Outcomes:

At the end of the course, students will be able to:

CO1	Appreciate the importance of structure and Abstract data type, and their basic usability in different applications.
CO2	Able to understand and apply various data structures such as stacks, queues, trees, graphs etc. to solve various computing problems.
CO3	Able to implement various kinds of searching and sorting techniques, and decide when to choose which technique
CO4	Able to identify and use a suitable data structure and algorithm to solve a real world problem

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3	PSO4
CO1	3	-	-	-	3	1	-	-	-	-	-	-	3	-	1	-
CO2	3	-	2	1	-	1	-	-	-	-	-	-	3	-	-	-
CO3	3	-	2	1	-	-	-	-	-	-	-	-	3	2	-	-
CO4	3	2	3	3	1	-	-	-	-	-	-	-	3	2	1	-
Average	3	0.25	1.75	1.25	0.25	0.5	-	-	-	-	-	-	3	1	0.5	-

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Content & Competencies	
Sr. No.	**Title**
1	Write a program that uses functions to perform the following operations on singly linked list.: i) Creation ii) Insertion iii) Deletion iv) Traversal (C1: Knowledge)
2	Write a program that uses functions to perform the following operations on doubly linked list.: i) Creation ii) Insertion iii) Deletion iv) Traversal (C1: Knowledge)
3	Write a program that uses functions to perform the following operations on circular linked list.: i) Creation ii) Insertion iii) Deletion iv) Traversal (C1: Knowledge)
4	Write a program that implement stack (its operations) using i) Arrays ii) Pointers (C1: Knowledge)
5	Write a program that implement Queue (its operations) using i) Arrays ii) Pointers (C1: Knowledge)
6	Write a program that implements the following sorting methods to sort a given list of integers in ascending order i) Bubble sort ii) Selection sort iii) Insertion sort. (C1: Knowledge)
7	Write a program that uses both recursive and non recursive functions to perform the following searching operations for a Key value in a given list of integers: i) Linear search ii) Binary search. (C1: Knowledge)
8	Write a program to implement the tree traversal methods. (C1: Knowledge)
9	Write a program to implement the graph traversal methods. (C1: Knowledge)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours

Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	05
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				

Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

References:	TEXTBOOKS: 1. Fundamentals of Data Structures in C, 2nd Edition, E. Horowitz, S. Sahni and Susan Anderson Freed, Universities Press. 2. Data Structures using C – A. S. Tanenbaum, Y. Langsam, and M. J. Augenstein, PHI/Pearson Education.
	REFERENCE: 1. Data Structures: A Pseudocode Approach with C, 2nd Edition, R. F. Gilberg and B. A. Forouzan, Cengage Learning

SEMESTER - VI

Course Code	Course Title
	Dynamics of Machines
	Fluid Machines
	Design of Machine Elements
	Instrumentation and Control Engineering
Program Electives Course - IV	
	Fluid Power System
	Design for Manufacturing & Assembly
	Supply Chain and Logistic Management
	Finite Element Methods
	Nano-Technology and Surface Engineering
	SEC-IV (Digital Manufacturing)
	Dynamics of Machines Lab
	Fluid Machines Lab
	Design of Machine Elements Lab
	Instrumentation and Control Engineering Lab
Minor Elective Course-IV (Robotics)	
	Robot Operating and Control Systems
	Robot Operating and Control Systems Lab
Minor Elective Course-IV (Electric Vehicles)	
	EV Charging Infrastructure Technology
	EV Charging Infrastructure Technology Lab

Minor Elective Course-IV (Computer Science Engineering)	
	Data Visualization
	Data Visualization Lab

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Dynamics of Machines
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Kinematics of Machines
Course Synopsis	Dynamic loads and undesired oscillations increase with higher speed of machines. At the same time, industrial safety standards require better vibration reduction. This course covers parameter identification, balancing of mechanisms, torsional and bending vibrations, vibration isolation, and the dynamic behavior of drives and machine frames as complex systems. Typical dynamic effects, such as the gyroscopic effect, damping and absorption, shocks, nonlinear and self-excited vibrations are covered in dynamics of machinery. Upon completion, students should be able to analyze the effect of dynamic forces on systems and try to minimize the negative impact of such effects.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Demonstrate skills to design flywheel for an IC engine and punching press with the consideration of geometrical and economical constraints.
CO2	Perform static and dynamic balancing of high-speed rotary and reciprocating machines.
CO3	Analyze free and forced vibrations of machines, engines and structures.
CO4	Apply the concept of governors for speed control.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	-	-	-	1	-	1	3	3	3	1
CO2	3	3	3	3	2	1	-	-	1	1	-	2	3	3	-
CO3	3	2	2	2	3	1	-	-	-	-	1	2	3	2	-
CO4	3	2	2	2	2	-	1	-	-	-	1	2	3	2	-
Average	3	2.25	2.5	2.25	2	0.5	0.25	0	0.5	0.25	0.75	2.25	3	2.5	0.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	**D'Alembert's Principle** (C4): Understanding D'Alembert's principle in mechanics, which states that the sum of the applied forces and inertial forces on a system is equal to zero in equilibrium or constant velocity conditions. (C4) Ability to apply D'Alembert's principle to analyze the dynamic behavior of mechanical systems, including mechanisms and engines. (C4) Equivalent Offset Inertia Force (C4): Understanding the concept of equivalent offset inertia force in reciprocating machinery, which accounts for the dynamic effects of the reciprocating masses. (C4) Ability to calculate and analyze the equivalent offset inertia force in mechanisms and reciprocating engines. (C4) Dynamic Analysis of Four-Bar Mechanism (C4): Proficiency in performing dynamic analysis of four-bar mechanisms, considering the forces, accelerations, and velocities involved. (C4) Ability to determine the dynamic response, including displacements, velocities, and accelerations of the mechanism's links. (C4) Dynamic Analysis of Reciprocating Engines (C4): Understanding the dynamic analysis of reciprocating engines, including the analysis of piston effort, crank effort, turning moment on the crankshaft, and inertia forces. (C4) Ability to calculate and analyze the dynamic forces and moments in reciprocating engines using methods such as graphical analysis and mathematical equations. (C4)

	Inertia of Connecting Rod (C3): Knowledge of the inertia characteristics of the connecting rod in reciprocating engines, including its mass, length, and distribution. (C3) Understanding the impact of the connecting rod's inertia on the engine's dynamic behavior, such as piston acceleration and reciprocating forces. (C3) Inertia Force in Reciprocating Engines (Graphical Method) (C4): Proficiency in using graphical methods to analyze and determine the inertia forces in reciprocating engines, such as the construction and interpretation of inertia force diagrams. (C4) Ability to evaluate the magnitude, direction, and effects of inertia forces on engine components. (C4) Turning Moment Diagrams (C4): Understanding the concept of turning moment diagrams in reciprocating engines and other rotating machinery, which represent the variation of turning moment with the crankshaft angle. (C4) Ability to construct and interpret turning moment diagrams to analyze the torque fluctuations and balance in engines. (C4) Single and Multi-Cylinder Engines (C4): Knowledge of the characteristics and behavior of single-cylinder and multi-cylinder engines, including the effects of firing order, crankshaft arrangement, and balancing. (C4) Understanding the dynamic differences and considerations between single-cylinder and multi-cylinder engines in terms of forces, vibrations, and energy fluctuations. (C4) Fluctuation of Energy and Flywheels (C4): Understanding the concept of energy fluctuation in reciprocating engines and the need for flywheels to store and release energy. (C4) Ability to analyze the energy fluctuation and the selection, sizing, and application of flywheels to dampen speed variations and improve engine performance. (C4) Applications in Engines and Punching Presses (C3): Knowledge of the practical applications and significance of dynamic analysis in engine design, optimization, and performance improvement. (C3) Understanding the use of dynamic analysis techniques in punching presses to ensure smooth operation, minimize vibrations, and enhance productivity. (C3)
2	Static and Dynamic Balancing of Rotating Masses (C4): Understanding the concept of static and dynamic balancing in rotating machinery to minimize vibrations and improve stability. (C4) Ability to calculate and apply the principles of static and dynamic balancing to determine the required counterweights or adjustments for balanced rotation.

	(C4) Balancing of Reciprocating Masses (C4): Knowledge of the methods and techniques used to balance reciprocating masses in engines and machinery. (C4) Understanding the effects of unbalanced reciprocating masses on vibrations, forces, and engine performance. (C4) Balancing of Locomotives (C4): Understanding the specific challenges and considerations in balancing locomotives, which involve complex systems with reciprocating and rotating masses. (C4) Ability to analyze and implement balancing techniques to reduce vibrations, improve efficiency, and ensure smooth operation in locomotives. (C4) Partial Balancing of Reciprocating Masses (C4): Knowledge of partial balancing methods used in reciprocating engines to reduce the magnitude of unbalanced forces and vibrations. (C4) Understanding the limitations and trade-offs associated with partial balancing and the impact on engine performance. (C4) Multi-Cylinder Inline and Radial Engines (C4): Understanding the principles and challenges of balancing multi-cylinder inline and radial engines, including the effects of firing order, crankshaft arrangement, and cylinder layout. (C4) Ability to analyze and implement balancing techniques specific to multi-cylinder engines to minimize vibrations, improve performance, and maintain smooth operation. (C4)
3	Introduction to Vibration (C2): Understanding the basic concept of vibration as the oscillation or movement of an object or system from its equilibrium position. (C2) Familiarity with the importance of studying vibration in various engineering applications and its impact on system performance. (C2) Terminology of Vibration (C2): Knowledge of the fundamental terminology used in the field of vibration, including terms such as displacement, velocity, acceleration, frequency, amplitude, and resonance. (C2) Ability to use and interpret these terms in the analysis and characterization of vibrating systems. (C2) Classification of Vibrations (C2): Understanding the different types and classifications of vibrations based on various criteria such as source, nature, and excitation. (C2) Knowledge of classifications such as free vibration, forced vibration, deterministic vibration, random vibration, and self-excited vibration. (C2)

	Undamped and Damped Free Vibration of Single Degree of Freedom Systems (C3): Understanding the principles and equations governing the undamped and damped free vibrations of single degree of freedom systems. (C3) Ability to analyze and solve problems related to undamped and damped free vibrations using equations of motion and appropriate boundary conditions. (C3) Viscous Damping (C3): Understanding the concept and characteristics of viscous damping in vibrating systems, including its effect on damping ratio and system response. (C3) Ability to analyze and quantify the influence of viscous damping in vibrating systems using mathematical models and damping ratios. (C3) Introduction to Coulomb Damping (C2): Familiarity with the concept of Coulomb damping, which involves dry friction and the resistance to motion in vibrating systems. (C2) Understanding the effects of Coulomb damping on system behavior and the challenges it presents in vibration analysis. (C2) Forced Vibration (C3): Understanding the principles of forced vibration, which occurs when a system is subjected to external forces or excitations. (C3) Knowledge of the response characteristics and analysis techniques for forced vibration, including the calculation of resonance and frequency response. (C3)
4	Functions of Governors (C2): Understanding the primary function of governors, which is to regulate and control the speed or position of a machine or system. (C2) Familiarity with the various applications of governors in different types of machines, such as engines, turbines, and generators. (C2) Gravity-Controlled and Spring-Controlled Governor Characteristics (C3): Understanding the operating principles and characteristics of gravity-controlled governors, which rely on the force of gravity to regulate speed. (C3) Understanding the operating principles and characteristics of spring-controlled governors, which utilize the force of a spring to control speed. (C3) Knowledge of the different types of governors within these categories, such as the Watt governor and the Hartnell governor. (C3) Stability, Hunting, and Isochronism (C4): Understanding the concepts of stability, hunting, and isochronism in governors. (C4) Knowledge of the factors that affect the stability of governors and their impact on the performance of the controlled system. (C4) Understanding the phenomenon of hunting, which refers to the oscillation or fluctuation of speed in a governor-controlled system. (C4)

	Understanding the concept of isochronism, which relates to the ability of a governor to maintain a constant speed under varying load conditions. (C4) Effect of Friction (C3): Understanding the influence of friction in governor systems and its impact on system performance. (C3) Knowledge of the different types of friction present in governors, such as Coulomb friction and viscous friction. (C3) Ability to analyze and calculate the effect of friction on the equilibrium speeds and ranges of speed in governors. (C3) Calculation of Equilibrium Speeds and Ranges of Speed of Governors (C4): Ability to perform calculations to determine the equilibrium speeds and ranges of speed in governors based on the governor characteristics and system parameters. (C4) Understanding the mathematical equations and methods used to calculate these values, such as the governor equation and the use of control curves. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	4
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	7
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)

Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

1. S.S. Rattan (2009), "Theory of Machines", 3rd Edition, Tata McGraw-Hill. ISBN: 978-0-070-14477-4.
2. A.Ghosh (2009), Theory of Mechanisms and Machines, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, ISBN: 978-8-185-93893-6.
3. Thomas Bevan (2009), Theory of Machines, 3rd Edition, Pearson Education, ISBN: 978-8-131-72965-6.
4. Kenneth J Waldron and Gary L. Kinzel (2007), Kinematics, Dynamics, and Design of Machinery, 2nd Edition, John-Wiley and Sons Inc., New York, ISBN: 978-8-126-51255-3.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Fluid Machines
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Fluid Mechanics
Course Synopsis	This subject deals with in depth knowledge of Impact of jets, Hydraulic Turbines, Rotary motion of liquids, Roto-dynamic pumps, Positive displacement pumps & Compressors.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Discuss the characteristics of centrifugal pump and reciprocating pumps
CO2	Calculate forces and work done by a jet on fixed or moving plate and curved plates
CO3	Know the working of turbines and select the type of turbine for an application.
CO4	Do the analysis of air compressors and select the suitable one for a specific application

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	1	-	-	1	1	-	1	3	3	-
CO2	3	2	3	2	2	1	-	-	1	-	-	1	3	3	-
CO3	3	3	3	2	1	1	-	-	-	-	-	1	3	2	-
CO4	3	3	2	3	2	-	1	-	-	-	-	1	3	3	-
Average	3	2.5	2.5	2.25	1.75	0.75	0.25	0	0.5	0.25	0	1	3	2.75	0

Course Content:			
L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
3	**0**	**0**	**3**

Content & Competencies

Unit	Content	Competency
1	Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve),– Series of vanes - work done and efficiency. Hydraulic Turbines : Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done , losses and efficiencies, design of Pelton wheel – Inward and outward flow reaction turbines- Francis Turbine – Constructional features – Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles- work done and efficiencies – Characteristic curves of turbines – theory of draft tubes – surge tanks – Cavitation in turbines Governing of turbines – Specific speed of turbine , Type Number– Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power.	C1, C2, C3
2	Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps- centrifugal pump impeller types,-velocity triangles-manometric head- work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps- NPSH required and available- Type number-Pumps in series and parallel operations. Performance characteristics- Specific speed-Shape numbers – Impeller shapes based on shape numbers.	C1, C2, C3
3	Positive displacement pumps- reciprocating pump – Single acting and double acting- slip, negative slip and work required and efficiency- indicator diagram-acceleration head - effect of acceleration and friction on indicator diagram – speed calculation- Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps-selection of pumps-pumping devices-hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.	C1, C2, C3
4	Compressors: classification of compressors, reciprocating	C1, C2, C3

	compressor-single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivered (FAD) Centrifugal compressor-working, velocity diagram, work done, power required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and chocking. Axial flow compressors:- working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	28
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	9
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. S K Som, Introduction to Fluid Mechanics and Fluid Machines ,McGraw Hill Education India 2011 2. Bansal R. K., A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 2005. 3. Cengel Y. A. and J. M. Cimbala, Fluid Mechanics, Tata McGraw Hill, 2013 4. Yahya S. M, Fans, Blower and Compressor, Tata McGraw Hill, 2005. 5. Rajput R. K, Fluid Mechanics and Hydraulic Machines, S. Chand & Co.,2006.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Design of Machine Elements**
Academic Year	II
Semester	IV
Number of Credits	3
Course Prerequisite	Strength of Materials
Course Synopsis	Mechanical Machine Design is an essential course for mechanical engineering students. This course is an introduction to the basic principles of modern engineering. It provides the students with fundamental skills of engineering and the ability to apply the theories of science to practice and understand the factors; such as stresses, deformations, and failure criteria, influencing the machine elements like shafts, springs, belts, bearings, gears etc. The main objective of design of machine elements is that the machine should function properly to satisfy the needs of the customer and it should be safe against the predicted modes of failure.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Explain the influence of steady and variable stresses in machine component design.
CO2	Apply the concepts of design to temporary and permanent joints.
CO3	Apply the concepts of design to shafts, keys and couplings.
CO4	Apply the concepts of design to Springs and Bearings.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	1	1	1	1	3	2	3	1
CO2	3	2	2	2	1	1	1	1	1	1	1	2	1	3	2
CO3	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3

CO4	3	3	3	3	3	1	1	1	1	1	1	3	1	3	3
Average	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Fundamentals of Machine Design (C3): Engineering Design (C3): Understanding the concept of engineering design and its importance in the development of machines. (C3) Familiarity with the design process and the different phases involved, such as conceptual design, detailed design, and finalization. (C3) Phases of Design (C3): Knowledge of the different phases of the design process, including problem identification, conceptualization, analysis, synthesis, optimization, and evaluation. (C3) Understanding the iterative nature of the design process and the need for continuous refinement and improvement. (C3) Design Consideration (C3): Understanding the various factors that need to be considered during the design process, such as functional requirements, performance criteria, manufacturability, and cost. (C3) Knowledge of the importance of considering factors such as safety, ergonomics, environmental impact, and maintenance in the design of machines. (C3) Standards and Codes (C2): Familiarity with relevant engineering standards and codes that provide guidelines and specifications for machine design. (C2) Understanding the importance of adhering to standards and codes to ensure safe and reliable machine operation. (C2) Selection of Materials (C3): Understanding the factors influencing the selection of materials for machine design, such as mechanical properties, availability, cost, and compatibility with operating conditions. (C3) Knowledge of different types of materials commonly used in machine design, such as metals, polymers, and composites. (C3) Design against Static and Dynamic Load (C3):

	Understanding the principles of designing machines to withstand static and dynamic loads, considering factors such as strength, stiffness, and fatigue resistance. (C3) Knowledge of the methods used to analyze and predict the effects of static and dynamic loads on machine components. (C3) Modes of Failure, Factor of Safety (C3): Understanding the different modes of failure in machine components, such as fracture, fatigue, and excessive deformation. (C3) Knowledge of the concept of factor of safety and its importance in ensuring the reliability and durability of machine designs. (C3) Principal Stresses, Theories of Failure (C3): Understanding the concept of principal stresses and their role in determining the state of stress in machine components. (C3) Familiarity with theories of failure, such as the maximum shear stress theory, maximum distortion energy theory (Von Mises criterion), and maximum principal stress theory. (C3) Stress Concentration, Stress Concentration Factors (C3): Understanding the phenomenon of stress concentration and its impact on the strength and integrity of machine components. (C3) Knowledge of stress concentration factors and their calculation methods for different geometric features and loading conditions. (C3) Variable Stress, Fatigue Failure, Endurance Limit (C3): Understanding the effects of variable stress and fatigue loading on machine components and their potential to cause failure. (C3) Knowledge of fatigue failure mechanisms, such as crack initiation and propagation, and the concept of endurance limit (fatigue strength). (C3) Design for Finite and Infinite Life, Soderberg and Goodman Criteria (C3): Understanding the concepts of finite life and infinite life design approaches for machine components. (C3) Familiarity with Soderberg and Goodman criteria for fatigue design, considering the combined effects of static and dynamic stresses. (C3)
2	Riveted Joints (C4): Understanding the different types of rivets used in engineering applications, such as solid rivets, tubular rivets, and blind rivets. (C4) Knowledge of the materials commonly used for rivets, considering factors such as strength, corrosion resistance, and ease of installation. (C4) Familiarity with caulking and fullering techniques used to secure rivets in place and ensure a tight joint. (C4) Ability to analyze riveted joints, considering factors such as load distribution,

	stress concentration, and joint efficiency. (C4) Understanding the failures that can occur in riveted joints, such as shearing, bearing, and tearing, and methods for preventing them. (C4) Knowledge of specific applications of riveted joints, such as in boiler construction and the use of riveted brackets in structural assemblies. (C4) Welded Joints (C4): Understanding the different types of welded joints, including butt welds and fillet welds, and their respective strength characteristics. (C4) Ability to calculate the strength of butt and fillet welds based on factors such as weld size, material properties, and loading conditions. (C4) Knowledge of the behavior of eccentrically loaded welded joints and techniques for analyzing their strength and stability. (C4) Threaded Fasteners (C4): Understanding the stresses experienced by threaded fasteners, such as bolts and screws, under various loading conditions. (C4) Ability to consider the effects of initial tension (preload) on the performance and strength of threaded fasteners. (C4) Knowledge of design principles for threaded fasteners, including considerations for static, dynamic, and impact loads. (C4) Familiarity with methods for designing bolted joints under eccentric loading conditions, accounting for factors such as offset distance and resultant forces. (C4) Design of Temporary Joints (C3): Understanding the design considerations and applications of temporary joints, such as cotter joints and knuckle joints. (C3) Knowledge of the design principles for cotter joints, including cotter material selection, sizing, and proper installation. (C3) Familiarity with the design principles for knuckle joints, considering factors such as pin diameter, clearance, and joint flexibility. (C3)
3	Design of Shafts (C4): Understanding the principles of shaft design, including considerations for torsion, strength, and rigidity. (C4) Ability to design solid and hollow shafts subjected to steady loading, ensuring adequate strength and rigidity based on material properties and design factors. (C4) Familiarity with relevant industry codes and standards such as ASME and BIS codes for power transmission shafting, ensuring compliance with safety and performance requirements. (C4) Knowledge of design principles for shafts subjected to combined loading conditions, such as bending, torsion, and axial loading, considering factors such

	as load distribution and stress concentration. (C4) Understanding the design principles for shafts subjected to fluctuating loads, including considerations for fatigue strength, endurance limit, and factors of safety. (C4) Design of Keys and Couplings (C3): Keys: Knowledge of the different types of keys used in engineering applications and their respective applications, such as parallel keys and tapered sunk keys. (C3) Understanding the design considerations for parallel and tapered sunk keys, considering factors such as key size, material selection, and fit tolerance. (C3) Ability to design square and rectangular sunk keys based on load requirements, keyway dimensions, and material properties. (C3) Couplings: Understanding the different types of couplings used in machinery, including rigid and flexible couplings, and their applications. (C3) Familiarity with the design principles for flange couplings, ensuring proper alignment, torque transmission, and ease of assembly. (C3) Knowledge of the design principles for bush and pin type couplings, considering factors such as load capacity, misalignment compensation, and vibration damping. (C3)
4	Design of Pipe Joints (C4): Understanding the design principles for circular, oval-shaped, and square flanged pipe joints, considering factors such as pipe material, operating conditions, and sealing requirements. (C4) Ability to select appropriate joint configurations, gaskets, and fasteners to ensure leak-proof and reliable pipe connections. (C4) Knowledge of industry standards and codes related to pipe joint design, such as ASME B31.1 and ASME B16.5, ensuring compliance with safety and performance requirements. (C4) Design of Helical Springs (C4): Understanding the types and applications of helical springs, such as compression springs, extension springs, and torsion springs. (C4) Familiarity with the properties and selection of spring materials based on factors such as strength, elasticity, and corrosion resistance. (C4) Ability to design helical springs to withstand static and variable loads, considering factors such as load-deflection characteristics, stress levels, and fatigue life. (C4) Knowledge of design considerations for spring ends, including end types (closed, open) and their effects on spring performance. (C4) Design of Leaf Springs (C3):

	Understanding the design principles and applications of leaf springs in various industries, such as automotive and suspension systems. (C3) Familiarity with the selection and properties of leaf spring materials, considering factors such as strength, flexibility, and fatigue resistance. (C3) Ability to design leaf springs to withstand static and variable loads, ensuring proper deflection, stress distribution, and fatigue life. (C3) Knowledge of design considerations for leaf spring geometry, including the number of leaves, length, width, and curvature, to meet load requirements. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓

Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback 2. Course Exit Survey			
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.				
References:	(List of reference books)			
	1. Bhandari, V. B. (2016), “Design of Machine Elements”, India: McGraw-Hill Education(India), ISBN: 9789339221126, 9339221125 2. Khurmi, R. S., Gupta, J. K. (2005). A Textbook of Machine Design. India: Eurasia PublishingHouse, ISBN: 9788121925372, 8121925371			

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Instrumentation and Control Engineering**
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Engineering Maths
Course Synopsis	The objective of this course is to present sufficient background in different instruments and sensors and their use in control system design. This course combines knowledge, techniques, and methodologies from various sources, using techniques from transform theory and basic principle of classical physics based upon which different instruments and sensors are built.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand fundamental elements of instrumentation, measurement and control systems.
CO2	Build mathematical models of simple physical systems using transfer functions.
CO3	Will be able to design a control system for any required objective by using the theory of control system and implementing it with various sensors and transducers.
CO4	Can easily identify, formulate, and solve engineering problems.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	1	1	1	1	1	1	2	2	3	1
CO2	3	2	3	3	2	1	1	1	1	1	1	2	1	3	3
CO3	3	2	3	3	3	1	1	1	1	1	1	2	-	3	3
CO4	3	3	3	3	3	3	2	1	1	1	1	3	-	3	2

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	Content & Competencies
1	General concepts of Mechanical measuring instruments (C1): Understanding the basic principles and functions of mechanical measuring instruments used for various measurements in engineering and industrial applications. (C1) Familiarity with the components and working principles of mechanical measuring instruments, including scales, pointers, dials, and measurement mechanisms. (C1) Knowledge of common mechanical measuring instruments such as Vernier calipers, micrometers, dial indicators, and depth gauges. (C1) Elements of a measuring system (C2): Understanding the components and elements of a measuring system, including the primary sensing element, signal conditioning, data display, and recording devices. (C2) Familiarity with the roles and functions of each element in a measuring system, such as the transducer, amplifier, filter, and data acquisition system. (C2) Knowledge of the interconnections and interfaces between different elements of a measuring system to ensure accurate and reliable measurements. (C2) Requirements of measuring instruments (C2): Understanding the key requirements of measuring instruments, including accuracy, precision, sensitivity, resolution, repeatability, and reliability. (C2) Familiarity with the importance of calibration, maintenance, and periodic verification of measuring instruments to ensure their proper functioning. (C2) Knowledge of environmental factors, such as temperature, humidity, and vibration, and their effects on the performance of measuring instruments. (C2) Static and dynamic characteristics of measuring instruments (C3): Understanding the static characteristics of measuring instruments, including linearity, hysteresis, zero offset, and sensitivity. (C3) Familiarity with the dynamic characteristics of measuring instruments, such as response time, natural frequency, and damping ratio. (C3) Knowledge of the factors affecting the static and dynamic characteristics of measuring instruments and their impact on measurement accuracy and reliability. (C3) Errors in measurements (C3): Understanding the sources of errors in measurements, including systematic errors (bias) and random errors (noise). (C3) Familiarity with the types of errors, such as instrumental errors, environmental errors, and human errors, and their effects on measurement results. (C3) Knowledge of error analysis techniques, such as error propagation, statistical analysis, and uncertainty calculations, to evaluate and minimize measurement

	errors. (C3) Introduction to Transducers and Sensors (C1): Understanding the basic concepts and principles of transducers and sensors in measurement systems. (C1) Familiarity with the role of transducers and sensors in converting physical quantities, such as temperature, pressure, displacement, and force, into electrical signals. (C1) Knowledge of the classification and types of transducers and sensors based on their working principles, such as resistive, capacitive, inductive, and optical sensors. (C1)
2	Measurement of vibrations (C4): Understanding the principles and techniques used to measure vibrations in mechanical systems. (C4) Familiarity with accelerometers, which are commonly used sensors to measure vibration amplitude, frequency, and acceleration. (C4) Knowledge of vibration measurement techniques, such as frequency analysis, time-domain analysis, and modal analysis, to assess the dynamic behavior of structures and machinery. (C4) Measurement of Low, Medium, and High pressures (C3): Understanding the principles and instruments used to measure pressures across different ranges. (C3) Familiarity with pressure measurement devices, such as pressure gauges, pressure transducers, and pressure sensors, and their applications in various industries. (C3) Knowledge of calibration techniques, pressure units, and pressure measurement standards to ensure accurate and reliable pressure measurements. (C3) Measurement of temperature (C3): Understanding the methods and instruments used to measure temperature in various applications. (C3) Familiarity with different temperature measurement devices, including bi-metallic thermometers, thermocouples, resistance temperature detectors (RTDs), thermistors, and pyrometers. (C3) Knowledge of temperature measurement principles, temperature scales, calibration procedures, and temperature measurement ranges for different sensors. (C3) Measurement of flow (C3): Understanding the techniques and devices used to measure fluid flow rates. (C3) Familiarity with flow measurement instruments, such as hot wire anemometers, magnetic flow meters, and ultrasonic flow meters. (C3) Knowledge of flow measurement principles, flow velocity profiles, flow

	measurement standards, and calibration procedures for accurate flow rate determination. (C3)
3	Measurement of displacement (C3): Understanding the principles and techniques used to measure linear and angular displacement in mechanical systems. (C3) Familiarity with displacement measurement devices, such as dial indicators, linear variable differential transformers (LVDTs), potentiometers, and encoders. (C3) Knowledge of calibration procedures, measurement resolution, and accuracy considerations for displacement measurement. (C3) Measurement of Force (C3): Understanding the principles and instruments used to measure force in mechanical systems. (C3) Familiarity with force measurement devices, such as proving rings, strain gauges, load cells, and piezoelectric sensors. (C3) Knowledge of calibration techniques, force units, and force measurement standards to ensure accurate and reliable force measurements. (C3) Measurement of torque (C3): Understanding the methods and instruments used to measure torque in rotating systems. (C3) Familiarity with torque measurement devices, such as torque wrenches, torque transducers, and strain gauge-based torque sensors. (C3) Knowledge of calibration procedures, torque units, and torque measurement standards to ensure accurate and reliable torque measurements. (C3) Measurement of Speed (C3): Understanding the techniques and devices used to measure rotational speed and linear speed. (C3) Familiarity with speed measurement instruments, such as tachometers, encoders, and proximity sensors. (C3) Knowledge of calibration procedures, speed units, and speed measurement techniques for accurate speed determination. (C3) Case study assignments (C4): Applying the knowledge and principles of measurement techniques to real-world case studies and practical scenarios. (C4) Analyzing and solving measurement-related problems, such as selecting appropriate measurement instruments, interpreting measurement data, and making informed decisions. (C4) Developing critical thinking and problem-solving skills through case study assignments focused on measurement applications and challenges. (C4)
4	Introduction to Control Systems (C2):

	Understanding the basic principles and concepts of control systems. (C2) Differentiating between open-loop and closed-loop control systems. (C2) Recognizing the role of servomechanisms in control systems. (C2) Transfer Function and Block Diagrams (C3): Understanding the concept of transfer functions and their significance in control systems. (C3) Applying block diagram reduction techniques using algebraic manipulations. (C3) Analyzing and simplifying complex control system diagrams using signal flow graphs. (C3) Controllers and Time Response (C3): Familiarity with different types of controllers used in control systems, such as proportional, integral, and derivative controllers. (C3) Analyzing the time response of first-order and second-order systems under different input signals. (C3) Solving problems related to time response analysis in control systems. (C3) Frequency Domain Analysis (C3): Understanding the concept of frequency domain analysis and its applications in control systems. (C3) Interpreting and plotting polar and Bode plots to analyze system response in the frequency domain. (C3) Identifying system stability using frequency domain analysis techniques. (C3) Stability Analysis (C3): Familiarity with stability concepts in control systems. (C3) Applying the Routh-Hurwitz criterion to determine system stability. (C3) Solving stability-related problems using the Routh-Hurwitz criterion. (C3) Exposure to Industrial Applications (C4): Gaining knowledge and awareness of current industrial trends and applications in control systems. (C4) Understanding the practical implementation and use of control systems in various industries. (C4) Analyzing case studies and examples of control systems used in real-world industrial settings. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5

Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

	1. Instrumentation and Control Paperback – 2011by Patranabis D. (ISBN-10: 8120342461, ISBN- 13: 978-8120342460) 2. Instrumentation and Process Control Paperback – 2019 by D. C. Sikdar. (ISBN-10: 9789382609049, ISBN-13: 978-9382609049) 3. J.P. Holman (2004), Experimental Methods for Engineers, Tata McGraw-Hill (ISBN-10: 0070586748, ISBN-13: 978-0070586741) 4. I.J. Nagrath and M. Gopal (1999), Control Systems Engineering, New Age Int. Pub (ISBN- 10: 9789386070111, ISBN-13: 978-9386070111)

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Dynamics of Machines Lab**
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	Kinematics of Machines
Course Synopsis	The objective of this Lab-work course is to provide students with sufficient hands-on experience in working on balancing of mechanisms, torsional and bending vibrations, typical dynamic effects such as the gyroscopic effect, damping and absorption etc. Upon completion, students should be able to practically analyze the effect of dynamic forces on systems and try to minimize the negative impact of such effects.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Demonstrate skills to design flywheel for an IC engine and punching press with the consideration of geometrical and economical constraints.
CO2	Perform static and dynamic balancing of high-speed rotary and reciprocating machines.
CO3	Analyze free and forced vibrations of machines, engines and structures.
CO4	Apply the concept of governors for speed control.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO11**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	2	3	2	1	-	-	-	1	-	1	3	3	3	1
CO2	3	3	3	3	2	1	-	-	1	1	-	2	3	3	-
CO3	3	2	2	2	3	1	-	-	-	-	1	2	3	2	-
CO4	3	2	2	2	2	-	1	-	-	-	1	2	3	2	-
Average	3	2.25	2.5	2.25	2	0.5	0.25	0	0.5	0.25	0.75	2.25	3	2.5	0.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sl.No.	**Content & Competencies**
1	To perform experiment on watt and Porter Governors to prepare performance

	characteristic Curves, and to find stability & sensitivity. (C3, C4)
2	To perform experiment on Proell Governors to prepare performance characteristic Curves, and to find stability & sensitivity. (C3, C4)
3	To perform experiment Hartnell Governors to prepare performance characteristic Curves, and to find stability & sensitivity. (C3, C4)
4	To study gyroscopic effects through models. (C3, C4)
5	To determine gyroscopic couple on Motorized Gyroscope. (C3, C4)
6	To perform the experiment for static balancing on static balancing machine. (C3,C4)
7	To perform the experiment for dynamic balancing on dynamic balancing machine. (C3, C4)
8	Determine the moment of inertial of connecting rod by compound pendulum method and tri-flair suspension pendulum. (C3, C4)
9	To study Dynamically equivalent system. (C2, C1)
10	To study various types of dynamometer. (C2, C1)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce

--	University Examination

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. S.S. Rattan (2009), "Theory of Machines", 3rd Edition, Tata McGraw-Hill. ISBN: 978-0-070-14477-4.
2. A.Ghosh (2009), Theory of Mechanisms and Machines, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, ISBN: 978-8-185-93893-6.
3. Thomas Bevan (2009), Theory of Machines, 3rd Edition, Pearson Education, ISBN: 978-8-131-72965-6.
4. Kenneth J Waldron and Gary L. Kinzel (2007), Kinematics, Dynamics, and Design of Machinery, 2nd Edition, John-Wiley and Sons Inc., New York, ISBN: 978-8-126-51255-3.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Fluid Machines Lab
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	Fluid Mechanics & Fluid Machines
Course Synopsis	This lab deals with hands on knowledge of Impact of jets, Hydraulic Turbines, Rotary motion of liquids, Roto-dynamic pumps, Positive displacement pumps & Compressors.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the working of centrifugal pumps and reciprocating pumps
CO2	Calculate forces and work done by a jet on fixed or moving plate and curved plates
CO3	Understand the working of turbines (Both Impulse and Reaction turbine)
CO4	Analyze the working of air compressors and select the suitable one for a specific application.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	1	-	-	1	1	-	1	3	3	-
CO2	3	2	3	2	2	1	-	-	1	-	-	1	3	3	-
CO3	3	3	3	2	1	1	-	-	-	-	-	1	3	2	-
CO4	3	3	2	3	2	-	1	-	-	-	-	1	3	3	-
Average	3	2.5	2.5	2.25	1.75	0.75	0.25	0	0.5	0.25	0	1	3	2.75	0

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sl. No.	**Content & Competencies**
1	Impact of jet on a flat surface. (C3, C4)
2	Impact of jet on a curved surface. (C3, C4)

3	Conducting experiments and drawing the characteristic curves of Pelton turbine. (C3, C4)
4	Conducting experiments and drawing the characteristics curves of Francis turbine. (C3, C4)
5	Conducting experiments and drawing the characteristic curves of Kaplan turbine. (C3, C4)
6	Conducting experiments and drawing the characteristic curves of Gear pump. (C3, C4)
7	Conducting experiments and drawing the characteristic curves of reciprocating pump (C3, C4)
8	Conducting experiments and drawing the characteristic curves of centrifugal pump/ submergible pump. (C3, C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	22
Seminar/Journal Club	--
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. S K Som, Introduction to Fluid Mechanics and Fluid Machines ,McGraw Hill Education India 2011
2. Bansal R. K., A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications,2005.
3. Cengel Y. A. and J. M. Cimbala, Fluid Mechanics, Tata McGraw Hill, 2013
4. Yahya S. M, Fans, Blower and Compressor, Tata McGraw Hill, 2005.
5. Rajput R. K, Fluid Mechanics and Hydraulic Machines, S. Chand & Co.,2006.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Design of Machine Elements Lab**
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	Engineering Graphics and Design
Course Synopsis	Mechanical Machine Design is an essential course for mechanical engineering students. This course is an introduction to the basic principles of modern engineering. It provides the students with fundamental skills of engineering and the ability to apply the theories of science to practice and understand the factors; such as stresses, deformations, and failure criteria, influencing the machine elements like shafts, springs, belts, bearings, gears etc. The main objective of design of machine elements is that the machine should function properly to satisfy the needs of the customer and it should be safe against the predicted modes of failure.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Explain the influence of steady and variable stresses in machine component design.
CO2	Apply the concepts of design to temporary and permanent joints.
CO3	Apply the concepts of design to shafts, keys and couplings.
CO4	Apply the concepts of design to Springs and Bearings.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	1	1	1	1	3	2	3	1
CO2	3	2	2	2	1	1	1	1	1	1	1	2	1	3	2
CO3	3	2	2	2	1	1	1	1	1	1	1	2	1	3	3

CO4	3	3	3	3	3	1	1	1	1	1	1	3	1	3	3
Average	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Unit	Content & Competencies
1	To Design and Draw the Permanent Joints: Riveted Joints (C1, C2)
2	To Design and Draw the Permanent Joints: Welded Joints (C1, C2)
3	To Design and Draw the Non-Permanent Joints: Bolted Joints (C1, C2,C3)
4	To Design and Draw the Non-Permanent Joints: Cotter Joints (C1, C2,C3)
5	To Design and Draw the Non-Permanent Joints: Knuckle Joints (C1, C2)
6	To Design and Draw the Non-Permanent Joints: Muff Coupling (C1, C2)
7	To Design and Draw the Non-Permanent Joints: Flange Coupling (C1, C2)
8	To Design and Draw the Non-Permanent Joints: Flexible Coupling (C1, C2,C3)
9	To Design and Draw the Machine Elements: Solid & Hollow Shaft (C1, C2)
10	To Design and Draw the Machine Elements: Helical & Leaf Springs (C1, C2)
11	To Design and Draw the Machine Elements: Flanged Pipe Joint (C1, C2,C3)
12	To Design and Draw the Machine Elements: Ovel Pipe Joint (C1, C2,C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	22
Seminar/Journal Club	--
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--

Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. Bhandari, V. B. (2016), "Design of Machine Elements", India: McGraw-Hill Education(India), ISBN: 9789339221126, 9339221125
2. Khurmi, R. S., Gupta, J. K. (2005). A Textbook of Machine Design. India: Eurasia PublishingHouse, ISBN: 9788121925372, 8121925371

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Instrumentation and Control Engineering Lab**
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	Engineering Maths
Course Synopsis	The objective of this Lab-work course is to provide students with sufficient hands-on experience in working with different instruments. This course combines knowledge, techniques, and methodologies from various sources, using techniques from transform theory and basic principle of classical physics based upon which different instruments and sensors are built.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Demonstrate the various parameters of measurements using instruments.
CO2	Determine the magnitude of parametric measurements such as load, torque and temperature.
CO3	Measure displacement and flow using different instruments.
CO4	Measure speed and know the various uses of strain gauges.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	1	0	1	0	0	0	3	2	3	1
CO2	3	2	3	3	2	1	0	0	0	1	1	3	1	3	3
CO3	3	2	3	3	2	1	0	0	0	0	1	3	-	3	3
CO4	3	3	3	3	3	2	0	0	1	1	0	3	-	3	2
Average	3	2	2.75	2.75	2	1.25	-	0.25	0.25	0.5	0.5	3	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sl. No.	**Content & Competencies**
1	To study the characteristics of LVDT. (C1, C2)
2	To measure the load using load cell. (C2, C3)

3	To measure the temperature using thermocouple. (C2, C4)
4	Measurement of torque using torque measurement setup. (C1, C2)
5	To measure the temperature using RTD. (C2,C3)
6	Speed measurement using stroboscope. (C2)
7	Flow measurement experiment. (C2)
8	DC motor speed control. (C2)
9	Experiment on Dynamometers. (C1, C2)
10	Strain Measurement using Strain Gauge. (C1, C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	22
Seminar/Journal Club	--
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓

University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. Instrumentation and Control Paperback – 2011by Patranabis D. (ISBN-10: 8120342461, ISBN- 13: 978-8120342460)
2. Instrumentation and Process Control Paperback – 2019 by D. C. Sikdar. (ISBN-10: 9789382609049, ISBN-13: 978-9382609049)
3. J.P. Holman (2004), Experimental Methods for Engineers, Tata McGraw-Hill (ISBN-10: 0070586748, ISBN-13: 978-0070586741)
4. I.J. Nagrath and M. Gopal (1999), Control Systems Engineering, New Age Int. Pub (ISBN- 10: 9789386070111, ISBN-13: 978-9386070111)

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Fluid Power System**
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Fluid Mechanics
Course Synopsis	A fluid power system has a pump driven by a prime mover (such as an electric motor or IC engine) that converts mechanical energy into fluid energy. This fluid flow is used to actuate a device such as: A Hydraulic cylinder or Pneumatic cylinder, A Hydraulic motor or Pneumatic motor, A Rotary actuator etc.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Find the importance of fluid power technology in industries and to obtain knowledge on hydraulic and pneumatic components.
CO2	Gets exposure to the basics of fluid flow including the physical laws affecting fluid standards and symbols used in industrial applications..
CO3	Gain knowledge of that how to control the Hydraulic and Pneumatic Systems.
CO4	Gain knowledge of the various components in fluid power industry and solve problems related to pumps.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO2	PSO3
CO1	3	1	2	1	2	-	-	-	-	-	-	2	2	3	1
CO2	3	2	2	2	2	-	-	-	-	-	-	2	1	3	3
CO3	3	2	3	2	2	-	-	-	-	-	-	2	-	3	3
CO4	3	2	3	3	3	-	-	-	-	-	-	2	-	3	2
Average	3	1.75	2.5	2	2.25	-	-	-	-	-	-	2	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Hydraulics and Pneumatics (C1): Understanding the basic difference between hydraulics and pneumatics in terms of the medium used (liquid vs. gas). (C1) Recognizing the standards and regulations associated with hydraulics and pneumatics. (C1) Identifying the wide range of applications where hydraulics and pneumatics are utilized. (C1) Basic Principles of Hydraulics (C2): Understanding the fundamental principle of hydraulics based on Pascal's law, which states that pressure is transmitted equally in all directions in an enclosed fluid. (C2) Recognizing the transmission and multiplication of force in hydraulic systems. (C2) Familiarity with the basic properties of hydraulic fluids, including viscosity, density, and compressibility. (C2) Liquid Flow and Pressure in Hydraulics (C2): Understanding the principles of liquid flow in hydraulic systems, including concepts such as flow rate, velocity, and discharge. (C2) Recognizing the concept of static head pressure and its importance in hydraulic systems. (C2) Understanding pressure loss in hydraulic systems due to factors such as friction and pipe fittings. (C2) Power in Hydraulics (C2): Understanding the concept of power in hydraulic systems and how it relates to force and flow rate. (C2) Recognizing the relationship between pressure, flow rate, and power in hydraulic systems. (C2) Basic Principles of Pneumatics (C2): Understanding the fundamental principles of pneumatics, including absolute pressure and temperature. (C2) Familiarity with gas laws, such as Boyle's law, Charles's law, and Gay-Lussac's law, and their application in pneumatics. (C2) Recognizing the concept of vacuum and its relevance in pneumatic systems. (C2)
2	Hydraulic Pump (C2): Identifying the graphic symbol used to represent a hydraulic pump in

	schematics and diagrams. (C2) Understanding the different types of hydraulic pumps, such as gear pumps, vane pumps, and piston pumps, and their respective operating principles. (C2) Recognizing the relationship between pump flow and pressure in hydraulic systems. (C2) Understanding the concept of pump drive torque and power, which relates to the input power required to drive the pump. (C2) Familiarity with pump efficiency and its importance in evaluating the performance of hydraulic pumps. (C2) Air Compressor (C2): Identifying the graphic symbol used to represent an air compressor in schematics and diagrams. (C2) Understanding the different types of air compressors, such as reciprocating compressors, rotary screw compressors, and centrifugal compressors, and their respective operating principles. (C2) Recognizing the factors involved in compressor sizing, including the desired air flow rate and pressure requirements. (C2) Familiarity with the concept of vacuum pumps and their application in creating and maintaining a vacuum in pneumatic systems. (C2)
3	Cylinders (C2): Understanding the function and application of cylinders in hydraulic and pneumatic systems. (C2) Identifying the various types of cylinders, such as single-acting and double-acting cylinders. (C2) Recognizing the graphic symbol used to represent cylinders in hydraulic and pneumatic schematics. (C2) Understanding the basic operation and principles of cylinders, including the conversion of fluid or air pressure into linear motion. (C2) Accumulators (C2): Understanding the purpose and function of accumulators in hydraulic systems. (C2) Recognizing the different types of accumulators, such as bladder, piston, and diaphragm accumulators. (C2) Understanding the role of accumulators in storing energy, absorbing shocks, and compensating for pressure fluctuations. (C2) FRL (Filter-Regulator-Lubricator) (C2): Understanding the purpose and function of FRL units in pneumatic systems. (C2) Recognizing the individual components of an FRL unit, including the filter, regulator, and lubricator. (C2)

	Understanding the importance of filtration, pressure regulation, and lubrication in maintaining proper pneumatic system operation. (C2) Directional Control Valves (C2): Understanding the function and application of directional control valves in hydraulic and pneumatic systems. (C2) Identifying the different types of directional control valves, such as spool valves and poppet valves. (C2) Familiarity with the symbols used to represent directional control valves in hydraulic and pneumatic schematics. (C2) Pressure Control Valves (C2): Understanding the function and application of pressure control valves in hydraulic systems. (C2) Recognizing different types of pressure control valves, such as relief valves, pressure reducing valves, and sequence valves. (C2) Understanding the role of pressure control valves in regulating and maintaining desired pressure levels in hydraulic systems. (C2) Flow Control Valves (C2): Understanding the function and application of flow control valves in hydraulic systems. (C2) Recognizing different types of flow control valves, such as throttle valves and flow restrictors. (C2) Understanding the role of flow control valves in regulating and controlling fluid flow rates in hydraulic systems. (C2) Electronic Control Components (C3): Understanding the function and application of electronic control components in hydraulic and pneumatic systems. (C3) Familiarity with electronic control components such as solenoid valves, proportional valves, and electronic sensors. (C3) Recognizing the symbols used to represent electronic control components in hydraulic and pneumatic schematics. (C3)
4	Introduction (C1): Understanding the basic concepts and principles of hydraulic systems. (C1) Recognizing the applications and advantages of hydraulic systems in various industries. (C1) Familiarity with the components and terminology used in hydraulic systems. (C1) Sealing Devices (C2): Understanding the importance of sealing devices in hydraulic systems. (C2) Identifying different types of sealing devices, such as O-rings, seals, and gaskets. (C2)

	Recognizing the function and application of sealing devices in preventing fluid leakage in hydraulic systems. (C2) Reservoir System (C1): Understanding the purpose and function of the reservoir in a hydraulic system. (C1) Recognizing the components and features of a reservoir, such as the filler cap, breather, and drain plug. (C1) Understanding the role of the reservoir in storing hydraulic fluid, dissipating heat, and allowing for fluid expansion and contraction. (C1) Filters and Strainers (C2): Understanding the importance of filters and strainers in hydraulic systems. (C2) Identifying different types of filters and strainers, such as inline filters and suction strainers. (C2) Recognizing the function and application of filters and strainers in removing contaminants from hydraulic fluid and protecting system components. (C2) Beta Ratio of Filters (C3): Understanding the concept of the Beta ratio in hydraulic filters. (C3) Recognizing the significance of the Beta ratio in evaluating the filtration efficiency of hydraulic filters. (C3) Interpreting Beta ratio values to determine the effectiveness of a filter in removing particles of a certain size. (C3) Wear of Moving Parts (C2): Understanding the factors that contribute to the wear of moving parts in hydraulic systems. (C2) Recognizing the types of wear, such as abrasive wear, adhesive wear, and fatigue wear. (C2) Understanding the importance of proper lubrication, maintenance, and material selection in minimizing wear in hydraulic systems. (C2) Gases in Hydraulic Fluids (C2): Understanding the presence and effects of gases in hydraulic fluids. (C2) Recognizing the sources of gas contamination in hydraulic systems. (C2) Understanding the potential problems caused by gases, such as cavitation and foaming, and the methods to mitigate them. (C2) Temperature Control (C2): Understanding the importance of temperature control in hydraulic systems. (C2) Recognizing the factors that affect the temperature of hydraulic fluid, such as system load and ambient conditions. (C2) Familiarity with temperature control methods, such as cooling systems and heat exchangers, to maintain optimal operating temperatures. (C2) Troubleshooting (C3):

	Understanding the process of troubleshooting hydraulic systems. (C3) Recognizing common problems and malfunctions in hydraulic systems, such as leaks, pressure issues, and component failures. (C3) Applying systematic troubleshooting techniques to identify and resolve hydraulic system issues. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓

Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.	

References:	(List of reference books)
	(i)M. Rabie (2009), Fluid power Engineering, McGraw-Hill, NY, ISBN: 978-0-071-62246-2. **ii)** Espositho (2009), Fluid power with application, 6th edition, Prentice Hall, ISBN: 978- 81-7758- 580-3. **iii)** Robert P. Kokernak (1999), Fluid power technology, 2nd edition, Prentice Hall, ISBN: 978-0-139- 12487-7.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Design for Manufacturing & Assembly
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Engineering Workshop, Manufacturing Processes and Technology
Course Synopsis	The Design for Manufacturing & assembly is challenging subject that includes design principles for manufacturability and Influencing factors on Design. To learn about the machining, casting and environmental consideration while design. The aim of present course is to introduce and aware students about the basic design process with general design principles which based on different aspects of manufacturing as well assembly

Course Outcomes:

At the end of the course, students will be able to:

CO1	Get to know about various internal and external characteristic of material affecting design.
CO2	To know general design principles for manufacturability.
CO3	Introduction of basic design process based on different aspects of different manufacturing processes like machining, drilling etc.
CO4	Student will have idea about various phases in the life of a product.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	-	-	-	-	3	3	2	1
CO2	3	3	3	3	2	-	-	-	-	-	-	2	3	-	-
CO3	3	2	2	2	2	-	-	-	-	-	-	2	3	-	1
CO4	3	-	-	-	2	-	-	-	-	-	-	3	3	1	1
Average	3	2.7	2.7	2.3	2.0	-	-	-	-	-	-	2.5	3	0.75	0.75

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Strength and Mechanical Factors (C2): Understanding the concept of strength and its importance in mechanical design. (C2) Familiarity with mechanical factors such as stress, strain, and deformation. (C2) Recognizing the significance of considering strength and mechanical factors in the design and analysis of mechanical components and structures. (C2) Mechanism Selection (C2): Understanding the process of selecting appropriate mechanisms for a given application. (C2) Recognizing different types of mechanisms, such as linkages, gears, cams, and belts. (C2) Evaluating the advantages, limitations, and suitability of different mechanisms based on design requirements and constraints. (C2) Evaluation Method (C3): Understanding the methods used to evaluate the performance and effectiveness of mechanical systems. (C3) Recognizing the importance of performance criteria, such as efficiency, reliability, and durability. (C3) Applying evaluation methods, such as simulation, testing, and analysis, to assess the performance and behavior of mechanical systems. (C3) Process Capability (C2): Understanding the concept of process capability in manufacturing. (C2) Recognizing the importance of process capability in achieving desired product quality and consistency. (C2) Evaluating process capability using statistical tools and techniques, such as process capability indices (Cp, Cpk) and control charts. (C2) Feature Tolerances (C2): Understanding the concept of tolerance and its role in defining acceptable variation in dimensions. (C2) Recognizing different types of tolerances, such as bilateral, unilateral, and geometric tolerances. (C2) Applying feature tolerances to specify acceptable dimensional variation in mechanical components. (C2)

	Geometric Tolerances (C3): Understanding the concept of geometric tolerancing and its importance in defining acceptable geometric variation. (C3) Recognizing different geometric tolerance symbols and their meanings, such as straightness, flatness, and circularity. (C3) Applying geometric tolerances to control form, orientation, and location of features in mechanical components. (C3) Assembly Limits (C2): Understanding the concept of assembly limits and their role in ensuring proper fit and functionality of mechanical assemblies. (C2) Recognizing the importance of dimensional tolerances and clearance allowances in determining assembly limits. (C2) Applying assembly limits to specify acceptable dimensional variation in mating parts and components. (C2) Datum Features (C2): Understanding the concept of datum features and their role in establishing reference points for dimensional control. (C2) Recognizing different types of datum features, such as planes, holes, and surfaces. (C2) Applying datum features to establish a coordinate system and control dimensional relationships in mechanical assemblies. (C2) Tolerance Stacks (C3): Understanding the concept of tolerance stacks and their importance in assessing the cumulative effects of dimensional variation. (C3) Recognizing the methods and techniques used to analyze and manage tolerance stacks. (C3) Applying tolerance stack analysis to ensure proper fit, functionality, and manufacturability of mechanical assemblies. (C3)
2	Working Principle (C2): Understanding the fundamental working principles of mechanical components and systems. (C2) Familiarity with the principles of operation for various mechanical devices, such as gears, bearings, valves, and actuators. (C2) Applying the working principles to analyze and design mechanical systems. (C2) Material (C2): Understanding the importance of material selection in mechanical design. (C2) Familiarity with different types of engineering materials, such as metals, polymers, ceramics, and composites. (C2) Evaluating material properties, including mechanical, thermal, and chemical

	characteristics, for specific design applications. (C2) Manufacture (C2): Understanding the manufacturing processes involved in producing mechanical components. (C2) Recognizing different manufacturing techniques, such as machining, casting, forging, and welding. (C2) Considering manufacturing constraints and limitations during the design process. (C2) Design - Possible Solutions (C3): Applying engineering principles and knowledge to generate multiple design solutions for a given problem. (C3) Evaluating the feasibility and effectiveness of different design alternatives. (C3) Selecting the most suitable design solution based on performance, cost, manufacturability, and other criteria. (C3) Materials Choice (C2): Understanding the influence of material selection on the performance and functionality of mechanical components. (C2) Considering factors such as material properties, availability, cost, and environmental impact when choosing materials. (C2) Evaluating and comparing different material options to make informed decisions. (C2) Influence of Materials on Form Design (C2): Recognizing how material properties and characteristics affect the form and shape of mechanical components. (C2) Considering material properties, such as strength, stiffness, and ductility, in the design of components. (C2) Optimizing form design to leverage the unique properties and capabilities of selected materials. (C2) Form Design of Welded Members, Forgings, and Castings (C2): Understanding the design considerations specific to welded members, forgings, and castings. (C2) Recognizing the structural integrity, load-bearing capacity, and manufacturing considerations for each process. (C2) Applying appropriate design guidelines and standards for welded members, forgings, and castings. (C2)
3	Design features to facilitate machining (C3): Incorporating design features that enhance the machinability of the part. (C3) Considering the capabilities and limitations of machining processes when designing features. (C3)

	Collaborating with manufacturing engineers to optimize the design for ease of machining. (C3) Drills (C3): Designing holes with appropriate diameters and depths for drilling operations. (C3) Providing adequate access and clearance for drill bits. (C3) Ensuring proper alignment and orientation of drilled holes. (C3) Milling Cutters (C3): Designing features that can be machined using milling cutters, such as slots, pockets, and contours. (C3) Optimizing the geometry of the part to minimize the number of milling operations required. (C3) Considering the size and type of milling cutter needed for specific machining tasks. (C3) Keyways (C3): Incorporating keyways to provide secure and accurate positioning of components. (C3) Ensuring proper dimensions and tolerances for keyways to accommodate keys and key stock. (C3) Designing keyways with sufficient clearance and accessibility for machining. (C3) Doweling Procedures (C3): Including dowel holes or features for precise alignment and assembly of components. (C3) Designing dowel holes with appropriate sizes and tolerances for dowel pins. (C3) Providing access for drilling dowel holes during the machining process. (C3) Counter Sunk Screws (C3): Incorporating counter sunk screw holes for flush mounting and fastening. (C3) Designing counter sink angles and dimensions to accommodate specific screw sizes and types. (C3) Ensuring proper alignment and accessibility for machining counter sunk screw holes. (C3) Reduction of Machined Area (C4): Minimizing the amount of material that needs to be machined through thoughtful design. (C4) Utilizing design techniques such as hollowing out or removing unnecessary material to reduce machining requirements. (C4) Considering the structural integrity and functional requirements while reducing the machined area. (C4)

	Simplification by Separation (C4): Breaking down complex features or components into simpler and more manageable parts. (C4) Designing separate components that can be machined individually and then assembled. (C4) Improving manufacturing efficiency by reducing the complexity of machining operations. (C4)
4	Redesign of castings based on parting line considerations (C4): Analyzing the parting line of the casting to ensure proper mold separation during the casting process. (C4) Redesigning the part geometry to facilitate a more efficient and effective parting line. (C4) Minimizing undercuts and complex features that can complicate the mold design and increase production costs. (C4) Minimizing core requirements (C4): Optimizing the part design to minimize the need for intricate or large cores in the casting process. (C4) Reducing the complexity of internal features that require cores, which can streamline the casting process. (C4) Exploring alternative design approaches to eliminate or simplify the use of cores in the casting design. (C4) Machined holes (C3): Assessing the feasibility of incorporating machined holes directly into the casting design. (C3) Redesigning the casting to include features that can be machined rather than requiring additional drilling or machining operations. (C3) Ensuring proper tolerances, access, and alignment for machined holes within the casting. (C3) Re-design of cast members to obviate cores (C4): Evaluating the possibility of redesigning the casting to eliminate the need for specific core features. (C4) Redistributing material or modifying the geometry to achieve the desired functionality without relying on cores. (C4) Considering alternative casting methods or approaches that can help eliminate or simplify core requirements. (C4) Identification of uneconomical design (C4): Assessing the design for potential inefficiencies or cost-intensive features in the casting process. (C4) Identifying areas where design modifications can lead to improved manufacturing efficiency and reduced costs. (C4)

	Considering factors such as material usage, machining requirements, and production complexity in the evaluation of design economics. (C4) Modifying the design (C4): Making necessary design changes to improve the manufacturability and cost-effectiveness of the casting. (C4) Collaborating with casting engineers and manufacturers to refine the design based on their expertise and recommendations. (C4) Balancing functional requirements, cost considerations, and manufacturability in the design modification process. (C4) Group technology (C4): Applying the principles of group technology to identify common features and design elements that can be standardized or grouped together for more efficient casting production. (C4) Analyzing the design for opportunities to standardize components, processes, or materials to streamline manufacturing. (C4) Implementing design strategies that enable the use of modular or standardized components in casting production. (C4) Computer Applications for DFMA (C5): Utilizing computer-aided design (CAD) software and simulation tools to optimize the casting design for manufacturing and assembly. (C5) Applying computer-aided engineering (CAE) techniques for virtual casting simulations and analysis to identify potential issues and optimize the design before production. (C5) Employing design for manufacturing and assembly (DFMA) software tools to evaluate the cost, manufacturability, and assembly efficiency of the casting design. (C5) Recent trends and promising techniques for designing components for manufacturing (C6): Staying updated with the latest advancements in casting design techniques, materials, and technologies. (C6) Exploring emerging trends such as additive manufacturing, advanced casting methods, and optimization algorithms for design improvements. (C6) Investigating innovative approaches such as generative design, topology optimization, and digital twin simulations for enhanced casting design and manufacturing. (C6)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	33
Practical	--

Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	6
Case/Project Based Learning (CBL)	--
Revision	2
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	
Journal Club	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps
1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)

	1. Kevien Otto and Kristin Wood, Product Design. Pearson Publication, 2004, ISBN-13 :-9780130212719 2. Product design and development, by K.T. Ulrich and S.D. Eppinger, Tata McGraw Hill, ISBN 9780070146792 3. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994, ISBN 978-0824791766

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Supply Chain and Logistic Managements
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	This is a course in supply chain management (SCM), a term which denotes the integration of key business processes from end user through original suppliers for the purpose of adding value for the firm, its key Supply chain members, to include customers and other stakeholders. This course presents a framework for SCM that requires cross-functional integration of key business processes within the firm and across the network of firms that comprise the supply chain.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understanding the concept of Logistic Managements.
CO2	Understanding the concept of Supply Chain Management.
CO3	Understanding the concept of matching Supply and Demand.
CO4	Understanding the concept of Strategic Management.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	2	-	2	2	1	3	2	1	-	-
CO2	3	-	-	-	-	3	-	2	3	1	3	2	1	-	-
CO3	3	-	-	-	2	2	-	3	2	1	3	3	1	-	-
CO4	3	-	-	-	-	3	-	3	2	1	3	2	1	-	-
Average	3	-	-	-	1.5	2.5	-	2.5	2.25	1	3	2.25	1	-	-

Course Content:					
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Logistic Managements Introduction (C1): Understanding the basics of logistics management and its importance in supply chain operations. (C1) Exploring the role of logistics in achieving operational efficiency and customer satisfaction. (C1) Recognizing the key components and activities involved in logistics management. (C1) Logistics system design (C2): Analyzing the structure and design of logistics systems to meet customer demands and optimize operational performance. (C2) Evaluating factors such as network design, facility location, transportation modes, and inventory management in logistics system design. (C2) Balancing cost considerations, service levels, and sustainability in designing logistics systems. (C2) Demand planning (C2): Understanding the process of demand planning in logistics management. (C2) Analyzing historical data, market trends, and customer insights to forecast demand accurately. (C2) Utilizing demand planning techniques and tools to optimize inventory levels, production schedules, and transportation requirements. (C2) Multiple channel distribution (C3): Understanding the concept of multiple channel distribution in logistics management. (C3) Exploring the challenges and opportunities associated with distributing products through various channels such as brick-and-mortar stores, e-commerce platforms, wholesalers, and distributors. (C3) Designing and managing distribution networks that cater to different customer segments and channels. (C3) Multiple channel system (C3): Understanding the complexities and considerations involved in managing a			

	multiple channel system. (C3) Addressing issues related to inventory allocation, order fulfillment, customer service, and channel coordination. (C3) Implementing strategies to ensure seamless integration and collaboration across multiple channels. (C3) Model development (C4): Developing models and analytical tools to optimize logistics operations and decision-making. (C4) Utilizing mathematical modeling, simulation, and optimization techniques to improve logistics system performance. (C4) Incorporating factors such as demand variability, transportation costs, service levels, and capacity constraints in model development. (C4) Concept of warehousing (C2): Understanding the role and significance of warehousing in logistics management. (C2) Exploring different types of warehouses, such as distribution centers, cross-docking facilities, and fulfillment centers. (C2) Analyzing factors such as location, layout, storage systems, and inventory management in warehouse design and operations. (C2) Methods of storage (C3): Examining different methods and techniques for storage and inventory management in warehouses. (C3) Evaluating storage systems such as pallet racks, shelving, mezzanines, and automated storage and retrieval systems (AS/RS). (C3) Optimizing storage layouts, picking strategies, and space utilization in warehouse operations. (C3) Primary and secondary transportation (C2): Understanding the concepts of primary and secondary transportation in logistics management. (C2) Differentiating between modes of transportation, such as road, rail, air, and sea, and their suitability for different types of goods and distances. (C2) Managing transportation operations, including carrier selection, route optimization, freight consolidation, and tracking. (C2) Logistics information system (C3): Understanding the role of information systems in managing logistics operations

	and supply chain visibility. (C3) Exploring technologies such as warehouse management systems (WMS), transportation management systems (TMS), and enterprise resource planning (ERP) systems in logistics information management. (C3) Leveraging data analytics, real-time tracking, and integration with trading partners to enhance logistics processes and decision-making. (C3) Logistics costing (C4): Understanding the cost components and financial implications of logistics activities. (C4) Analyzing cost drivers, such as transportation, inventory holding, warehousing, and order processing, in logistics costing. (C4) Applying cost management techniques, including activity-based costing (ABC), cost benchmarking, and cost reduction strategies, in logistics operations. (C4)
2	Supply Chain Management Understanding the Supply Chain (C1): Gaining knowledge of the components, activities, and entities involved in a supply chain. (C1) Understanding the interdependencies and flows of materials, information, and funds within a supply chain. (C1) Recognizing the importance of effective supply chain management in achieving organizational goals. (C1) Process view (C2): Viewing the supply chain as a series of interconnected processes that transform inputs into outputs. (C2) Analyzing and mapping the various processes within a supply chain to identify bottlenecks, inefficiencies, and areas for improvement. (C2) Implementing process improvement strategies, such as lean management and Six Sigma, to optimize supply chain performance. (C2) Decision phases and importance of supply chain (C2): Identifying the different decision phases in supply chain management, including strategic, tactical, and operational decisions. (C2) Understanding the significance of effective decision-making at each phase to ensure alignment with organizational goals and customer requirements. (C2) Recognizing the impact of supply chain decisions on key performance metrics, such as cost, quality, delivery, and customer satisfaction. (C2) Supply chain management and logistics (C2):

	Understanding the relationship between supply chain management and logistics. (C2) Recognizing logistics as a key function within supply chain management, responsible for the efficient movement of goods, information, and resources. (C2) Exploring the various activities and processes involved in logistics, such as transportation, warehousing, inventory management, and order fulfillment. (C2) Supply chain and the value chain (C3): Understanding the concept of the value chain and its relationship to the supply chain. (C3) Recognizing that the supply chain is a critical component of the value chain, responsible for creating and delivering value to customers. (C3) Identifying opportunities to add value at each stage of the supply chain, from sourcing raw materials to delivering finished products to end customers. (C3) Competitive advantage (C3): Understanding the role of the supply chain in gaining and sustaining competitive advantage. (C3) Recognizing that an efficient and effective supply chain can contribute to cost reduction, quality improvement, faster response times, and enhanced customer satisfaction, leading to a competitive edge. (C3) Analyzing the strategic alignment between supply chain capabilities and overall business strategy to achieve competitive advantage. (C3) Supply chain and competitive performance (C4): Examining the relationship between supply chain performance and overall competitive performance. (C4) Understanding that a well-managed supply chain can positively impact key performance indicators, such as market share, profitability, market responsiveness, and customer loyalty. (C4) Monitoring and measuring supply chain performance metrics to identify areas of improvement and enhance competitive performance. (C4) Changing competitive environment (C4): Recognizing the dynamic and evolving nature of the competitive environment and its impact on supply chain management. (C4) Understanding the need for agility, flexibility, and adaptability in supply chain strategies to respond to changing market conditions, customer preferences, and technological advancements. (C4)

	Anticipating and proactively addressing potential disruptions and risks in the supply chain to maintain a competitive edge. (C4) Supply Chain drivers and obstacles (C3): Identifying the key drivers that influence supply chain performance, such as demand variability, lead time, inventory levels, transportation costs, and supplier relationships. (C3) Understanding the obstacles and challenges faced in managing a supply chain, including lack of coordination, information asymmetry, supply chain disruptions, and sustainability issues. (C3) Developing strategies to mitigate obstacles and leverage drivers to optimize supply chain performance and achieve strategic objectives. (C3)
3	Matching supply and demand (C4): Recognizing the importance of aligning supply and demand within the supply chain. (C4) Understanding the challenges associated with matching supply and demand, such as lead time gaps, variability in demand, and fluctuations in market conditions. (C4) Developing strategies and techniques to effectively balance supply and demand to meet customer requirements and optimize operational efficiency. (C4) The lead time gap (C4): Understanding the concept of lead time and its impact on supply chain operations. (C4) Recognizing the lead time gap as the time difference between customer demand and the time required to fulfill that demand. (C4) Implementing measures to reduce lead time gaps, such as improving production and delivery processes, enhancing supply chain visibility, and adopting agile and responsive strategies. (C4) Improving the visibility of demand (C4): Recognizing the importance of accurate and timely demand information in supply chain planning and execution. (C4) Implementing demand forecasting techniques and demand sensing tools to improve the visibility of demand signals. (C4) Utilizing technologies such as advanced analytics, artificial intelligence, and machine learning to enhance demand visibility and accuracy. (C4) Supply chain fulcrum (C4):

	Understanding the concept of the supply chain fulcrum as a strategic focal point for balancing supply and demand. (C4) Identifying the critical components and processes within the supply chain that need to be optimized to achieve a balanced and efficient supply and demand relationship. (C4) Developing strategies to leverage the supply chain fulcrum, such as optimizing inventory levels, improving production flexibility, and enhancing collaboration with suppliers and customers. (C4) Forecast for capacity (C4): Recognizing the importance of capacity planning in meeting future demand requirements. (C4) Using demand forecasts to assess and plan for the necessary capacity in terms of production capabilities, resources, and infrastructure. (C4) Employing techniques such as capacity modeling, scenario analysis, and capacity utilization optimization to ensure sufficient capacity to meet forecasted demand. (C4) Execute against demand (C4): Implementing effective strategies to execute and fulfill customer demand. (C4) Optimizing production scheduling, inventory management, and logistics operations to meet customer requirements in a timely manner. (C4) Deploying agile and responsive supply chain practices to quickly adapt to changes in demand and ensure on-time delivery. (C4) Demand management and aggregate planning (C3): Understanding the importance of demand management and aggregate planning in aligning supply and demand. (C3) Implementing demand management strategies, such as demand shaping, pricing strategies, and promotions, to influence and manage customer demand. (C3) Conducting aggregate planning to optimize production and resource allocation based on forecasted demand patterns and operational constraints. (C3) Collaborative planning, forecasting, and replenishment (C4): Recognizing the value of collaborative efforts between supply chain partners in managing supply and demand. (C4) Engaging in collaborative planning, forecasting, and replenishment (CPFR) initiatives to share information, synchronize activities, and improve forecast accuracy. (C4) Utilizing technology-enabled platforms and systems to facilitate real-time data

	sharing, collaborative decision-making, and efficient replenishment processes. (C4)
4	Creating the responsive supply chain (C5): Understanding the importance of a responsive supply chain in meeting customer demands and adapting to market changes. (C5) Implementing strategies to build a responsive supply chain, such as agile manufacturing, flexible capacity planning, and quick response to customer needs. (C5) Adopting technologies and tools that enable real-time visibility, collaboration, and data-driven decision-making to enhance responsiveness. (C5) Product 'push' versus demand 'pull' (C5): Recognizing the difference between a product-centric approach (push) and a customer-centric approach (pull) in supply chain management. (C5) Understanding the benefits and challenges associated with each approach and their impact on inventory levels, customer satisfaction, and overall supply chain performance. (C5) Implementing demand-driven strategies, such as demand sensing, just-in-time production, and postponement, to align supply with actual customer demand. (C5) The Japanese philosophy (C6): Understanding the principles and practices of the Japanese philosophy in supply chain management, such as lean manufacturing, continuous improvement (kaizen), and total quality management (TQM). (C6) Learning from the successful implementation of Japanese manufacturing techniques and applying them to improve supply chain performance, reduce waste, and enhance customer value. (C6) Embracing a culture of collaboration, employee empowerment, and customer focus as integral parts of the Japanese philosophy. (C6) Foundations of agility (C5): Understanding the foundational elements of an agile supply chain, including flexibility, responsiveness, adaptability, and resilience. (C5) Incorporating agility into supply chain design, operations, and decision-making processes to quickly respond to market changes, customer demands, and disruptions. (C5) Implementing strategies such as modular design, supplier collaboration, risk management, and agile logistics to enhance supply chain agility. (C5)

	Route map to responsiveness (C5): Developing a route map or strategic roadmap to guide the transformation of the supply chain towards greater responsiveness. (C5) Identifying key milestones, objectives, and initiatives that will enable the organization to become more agile and responsive in its supply chain operations. (C5) Monitoring progress, adjusting strategies, and continuously improving the route map to ensure ongoing responsiveness to market dynamics and customer expectations. (C5) Strategic lead-time management (C5): Recognizing the significance of lead time in supply chain performance and competitiveness. (C5) Implementing strategies to reduce lead time, such as process optimization, supply chain collaboration, information sharing, and advanced planning systems. (C5) Managing lead time variability and uncertainty through risk management, contingency planning, and buffer stock strategies. (C5) Time-based competition (C5): Understanding the importance of time as a competitive advantage in the marketplace. (C5) Emphasizing speed, responsiveness, and efficiency in supply chain processes to gain a competitive edge. (C5) Implementing time-based strategies such as quick response (QR), time-based pricing, time-to-market optimization, and fast order fulfillment. (C5) Logistics pipeline management (C4): Understanding the concept of the logistics pipeline and its role in supply chain management. (C4) Managing the flow of materials, information, and products through the pipeline to ensure timely and efficient delivery. (C4) Implementing strategies for pipeline management, such as demand forecasting, inventory optimization, transportation planning, and warehouse management. (C4) Planning and managing inventories in a supply chain (C4): Recognizing the importance of effective inventory planning and management in achieving supply chain efficiency and customer satisfaction. (C4)

	Analyzing economies of scale in supply chain cycle inventory to optimize production and storage costs. (C4) Developing strategies to manage uncertainty in supply chain demand and supply, such as safety stock, reorder point planning, and demand-driven inventory replenishment. (C4) Determining the optimal level of product availability through demand forecasting, service level agreements, and customer segmentation. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓

<table>
<tr><td colspan="2">University Examination</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="2">Feedback Process</td><td colspan="4">1. Student’s Feedback
2. Course Exit Survey</td></tr>
<tr><td colspan="6">Students Feedback is taken through various steps
1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
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<tr><td>References:</td><td colspan="5">(List of reference books)</td></tr>
<tr><td></td><td colspan="5">i) Christopher, M. Logistics & Supply Chain Management, Prentice Hall, 5th Edition, 2016, ISBN:1292083794.
ii) John T. Mentzer, J.T. Supply Chain Management, illustrated edition, SAGE Publications(2001),1st Edition,ISBN: 1412918057</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Finite Element Methods
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Engineering Math, Strength of Materials
Course Synopsis	The finite element method (FEM) is among one of the most powerful tool for the numeric solution of wide range of engineering problems. The application ranges from deformation and stress analysis of civil and Mechanical structures, automotive components, aircraft designs, heat flux analysis, fluid flow problems, and electrical magnetic flux problem. Upon completion, students should be able to solve the problems in solid mechanics and heat transfer using FEM.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply the knowledge of mathematics and engineering to solve problems in structural and thermal engineering by approximate and numerical methods.
CO2	To understand the free and forced vibrations with two-degree freedom system.
CO3	To learn the methods to solve vibration problems with multi-degree freedom system.
CO4	To understand the basics of vibration of continuous systems and experimental methods in vibration analysis and the working of vibration measuring instruments.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	2	2	3	3	3	2	2
CO2	3	2	2	3	1	1	1	1	1	1	2	2	3	2	1
CO3	3	1	2	2	2	2	2	1	2	1	2	2	3	1	2
CO4	3	2	1	1	2	1	1	2	3	2	3	3	3	2	1

Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Introduction to Finite Element Method (FEM) (C1) Definition and significance of the Finite Element Method Historical background and development of FEM Comparison with other numerical methods for solving differential equations Advantages and limitations of FEM Method of Weighted Residuals (C2) Overview of the method of weighted residuals Formulation of differential equations using weighted residual approach Weighting functions and choice of basic functions Weighted residual approximation and error estimation Variation Approach for Solving Differential Equations (C3) Introduction to the variation approach for solving differential equations Euler-Lagrange equation and the principle of stationary action Functionals and variational calculus Application of variation approach to obtain weak form of differential equation
2	Element Types and Properties (C4) Overview of different types of finite elements (e.g., linear, quadratic, higher-order elements) Properties of finite elements, such as element shape, size, and interpolation functions Selection criteria for choosing appropriate element types for specific applications Considerations for element distortion, aspect ratio, and quality Boundary Conditions (C5) Definition and classification of boundary conditions in FEM Types of boundary conditions, including displacement, traction, and mixed boundary conditions Imposition of boundary conditions in FEM models Treatment of essential and natural boundary conditions Stress-Strain Determination (C3) Calculation of stresses and strains in finite element models Material constitutive models and their implementation in FEM Calculation of stress and strain components based on displacement field and material properties Evaluation of stress and strain distributions within the finite element model Solution Techniques (C4) Overview of solution techniques in FEM, such as direct and iterative methods

	Formulation and solution of the system of algebraic equations arising from the discretization process Solution algorithms for linear and nonlinear problems Considerations for computational efficiency and accuracy in solution techniques Mesh Refinement (C2) Importance of mesh refinement in FEM analysis Criteria for mesh refinement, such as element size, aspect ratio, and local solution accuracy Techniques for mesh refinement, including uniform and adaptive refinement Impact of mesh refinement on solution accuracy and computational cost Convergence Criterion (C3) Definition and significance of convergence in FEM analysis Convergence criteria for assessing the accuracy and stability of solutions Techniques for monitoring convergence during the iterative solution process Strategies for achieving convergence in FEM simulations Frames, Beams, and Axial Elements (C5) Introduction to frame and beam elements in FEM Modeling and analysis of structural components subjected to axial loads Calculation of displacements, stresses, and strains in frame and beam elements Considerations for modeling material and geometric nonlinearities in frame and beam elements Plane Stress and Plane Strain (C4) Definition and characteristics of plane stress and plane strain conditions Modeling and analysis of two-dimensional structures subjected to plane stress or plane strain Calculation of stresses, strains, and displacements in plane stress and plane strain elements Considerations for selecting appropriate element types for plane stress and plane strain problems Shape Function Equations (C4) Introduction to shape functions and their role in FEM analysis Derivation and formulation of shape function equations for different element types Calculation of nodal values and coefficients in shape function equations Application of shape functions in the interpolation of field variables in FEM models
3	Finite Element Formulation for Linear Elastic Continuum (C4) Formulation of the stiffness matrix and load vector for linear elastic materials Constitutive equations for linear elastic behavior and their incorporation into the finite element formulation Derivation and implementation of the governing equations for linear elasticity Considerations for boundary conditions and modeling of geometric nonlinearities in linear elastic FEM analysis Extended Laplace Equation with Inertia and Dissipative Terms (C5) Introduction to the extended Laplace equation with inertia and dissipative terms Formulation of the finite element equations for solving the extended Laplace

	equation Considerations for modeling inertial and dissipative effects in FEM analysis Application of the extended Laplace equation to problems in fluid dynamics, heat transfer, and other fields Plate Bending and 'C' Elements (C4) Formulation and analysis of plate bending problems using finite elements Introduction to plate bending theories, such as Kirchhoff and Reissner-Mindlin theories Implementation of plate bending elements in FEM simulations Considerations for modeling and analyzing plates with different boundary conditions and loading conditions Nonconforming Elements and Patch Test (C3) Introduction to nonconforming finite elements and their applications Formulation and analysis of nonconforming elements in FEM Patch test as a verification technique for assessing the accuracy of nonconforming elements Considerations for using nonconforming elements in FEM analysis and their limitations FEM Analysis of Plates and Shells (C5) Modeling and analysis of plates and shells using finite elements Formulation and implementation of plate and shell elements in FEM simulations Considerations for modeling and analyzing different types of plate and shell structures Calculation of displacements, stresses, and strains in plate and shell elements
4	Dynamic and Nonlinear Problems (C5) Introduction to dynamic and nonlinear analysis in finite element method Formulation and solution techniques for dynamic problems, such as modal analysis and response analysis Considerations for modeling and analyzing nonlinear behavior, including material and geometric nonlinearity Implementation of time integration schemes for solving dynamic problems Material and Geometric Nonlinearity (C5) Modeling and analysis of material and geometric nonlinearity in finite element method Incorporation of nonlinear material behavior, such as plasticity and hyperelasticity, into the analysis Considerations for modeling large deformations and geometric nonlinearities Solution techniques for handling nonlinear problems using iterative procedures Axisymmetric Problems - Classical Solution (C4) Introduction to axisymmetric problems and their classical solutions Formulation and analysis of axisymmetric structures using finite elements Considerations for modeling axisymmetric geometries and boundary conditions Comparison of finite element solutions with classical analytical solutions for axisymmetric problems Finite Element Solution of Free Vibration Problems (C4) Formulation and analysis of free vibration problems using finite elements

	Solution techniques for finding natural frequencies and mode shapes Considerations for modeling and analyzing different types of vibrating structures Calculation of natural frequencies and mode shapes using finite element method Principles of Transient Dynamic Analysis (C4) Introduction to transient dynamic analysis and its principles Formulation and implementation of time-dependent loads and boundary conditions Solution techniques for solving transient dynamic problems using finite element method Analysis of structural response to time-varying loads and dynamic events Laboratory Work for Solid Mechanics Problems using FE Packages (C3) Hands-on laboratory exercises using finite element software packages Solving solid mechanics problems, such as static analysis and vibration analysis, using FE software Interpretation and analysis of the results obtained from FE simulations Practical application of finite element method to real-world engineering problems Current Industry Trends (C6) Exploration of current trends and advancements in the field of solid mechanics and finite element analysis Discussion of emerging technologies and methodologies in the industry Understanding the impact of new developments on the design and analysis of engineering structures Exposure to case studies and real-world applications showcasing the latest industry practices

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References: (List of reference books)

i) Tirupathi R. Chandrupatla (2009), Finite Element Analysis for Engineering and Technology, 1st Edition, University Press. ISBN:978-8-173-71427-6.

ii) P. Seshu (2010), Text book of Finite Element Analysis, Prentice Hall of India. ISBN:978-8-120-32315-5.

Faculty of engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Nano-Technology and Surface Engineering**
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	**Materials Engineering and Technology**
Course Synopsis	Surface engineering is a sub-discipline of Materials Science and Materials Engineering which deals with the surface of a solid and its modifications. The primary goal of Surface Engineering of nanomaterials is to modify the properties of surface to improve its electrical and thermal properties, and to improve the compatibility of nanomaterials with some matrix when they are used as reinforcing fillers in composites for high performance applications. The course should give a basic introduction to chemical and physical principles in the synthesis of inorganic nanostructured materials. In addition, basic principles of finite size effects will be covered. The course will also cover different methods for synthesis and characterization of different nanostructures and nanostructured bulk materials.

Course Outcomes:

At the end of the course students will be able to:

CO1	Use of surface engineering and Nanomaterials for various industrial applications.
CO2	To understand the basic concepts of Surface Engineering of Nanomaterials
CO3	Qualitatively describe how the nanoparticle size can affect the morphology, crystal structure, reactivity, and electrical properties.
CO4	Describe Microencapsulation and their application in industry

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	0	2	2	3	0	0	0	0	0	0	3	2	3	1

CO2	3	0	0	0	0	2	0	0	1	0	0	2	1	3	3
CO3	3	3	3	3	3	2	2	0	0	0	2	3	-	3	3
CO4	3	3	3	3	3	0	0	0	0	0	3	3	-	3	2
Average	3	1.5	2	2	2.25	1	0.5	0	0.25	0	1.25	2.75	0.75	3	2.25

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**	
1	**Tribology & its classification (C1):** Understanding the fundamental concepts of tribology and its classification in the field of engineering and materials science. (C1) Friction tribology (C2): Knowledge of the principles of friction and its various types. (C2) Understanding the factors influencing frictional behavior and the methods to control and reduce friction. (C2) Wear & corrosion (C2): Familiarity with the mechanisms of wear and corrosion. (C2) Knowledge of the factors contributing to wear and corrosion and their effects on materials. (C2) Understanding the methods to prevent and mitigate wear and corrosion. (C2) Lubrication (C3): Understanding the principles of lubrication and the selection of lubricants. (C3) Knowledge of different lubrication regimes and their applications. (C3) Ability to analyze lubrication requirements and select appropriate lubricants for specific applications. (C3) Effect of tribology on surface of nanomaterials (C3): Awareness of the impact of tribological processes on the surface properties of nanomaterials. (C3) Understanding the challenges and considerations for tribological testing and characterization of nanomaterial surfaces. (C3) Conventional surface engineering (C4): Knowledge of the principles and techniques used in conventional surface engineering. (C4) Understanding the surface modification methods and their effects on material properties. (C4) Types of surface modifications (C4):	

	Familiarity with different types of surface modifications, including physical and chemical methods. (C4) Understanding the advantages, limitations, and applications of each surface modification technique. (C4) Physical modifications (C4): Knowledge of physical surface modification techniques such as shot peening, surface grinding, and laser treatment. (C4) Understanding the effects of physical modifications on surface properties and material performance. (C4) Chemical modifications (C4): Understanding chemical surface modification techniques such as surface coating, plating, and chemical etching. (C4) Knowledge of the principles behind chemical modifications and their effects on material properties. (C4) Applications of surface engineering towards nanomaterials (C5): Familiarity with the application of surface engineering techniques to enhance the performance of nanomaterials. (C5) Understanding the unique challenges and considerations when applying surface engineering to nanomaterials. (C5)
2	Deposition and surface modification methods (C4): Understanding the principles and techniques of deposition for surface modification. (C4) Familiarity with various deposition methods used, including physical vapor deposition (PVD) and chemical vapor deposition (CVD). (C4) Physical vapor deposition (PVD) (C4): Knowledge of the process and equipment used in physical vapor deposition. (C4) Understanding the deposition mechanisms and the formation of thin films through PVD. (C4) Chemical vapor deposition (CVD) (C4): Familiarity with the process and equipment used in chemical vapor deposition. (C4) Knowledge of the deposition mechanisms and the growth of thin films through CVD. (C4) Advanced surface modification practices (C5): Understanding advanced techniques and practices for surface modification, such as ion implantation, plasma treatment, and laser surface engineering. (C5) Familiarity with the advantages and limitations of these advanced surface modification methods. (C5)

	Advantages of deposition for surface modification (C4): Knowledge of the benefits of deposition techniques in surface modification, including precise control over film thickness, composition, and microstructure. (C4) Understanding the improved surface properties achieved through deposition, such as enhanced hardness, wear resistance, and corrosion resistance. (C4) Synthesis, processing, and characterization of nano-structured coatings (C5): Familiarity with the methods of synthesizing nano-structured coatings, including bottom-up and top-down approaches. (C5) Understanding the processing techniques involved in the deposition of nano-structured coatings. (C5) Knowledge of the characterization methods used to assess the structure, morphology, and properties of nano-structured coatings. (C5) Functional coatings (C5): Understanding the concept of functional coatings and their applications in specific engineering contexts, such as anti-reflective coatings, self-cleaning coatings, and bioactive coatings. (C5) Knowledge of the materials and techniques used to create functional coatings with tailored properties. (C5) Advanced coating practices (C5): Familiarity with advanced coating methods, such as magnetron sputtering, atomic layer deposition (ALD), and electrochemical deposition. (C5) Understanding the advantages and limitations of these advanced coating practices. (C5) Characterization of nano-coatings (C5): Knowledge of characterization techniques used to evaluate the properties of nano-coatings, including surface roughness measurement, thickness analysis, and mechanical testing. (C5) Understanding the interpretation of characterization data to assess the performance and quality of nano-coatings. (C5) Applications of nano-coatings (C5): Familiarity with the diverse applications of nano-coatings in various industries, such as automotive, aerospace, electronics, and biomedical. (C5) Understanding the benefits and specific functional aspects of nano-coatings in these applications. (C5)
3	Need of advanced methods for surface and coating testing's (C4): Understanding the limitations of traditional testing methods for surface and coating evaluation. (C4) Recognizing the need for advanced techniques to assess the performance and quality of surfaces and coatings. (C4)

	Size dependency in nanostructures of nano-coatings (C5): Understanding the influence of size on the structural characteristics of nano-coatings. (C5) Recognizing the importance of size control in achieving desired properties and performance in nano-coatings. (C5) Size effect in electrochemical properties of nanostructured coatings (C5): Understanding how the size of nanostructures in coatings affects their electrochemical behavior and properties. (C5) Recognizing the size-dependent changes in corrosion resistance, conductivity, and other electrochemical characteristics of nanostructured coatings. (C5) Size effect in mechanical properties of nanostructured coatings (C5): Understanding the impact of size on the mechanical properties of nanostructured coatings, such as hardness, strength, and wear resistance. (C5) Recognizing the size-dependent changes in mechanical behavior and performance of nanostructured coatings. (C5) Size effect in physical and other properties of nanostructured coatings (C5): Recognizing the influence of size on various physical properties of nanostructured coatings, including optical, thermal, and magnetic properties. (C5) Understanding the size-dependent changes in other functional properties, such as surface energy, adhesion, and catalytic activity, in nanostructured coatings. (C5) Thin films for surface engineering of nanomaterials (C5): Understanding the use of thin films as a surface engineering technique for nanomaterials. (C5) Familiarity with the advantages and applications of thin films in modifying the surface properties of nanomaterials. (C5) Sputtering techniques (C4): Knowledge of the sputtering process and its variants, such as magnetron sputtering and reactive sputtering. (C4) Understanding the principles and parameters involved in sputtering thin film deposition. (C4) Evaporation processes (C4): Familiarity with the evaporation techniques used for thin film deposition, including thermal evaporation and electron beam evaporation. (C4) Knowledge of the process parameters and considerations for successful evaporation-based thin film deposition. (C4) Thin film deposition through gas phase techniques (C4): Understanding the gas phase deposition methods, such as chemical vapor deposition (CVD) and physical vapor deposition (PVD), used for thin film

	fabrication. (C4) Familiarity with the process principles and equipment involved in gas phase thin film deposition. (C4) Liquid phase techniques (C4): Knowledge of the liquid phase techniques employed for thin film deposition, such as dip coating, spin coating, and sol-gel processing. (C4) Understanding the advantages, limitations, and specific applications of liquid phase methods in thin film fabrication. (C4)
4	Processes, Microencapsulation: Kinetics of release (C4): Understanding the principles and mechanisms governing the release kinetics of microencapsulated materials. (C4) Familiarity with the factors influencing the rate and duration of release from microcapsules. (C4) Plating of nanocomposite coatings (C4): Knowledge of the plating techniques used to deposit nanocomposite coatings. (C4) Understanding the advantages and challenges associated with plating nanocomposite coatings. (C4) Advantages of microencapsulation over other conventional methods (C4): Recognizing the benefits of microencapsulation as a surface modification technique compared to other traditional methods. (C4) Understanding the enhanced stability, controlled release, and protection provided by microencapsulation. (C4) Current trends in surface modification of nanomaterials (C5): Keeping up-to-date with the latest advancements and emerging techniques in surface modification of nanomaterials. (C5) Familiarity with recent research and developments in the field of nanomaterial surface modification. (C5) Modified Nanomaterials: In-use for consumer products (C5): Recognizing the widespread application of modified nanomaterials in consumer products across various industries. (C5) Understanding the benefits and functionalities provided by modified nanomaterials in consumer goods. (C5) Main problems in synthesis of modified nanomaterials (C4): Identifying the common challenges and issues encountered during the synthesis of modified nanomaterials. (C4) Understanding the factors affecting the successful synthesis of modified nanomaterials, such as scalability, reproducibility, and stability. (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**

Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) Bharat Bhusan, Introduction to Tribology, John Wiley & Sons, USA.ISBN: 978-111994453,2013,
ii) Mahmood Aliofkhazrae,Nanocoatings: Size Effect in Nanostructured Films, Springer-Verlag, USA.2021,ISBN: 978-0444632371

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**SEC-IV (Digital Manufacturing)**
Academic Year	III
Semester	VI
Number of Credits	2
Course Prerequisite	Manufacturing Processes and Technology
Course Synopsis	This course introduces students to the concepts and tools of digital manufacturing, focusing on the integration of digital technologies in modern manufacturing processes. Students will learn about computer-aided design (CAD), computer-aided manufacturing (CAM), and additive manufacturing techniques. The course emphasizes hands-on experience with digital manufacturing software and equipment.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the principles and applications of digital manufacturing technologies.
CO2	Apply computer-aided design (CAD) software to create 3D models for manufacturing.
CO3	Utilize computer-aided manufacturing (CAM) software to generate tool paths for machining processes.
CO4	Implement additive manufacturing techniques and evaluate their advantages and limitations.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	3	1	1	1	-	1	1	1	3	2	1
CO2	3	3	3	2	3	1	1	-	-	1	1	1	3	3	1
CO3	3	3	3	2	3	-	-	-	-	-	1	1	3	3	-
CO4	3	3	3	3	3	-	-	-	-	-	1	1	3	3	-

Average	3	2.75	2.75	2.25	3	0.5	0.5	0.25	-	0.5	1	1	3	2.75	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Sr. No.	**Content & Competencies**
1	Introduction to Digital Manufacturing (4 hours) Overview of digital manufacturing concepts and technologies (C1: Remembering) Digitalization and Industry 4.0 (C2: Understanding) Trends and applications of digital manufacturing (C2: Understanding)
2	Computer-Aided Design (CAD) for Manufacturing (8 hours) Introduction to CAD software for manufacturing (C2: Understanding) 3D modeling techniques and best practices (C3: Applying) Design for manufacturability considerations (C3: Applying)
3	Computer-Aided Manufacturing (CAM) Basics (8 hours) CAM software overview and functionality (C2: Understanding) Toolpath generation for milling, turning, and drilling operations (C3: Applying) Simulation and verification of machining processes (C3: Applying)
4	CNC Machining and Tooling (8 hours) CNC machine tools and their components (C2: Understanding) Tooling selection and considerations (C3: Applying) Machining operations and strategies (C3: Applying)
5	Additive Manufacturing (8 hours) Introduction to additive manufacturing techniques (C2: Understanding) Types of 3D printers and their working principles (C2: Understanding) Design considerations for additive manufacturing (C3: Applying)
6	Simulation and Optimization in Digital Manufacturing (6 hours) Process simulation and optimization tools (C2: Understanding) Virtual prototyping and digital twin concepts (C4: Analyzing) Process parameter optimization (C3: Applying)
7	Quality Control and Inspection in Digital Manufacturing (6 hours) Metrology and inspection techniques in digital manufacturing (C2: Understanding) Geometric dimensioning and tolerancing (C3: Applying) Statistical process control (SPC) in manufacturing (C3: Applying)
8	Digital Manufacturing Applications and Case Studies (8 hours) Real-world applications of digital manufacturing (C4: Analyzing) Case studies and industry examples (C2: Understanding) Integration of digital manufacturing in supply chain management (C2: Understanding)

9	Project Work (10 hours) Hands-on project involving digital manufacturing processes (C5: Creating) Design and fabrication of a prototype using digital manufacturing techniques (C3: Applying) Documentation and presentation of the project (C3: Applying)

Teaching - Learning Strategies and Contact Hours

Teaching-Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	10
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	10
Revision	5
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Viva-voce	Practical Examination & Viva-voce
Problem Based Learning (PBL)	University Examination
Assignment	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Assignment	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process		1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through the Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of the semester.		
References:	(List of reference books)	
	1. "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David W. Rosen, and Brent Stucker, Springer Nature, Edition Year: 2015, ISBN: 978-1493921126 2. "Digital Manufacturing: The Industrialization of "Art to Part" 3D Additive Printing", Chandrakant Patel, Chun-Hsien Chen, Elsevier ISBN: 9780323950633 3. "Practical Guide to Digital Manufacturing: First-Time-Right for Design of Products, Machines, Processes and System Integration", Springer Nature, 2021, ISBN: 978-3-030-70303-5	

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Robot Operating and Control Systems**
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	**Robotics Engineering & Applications**
Course Synopsis	The main aim of this course is to introduce the Robot Operating and control system. This course gives a brief understanding of the UNIX, architecture of operating system, computation graph level, debugging and Visualization. To give a practical exposure various case studies will be introduced.

Course Outcomes:

At the end of the course students will be able to:

CO1	Describe the need for ROS and its significance. Summarize the Linux commands used in robotics.
CO2	Discuss about the concepts behind navigation through file system.
CO3	Explain the concepts of Node debugging
CO4	Analyze the issues in hardware interfacing and discuss about the applications of ROS

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	0	1	1	3	2	3	1	2	2	1	1	2	3	1
CO2	3	2	2	1	3	0	2	0	0	0	1	3	1	3	3
CO3	3	2	3	2	3	1	2	1	0	0	0	2	-	3	3
CO4	3	2	1	0	2	0	1	0	1	1	1	2	-	3	2
Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	0.75	3	2.25

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Introduction –The ROS Equation - History (C2): Understanding the basic concept and significance of the ROS (Robot Operating System) equation. (C2) Familiarity with the historical background and evolution of ROS as a prominent meta-operating system in robotics. (C2) Distributions - difference from other meta-operating systems (C3): Identifying the various distributions and versions of ROS available. (C3) Understanding the distinguishing features and advantages of ROS compared to other meta-operating systems in the context of robotics. (C3) Services - ROS framework (C2): Knowledge of the services provided by ROS for developing and controlling robotic systems. (C2) Understanding the architecture and components of the ROS framework. (C2) Operating system - releases (C2): Familiarity with the role of ROS as an operating system for robotics applications. (C2) Keeping up-to-date with the different releases and updates of ROS, including their new features and improvements. (C2) UNIX commands - file system - redirection of input and output (C2): Proficiency in using UNIX commands for file system management and manipulation. (C2) Understanding the concept and usage of input and output redirection in UNIX-based systems. (C2) File system security - Changing access rights (C3): Knowledge of file system security mechanisms and techniques, including changing access rights and permissions. (C3) Understanding the importance of maintaining secure file systems in the context of data protection and system integrity. (C3) Process commands - compiling, building, and running commands (C2): Proficiency in executing process commands in a UNIX-based environment, such as compiling, building, and running programs. (C2) Familiarity with the command-line tools and techniques used for software development and execution. (C2) Handling variables (C2):			

	Understanding the concept of variables in programming and their role in storing and manipulating data. (C2) Proficiency in handling variables within the UNIX command-line environment. (C2)
2	File system - packages - stacks - messages - services - catkin workspace - working with catkin workspace - working with ROS navigation and listing commands (C2): Understanding the organization of files and directories in the ROS file system. Familiarity with creating and managing packages and stacks in ROS. Knowledge of ROS messages and services and their role in communication between nodes. Proficiency in working with the catkin workspace for building and managing ROS packages. Ability to navigate and use ROS navigation and listing commands for exploring the file system and managing ROS components. Navigation through file system - Understanding of Nodes - topics - services - messages - bags - master - parameter server (C3): Proficiency in navigating through the ROS file system to locate and manage files and directories. Understanding the concept of nodes in ROS and their role in distributed computation. Knowledge of topics, services, and messages as communication mechanisms between nodes. Familiarity with ROS bags and their usage for recording and playing back data. Understanding the role of the ROS master in managing communication between nodes. Knowledge of the parameter server and its usage for storing and accessing configuration parameters in ROS.
3	Debugging of Nodes - topics - services - messages - bags - master - parameter - visualization using Gazebo - Rviz - URDF modeling - Xacro - launch files (C4): Proficiency in debugging nodes in ROS, including troubleshooting issues related to topics, services, messages, bags, the ROS master, and parameter settings. Ability to visualize and simulate robot models and environments using Gazebo and Rviz. Understanding and proficiency in creating and modifying URDF models using Xacro for robot description in ROS. Knowledge of launch files and their usage for managing multiple nodes and configurations in ROS.

	Hardware Interface: Sensor Interfacing - Sensor Drivers for ROS - Actuator Interfacing - Motor Drivers for ROS (C5): Proficiency in interfacing sensors with ROS, including writing sensor drivers to enable data acquisition and processing. Ability to interface actuators, such as motors, with ROS using motor drivers to control their movement and behavior. Understanding of hardware integration with ROS and the concepts of sensor-actuator communication in robotic systems.
4	Navigation stack - creating transforms - odometer - IMU - laser scan - base controller - robot configuration - cost map - base local planner - global planner - localization - sending goals - TurtleBot - the low-cost mobile robot (C4): Proficiency in setting up and configuring the navigation stack in ROS, which includes creating transforms to establish the coordinate systems between various sensors and the robot. Knowledge and utilization of odometry and IMU data for robot localization and pose estimation. Understanding and implementation of laser scan data processing for environment perception and obstacle avoidance. Ability to configure the base controller to control the motion of the robot, including velocity and trajectory planning. Familiarity with robot configuration files and their customization for specific robot models, such as the TurtleBot. Proficiency in building and utilizing cost maps for path planning and obstacle avoidance in navigation. Understanding and configuration of the base local planner, which determines the local trajectory of the robot based on sensor inputs and global planning. Knowledge and utilization of global planners to generate high-level paths for the robot to navigate towards predefined goals. Understanding and implementation of localization techniques, such as AMCL (Adaptive Monte Carlo Localization), for accurate position estimation of the robot. Ability to send goals to the navigation stack and monitor the robot's progress towards reaching those goals.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26

Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:
i) Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2013. **ii)** AnisKoubaa, “Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018. **iii)** Kumar Bipin, “Robot Operating System Cookbook”, Packt Publishing, 2018. **iv)** Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press, 2017. **v)** Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Robot Operating and Control Systems Lab**
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	**Robotics Engineering & Applications**
Course Synopsis	The main aim of this course is to introduce the Robot Operating and Control system. This course gives a brief understanding of the UNIX, architecture of operating system, computation graph level, debugging and Visualization. To give a practical exposure various case studies will be introduced.

Course Outcomes:

At the end of the course students will be able to:

CO1	Describe the need for ROS and its significance. Summarize the Linux commands used in robotics.
CO2	Discuss about the concepts behind navigation through file system.
CO3	Explain the concepts of Node debugging
CO4	Analyze the issues in hardware interfacing and discuss about the applications of ROS

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	-	-	-	1	-	2	**3**	**3**	**2**
CO2	3	2	2	2	2	1	-	-	-	1	-	3	**3**	**3**	**2**
CO3	3	2	2	2	2	1	-	-	-	1	-	3	**3**	**3**	**3**
CO4	3	2	2	2	2	1	-	-	-	1	-	3	**2**	**2**	**1**
Average	3	2	2	1.75	2	1	-	-	-	1	-	2.75	**2.75**	**2.75**	**2**

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sr. No.	**Content & Competencies**
1	To study various ROS and their significance. C1, C2
2	To study and understand the UNIX Commands used in Robotics C1, C2
3	To study the Navigation through file system. C1, C2
4	To study the Debugging of Nodes. C1, C2
5	To study the visualization using Gazebo. C1, C2
6	To study the Hardware Interface of Robots. C1, C2
7	To study the Sensor Interfacing and Sensor Drivers for ROS. C1, C2
8	To study the Actuator Interfacing and Motor Drivers for ROS. C1, C2

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce

--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) Jason M O'Kane, “A Gentle Introduction to ROS”, Create Space, 2013.
ii) Anis Koubaa, “Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
iii) Kumar Bipin, “Robot Operating System Cookbook”, Packt Publishing, 2018.
iv) Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press, 2017.
v) Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	EV Charging Infrastructure Technology
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	Introduction to Electric and Hybrid Vehicle
Course Synopsis	This subject deals with explaining various technical parameters of an EV charging infrastructural network. It also distinguishes between various types of batteries used for EV applications and to develop battery charger for an EV.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Elaborate various technical parameters of batteries.
CO2	Distinguish between various types of batteries used for EV applications.
CO3	Develop battery charger for an EV
CO4	Develop and Design the Charging Infrastructure.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	2	3	1	2	2	1	1	3	2	-
CO2	3	2	2	1	3	-	2	-	-	-	1	3	3	2	-
CO3	3	2	3	2	3	1	2	1	-	-	-	2	3	1	1
CO4	3	2	1	-	2	-	1	-	1	1	1	2	3	2	1
Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week

3	0	0	3

Unit	**Content & Competencies**
1	Cell and battery voltages (C1): Understand the concept of cell voltage, which is the electrical potential difference between the positive and negative terminals of a single cell (C1) Learn about battery voltage, which is the combined voltage of multiple cells connected in series (C1) Charge (or Amphour) capacity (C1): Understand the concept of charge capacity or amp-hour (Ah) capacity, which represents the total amount of electrical charge a battery can store (C1) Learn how charge capacity is measured and specified for different types of batteries (C1) Energy stored (C1): Understand that batteries store electrical energy in the form of chemical energy, which is converted to electrical energy during discharge (C1) Learn how to calculate the energy stored in a battery using the equation: Energy = Voltage x Charge Capacity (C1) Energy density (C1): Understand the concept of energy density, which refers to the amount of energy stored per unit volume or mass of the battery (C1) Learn how different battery chemistries have varying energy densities, which can affect their application and performance (C1) Specific power (C1): Understand the concept of specific power, which refers to the rate at which a battery can deliver electrical power per unit mass or volume (C1) Learn how specific power is influenced by the internal resistance and chemical reactions within the battery (C1) Amphour (or charge) efficiency (C1): Understand the concept of amp-hour efficiency, which measures the ratio of the actual charge delivered by the battery to the theoretical charge based on the battery's capacity (C1) Learn how factors such as internal resistance, self-discharge, and inefficiencies in charging and discharging processes can affect amp-hour efficiency (C1) Energy efficiency (C1): Understand the concept of energy efficiency, which measures the ratio of the energy output of the battery to the energy input during charging (C1) Learn how factors such as heat dissipation, losses in the charging/discharging process, and self-discharge can impact energy efficiency (C1) Self-discharge rates (C1): Understand that batteries can undergo self-discharge, which is the gradual loss of charge over time without any external load (C1) Learn about the factors that affect self-discharge rates, such as battery chemistry, temperature, and storage conditions (C1) Battery geometry (C1): Understand that batteries come in various shapes and sizes, and their geometry

	can impact factors such as capacity, energy density, and internal resistance (C1) Learn about common battery geometries, including cylindrical, prismatic, and pouch cells (C1) Battery temperature, heating, and cooling needs (C1): Understand that temperature has a significant impact on battery performance, including capacity, power output, and lifespan (C1) Learn about the ideal temperature range for battery operation and the need for thermal management systems to control temperature (C1) Battery life and number of deep cycles (C1): Understand that battery life refers to the expected lifespan of a battery, typically measured in cycles or years (C1) Learn that deep cycles, which involve discharging the battery to a low state of charge, can affect battery life and the number of cycles a battery can endure (C1)
2	Battery Chargers: Charge equalization (C3): Proficiency in understanding and implementing charge equalization techniques in battery charging systems. This involves balancing the charge levels of individual cells within a battery pack to ensure optimal performance and longevity. Conductive chargers - Basic charger circuits (C3): Proficiency in designing and analyzing basic charger circuits for conductive battery charging. This includes the understanding of charging algorithms, voltage and current regulation, and safety features. Microprocessor-based charger circuit (C4): Proficiency in designing and implementing charger circuits that utilize microprocessors or microcontrollers for advanced charging control and monitoring. This involves programming and integrating various functionalities such as charge termination, temperature monitoring, and communication interfaces. Arrangement of an off-board conductive charger (C2): Familiarity with the setup and configuration of off-board conductive chargers, which are designed to charge batteries outside of the device or system they are used in. This includes the understanding of connectors, cables, and safety considerations. Standard power levels of conductive chargers (C2): Understanding the different power levels and charging standards associated with conductive chargers. This includes knowledge of charging rates, voltage levels, and compatibility with different battery chemistries and applications. Inductive chargers - Principle of inductive charging (C3): Proficiency in understanding the principles of inductive charging, which involves transferring energy wirelessly through electromagnetic fields between

	a charging pad or base station and the battery. This includes knowledge of magnetic coupling, resonant circuits, and power transfer efficiency. Soft-switching power converter for inductive charging (C4): Proficiency in designing and implementing soft-switching power converters specifically for inductive charging applications. This involves the use of advanced switching techniques to reduce power losses and improve overall efficiency. Battery indication methods (C2): Familiarity with different methods used to indicate the state of charge or battery status. This includes visual indicators (LEDs), digital displays, or communication interfaces that provide information about the battery's charge level, voltage, or remaining capacity
3	Lead Acid Batteries: Lead acid battery basics (C2): Understanding the fundamental principles and construction of lead acid batteries, including the electrochemical reactions and components involved. Special characteristics of lead acid batteries (C2): Familiarity with the unique characteristics of lead acid batteries, such as their ability to deliver high currents, tolerance to overcharging, and low self-discharge rates. Battery life and maintenance (C2): Understanding the factors that affect the lifespan of lead acid batteries and the maintenance practices required to maximize their performance and longevity. Battery charging (C3): Proficiency in the principles and techniques of charging lead acid batteries, including proper voltage and current regulation, charge termination methods, and considerations for different charging rates. Nickel-based Batteries: Introduction to Nickel-based Batteries (C2): Understanding the basics of nickel-based batteries, including their composition, working principles, and common applications. Nickel Cadmium (C2): Familiarity with the specific characteristics, advantages, and limitations of nickel-cadmium (NiCd) batteries, including their energy density, memory effect, and environmental considerations. Nickel Metal Hydride Batteries (C2): Understanding the features, advantages, and limitations of nickel-metal hydride (NiMH) batteries, including their higher energy density, lack of memory effect, and applications in various devices. Sodium-based Batteries: Introduction to Sodium-based Batteries (C2): Understanding the basics of sodium-based batteries, including their composition, working principles, and potential applications. Sodium Sulphur Batteries (C2): Familiarity with the characteristics and

	considerations of sodium-sulphur (NaS) batteries, including their high energy density, operating temperature requirements, and applications in grid-level energy storage. Sodium Metal Chloride (Zebra) Batteries (C2): Understanding the features and advantages of sodium metal chloride (Zebra) batteries, including their high operating temperature, long cycle life, and suitability for renewable energy storage. Lithium Batteries: Introduction to Lithium Batteries (C2): Understanding the basics of lithium batteries, including their composition, working principles, and widespread use in various applications. The Lithium Polymer Battery (C2): Familiarity with the characteristics and considerations of lithium polymer batteries, including their flexible form factor, high energy density, and applications in portable electronic devices. The Lithium-ion Battery (C2): Understanding the features, advantages, and limitations of lithium-ion (Li-ion) batteries, including their high energy density, low self-discharge rate, and applications in electric vehicles, laptops, and smartphones. Metal Air Batteries: Introduction to Metal Air Batteries (C2): Understanding the basics of metal air batteries, including their composition, working principles, and potential advantages in terms of energy density and cost-effectiveness. The Aluminum Air Battery (C2): Familiarity with the characteristics and considerations of aluminum-air batteries, including their high theoretical energy density, challenges associated with electrolyte management, and potential applications in electric vehicles. The Zinc Air Battery (C2): Understanding the features and advantages of zinc-air batteries, including their high energy density, long shelf life, and applications in hearing aids and other small electronic devices.
4	Domestic Charging Infrastructure (C1): Understanding the concept of domestic charging infrastructure for electric vehicles (EVs) and its role in enabling convenient and accessible charging at residential locations. Public Charging Infrastructure (C1): Understanding the concept of public charging infrastructure for EVs and its significance in providing charging facilities in public spaces, such as parking lots, shopping centers, and roadside stations. Normal Charging Station (C1): Familiarity with normal charging stations that provide standard charging power

	levels for EVs, typically using alternating current (AC) chargers. Knowledge of their functionality, interface, and charging time. Occasional Charging Station (C1): Understanding occasional charging stations, which are designed for intermittent or occasional use, such as at workplaces, recreational areas, or other locations where EV users may spend longer periods. Fast Charging Station (C2): Proficiency in the concept of fast charging stations that provide higher charging power levels, enabling quicker charging times for EVs. Knowledge of direct current (DC) fast chargers and their compatibility with different EV models. Battery Swapping Station (C2): Understanding battery swapping stations, where the depleted battery of an EV can be exchanged for a fully charged one, enabling rapid turnaround times and extending the driving range of EVs. Move-and-charge Zone (C1): Familiarity with move-and-charge zones, which incorporate wireless charging technologies or conductive charging systems embedded in the road or parking surfaces. Understanding their potential to provide continuous charging while driving or parking.

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1

Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References: (List of reference books)

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	EV Charging Infrastructure Technology Lab
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	Introduction to Electric and Hybrid Vehicle
Course Synopsis	This subject deals with explaining various technical parameters of an EV charging infrastructural network. It also distinguishes between various types of batteries used for EV applications and to develop battery charger for an EV.

Course Outcomes:

At the end of the course students will be able to:

CO1	Elaborate various technical parameters of batteries.
CO2	Distinguish between various types of batteries used for EV applications.
CO3	Develop battery charger for an EV
CO4	Develop and Design the Charging Infrastructure.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	2	3	1	2	2	1	1	3	2	-
CO2	3	2	2	1	3	-	2	-	-	-	1	3	3	2	-
CO3	3	2	3	2	3	1	2	1	-	-	-	2	3	1	1
CO4	3	2	1	-	2	-	1	-	1	1	1	2	3	2	1
Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Sr. No.	Content & Competencies
1	To study about different charging systems: Constant voltage, Constant current & Pulse charging systems. (C1, C2)
2	To study principle and analyze performance of AC and DC chargers, Semi-fast, fast and quick chargers. (C1, C2)
3	To study about different types of Batteries used in EV's. (C1,C2)
4	Analysis of Dynamic wireless charger. (C1, C2)
5	To study about Wireless standards including Qi, PMA, A4WP, Magnet, conductive charger standard including CHAdeMO, SAE and IEC, Connection and plug. (C1, C2)
6	Analysis of pantograph and study about load management. (C1, C2)
7	To study about battery swapping technology. (C1, C2)
8	Comparison of EV technology with Hydrogen and solid fuel technologies. (C1, C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA

Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

- **i)** Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
- **ii)** C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
- **iii)** Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
- **iv)** James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	Data Visualization
Academic Year	III
Semester	VI
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	To enable students with a basic understanding of recent advancements in Big Data and using insights, statistical models, visualization techniques for its effective application in Business intelligence. The course covers topics like: Big Data Technology Landscape, Business implementation of Big data, Hive (ETL), Pig, sparkR, Hadoop, framework for big data analysis, OLTP vs OLAP, Tableau.

Course Outcomes:

At the end of the course students will be able to:

CO1	Develop in depth understanding of the key technologies in data science and business analytics: Extraction transformation and loading (ETL) using Hive and Pig, machine learning, predictive modelling and visualization techniques.
CO2	Work with Big Data framework: Hadoop (HDFS and MapReduce), Hadoop Ecosystem & spark.
CO3	Employ cutting edge tools and technologies to analyze Big Data.
CO4	Understanding the concept of analysis of big data.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO4
CO1	3	2	1	-	-	-	-	-	-	-	-	1	1	1	-	-
CO2	3	2	1	1	-	-	-	-	-	-	-	1	1	1	1	-
CO3	3	2	1	-	-	-	-	-	-	-	-	1	-	1	-	-
CO4	3	2	1	1	-	-	-	-	-	-	-	1	-	1	1	-
Average	3	2	**1**	0.5	-	-	-	-	-	-	-	**1**	0.5	**1**	0.5	-

Course Content:

L (Hours/ Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**-**	**-**	**3**

Unit	Content & Competency’s	Competency
1	Give brief Introduction to Data Analytics. (C2: Comprehension) 1. Define the following terms: Data Visualization, correlation, Regression, Forecasting, Classification, Clustering. (C1: Knowledge) 2. Describe Fundamentals of Big Data. (C2: Comprehension) 3. Analyze Big Data Technology Component. (C4: Analysis) 4. Explain Big Data Architecture and Big Data Warehouse. (C2: Comprehension) 5. Distinguish Functional vs Procedural programming models for Big Data. (C2: Comprehension)	
2	1. Explain Hadoop Ecosystem with HDFS, MapReduce, Pig Overview, Pig Grunt Shell. (C2: Comprehension) 2. Describe Hive Architecture. (C2: Comprehension) 3. State HQL & Advanced HQL. (C1: Knowledge) 4. Explain Spark Overview, Spark RDD and SparkR. (C2: Comprehension)	
3	1. Discuss: i) Latest trends in big data. a. ii) big data computation. b. iii) more on big data storage.	

	2. Discuss big data computational limitations. (C2: Comprehension) 3. Explain Big data analytics and framework for big data analysis. (C2: Comprehension)
4	1. Describe Approaches for analysis of big data. (C2: Comprehension) 2. Define Decision trees. (C1: Knowledge). 3. Explain predictive analysis on big data. (C2: Comprehension) 4. Discuss Text analysis and big data using twitter data. (C2: Comprehension) 5. Explain the role of data analyst. (C2: Comprehension) 6. Explain following: BI, Business View of IT applications, Digital Data, Why, What and How BI? BI project life cycle. (C2: Comprehension) 7. Differentiate OLTP vs OLAP. (C2: Comprehension)

Teaching Learning Strategies and Contact Hours

Learning Strategies	**Contact Hours**
Lecture	30
Practical	
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	2
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	3
Revision	4
Others If any:	
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Quiz	Mid Semester Examination 2
Seminars	University Examination
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✔	✔	✔	✔
Assignment / Presentation	✔	✔	✔	✔
Unit test	✔	✔	✔	✔
Mid Semester Examination 1	✔	✔	✔	✔
Mid Semester Examination 2	✔	✔	✔	✔
University Examination	✔	✔	✔	✔
Feedback Process	1. Student’s Feedback			

References:	Textbooks: 1. Michael Minelli,Michele Chambers and Ambiga Dhiraj, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses (1 ed.), Wiley CIO, 2013. ISBN 978-8126544691. 2. Alapati Sam R., Expert Hadoop Administration: Managing, Tuning, and Securing Spark, YARN, and HDFS (1 ed.), Pearson Education, 2017. ISBN 978- 9386873538.
	References: 1. T. white, Hadoop: The Definitive Guide (3 ed.), O’ Reilly Media, 2012. ISBN 978-1449311520.

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Data Visualization Lab
Academic Year	III
Semester	VI
Number of Credits	1
Course Prerequisite	NIL
Course Synopsis	To enable students with a basic understanding of recent advancements in Big Data and using insights, statistical models, visualization techniques for its effective application in Business intelligence. The course covers topics like: Big Data Technology Landscape, Business implementation of Big data, Hive (ETL), Pig, sparkR, Hadoop, framework for big data analysis, OLTP vs OLAP, Tableau.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Develop in depth understanding of the key technologies in data science and business analytics: Extraction transformation and loading (ETL) using Hive and Pig, machine learning, predictive modelling and visualization techniques.
CO2	Work with Big Data framework: Hadoop (HDFS and MapReduce), Hadoop Ecosystem & spark.
CO3	Employ cutting edge tools and technologies to analyze Big Data.
CO4	Understanding the concept of analysis of big data.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3	PSO4
CO1	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1	-
CO2	3	2	1	-	-	-	-	-	-	-	-	1	1	1	1	-
CO3	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1	-
CO4	3	2	1	1	1	-	-	-	-	-	-	1	1	1	1	-
Average	3	2	1	0.5	0.5	-	-	-	-	-	-	1	0.5	0.5	1	-

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	**0**	**2**	**2**

Content & Competency

Sr. No.	Title
1	Install Oracle Virtual box and create two VMs on your laptop. (C3: Application)
2	Install Turbo C in guest OS and execute C program. (C3: Application)
3	Test ping command to test the communication between the guest OS and Host OS. (C5: Synthesis)
4	Develop a simple hadoop application called Word Count. It counts the number of occurrences of each word in a given input set. (C5: Synthesis)
5	Develop hadoop application to count no of characters, no of words and each character frequency. (C5: Synthesis)
6	Develop hadoop application to process given data and produce results such as finding the year of maximum usage, year of minimum usage. (C5: Synthesis)
7	Develop hadoop application to process given data and produce results such as how many female and male students in both schools the results should be in following format. GP-F #number GP-M #numbers MS-F #number MS-M #number (C5: Synthesis)

8	Establish an AWS account. Use the AWS Management Console to launch an EC2 instance and connect to it. (C5: Synthesis)
9.	Design a protocol and use Simple Queue Service(SQS)to implement the barrier synchronization after the first phase. (C5: Synthesis)
10	Use the Zookeeper to implement the coordination model in Problem 10. (C3: Application)
Note:	

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	05
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination	University Examination

(OSPE)	
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✔	✔	✔	✔
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✔	✔	✔	✔
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✔	✔	✔	✔

Feedback Process	1. Student's Feedback 2. Course Exit Survey

References:	Textbooks: 1. Michael Minelli,Michele Chambers and Ambiga Dhiraj, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's

	Businesses (1 ed.), Wiley CIO, 2013. ISBN 978-8126544691. 2. Alapati Sam R., Expert Hadoop Administration: Managing, Tuning, and Securing Spark, YARN, and HDFS (1 ed.), Pearson Education, 2017. ISBN 978-9386873538.
	References: 1. T. white, Hadoop: The Definitive Guide (3 ed.), O' Reilly Media, 2012. ISBN 978-1449311520.

SEMESTER - VII

Course Code	Course Title
	Industrial Engineering
	Heat and Mass Transfer
	Automation in Manufacturing
	Machine Learning for Mechanical Engineering
Program Electives Course - V	
	Renewable Energy
	Rapid Manufacturing Technologies
	Work Study
	Mechatronics
	Chassis Design
	Heat and Mass Transfer Lab
	Automation in Manufacturing Lab
	Machine Learning for Mechanical Engineering Lab
	Industrial Training-II
	Capstone Project
Minor Elective Course-V (Robotics)	
	Cognitive Robotics
	Cognitive Robotics Lab
Minor Elective Course-V (Electric Vehicles)	
	Modelling and Simulation of EHV
	Modelling and Simulation of EHV Lab

Minor Elective Course-V (Computer Science Engineering)	
	Software Engineering
	Software Engineering Lab

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Industrial Engineering
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Manufacturing Processes and Technology
Course Synopsis	This course introduces the concepts of manufacturing economics and its critical parameters. Introducing thoroughly the concepts of Productivity, Fixed and Variable costs, Materials management, EOQ, Inventory management, Quality management, Production planning and control and Management Information systems.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Define and measure various productivities in industrial manufacturing.
CO2	Perform full cost analysis for a manufacturing system.
CO3	Understand the concept of Inventory control and its application.
CO4	Explain key features of Industrial and Quality Management.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	2	1	2	3	3	3	3	3	2	-
CO2	3	-	-	-	2	2	1	2	3	3	3	2	3	2	1
CO3	3	-	-	-	2	2	1	2	3	3	3	3	3	1	-
CO4	3	-	-	-	2	2	1	2	3	3	3	2	3	3	-
Average	3	-	-	-	1.75	2	1	2	3	3	3	2.5	3	2	0.25

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	**Definition of Industrial Engineering:** Objectives: Understanding the objectives of industrial engineering (C1) Method study: Learning about the concept and techniques of method study (C2) Principle of motion economy: Understanding the principles of motion economy in industrial engineering (C2) Techniques of method study - Various charts, THERBLIGS: Learning different techniques and tools used in method study, such as various charts and THERBLIGS (C3) Work measurement - various methods: Understanding different methods used for work measurement in industrial engineering (C2) Time study PMTS, determining time: Learning about time study techniques and how to determine time for different tasks (C3) Work sampling: Understanding the concept and application of work sampling in industrial engineering (C2) Numerical: Applying numerical methods and calculations in industrial engineering (C2) Productivity & Workforce Management: Productivity - Definition: Understanding the concept and definition of productivity in industrial engineering (C1) Various methods of measurement: Learning different methods used to measure productivity in industrial settings (C2) Factors affecting productivity: Understanding the factors that influence productivity in the workplace (C2) Strategies for improving productivity: Learning about various strategies and approaches to improve productivity (C3) Various methods of Job evaluation & merit rating: Understanding different methods used for job evaluation and merit rating (C3) Various incentive payment schemes: Learning about different incentive payment schemes used to motivate employees and improve productivity (C2) Behavioral aspects: Understanding the influence of human behavior on productivity and workforce management (C3) Financial incentives: Learning about the role of financial incentives in motivating employees and increasing productivity (C3)			
2	Manufacturing Cost Analysis: Fixed & variable costs: Understanding the concept of fixed and variable costs in			

	manufacturing (C1) Direct, indirect & overhead costs: Differentiating between direct, indirect, and overhead costs in manufacturing (C2) Job costing: Understanding the principles and methods of job costing in manufacturing (C2) Recovery of overheads: Learning about the techniques and approaches for overhead recovery in manufacturing (C2) Standard costing: Understanding the concept and application of standard costing in manufacturing (C2) Cost control: Learning strategies and techniques for controlling costs in manufacturing (C3) Cost variance Analysis - Labor, material, overhead in volume, rate & efficiency: Analyzing cost variances in labor, material, and overhead based on volume, rate, and efficiency (C3) Break even Analysis, Marginal costing & contribution: Understanding break-even analysis, marginal costing, and contribution in manufacturing (C2) Numerical: Applying numerical methods and calculations in manufacturing cost analysis (C2) Materials Management: Strategic importance of materials in manufacturing industries: Understanding the strategic importance of materials in manufacturing (C1) Relevant costs: Identifying and analyzing relevant costs in materials management (C2) Introduction to Forecasting: Simple & Weighted moving average methods: Learning about simple and weighted moving average methods for forecasting (C2) Objectives & variables of PPC: Understanding the objectives and variables of production planning and control (C1) Aggregate planning - Basic Concept, its relations with other decision areas: Understanding the concept of aggregate planning and its relationship with other decision areas in manufacturing (C2) Decision options - Basic & mixed strategies: Exploring basic and mixed strategies for decision making in manufacturing (C2) Master production schedule (MPS): Understanding the concept and importance of the master production schedule in manufacturing (C2) Scheduling Operations: Learning various methods for scheduling operations in manufacturing, including line and intermittent production systems (C3) Various methods for line & intermittent production systems, Gantt chart: Applying various methods and tools, such as Gantt charts, for scheduling line and intermittent production systems (C2)

	Introduction to JIT: Understanding the basics of Just-in-Time (JIT) manufacturing (C1) Numerical: Applying numerical methods and calculations in forecasting and production planning (C2)
3	Purchase discounts: Understanding the concept and calculation of purchase discounts in inventory management (C2) Sensitivity analysis: Analyzing the impact of changes in variables on inventory management decisions (C3) Inventory control systems - P, Q, S's Systems: Understanding different inventory control systems, including the P system, Q system, and S system (C2) Service level: Understanding the concept of service level and its importance in inventory management (C1) Stock out risk: Assessing and managing the risk of stockouts in inventory management (C2) Determination of order point & safety stock: Calculating the order point and safety stock levels to ensure efficient inventory management (C2) Selective inventory control - ABC, FSN, SDE, VED and three-dimensional: Understanding and implementing selective inventory control methods, such as ABC analysis, FSN analysis, SDE analysis, VED analysis, and three-dimensional analysis (C3) Numericals: Applying numerical methods and calculations in inventory control and management (C2)
4	Product Design and Development: Understanding various approaches to product design and development (C2) Knowledge of the product life cycle and its stages (C2) Recognizing the role of 3S's (Standardization, Simplification, Specialization) in product design (C1) Introduction to value engineering and analysis in product development (C1) Understanding the importance of ergonomics in product design (C2) Definition of quality: Understanding the concept of quality and its definition (C1) Familiarity with various approaches to achieving quality (C2) Concept of quality assurance systems: Knowledge of different quality assurance systems (C2) Understanding the costs associated with quality (C2) Statistical quality control (SQC): Understanding the principles of statistical quality control (C2) Knowledge of variables and attributes in SQC (C2) Ability to use X, R, P, and C-charts for quality control (C3) Acceptance sampling:

	Knowledge of acceptance sampling techniques (C2) Understanding the concept of the operating characteristic (OC) curve (C2) Familiarity with the concept of average outgoing quality limit (AOQL) (C2) Knowledge of single, double, and sequential sampling plans (C2) Introduction to Total Quality Management (TQM) and ISO-9000: Understanding the concept of Total Quality Management (TQM) (C1) Familiarity with ISO-9000 standards for quality management (C1)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	27
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	4
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	8
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. Industrial Engineering and organization management by S K Sharma and Swati Sharma (2013) SK Kataria & Sons Publishing House ISBN-13:978-8185749136 2. Industrial Engineering and production management by Martand Telsang (2006) S Chand; 2nd Revised Edition 2018 edition ISBN-13: 978-8121917735 3. Industrial Engineering and Management by O P Khanna Dhanpat Rai Publications (2018) ISBN-13: 978-8189928353.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Heat and Mass Transfer
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Engineering Thermodynamics
Course Synopsis	An introductory course in heat and mass transfer covering conduction, convection and radiation heat transfer, principles of heat exchanger and mass transfer. Heat transfer and mass transfer are kinetic processes that may occur and be studied separately or jointly. Studying them apart is simpler, but both processes are modeled by similar mathematical equations in the case of diffusion and convection (there is no mass-transfer similarity to heat radiation), and it is thus more efficient to consider them jointly.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply basic principles of fluid mechanics, thermodynamics, heat transfer for designing heat and mass transfer systems.
CO2	Model heat, mass and momentum transport systems and develop predictive correlation.
CO3	Model heat, mass and momentum transport systems and develop predictive correlation.
CO4	Apply the basic principles of heat exchanger applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	1	0	1	0	0	0	3	2	3	1
CO2	3	2	3	3	2	1	0	0	0	1	1	3	1	3	3
CO3	3	2	3	3	2	1	0	0	0	0	1	3	-	3	3
CO4	3	3	3	3	3	2	0	0	1	1	0	3	-	3	2
Average	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Basic concepts of heat transfer: Understanding the modes of heat transfer: conduction, convection, and radiation (C2) Familiarity with the laws governing heat transfer (C2) General equation of heat conduction: Knowledge of the general equation of heat conduction (C3) Ability to derive the equation in Cartesian and cylindrical coordinates (C4) One-dimensional steady-state heat conduction: Understanding of one-dimensional steady-state heat conduction (C2) Knowledge of heat transfer in simple geometries such as plane walls, cylinders, and spheres (C3) Heat transfer in composite walls, cylinders, and spheres: Familiarity with heat transfer in composite walls, cylinders, and spheres (C2) Understanding the concept of critical thickness of insulation (C2) Thermal contact resistance: Knowledge of thermal contact resistance (C3) Ability to calculate and analyze overall heat transfer coefficients (C4) Electrical analogy: Understanding the concept of using an electrical analogy for heat transfer analysis (C2) Heat generation in plane walls, cylinders, and spheres: Familiarity with heat generation in plane walls, cylinders, and spheres (C2) Extended surfaces: Understanding the concept of extended surfaces and their heat transfer characteristics (C2)			
2	Two- and Three-dimensional steady-state heat conduction: Understanding of two- and three-dimensional steady-state heat conduction (C2) Knowledge of analytical, graphical, and numerical methods for solving heat conduction problems (C3) Unsteady state heat conduction: Familiarity with unsteady state heat conduction (C2) Understanding of lumped parameter systems and their application in analyzing transient heat conduction (C3) Non-dimensional numbers in conduction: Knowledge of non-dimensional numbers such as Biot number and Fourier			

	number and their significance in conduction problems (C3) Types and applications of fins: Understanding the different types of fins and their applications in heat transfer (C2) Fin efficiency and effectiveness: Knowledge of fin efficiency and effectiveness and their importance in evaluating the performance of fins (C3) Fin performance: Familiarity with factors affecting the performance of fins and their optimization (C2)
3	Boundary layer theory: Understanding of boundary layer theory and its application to fluid flow (C2) Conservation equations for laminar flow: Knowledge of conservation equations of mass, momentum, and energy for laminar flow over a flat plate (C3) Turbulent flow over a flat plate: Familiarity with the behaviour of turbulent flow over a flat plate (C2) Internal flow through pipes and annular spaces: Understanding of internal flow characteristics and calculations for pipes and annular spaces (C3) Analogy between momentum and heat transfer: Knowledge of the analogy between momentum and heat transfer in fluid flow (C3) Natural convection in vertical: Familiarity with natural convection phenomena in vertical orientations (C2) Dimensional analysis: Understanding of dimensional analysis and its application in fluid flow and heat transfer problems (C3)
4	Condensation and Boiling: Understanding of condensation and boiling processes (C2) Knowledge of film-wise and drop-wise condensation (C3) Familiarity with film condensation on a vertical plate (C2) Understanding of different regimes of boiling (C2) Knowledge of forced convection boiling (C3) Radiation heat transfer: Understanding of radiation heat transfer (C2) Familiarity with thermal radiation and the laws governing radiation (C2) Knowledge of the black body concept and emissive power (C3) Understanding of radiation shape factor and its significance (C2) Familiarity with gray bodies and radiation shields (C2)

	Heat Exchangers: Knowledge of different types of heat exchangers and their practical applications (C3) Understanding of the use of Log Mean Temperature Difference (LMTD) and effectiveness-NTU methods in heat exchanger analysis (C3) Familiarity with compact heat exchangers, including plate heat exchangers (C2) Understanding of fouling factors and their impact on heat exchanger performance (C2) Knowledge of heat pipes and their applications (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓

<table>
<tr><td colspan="2">Mid Semester Examination 1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">Mid Semester Examination 2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">University Examination</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">Feedback Process</td><td colspan="4">1. Student’s Feedback
2. Course Exit Survey</td></tr>
<tr><td colspan="6">Students Feedback is taken through various steps
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<tr><td>References:</td><td colspan="5">(List of reference books)</td></tr>
<tr><td></td><td colspan="5">(i)R. C. Sachdeva (2005), Fundamentals of Heat and Mass Transfer, New Age International (P) Ltd. ISBN: 978-8-122-40076-2.
ii) P. K. Nag (2005), Heat Transfer, Tata McGraw Hill Publishing Company Limited. ISBN: 978-0-
070-60653-1.
iii) J. P. Holman (2005), Heat Transfer, 9th Edition, McGraw-Hill Publishing Company Limited.
ISBN: 978-0-070-29618-3.
iv) Dewitt Lavine, Bergmann and Incropera (2010), Fundamentals of Heat and Mass Transfer,
6th Edition, John Wiley & Sons, ISBN: 978-8-126-52764-9.
v) M. NecatOzisik, Helcio R.B. Orlande (2021), Inverse Heat Transfer: Fundamentals and Applications, 2nd Edition, CRC Press, Taylor & Francis, ISBN 9780367820671.</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Automation in Manufacturing
Academic Year	IV
Semester	VII
Number of Credits	2
Course Prerequisite	Manufacturing Processes and Technology
Course Synopsis	Automation in manufacturing is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. Students learn the importance of CAD/CAM principles in the Product development, programs related to manufacturing using codes and analyze the importance of networking in the manufacturing environment.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To understand the importance of Automation in Manufacturing.
CO2	To develop programs related to manufacturing using codes.
CO3	To understand the concept of group technology and flexible manufacturing system.
CO4	To understand in details about computer integrated manufacturing.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	1	1	-	-	-	1	-	3	2	3	1	1
CO2	3	2	3	3	3	-	-	-	1	-	-	2	3	1	-
CO3	3	2	1	1	2	-	-	-	2	-	2	3	3	2	-

CO4	3	2	1	1	1	-	-	-	3	2	3	2	3	3	1
Average	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
2	**0**	**0**	**2**

Unit	Content & Competencies
1	Types and strategies of automation: Understanding of different types of automation (C2) Knowledge of strategies for implementing automation in various industries (C3) Pneumatic and hydraulic components circuits: Familiarity with pneumatic and hydraulic components and their circuits (C2) Understanding of the working principles and applications of pneumatic and hydraulic systems (C3) Automation in machine tools: Knowledge of automation techniques used in machine tools (C3) Understanding of the integration of automation systems with machine tools (C3) Mechanical feeding and transfer in automation: Understanding of mechanical feeding and transfer mechanisms in automated systems (C3) Knowledge of machine tool control in automation (C3) Methods of work part transport and mechanical buffer storage: Familiarity with methods of work part transport in automated systems (C2) Understanding of mechanical buffer storage in automation (C2) Knowledge of control functions related to work part transport and buffer storage (C3) Design and fabrication considerations in automation: Understanding of design considerations in the implementation of automation (C3) Knowledge of fabrication considerations for automated systems (C2) Analysis of automated flow lines: Familiarity with the terminology related to automated flow lines (C2) Understanding of the analysis of transfer lines with and without buffer storage (C3) Knowledge of partial automation and its implementation (C3)
2	Automated material handling: Understanding of different types of equipment used in automated material

	handling (C2) Knowledge of the functions and capabilities of material handling systems (C3) Ability to analyze and design efficient material handling systems (C4) Familiarity with conveyor systems and their applications (C2) Knowledge of automated guided vehicle (AGV) systems and their operation (C3) Automated storage systems: Understanding of automated storage and retrieval systems (AS/RS) (C2) Knowledge of work-in-process storage and its integration with manufacturing processes (C3) Ability to interface handling and storage systems with manufacturing operations (C4)
3	Introduction to part families: Understanding the concept of part families and their importance in manufacturing (C2) Parts classification and cooling: Knowledge of different methods of parts classification (C2) Understanding the importance of cooling in manufacturing processes (C2) Group technology machine cells: Familiarity with group technology and its application in machine cells (C2) Understanding the benefits of implementing group technology in manufacturing (C3) Process Planning: Knowledge of Computer-Aided Process Planning (CAPP) (C2) Understanding the different types of CAPP systems (C3) Flexible manufacturing systems (FMS): Understanding the concept and components of flexible manufacturing systems (C2) Familiarity with Computer-Integrated Manufacturing Systems (CIMS) (C3) Knowledge of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) (C2)
4	Introduction to NC, CNC, DNC: Understanding the concepts of Numerical Control (NC), Computer Numerical Control (CNC), and Distributed Numerical Control (DNC) (C2) Manual part Programming: Familiarity with manual programming techniques for NC/CNC machines (C2) Ability to write NC codes manually for basic machining operations (C3) Computer Assisted Part Programming: Knowledge of Computer Assisted Part Programming methods (C2) Understanding the use of software tools to generate NC codes for machining

	operations (C3) Examples using NC codes: Ability to analyze and interpret sample NC code programs (C3) Understanding the sequence of commands and operations in NC code (C2) Adaptive Control: Familiarity with Adaptive Control systems and their application in machining processes (C2) Understanding the benefits and challenges of adaptive control (C3) Canned cycles and subroutines: Knowledge of canned cycles and subroutines in CNC programming (C2) Ability to use predefined machining cycles and subroutines to simplify programming tasks (C3) CAD/CAM approach to NC part programming: Understanding the integration of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) in NC part programming (C2) Knowledge of using CAD/CAM software to generate NC programs directly from 3D models (C3) APT language, machining from 3D models: Familiarity with APT (Automatically Programmed Tools) language for NC programming (C2) Ability to generate NC programs from 3D models using APT or similar programming languages (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	17
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	8
Case/Project Based Learning (CBL)	--
Revision	1
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**

Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References: (List of reference books)

1. Mikell P. Groover (2008), Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Pearson Education. ISBN: 978-8-120-33418-2.
2. Ibrahim Zeid (2009), Mastering CAD/CAM, 2nd Edition, Tata McGraw Hill International Edition, ISBN: 978-0-070- 15134-5.
3. P N Rao (2010), CAD/CAM Principles and Applications, 3rd Edition, Tata McGraw-Hill Education, ISBN: 978-0-070- 68193-4.
4. James A. Rehg and Henry W. Kraebber (2004), Computer Integrated Manufacturing, 3rd Edition, Pearson Education, ISBN: 978-0-131-13413-3

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Machine Learning for Mechanical Engineers
Academic Year	IV
Semester	VII
Number of Credits	1
Course Prerequisite	NA
Course Synopsis	This course deals with the basics of programming (Python) and use of linear Algebra, Statistics, probabilistic distributions etc. in it. Basics of Machine learning, data interpretation and mathematical tools like Regression analysis and its types used in various machine learning models. This course also includes a brief introduction to Neural Networks and its uses.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Able to differentiate machine learning from normal computer programming.
CO2	Able to interpret a given data for drawing inference, forecasting etc.
CO3	Able to successfully employ various mathematical tools to develop a machine learning algorithm.
CO4	Able to understand the basic structure and applications of Neural Networks.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	-	-	-	1	-	3	2	3	1	1
CO2	3	2	3	3	3	-	-	-	1	-	-	2	3	1	-
CO3	3	2	1	1	2	-	-	-	2	-	2	3	3	2	-
CO4	3	2	1	1	1	-	-	-	3	2	3	2	3	3	1

Average	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
1	0	0	1

Unit	Content & Competencies
1	Programming in Python and Libraries (Numpy, Pandas, Matplotlib, Seaborn): Proficiency in programming using Python language (C3) Ability to utilize Python libraries such as Numpy, Pandas, Matplotlib, and Seaborn for data manipulation, analysis, and visualization (C3) Linear Algebra with Python: Understanding and application of linear algebra concepts using Python (C3) Ability to perform matrix operations, solve linear equations, and compute eigen values and eigenvectors using Python (C3) Statistics, Probability and Probability Distributions with Python: Knowledge of statistical concepts and probability theory (C2) Proficiency in using Python to calculate probabilities, perform statistical analysis, and work with probability distributions (C3) Machine Learning Concepts: Understanding of fundamental concepts and principles of machine learning (C2) Knowledge of different machine learning algorithms, techniques, and evaluation methods (C2) Machine Learning vs Computer Program: Differentiating between machine learning and traditional computer programming approaches (C2) Understanding the advantages and limitations of machine learning compared to conventional programming (C2) Application of Machine Learning: Understanding the various real-world applications and domains where machine learning is utilized (C2) Knowledge of how machine learning is applied in fields such as finance, healthcare, marketing, etc. (C2) Relation between variables: Understanding the concept of the relationship between variables in a dataset (C2) Ability to analyze and interpret correlations and dependencies between variables using Python (C3) Supervised Learning Vs Unsupervised Learning:

	Differentiating between supervised and unsupervised learning algorithms (C2) Understanding the concepts of labeled and unlabeled data and their roles in machine learning (C2) Semi-Supervised Learning: Understanding the concept of semi-supervised learning and its applications (C2) Knowledge of techniques that leverage both labeled and unlabeled data for training models (C2) Reinforcement Learning: Understanding the principles and algorithms of reinforcement learning (C2) Knowledge of how reinforcement learning is used to train agents to make sequential decisions (C2)
2	Prediction: Differentiating between dependent variable (response variable) and independent variables (predictor variables) in the context of prediction (C2) Understanding the concepts of reducible error and irreducible error in prediction models (C2) Knowledge of expected value and variance as measures of central tendency and variability in prediction (C2) Inference: Understanding the role of predictors in making inferences about the response variable (C2) Analyzing the relationship between the response variable and predictors using statistical techniques (C2) Learning Methods: Differentiating between parametric and non-parametric learning methods (C2) Understanding the characteristics and assumptions of parametric and non-parametric models (C2) Model Flexibility vs. Interpretability: Understanding the trade-off between model flexibility and interpretability (C2) Evaluating the pros and cons of using more flexible models in terms of interpretability (C2) Model Accuracy and Selection: Assessing the quality of fit of a model to the data (C2) Understanding the concept of bias-variance trade-off in model accuracy (C2) Knowledge of the Bayes classifier and its application in classification tasks (C2) Understanding the K-Nearest Neighbors (KNN) algorithm and its use in prediction (C2)
3	Linear Regression: Understanding the basic concepts of linear regression (C2) Constructing a regression model for predicting the relationship between

	variables (C2) Selecting predictor variables for inclusion in the regression model (C2) Determining the functional form of the regression equation (C2) Recognizing the scope and limitations of the regression model (C2) Uses of Regression Analysis: Identifying the various uses of regression analysis, including description, control, and prediction (C2) Understanding the relationship between regression analysis and causality (C2) Formal Statement of Model: Formulating the formal statement of the regression model (C2) Recognizing important features of the regression model (C2) Understanding the meaning and interpretation of regression parameters (C2) Following the steps involved in regression analysis (C2) Estimation of Regression Function: Estimating the regression coefficients using the least squares method (C2) Applying gradient descent for estimating the variance terms in the regression model (C2)
4	Accuracy of Coefficients and Model: Evaluating the accuracy of regression coefficients (C3) Assessing the accuracy of the regression model using measures such as residual standard error and R-squared statistics (C3) Linear Methods of Classification: Understanding the basic concepts of linear classification methods (C3) Exploring examples that demonstrate the use of linear classification (C3) Recognizing the limitations of using linear regression for classification tasks (C3) Logistic Regression: Understanding the logistic regression model for binary classification (C4) Estimating the regression coefficients in logistic regression (C4) Extending logistic regression to handle multiple predictors (C4) Linear Discriminant Analysis: Understanding the linear discriminant analysis method for classification (C4) Nearest Neighbor Method: Exploring the nearest neighbor method for classification (C4) Machine Learning Models: Understanding the decision tree model for classification (C4) Exploring the support vector machine algorithm for classification (C4) Unsupervised Learning: Understanding the concept of unsupervised learning (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	10
Practical	--
Seminar/Journal Club	1
Small Group Discussion (SGD)	1
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	02
Case/Project Based Learning (CBL)	--
Revision	1
Others If any:	--
Total Number of Contact Hours	15

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. "An Introduction to Machine Learning", by Gopinath Rebala, Ajay Ravi, Sanjay Churiwala,1st Edition, 2019, ISBN: 3030157288 2. "Machine Learning", by Jaime G. Carbonell, Tom M. Mitchell, Volume-1, 2014 Edition, Publisher Elsevier, ISBN 9780080510545 3. "Neural Networks and Learning Machines", by Simon O. Haykin, Prentice Hall India Learning Private Limited; 3 edition (2010), ISBN-10: 8131763773

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Renewable Energy**
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Applied Thermodynamics
Course Synopsis	Renewable energy is a form of energy that comes from natural resources like sunlight, geothermal heat, wind, or hydel power. From sunlight, we get energy in the form of solar energy, from the wind we get wind power energy, from the force of the flow of the river we get hydel energy. There is also geothermal energy available in nature. Those energies are called renewable as the source of those energies will not get finished anyway. In the course of Renewable Energy, students need both theoretical and practical knowledge to understand the entire concept of renewable energy with ease. There are lots of things to learn in this course, such as energy infrastructure, rational use of energy, energy conservation, and management, energy policies, energy regulations, energy-environment interface, and many more.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Students will be able to perform an initial design of a renewable energy system.
CO2	Students will be able to design in detail a subsystem.
CO3	Students will be able to analyze how changes in functionality in a component will affect the other components of the system.
CO4	Students will be able to use laboratories and emulators of renewable energy systems to analyze relevant issues.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO2	PSO3
CO1	3	1	3	2	-	2	-	-	-	-	-	2	2	3	1
CO2	3	1	3	2	2	1	2	-	-	-	-	3	1	3	3
CO3	3	3	3	3	-	1	2	-	-	1	-	3	-	3	3

CO4	3	3	1	3	2	2	2	-	-	-	-	3	-	3	2
Average	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Definition and units of energy: Understanding the concept and definition of energy and its various units (C1) Forms of energy: Identifying and describing different forms of energy such as mechanical, thermal, electrical, chemical, etc. (C1) Conservation of energy: Understanding the principle of conservation of energy and its application in various systems (C2) Second law of thermodynamics: Explaining the second law of thermodynamics and its implications on energy transfer and conversion (C2) Energy flow diagram to the earth: Understanding the flow of energy from the sun to the earth through various processes (C1) Origin and time scale of fossil fuels: Exploring the formation of fossil fuels and their geological time scale (C2) Conventional energy sources: Identifying and describing conventional energy sources like coal, oil, natural gas, nuclear power, and hydroelectric power (C2) Role of energy in economic development and social transformation: Understanding the significance of energy in driving economic growth and societal changes (C2) Energy consumption in various sectors: Analyzing energy consumption patterns in different sectors such as residential, industrial, transportation, etc. (C2) Projected energy consumption for the next century: Examining future projections of energy demand and consumption based on current trends and growth scenarios (C2) Exponential increase in energy consumption: Understanding the implications of the exponential rise in energy usage on global energy resources, environmental impact, and economic factors (C2) Energy resources:

	Identifying and categorizing different energy resources based on their availability and utilization (C2) Impact of exponential rise in energy usage on the global economy: Analyzing the economic consequences and challenges associated with the rapid growth of energy consumption (C3) Energy demand and Energy dilemma index: Exploring the concept of energy demand and the complexities involved in balancing energy supply and demand (C3) Classification of energy resources: Categorizing energy resources as conventional/non-conventional and renewable/non-renewable (C2) Green energy and clean energy: Defining and understanding the concepts of green energy and clean energy with relevant examples (C1) Green footprint, Carbon footprint, Ecological footprint concepts: Explaining the concepts of green footprint, carbon footprint, and ecological footprint in relation to environmental impact assessment (C1)
2	Energy resources available in India: Understanding the energy resources available in India, including fossil fuels (coal, oil, natural gas) and renewable energy sources (solar, wind, hydro, biomass) (C2) Urban and rural energy consumption: Analyzing the differences in energy consumption patterns between urban and rural areas, including factors influencing energy usage (C3) Energy consumption pattern and its variation as a function of time: Examining the trends and variations in energy consumption over time, considering factors such as population growth, industrialization, and technological advancements (C3) Nuclear energy - promise and future: Exploring the potential and future prospects of nuclear energy as a source of power generation, including its benefits, challenges, and safety concerns (C3) Energy as a factor limiting growth: Understanding the role of energy availability and affordability as a critical factor in economic growth and development (C2) Need for use of new and renewable energy sources: Recognizing the importance of transitioning towards new and renewable energy sources to mitigate environmental impact, reduce dependence on fossil fuels, and ensure long-term sustainability (C2) National Green Tribunal (NGT) Act, NGT activities: Understanding the purpose, provisions, and functioning of the National Green

	Tribunal (NGT), as well as its role in addressing environmental issues and enforcing environmental laws (C3) Environmental degradation due to energy production and utilization: Recognizing the negative environmental impacts associated with energy production and consumption, including air and water pollution, habitat destruction, and ecosystem disruption (C2) Air and water pollution, depletion of ozone layer, global warming: Understanding the environmental consequences of energy-related activities, such as emissions of pollutants, depletion of ozone layer, and contribution to global warming and climate change (C2) Biological damage due to environmental degradation: Exploring the adverse effects of environmental degradation on biodiversity, ecosystems, and human health (C2) Environmental effects of thermal power station, nuclear power generation, hydroelectric power, geothermal power, ocean energy harvesting, wind energy harvesting, solar energy harvesting, bioenergy: Analyzing the specific environmental impacts associated with different types of power generation and renewable energy sources (C3)
3	Solar constant: Understanding the concept of solar constant, which refers to the amount of solar electromagnetic radiation received at the outer atmosphere of Earth (C1) Solar radiation spectrum: Exploring the spectrum of solar radiation, which includes different wavelengths and energy levels of electromagnetic radiation emitted by the sun (C1) Classification of solar cells: Familiarizing with the classification of solar cells based on their generations and materials used (C2) First generation: Single crystalline, polycrystalline solar cells (C2) Second generation: Thin-film solar cells, CdS, CIGs (C2) Third generation: Polymer-based solar cells, DSSC, perovskites, hybrid, quantum dots, multi-junction tandem cells (C2) Organic, inorganic, and hybrid solar cells (C2) Key elements of silicon solar cell: Understanding the essential components and working principles of a silicon solar cell, including the p-n junction and photovoltaic effect (C3) PV solar cell, module, panel, and array: Differentiating between the terms PV solar cell, module, panel, and array, and understanding their roles in solar energy conversion and utilization (C2) Solar thermal systems types: Exploring the different types of solar thermal systems, such as flat-plate

	collectors, concentrating collectors, and solar water heaters (C2) Applications of solar PV and solar thermal systems: Examining the various applications of solar photovoltaic (PV) systems, including residential, commercial, and utility-scale solar power generation (C3) Understanding the applications of solar thermal systems for water heating, space heating, and industrial processes (C3) Wind energy: Introduction to wind energy as a renewable source of power generation (C1) Principle of wind energy conversion: Understanding the principle of converting wind energy into electrical energy using wind turbines (C2) Advantages and disadvantages of windmills: Evaluating the advantages and disadvantages of utilizing windmills for electricity generation, considering factors such as cost, intermittency, environmental impact, and location requirements (C3) Applications of wind energy: Exploring the various applications of wind energy, including utility-scale wind farms, decentralized wind power systems, and off-grid power generation (C2)
4	Geothermal energy: Introduction to geothermal energy as a renewable energy source derived from the heat within the Earth's crust (C1) Estimates of geothermal power and understanding the potential of geothermal resources (C2) Different types of geothermal resources: hydrothermal (convective) resources, geo-pressured resources, hot dry rock resources of petrothermal systems, and magma resources (C2) Interconnection of geothermal and fossil systems and their significance (C3) Assessing the advantages and disadvantages of geothermal energy compared to other forms of energy (C3) Ocean energy: Introduction to ocean energy and its potential as a renewable energy source (C1) Principle of ocean thermal energy conversion (OTEC) and harnessing temperature differences in ocean waters for power generation (C2) Tidal power generation and the utilization of tidal movements to generate electricity (C2) Wave energy conversion and technologies for capturing energy from ocean waves (C2) Evaluating the advantages and disadvantages of ocean energy compared to other energy forms (C3) Bio-energy:

	Energy from biomass and its significance as a renewable energy source (C1) Sources of biomass and different biomass species used for energy production (C2) Conversion processes of biomass into fuels, including fermentation, pyrolysis, gasification, and combustion (C2) Biogas plants and the properties and characteristics of biogas (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

<table>
<tr><td colspan="2">Feedback Process</td><td>1. Student’s Feedback
2. Course Exit Survey</td></tr>
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<tr><td>References:</td><td colspan="2">(List of reference books)</td></tr>
<tr><td></td><td colspan="2">i) Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009.
ii) Fundamentals of Renewable Energy Resources by G. N. Tiwari, M. K. Ghosal, Narosa Pub., 2007.
iii) Solar Cells: From Materials to Device Technology edited by S. K. Sharma, Khuram Ali, Springer (2020)
iv) Rational Design of Solar Cells for Efficient Solar Energy Conversion edited by Alagarsamy Pandikumar, Ramasamy Ramaraj, Wiley.
v) Energy fables, Edited by edited by Jenny Rinkinen, Elizabeth Shove, Jacopo Torriti, Routledge a T&F group, (2019).</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Rapid Manufacturing Technologies
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Material Engineering & Technology, Manufacturing Processes and Technology
Course Synopsis	The syllabus includes importance of rapid additive manufacturing in advance manufacturing process and technology used in Rapid manufacturing. Data formats to acquire knowledge, techniques and skills to select relevant additive and rapid manufacturing process. It also includes case studies to explore the potential of rapid manufacturing in different industrial sectors.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To understand various Rapid manufacturing technologies.
CO2	To understand the use of techniques for processing of CAD models for rapid prototyping.
CO3	To understand the use of rapid manufacturing technology in reverse engineering.
CO4	Understand and apply fundamentals of rapid prototyping techniques.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	1	3	2	1	-	-	-	1	3	3	-	-
CO2	3	2	1	2	3	1	-	-	-	-	1	2	3	2	-
CO3	3	1	1	1	3	2	1	-	-	-	1	2	3	2	-
CO4	3	2	2	2	2	1	-	1	-	-	-	2	3	1	1
Average	3	1.5	1.25	1.5	2.75	1.5	0.5	0.25	-	-	0.75	2.25	3	1.25	0.25

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Introduction to Rapid Manufacturing: Overview of Rapid Manufacturing as a concept and its significance in modern manufacturing (C1) Understanding the key aspects of customization and mass customization in manufacturing (C1) Recognizing the need for efficient and accelerated manufacturing processes (C1) Classification of Rapid Manufacturing Processes: Differentiating between additive, subtractive, and formative rapid manufacturing processes (C2) Understanding the process chain involved in additive manufacturing and other rapid manufacturing processes (C2) Identifying the advantages and limitations of rapid manufacturing techniques (C2) Challenges in Rapid Manufacturing: Recognizing the challenges faced in implementing rapid manufacturing techniques (C3) Understanding the need for addressing issues such as material selection, process optimization, and quality control in rapid manufacturing (C3) Exploring research and development areas to overcome the limitations and improve the efficiency of rapid manufacturing (C3)			
2	Preprocessing: Understanding the process of preparing a CAD model for rapid manufacturing (C2) Converting CAD models into STL files, which are compatible with rapid manufacturing systems (C2) Diagnosing and identifying errors in STL files to ensure a smooth manufacturing process (C2) Considering part orientation and support generation/design for optimal printing results (C2) Slicing the 3D model into layers to create a tool path pattern for the manufacturing process (C2) Post processing: Removing support material from the manufactured part (C1) Improving the surface finish of the printed part through various techniques (C2)			

	Enhancing the accuracy of the printed part through post-processing methods (C2) Exploring methods to aesthetically improve the appearance of the additive manufactured products (C2) Modifying the properties of the additive manufactured products based on specific requirements (C2)
3	Vat Photo Polymerization-Based Additive Manufacturing: Understanding the process and working principles of vat photo polymerization-based additive manufacturing (C3) Exploring process parameters such as exposure time, layer thickness, and resin type (C3) Recognizing the advantages and disadvantages of vat photo polymerization-based processes (C3) Identifying suitable materials for vat photo polymerization-based additive manufacturing (C3) Powder Bed Fusion-Based Additive Manufacturing: Understanding the process and working principles of powder bed fusion-based additive manufacturing (C4) Exploring process parameters such as laser power, scanning speed, and powder bed temperature (C4) Recognizing the advantages and disadvantages of powder bed fusion-based processes (C4) Identifying suitable materials for powder bed fusion-based additive manufacturing (C4) Extrusion-Based Additive Manufacturing: Understanding the process and working principles of extrusion-based additive manufacturing (C3) Exploring process parameters such as nozzle diameter, layer height, and extrusion temperature (C3) Recognizing the advantages and disadvantages of extrusion-based processes (C3) Identifying suitable materials for extrusion-based additive manufacturing (C3) Material Jetting-Based Additive Manufacturing: Understanding the process and working principles of material jetting-based additive manufacturing (C3) Exploring process parameters such as droplet size, droplet spacing, and curing method (C3) Recognizing the advantages and disadvantages of material jetting-based processes (C3) Identifying suitable materials for material jetting-based additive manufacturing

	(C3) Binder Jetting-Based Additive Manufacturing: Understanding the process and working principles of binder jetting-based additive manufacturing (C3) Exploring process parameters such as binder saturation, layer thickness, and powder type (C3) Recognizing the advantages and disadvantages of binder jetting-based processes (C3) Identifying suitable materials for binder jetting-based additive manufacturing (C3) Direct Energy Deposition-Based Additive Manufacturing: Understanding the process and working principles of direct energy deposition-based additive manufacturing (C4) Exploring process parameters such as laser power, powder feed rate, and scanning speed (C4) Recognizing the advantages and disadvantages of direct energy deposition-based processes (C4) Identifying suitable materials for direct energy deposition-based additive manufacturing (C4) Sheet Lamination-Based Additive Manufacturing: Understanding the process and working principles of sheet lamination-based additive manufacturing (C2) Exploring process parameters such as sheet thickness, adhesive type, and pressure applied (C2) Recognizing the advantages and disadvantages of sheet lamination-based processes (C2) Identifying suitable materials for sheet lamination-based additive manufacturing (C2)
4	Case Study of Additive Manufacturing Processes: In the Medical Field: Application of additive manufacturing in the production of patient-specific implants, prosthetics, and surgical guides (C5) Case studies highlighting the use of additive manufacturing in creating custom-fit medical devices (C5) Advantages of additive manufacturing in the medical field, such as reduced lead time and improved patient outcomes (C5) In the Automobile Sector: Application of additive manufacturing in rapid prototyping of automotive components (C4) Case studies showcasing the use of additive manufacturing for tooling and jigs

	in automotive manufacturing (C4) Advantages of additive manufacturing in the automobile sector, such as cost reduction and design flexibility (C4) In the Defense Industry: Application of additive manufacturing in the production of lightweight and complex defense parts (C5) Case studies highlighting the use of additive manufacturing for rapid production of spare parts in military operations (C5) Advantages of additive manufacturing in the defense industry, such as enhanced customization and supply chain resilience (C5) In the Aerospace Industry: Application of additive manufacturing in the production of aerospace components, such as turbine blades and structural parts (C5) Case studies showcasing the use of additive manufacturing for lightweighting and performance optimization in aerospace (C5) Advantages of additive manufacturing in the aerospace industry, such as reduced weight and improved fuel efficiency (C5) In Other Fields like Arts, Fashion, and Jewelry: Application of additive manufacturing in the creation of intricate and customized art pieces, fashion accessories, and jewelry (C3) Case studies highlighting the use of additive manufacturing for on-demand production and unique designs (C3) Advantages of additive manufacturing in arts, fashion, and jewelry, such as design freedom and rapid production (C3) Rapid Manufacturing Processes: Subtractive: Understanding the subtractive manufacturing processes such as CNC machining and milling (C3) Exploring case studies where subtractive manufacturing is used for rapid production of parts (C3) Applications and advantages of subtractive manufacturing in terms of precision and material versatility (C3) Rapid Manufacturing Processes: Formative: Understanding the formative manufacturing processes such as injection molding and casting (C3) Exploring case studies where formative manufacturing is used for rapid production of parts (C3) Applications and advantages of formative manufacturing in terms of high-volume production and material properties (C3) Process Selection, Applications, and Case Studies: Understanding the factors influencing the selection of additive manufacturing

	processes based on requirements and constraints (C4) Exploring real-world applications and case studies across various industries where additive manufacturing processes are applied (C4) Analyzing the advantages, limitations, and suitability of different additive manufacturing processes for specific applications (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	32
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	1. Gibson, I., Rosen, D., Stucker, B. (2016), "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Germany: Springer New York, ISBN: 9781493944552, 149394455X 2. Gebhardt, A. (2012). Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing. Germany: Hanser Publications, ISBN: 9783446425521, 3446425527 3. Hötter, J., Gebhardt, A. (2016), "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Germany: Hanser Publications, ISBN: 9781569905821, 1569905827 4. Cooper, K. (2001), "Rapid Prototyping Technology: Selection and Application", United States: Taylor & Francis, ISBN: 9780824745240, 0824745248

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Work Study
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	This is a course based on Work study and industrial engineering play important role in job simplification, job design, job enrichment, value analysis/engineering, method analysis, operational analysis, etc. Work study has been utilized by companies to job productivity. Industrial engineering is the latest method employed to improve productivity. It deals with design, enhancement and setting up of engineering systems encompassing plants, machinery, workers, etc.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understanding of various productivities and work study in industrial manufacturing.
CO2	Understanding of Micro and Memo Motion Study.
CO3	Understanding of the concept of Work Measurement.
CO4	Understanding of different Ratings and Incentives.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	1	0	1	0	0	0	3	1	-	-
CO2	3	2	3	3	2	1	0	0	0	1	1	3	1	-	-
CO3	3	2	3	3	2	1	0	0	0	0	1	3	1	-	-
CO4	3	3	3	3	3	2	0	0	1	1	0	3	1	-	-
Average	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	1	-	-

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	**Introduction to Work-Study Productivity:** Productivity: Definition of productivity and its significance in individual enterprises (C2) Understanding the role of management in enhancing productivity (C3) Measurement of productivity in various aspects such as materials, buildings, machines, and power (C3) Factors influencing productivity and the need for productivity improvement programs (C3) Work Study: Definition of work study and its objective in optimizing work processes (C2) Scope of work study in analyzing and improving work methods and productivity (C3) Recognizing the importance of human factors in work study and their impact on productivity (C4) Understanding the relationship between work study and management, supervision, and workers (C4)			
2	Introduction to Method Study: Method Study is a systematic approach used to analyze and improve work methods and processes within an organization. It involves the identification and elimination of unnecessary steps, activities, and wasteful practices to enhance productivity and efficiency. Definition of Method Study and its significance in optimizing work methods (C2) Objectives of Method Study in improving productivity, quality, and safety (C3) Scope of Method Study in analyzing and optimizing various aspects of work processes (C3) Introduction to Activity Recording and Examination Aids used in Method Study (C2) Charts used in Method Study: Process Charts to visualize and analyze the sequence of activities in a process (C3) Flow Process Charts to represent the movement of materials, information, and workers in a process (C3) Travel Charts to record and analyze the movement of workers or materials within a workplace (C3)			

	Multiple Activity Charts to study and analyze multiple activities performed concurrently (C3) Micro and Memo Motion Study: Principles of Motion Economy for identifying and eliminating wasteful movements (C4) Classification of Movements to categorize and analyze different types of work movements (C4) Two-Handed Process Chart to study the simultaneous use of both hands in a process (C4) SIMO Chart (Simultaneous Motion Chart) to record and analyze multiple activities performed simultaneously (C4) Micro Motion Study to capture and analyze detailed and precise movements (C4) Development and Installation of the Improved Method: Definition and importance of developing an improved method based on the study findings (C3) Process of installing the improved method and ensuring its successful implementation (C3)
3	Introduction to Work Measurement: Work Measurement is the process of establishing the time required to perform a specific task or job by a qualified worker working at a defined level of performance. It aims to determine the most efficient and effective way of completing work tasks and serves as a basis for setting standards, scheduling, and resource allocation. Definition of Work Measurement and its importance in establishing time standards (C2) Objectives and benefits of Work Measurement in terms of productivity improvement and resource allocation (C3) Techniques used in Work Measurement, such as Time Study and Work Sampling (C3) Work Sampling: Need for Work Sampling as a statistical technique to determine the proportion of time spent on different activities (C4) Confidence Levels and Sample Size Determinations in Work Sampling (C4) Application of Work Sampling with simple problems (C4) Time Study: Definition of Time Study and its role in determining the standard time for a specific task (C3) Time Study Equipment used to capture and analyze work activities (C3) Selection of Jobs for Time Study and steps involved in conducting a Time Study

	(C3) Breaking Jobs into Elements to analyze and measure individual work elements (C3) Recording Information in Time Study, including observations and measurements (C3) Rating Systems used in Time Study to account for worker performance and work conditions (C3) Introduction to Ergonomics: Definition of Ergonomics and its focus on designing systems that fit the capabilities and limitations of humans (C2) Areas of Study under Ergonomics, including physical ergonomics, cognitive ergonomics, and organizational ergonomics (C2) Components of the Man-Machine System and their functions in relation to ergonomics (C3) Study of Development of Stress in the Human Body and its consequences in relation to ergonomics (C3) Introduction to Computer-based Ergonomics, Usability Engineering, and Human-Computer Interface (C2)
4	Ratings and Incentives: Scales of Rating: Introduction to Scales of Rating used in work measurement to assess worker performance (C2) Different types of Rating Scales, such as Graphic Rating Scales and Behavioral Rating Scales (C2) Factors Affecting Rate of Working: Identification of Factors Affecting Rate of Working, such as worker skill level, motivation, and work conditions (C2) Allowances and Standard Time Determination: Definition and importance of Allowances in work measurement to account for factors like fatigue and personal needs (C2) Determination of Standard Time by considering the time required for the task and allowances (C2) Predetermined Motion Time Study (PMTS): Introduction to Predetermined Motion Time Study (PMTS) as a method for analyzing work tasks based on predetermined time values (C3) Method Time Measurement (MTM) as a widely used PMTS system, its principles, and application (C3) Wages and Incentives: Introduction to Wages and Incentives as a means of motivating and rewarding employees (C2)

	Definition and explanation of Wage Differentials based on factors like job complexity, skill level, and market conditions (C2) Methods of Wage Payment, including time-based wages, piece-rate wages, and performance-based incentives (C3) Advantages and Disadvantages of different wage payment methods (C3) Financial Incentives and Non-Financial Incentives: Overview of Financial Incentives, such as bonuses, profit sharing, and commission-based systems (C2) Explanation of Non-Financial Incentives, including recognition, career advancement opportunities, and work-life balance initiatives (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓

Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Ralph M Barnes -Motion and Time study, ISBN:13:978981426182 Publisher: John Wiley, 7th edition 2009. **ii)** R. S. Bridger -Introduction to Ergonomics, ISBN:13:9780849373060, Publisher Taylor and Francis dated 20th Aug 2008, 3rdEdition

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Mechatronics
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Basics of Electronics and Electrical Engineering, Instrumentation & Control Engineering
Course Synopsis	Mechatronics is a design process that includes a combination of mechanical engineering, electrical engineering, control engineering and computer engineering. Mechatronics is a multidisciplinary field of engineering, that is to say, it rejects splitting engineering into separate disciplines. Originally, mechatronics just included the combination of mechanics and electronics, hence the word is a combination of mechanics and electronics; however, as technical systems have become more and more complex the word has been "updated" during recent years to include more technical areas.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Identify the elements of mechatronics system.
CO2	Select suitable sensors and actuators to meet specific requirements.
CO3	Select the controllers according to the need.
CO4	Demonstrate intelligent mechatronics system for engineering applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	1	1	1	1	2	2	3	3	3	2	1
CO2	3	1	2	3	2	1	1	1	2	1	2	2	3	1	2
CO3	3	2	2	2	2	1	1	1	1	1	2	2	3	2	2

CO4	3	2	1	1	2	2	2	2	3	2	3	3	3	2	1
Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	**Introduction to Mechatronics:** Definition and overview of Mechatronics as an interdisciplinary field combining mechanical engineering, electronics, and computer science (C2) Comparison of Conventional and Mechatronics approaches in designing products, emphasizing the integration of mechanical, electrical, and software components (C2) Mechatronics Design Process: Explanation of the Mechatronics Design Process, including requirements gathering, system design, component selection, and integration (C2) Importance of considering the interaction between mechanical, electrical, and software components in the design process (C2) Mechatronics in Manufacturing: Application of Mechatronics in Manufacturing, such as automated assembly systems, robotics, and CNC machines (C2) Benefits of using Mechatronics in manufacturing processes, including increased efficiency, precision, and flexibility (C2) Adaptive and Distributed Control Systems: Introduction to Adaptive Control Systems, which adjust their behavior based on changing conditions or feedback (C2) Explanation of Distributed Control Systems, where control functions are distributed among multiple components or devices (C2) Modeling and Simulation of Mechatronics Systems: Importance of Modeling and Simulation in Mechatronics to analyze and optimize system behavior (C2) Overview of techniques for modeling and simulating Mechatronics Systems, such as mathematical models and computer simulations (C2)
2	Architecture of Microprocessor and Microcontroller: Overview of the architecture of a microprocessor, which includes the CPU, memory, and input/output interfaces (C3) Explanation of the architecture of a microcontroller, which combines a

	microprocessor with on-chip memory and I/O peripherals (C3) System Interfacing for Sensors, Keyboard, Display, and Motors: Discussion of various interfacing techniques for connecting sensors, keyboards, displays, and motors to a microprocessor or microcontroller system (C3) Explanation of common protocols and interfaces used for system interfacing, such as GPIO, I2C, SPI, and UART (C3) Application Cases for Temperature Control, Warning, and Process Control Systems: Introduction to application cases where microprocessors or microcontrollers are used for temperature control, warning systems, and process control (C3) Examples of temperature control systems, such as thermostats or HVAC systems, where a microprocessor or microcontroller monitors and adjusts the temperature (C3) Application cases for warning systems, where a microprocessor or microcontroller detects and signals potential hazards or malfunctions (C3) Examples of process control systems, where a microprocessor or microcontroller regulates and monitors industrial processes (C3)
3	Architecture of Programmable Logic Controllers (PLCs): Overview of the architecture of a PLC, which consists of a central processing unit (CPU), input/output (I/O) modules, memory, and communication interfaces (C3) Explanation of the different components and their functions within a PLC system (C3) Input/Output Modules: Discussion of the various types of I/O modules used in PLC systems, including digital input and output modules, analog input and output modules, and specialty modules (C3) Explanation of how I/O modules interface with external devices and sensors to provide input and output signals to the PLC (C3) Programming Methods: Introduction to the different programming methods used in PLC systems, such as ladder logic, function block diagrams, structured text, and sequential function charts (C3) Overview of the programming software and tools used for creating and editing PLC programs (C3) Timers and Counters: Explanation of timers and counters as essential instructions in PLC programming, used for controlling timing and counting operations (C3) Examples of how timers and counters are used to control processes and sequence events in a PLC system (C3)

	Master Controls and Branching: Discussion of master control instructions that enable the PLC to coordinate and control multiple operations or subsystems (C3) Explanation of branching instructions that allow for decision-making and branching of program execution based on specific conditions or inputs (C3) Data Handling: Overview of data handling instructions in PLC programming, including data manipulation, comparison, and storage operations (C3) Examples of how data handling instructions are used to process and manipulate data within a PLC program (C3) Analog Input/Output: Introduction to analog input and output modules in PLC systems, which allow for the monitoring and control of analog signals (C3) Explanation of analog-to-digital and digital-to-analog conversion and how it is utilized in PLC systems (C3) Selection of PLC and Troubleshooting: Factors to consider when selecting a PLC, such as system requirements, I/O capacity, programming capabilities, and communication options (C2) Overview of common troubleshooting techniques and strategies for diagnosing and resolving issues in PLC systems (C2)
4	Fuzzy Logic Control in Mechatronics: Introduction to fuzzy logic and its applications in control systems (C2) Explanation of fuzzy logic control algorithms and how they are used to handle uncertain and imprecise information (C2) Examples of fuzzy logic control in mechatronic systems, such as temperature control, speed control, and decision-making processes (C2) Artificial Neural Networks in Mechatronics: Overview of artificial neural networks (ANNs) and their role in mechatronic systems (C2) Explanation of the structure and functioning of ANNs, including neurons, layers, and activation functions (C2) Applications of ANNs in mechatronic systems, such as pattern recognition, prediction, and control (C2) Algorithms: Discussion of various algorithms used in mechatronics, including control algorithms, optimization algorithms, and machine learning algorithms (C2) Examples of algorithmic techniques used in mechatronic systems, such as PID control, genetic algorithms, and backpropagation in neural networks (C2) Computer-Based Instrumentation:

	Introduction to computer-based instrumentation and its role in data acquisition, processing, and control in mechatronic systems (C2) Explanation of different types of sensors and transducers used for measuring physical quantities in mechatronic systems (C2) Real-Time Data Acquisition and Control: Overview of real-time data acquisition and control systems, which involve the collection and processing of data in real-time for immediate decision-making and control actions (C2) Explanation of techniques and protocols used for real-time data acquisition and control, such as fieldbus systems and industrial communication protocols (C2) Software Integration: Discussion of software integration in mechatronic systems, including the integration of control algorithms, data processing algorithms, and communication protocols (C2) Examples of software tools and platforms used for developing and integrating mechatronic systems (C2) Man-Machine Interface: Introduction to man-machine interfaces (MMIs) in mechatronic systems, which enable interaction and communication between humans and machines (C2) Explanation of different types of MMIs, such as graphical user interfaces (GUIs), touchscreens, and voice recognition systems (C2) Vision System: Overview of vision systems in mechatronics, which involve the use of cameras and image processing techniques for visual perception and object recognition (C2) Applications of vision systems in mechatronic systems, such as robotics, quality control, and surveillance (C2) Mechatronics System Case Studies: Analysis of real-world case studies where mechatronic systems have been successfully applied, highlighting their design, implementation, and performance (C2) Examination of the challenges faced and the solutions employed in the case studies (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	30
Practical	--
Seminar/Journal Club	5

Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps
1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) W. Bolton (2008), Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering, 4th Edition, Prentice Hall. ISBN: 978-0-273-74286-9. **ii)** Devdas Shetty and Richard A. Kolk (2012), Mechatronics System Design, 2nd Edition, C. L.Engineering, ISBN: 978-8-131-51828-1.

Faculty of engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Chassis Design**
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	**Engineering Graphics and Design**
Course Synopsis	This course is intended to allow you the opportunity to explore engine design fundamentals and learn what you can do to help during the machining process. You will also learn about clutch, gear box, suspension, steering, and frame systems.

Course Outcomes:

At the end of the course students will be able to:

CO1	The student can identify different areas of automobile chassis component design.
CO2	Design the front axle and Steering system of an automobile.
CO3	Design the clutch for flawless power transmission.
CO4	Analyze the assembly and maintenance of Gear box of an automobile.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	2	1	1	0	1	0	0	0	3	2	3	1
CO2	3	2	3	3	2	1	0	0	0	1	1	3	1	3	3
CO3	3	2	3	3	2	1	0	0	0	0	1	3	-	3	3
CO4	3	3	3	3	3	2	0	0	1	1	0	3	-	3	2
Average	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	**Content & Competencies**
1	Study of Loads, Moments, and Stresses on Frame Members: Understanding the concept of loads and moments acting on frame members in vehicles (C2) Analysis of the distribution of loads and moments on frame members (C2) Calculation of stresses on frame members using basic structural analysis principles (C2) Consideration of factors such as vehicle weight, payload, dynamic loads, and operating conditions in load analysis (C2) Design of Frame for Passenger and Commercial Vehicles: Design considerations for passenger and commercial vehicle frames, including structural integrity, stiffness, and durability (C2) Selection of suitable materials for frame construction, considering factors such as strength, weight, and cost (C2) Application of design principles and standards to ensure compliance with safety regulations and performance requirements (C2) Use of computer-aided design (CAD) software and simulation tools for frame design and optimization (C2) Design of Leaf Springs: Understanding the working principles and advantages of leaf springs in vehicle suspension systems (C2) Calculation of the required number of leaves and their dimensions based on load requirements and deflection criteria (C2) Consideration of material properties and manufacturing processes in leaf spring design (C2) Analysis of stress distribution and optimization of leaf spring design for improved ride comfort and load-carrying capacity (C2) Design of Coil Springs: Introduction to coil springs and their role in vehicle suspension systems (C2) Calculation of spring rate and deflection based on load requirements and desired suspension characteristics (C2) Selection of suitable wire diameter, coil diameter, and number of coils for the desired spring performance (C2) Consideration of material properties, fatigue life, and manufacturing processes in coil spring design (C2) Design of Torsion Bar Springs: Explanation of torsion bar springs and their applications in vehicle suspension

	systems (C2) Calculation of torsion bar dimensions and stiffness based on load requirements and desired suspension characteristics (C2) Consideration of material properties, torsion bar geometry, and mounting arrangements in torsion bar spring design (C2) Analysis of stress distribution and optimization of torsion bar spring design for improved suspension performance (C2)
2	Analysis of Loads, Moments, and Stresses at Different Sections of Front Axle: Determination of loads and moments acting on different sections of the front axle, considering factors such as vehicle weight, load distribution, and dynamic loads (C3) Calculation of stresses and deflections at critical sections of the front axle using structural analysis methods (C3) Evaluation of the strength and durability of the front axle design based on stress analysis results (C3) Optimization of the front axle design to ensure adequate strength and stiffness while minimizing weight (C3) Determination of Bearing Loads at Kingpin Bearings and Wheel Spindle Bearings: Calculation of bearing loads at the kingpin bearings and wheel spindle bearings based on the applied loads and moments (C3) Consideration of factors such as vehicle weight distribution, braking forces, and cornering loads in bearing load determination (C3) Selection of suitable bearing types and sizes to accommodate the calculated bearing loads (C3) Verification of bearing selection through analysis of bearing capacity and fatigue life (C3) Choice of Bearings: Understanding different types of bearings suitable for front axle applications, such as tapered roller bearings or ball bearings (C2) Evaluation of bearing characteristics, including load capacity, stiffness, friction, and durability (C2) Selection of appropriate bearing types based on application requirements, performance considerations, and cost-effectiveness (C2) Determination of Optimum Dimensions and Proportions for Steering Linkages: Analysis of steering linkages to determine the optimum dimensions and proportions for minimum steering error (C3) Consideration of factors such as steering geometry, linkage length, angle, and pivot locations in the design process (C3) Calculation of steering angles, tie rod lengths, and steering arm dimensions to

	achieve desired steering performance (C3) Validation of the steering linkage design through simulation or physical testing (C3) Design of Front Axle Beam: Selection of suitable materials for front axle beam construction, considering factors such as strength, stiffness, and weight (C2) Calculation of the beam dimensions and cross-sectional properties based on load requirements and desired deflection characteristics (C3) Analysis of stress distribution and optimization of the beam design for improved strength and durability (C3) Consideration of manufacturing processes, such as forging or welding, in the axle beam design (C2)
3	Design of Single Plate Clutch: Determination of the torque capacity requirement based on the engine power and maximum operating conditions (C3) Selection of suitable friction material for the clutch plate, considering factors such as coefficient of friction, wear resistance, and heat dissipation (C2) Calculation of the clutch plate dimensions, including outer and inner diameters, thickness, and number of friction surfaces, to achieve the desired torque capacity (C3) Design of the clutch cover and pressure plate assembly to provide adequate clamping force on the clutch plate (C3) Analysis of the contact pressure distribution and thermal performance of the clutch design (C3) Design of Multi-Plate Clutch: Determination of the torque capacity requirement and the number of clutch plates based on the engine power and maximum operating conditions (C3) Selection of suitable friction material for the clutch plates, considering factors such as coefficient of friction, wear resistance, and heat dissipation (C2) Calculation of the clutch plate dimensions, including outer and inner diameters, thickness, and number of friction surfaces, to achieve the desired torque capacity (C3) Design of the clutch housing and pressure plate assembly to provide adequate clamping force on the clutch plates (C3) Analysis of the contact pressure distribution and thermal performance of the clutch design (C3) Design of Centrifugal Clutch: Determination of the required engagement speed and engagement characteristics based on the engine speed and desired operating conditions (C3) Calculation of the centrifugal force acting on the clutch shoes and determination

	of the required spring force for disengagement (C3) Design of the clutch shoe dimensions and geometry to achieve the desired engagement and disengagement characteristics (C3) Selection of suitable friction material for the clutch shoes, considering factors such as coefficient of friction and wear resistance (C2) Analysis of the clutch performance, including energy dissipation and torque capacity, under different operating conditions (C3) Design of Cone Clutch: Calculation of the torque capacity requirement based on the engine power and maximum operating conditions (C3) Design of the cone clutch surfaces, including the cone angles and dimensions, to achieve the desired torque capacity and engagement characteristics (C3) Selection of suitable friction material for the cone surfaces, considering factors such as coefficient of friction and wear resistance (C2) Analysis of the contact pressure distribution and thermal performance of the clutch design (C3) Consideration of the lubrication and cooling requirements for the cone clutch design (C2)
4	Basic consideration in design (C3): Understand the function and purpose of a design (C3) Select suitable materials based on specific requirements (C4) Consider safety standards and regulations (C3) Take into account ergonomic factors (C4) Design for manufacturability (C3) Determination of speed range (C2): Define the desired range of speeds for the application (C2) Analyze torque-speed characteristics (C3) Select appropriate power transmission components (C4) Consider factors like efficiency and space constraints (C4) Concept of structure diagram (C4): Create a schematic representation of the overall structure and components (C4) Identify main elements and their relationships (C3) Visualize flow of energy, signals, or materials (C4) Use standard symbols and conventions (C3) Label and organize the diagram effectively (C3) Graphical representation of Ray and speed diagram (C4): Plot torque-speed and power graphs (C3) Analyze the relationship between torque, speed, and power (C4) Understand the Ray diagram for power output (C4) Identify operating points and efficiency (C4)

	Gearbox layout (C5): Determine required gear ratios (C4) Select suitable gear types based on load capacity and efficiency (C4) Arrange gears logically to achieve desired ratios (C4) Consider gear meshing, backlash, lubrication, and housing design (C4) Optimize layout to minimize size, weight, and power losses (C5)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey
Students Feedback is taken through various steps 1. Regular feedback through Mentor Mentee system. 2. Feedback between the semester through google forms. 3. Course Exit Survey will be taken at the end of semester.	
References:	
i) Dean Averns, "Automobile Chassis Design", Illife Book Co., 2001. **ii)** Design of machine Elements by Bhandari, Tata McGraw-Hill Publishing Company Ltd **iii)** Machine Design by Sharma-Agarwal, S.K.Kataria & Sons **iv)** Machine Design by Sadhusingh, Khanna Publishers,	

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Heat and Mass Transfer Laboratory**
Academic Year	IV
Semester	VII
Number of Credits	1
Course Prerequisite	Engineering Thermodynamics
Course Synopsis	An introductory course in heat and mass transfer covering conduction, convection and radiation heat transfer, principles of heat exchanger and mass transfer. Heat transfer and mass transfer are kinetic processes that may occur and be studied separately or jointly. Studying them apart is simpler, but both processes are modeled by similar mathematical equations in the case of diffusion and convection (there is no mass-transfer similarity to heat radiation), and it is thus more efficient to consider them jointly.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply basic principles of fluid mechanics, thermodynamics, heat transfer for designing heat and mass transfer systems.
CO2	Model heat, mass and momentum transport systems and develop predictive correlation.
CO3	Model heat, mass and momentum transport systems and develop predictive correlation.
CO4	Apply the basic principles of heat exchanger applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PSO2**	**PSO3**
CO1	3	1	2	2	1	1	0	1	0	0	0	3	2	3	1
CO2	3	2	3	3	2	1	0	0	0	1	1	3	1	3	3
CO3	3	2	3	3	2	1	0	0	0	0	1	3	-	3	3
CO4	3	3	3	3	3	2	0	0	1	1	0	3	-	3	2
Average	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**2**	**2**

Sl.No.	**Content & Competencies**
1	To calculate thermal conductivity of insulating material in the form of slab. (C1, C2)
2	To calculate total thermal resistance and thermal conductivity of composite wall. (C2,C3)
3	To calculate the thermal conductivity of insulating powder. (C2, C4)
4	To calculate the thermal conductivity of given liquid (glycerin). (C2, C1)
5	To calculate the average heat transfer coefficient of vertical cylinder under natural convection. (C2,C3)
6	To calculate surface heat transfer coefficient for a pipe by forced convection and compare heat transfer coefficient for different air flow rates and heat flow rates. (C2)
7	To calculate the heat transfer coefficient experimentally and theoretically for free and forced convection and compare the theoretical temperature distribution with experimentally obtained distribution. (C2)
8	To study the Boiling Heat Transfer phenomenon for pool boiling of water. (C2)
9	To conduct test on a heat pipe and compare the temperature distribution and rate of heat transfer with geometrically similar copper and stainless-steel tubes. (C2, C1)
10	To determine the value of Stefan-Boltzmann constant for radiation heat transfer. (C2, C1)
11	To measure the property of emissivity of the test plate surface at various temperatures. (C2)
12	To study and compare temperature distribution, heat transfer rate, overall heat transfers coefficient in parallel flow and counter flow heat exchanger. (C2, C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10

Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

(i)R. C. Sachdeva (2005), Fundamentals of Heat and Mass Transfer, New Age International (P) Ltd. ISBN: 978-8-122-40076-2.
ii) P. K. Nag (2005), Heat Transfer, Tata McGraw Hill Publishing Company Limited. ISBN: 978-0-070-60653-1.
iii) J. P. Holman (2005), Heat Transfer, 9th Edition, McGraw-Hill Publishing Company Limited. ISBN: 978-0-070-29618-3.
iv) Dewitt Lavine, Bergmann and Incropera (2010), Fundamentals of Heat and Mass Transfer, 6th Edition, John Wiley & Sons, ISBN: 978-8-126-52764-9.
v) M. NecatOzisik, Helcio R.B. Orlande (2021), Inverse Heat Transfer: Fundamentals and Applications,

2nd Edition, CRC Press, Taylor & Francis, ISBN 9780367820671.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Automation in Manufacturing Lab
Academic Year	IV
Semester	VII
Number of Credits	2
Course Prerequisite	Manufacturing Processes and Technology
Course Synopsis	Automation in manufacturing lab deals with the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. Students learn the importance of CAD/CAM principles in the Product development, programs related to manufacturing using codes and analyze the importance of networking in the manufacturing environment.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To understand the importance of Automation in Manufacturing.
CO2	To develop programs related to manufacturing using codes.
CO3	To understand the concept of group technology and flexible manufacturing system.
CO4	To understand in details about computer integrated manufacturing.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	1	1	1	1	1	3	2	3	1	1
CO2	3	2	3	3	3	1	1	1	1	1	1	2	3	1	-
CO3	3	2	1	1	2	1	1	1	2	1	2	3	3	2	-
CO4	3	2	1	1	1	1	1	1	3	2	3	2	3	3	1

Average	3	2.25	1.5	1.5	1.75	1	1	1	1.75	1.25	2.25	2.25	3	1.75	0.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**

Unit	**Content & Competencies**
1	Make the part family/family table of a bolt (C2)
2	Tool path generation (C3)
3	Part programming (C2)
4	G & M codes development for machining operations (C2)
5	Physical interpretation of machining features and tool geometries (C2)
6	Part Programming- CNC Machining Centre i) Linear Cutting. ii) Circular cutting. iii) Cutter radius Compensation iv) CANNED cycle operation (C4)
7	Part Programming i) Straight, Taper and Radius Turning. ii) Thread Cutting. iii) Rough and Finish Turning Cycle. iv) Drilling and Tapping Cycle. (C4)
8	Contour milling using CNC milling machine (C4)
9	Spur gear cutting in CNC milling machine (C4)
10	CL Data and Post Process generation using CAM packages. (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	10

Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	20
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. Mikell P. Groover (2008), Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Pearson Education. ISBN: 978-8-120-33418-2.
2. Ibrahim Zeid (2009), Mastering CAD/CAM, 2nd Edition, Tata McGraw Hill International Edition, ISBN: 978-0-070- 15134-5.
3. P N Rao (2010), CAD/CAM Principles and Applications, 3rd Edition, Tata McGraw-Hill Education, ISBN: 978-0-070- 68193-4.
4. James A. Rehg and Henry W. Kraebber (2004), Computer Integrated Manufacturing, 3rd Edition, Pearson Education, ISBN: 978-0-131-13413-3

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Machine Learning for Mechanical Engineers Lab
Academic Year	IV
Semester	VII
Number of Credits	2
Course Prerequisite	NA
Course Synopsis	This course deals with the basics of programming (Python) and use of linear Algebra, Statistics, probabilistic distributions etc. in it. Basics of Machine learning, data interpretation and mathematical tools like Regression analysis and its types used in various machine learning models. This course also includes a brief introduction to Neural Networks and its uses.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Able to differentiate machine learning from normal computer programming.
CO2	Able to interpret a given data for drawing inference, forecasting etc.
CO3	Able to successfully employ various mathematical tools to develop a machine learning algorithm.
CO4	Able to understand the basic structure and applications of Neural Networks.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	-	-	-	1	-	3	2	3	1	1
CO2	3	2	3	3	3	-	-	-	1	-	-	2	3	1	-
CO3	3	2	1	1	2	-	-	-	2	-	2	3	3	2	-
CO4	3	2	1	1	1	-	-	-	3	2	3	2	3	3	1
Average	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5

Course Content:			
L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
0	**0**	**4**	**4**
Content & Competencies			

Unit	Content & Competencies
1	Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a.CSV file. C5
2	For a given set of training data examples stored ina .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples. C4
3	Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample C5
4	Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets. C4
5	Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets. C5
6	Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy. precision, and recall for your data set. C4
7	Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/APL C5
8	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program. C4

9	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. C4
10	Implement the non-parametric Locally Weighted Regresion algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs. C5

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	30
Seminar/Journal Club	--
Small Group Discussion (SGD)	20
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback			

	2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. "An Introduction to Machine Learning", by Gopinath Rebala, Ajay Ravi, Sanjay Churiwala,1st Edition, 2019, ISBN: 3030157288
2. "Machine Learning", by Jaime G. Carbonell, Tom M. Mitchell, Volume-1, 2014 Edition, Publisher Elsevier, ISBN 9780080510545
3. "Neural Networks and Learning Machines", by Simon O. Haykin, Prentice Hall India Learning Private Limited; 3 edition (2010), ISBN-10: 8131763773

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Cognitive Robotics
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Robotics Engineering and Its Application
Course Synopsis	This course teaches the fundamentals for the Cognitive Robots. This course provides an introduction about the Cybernetic View of Robot Cognition and Perception, Map Building. The course gives a detailed knowledge of the Randomized Path Planning and Simultaneous Localization and Mapping (SLAM). Also provide the detailing of Robot Programming Packages and Imaging Geometry.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Discuss about the basic principles of telerobotic
CO2	Describe the concepts of wired and wireless communication for networked telerobotic systems.
CO3	Design and fabricate the software architecture and interface for networked robot systems on the web.
CO4	Analyze the performance of mobile robots controlled through the web.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	3	0	1	1	3	2	3	1	2	2	1	1	3	1	-
CO2	3	2	2	1	3	0	2	0	0	0	1	3	3	1	-
CO3	3	2	3	2	3	1	2	1	0	0	0	2	3	1	-
CO4	3	2	1	0	2	0	1	0	1	1	1	2	3	1	1

Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1	0.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Introduction to the Model of Cognition (C3): Understand the basic concepts and components of cognitive models (C3) Explore different approaches to modeling cognition (C3) Recognize the importance of cognition in artificial intelligence and robotics (C3) Visual Perception (C4): Understand the process of visual perception in humans and machines (C4) Study principles of image formation, feature extraction, and object recognition (C4) Analyze different computational models of visual perception (C4) Explore applications of visual perception in robotics and computer vision (C4) Visual Recognition (C4): Study algorithms and techniques for visual object recognition (C4) Understand the challenges and limitations of visual recognition systems (C4) Evaluate different approaches to object detection, classification, and tracking (C4) Explore real-world applications of visual recognition in robotics (C4) Machine Learning (C5): Understand the principles and techniques of machine learning (C5) Study different types of learning algorithms, including supervised and unsupervised learning (C5) Apply machine learning algorithms to solve classification, regression, and clustering problems (C5) Evaluate the performance and generalization ability of machine learning models (C5) Soft Computing Tools (C4): Understand the concept of soft computing and its different components (C4) Study techniques such as fuzzy logic, neural networks, and genetic algorithms (C4) Apply soft computing tools to solve complex problems in robotics and artificial intelligence (C4) Evaluate the strengths and limitations of soft computing approaches (C4) Robot Cognition (C5): Understand the concept of robot cognition and its role in intelligent robotics (C5) Study cognitive architectures and models for robots (C5) Explore the integration of perception, learning, and decision-making in robotic

	systems (C5) Evaluate the performance and adaptability of robot cognitive systems (C5) Constructing a 2D World Map (C4): Understand the concept of world mapping in robotics (C4) Study different techniques for constructing 2D maps using sensor data (C4) Analyze data structures suitable for representing and storing map information (C4) Evaluate algorithms for map building and localization in robotic systems (C4) Data Structure for Map Building (C4): Understand the importance of efficient data structures in map building (C4) Study different data structures such as grids, trees, and graphs for map representation (C4) Analyze the trade-offs between memory usage, computational complexity, and map accuracy (C4) Evaluate the performance of data structures in map building algorithms (C4) Explanation of the Algorithm (C4): Understand the principles and steps of the map building algorithm (C4) Explain the underlying logic and mathematical concepts used in the algorithm (C4) Analyze the algorithm's complexity, efficiency, and scalability (C4) Evaluate the algorithm's performance on different types of sensor data (C4) An Illustration of Procedure Traverse Boundary (C4): Understand the procedure for traversing the boundary of the environment (C4) Study the specific steps and actions involved in the traversal process (C4) Analyze the algorithm's performance in different boundary scenarios (C4) Evaluate the accuracy and robustness of the boundary traversal procedure (C4) An Illustration of Procedure Map Building (C4): Understand the procedure for map building using sensor data (C4) Study the specific steps and actions involved in the map building process (C4) Analyze the algorithm's performance in different mapping scenarios (C4) Evaluate the accuracy and completeness of the generated maps (C4) Robot Simulation (C3): Understand the importance of simulation in robotics (C3) Study different simulation techniques and tools for robot testing and evaluation (C3) Apply simulation methods to validate and refine the map building algorithm (C3) Analyze the simulation results and make improvements to the algorithm (C3) Execution of the Map Building Program (C3): Understand the steps and requirements for executing the map building program on a robot (C3) Study the integration of sensor data acquisition, processing, and map generation (C3) Evaluate the program's performance and accuracy in real-world robotic scenarios (C3) Analyze and interpret the generated maps for further analysis and decision-

	making (C3)
2	Introduction (C2): Understand the basic concepts and importance of robot path planning (C2) Study the challenges and considerations involved in planning paths for robots (C2) Recognize the role of path planning in achieving efficient and safe robot navigation (C2) Representation of the Robot's Environment (C3): Study different methods and data structures for representing the robot's environment (C3) Explore techniques such as occupancy grids, point clouds, or 2D/3D maps (C3) Understand the trade-offs between accuracy, memory usage, and computational complexity (C3) Evaluate the suitability of different representation methods for specific robotic applications (C3) Review of Configuration Spaces (C3): Understand the concept of configuration space in robot path planning (C3) Study different types of configuration spaces, such as Euclidean or C-space (C3) Analyze the properties and limitations of configuration spaces for robot motion planning (C3) Apply mathematical tools and algorithms to compute and analyze configuration spaces (C3) Visibility Graphs, Voronoi Diagrams, Potential Fields, and Cell Decomposition (C4): Study advanced techniques for robot path planning, including visibility graphs, Voronoi diagrams, potential fields, and cell decomposition (C4) Understand the principles and algorithms behind these methods (C4) Analyze the advantages and limitations of each approach in different environments (C4) Apply these techniques to plan paths for robots in complex scenarios (C4) Planning with Moving Obstacles (C4): Study methods for robot path planning in dynamic environments with moving obstacles (C4) Understand the challenges and considerations of incorporating dynamic obstacle information (C4) Explore algorithms such as time-based or prediction-based planning to account for moving obstacles (C4) Analyze the performance and effectiveness of these algorithms in dynamic scenarios (C4) Probabilistic Roadmaps and Rapidly Exploring Random Trees (C5): Understand the principles and algorithms of probabilistic roadmaps (PRMs) and rapidly exploring random trees (RRTs) (C5) Study the advantages and limitations of these sampling-based methods (C5) Apply PRMs and RRTs to plan paths for robots in complex and high-dimensional spaces (C5) Evaluate the efficiency, completeness, and optimality of the generated paths

	(C5) Execution of the Quad tree-Based Path Planner Program (C3): Understand the steps and requirements for executing a quad tree-based path planner program (C3) Study the implementation and integration of the quad tree data structure (C3) Evaluate the program's performance and efficiency in path planning tasks (C3) Analyze and interpret the generated paths for further analysis and decision-making (C3)
3	Problem Definition (C2): Understand the problem of Simultaneous Localization and Mapping (SLAM) in robotics (C2) Define the goals and challenges of SLAM (C2) Identify the importance of SLAM in autonomous navigation and mapping (C2) Mathematical Basis (C3): Study the mathematical foundations and models used in SLAM (C3) Explore concepts such as probabilistic inference, Bayesian filtering, and optimization (C3) Understand the representation of uncertainty and the estimation of robot poses and landmark positions (C3) Analyze the statistical and computational methods employed in SLAM algorithms (C3) Examples: SLAM in Landmark Worlds (C4): Study specific examples and scenarios where SLAM is applied in landmark-based environments (C4) Analyze the challenges and solutions for SLAM in different types of environments (C4) Understand the data association problem and the use of landmark measurements in SLAM (C4) Evaluate the performance and accuracy of SLAM algorithms in landmark worlds (C4) Taxonomy of the SLAM Problem (C3): Explore the different classifications and taxonomies of SLAM approaches and algorithms (C3) Understand the categorization of SLAM methods based on feature-based, grid-based, or topological representations (C3) Analyze the trade-offs and advantages of different SLAM paradigms (C3) Recognize the variations and extensions of SLAM, such as online versus offline, full SLAM versus online SLAM (C3) Extended Kalman Filter (C4): Study the Extended Kalman Filter (EKF) as a popular method for SLAM estimation (C4) Understand the principles of state estimation and covariance propagation in EKF (C4) Analyze the limitations and assumptions of EKF in SLAM (C4) Apply the EKF algorithm to estimate robot poses and landmark positions in

	SLAM (C4) Graph-Based Optimization Techniques (C5): Explore graph-based optimization techniques for SLAM, such as pose graph optimization or factor graph optimization (C5) Understand the representation of SLAM problems as graphs and the use of optimization algorithms (C5) Analyze the advantages and scalability of graph-based methods in large-scale SLAM (C5) Apply graph-based optimization techniques to improve the accuracy and consistency of SLAM estimates (C5) Particle Methods (C4): Study particle-based methods, such as Monte Carlo Localization (MCL) or Particle Filters, for SLAM (C4) Understand the principles of particle filtering and resampling in SLAM (C4) Analyze the advantages and limitations of particle methods in SLAM (C4) Apply particle-based algorithms to estimate robot poses and landmark positions in SLAM (C4) Relation of Paradigms (C3): Understand the relationships and connections between different SLAM paradigms and methods (C3) Analyze the trade-offs and complementarity between filter-based, optimization-based, and particle-based approaches (C3) Recognize the strengths and weaknesses of different SLAM paradigms in different scenarios (C3)
4	Robot Parameter Display (C2): Develop a program to display and monitor various parameters of a robot, such as position, velocity, and sensor readings (C2) Implement a graphical user interface (GUI) or a command-line interface (CLI) to visualize and update the robot's parameters in real-time (C2) Utilize appropriate programming techniques to ensure accurate and efficient data display (C2) Program for Bot Speak (C2): Design a program that enables the robot to generate audible speech or voice output (C2) Implement text-to-speech synthesis or pre-recorded speech playback functionality in the program (C2) Incorporate appropriate speech generation libraries or APIs to ensure natural and intelligible robot speech (C2) Program for Sonar Reading Display (C3): Develop a program to read and display sensor data from a sonar sensor or ultrasonic range finder (C3) Implement appropriate data acquisition techniques to capture and process sonar readings (C3) Visualize the sonar data using graphs, plots, or a user-friendly interface (C3) Program for Wandering Within the Workspace (C3): Design a program that allows the robot to move autonomously within a

	predefined workspace or environment (C3) Implement path planning and obstacle avoidance algorithms to enable safe and efficient robot navigation (C3) Integrate appropriate sensor inputs (e.g., cameras, proximity sensors) to perceive the environment and make navigation decisions (C3) Program for Tele-operation (C3): Develop a program that enables remote control or tele-operation of the robot using a computer or a handheld device (C3) Implement communication protocols and interfaces to transmit control commands and receive feedback from the robot (C3) Ensure responsive and reliable tele-operation by managing latency and communication issues (C3) A Complete Program for Autonomous Navigation (C4): Design and implement a comprehensive program for autonomous navigation of the robot (C4) Integrate perception, localization, mapping, path planning, and control algorithms to enable autonomous operation (C4) Optimize the program for efficiency and robustness in real-world environments (C4) Consider safety measures and fail-safe mechanisms to ensure reliable autonomous navigation (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	3
Small Group Discussion (SGD)	3
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	10
Case/Project Based Learning (CBL)	--
Revision	3
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is

	optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", Springer Verlag Berlin and Heidelberg, 2007. **ii)** Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005. **iii)** Sebastian Tharun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005. **iv)** Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008. **v)** Hooman Somani,"Cognitive Robotics", CRC Press, 2015.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Cognitive Robotics Lab
Academic Year	IV
Semester	VII
Number of Credits	1
Course Prerequisite	Robotics Engineering and Its Application
Course Synopsis	This Lab course teaches the fundamentals for Practical Cognitive Robots. Lab work provides an introduction about the Cybernetic View of Robot Cognition and Perception. The course gives a practical knowledge of the Randomized Path Planning and Simultaneous Localization and Mapping (SLAM). Also provide the detailing of Robot Programming Packages and Imaging Geometry.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Discuss about the basic principles of telerobotic
CO2	Describe the concepts of wired and wireless communication for networked telerobotic systems.
CO3	Design and fabricate the software architecture and interface for networked robot systems on the web.
CO4	Analyze the performance of mobile robots controlled through the web.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	1	1	3	2	3	1	2	2	1	1	3	1	-
CO2	3	2	2	1	3	0	2	0	0	0	1	3	3	1	-
CO3	3	2	3	2	3	1	2	1	0	0	0	2	3	1	-
CO4	3	2	1	0	2	0	1	0	1	1	1	2	3	1	1

Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1	0.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	0	2	2

Unit	Content & Competencies
1	To study in detail about the Cognition and perception. (C2)
2	To study the different types of map building. (C2)
3	To study how to execute the programs in robots. (C2)
4	To analyze the various path planning techniques. (C3)
5	To study the different programs used for robot's environment. (C2)
6	To study the simultaneous localization and mapping based techniques. (C2)
7	To study various robot programming packages for Display, tele-operation etc. (C2)
8	To study and perform robot simulation. (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", Springer Verlag Berlin and Heidelberg, 2007.
2. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.
3. Sebastian Tharun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
4. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.
5. Hooman Somani,"Cognitive Robotics", CRC Press, 2015.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Modeling and Simulation of EHV
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	Introduction to Electric and Hybrid Vehicles
Course Synopsis	This subject will help students to understand the modeling of electric vehicle performance parameters. It will also introduce students to model battery for electric vehicles and drive train characteristics. The concepts of energy management system and vehicle dynamic control systems will be explained at an introductory level.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the modeling of vehicle performance parameters.
CO2	Model battery for electric vehicles.
CO3	Describe the drive train characteristics.
CO4	Apply the concepts of energy management system.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	2	3	1	2	2	1	1	3	2	-
CO2	3	2	2	1	3	-	2	-	-	-	1	3	3	1	1
CO3	3	2	3	2	3	1	2	1	-	-	-	2	3	1	1
CO4	3	2	1	-	2	-	1	-	1	1	1	2	3	2	-
Average	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.5	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week

3	0	0	3

Unit	Content & Competencies
1	Modelling Vehicle Acceleration (C4): Acceleration performance parameters (C4): Define and analyze key parameters that characterize a vehicle's acceleration performance, such as 0-60 mph time, 0-100 km/h time, and quarter-mile time (C4) Understand the significance of these parameters in assessing a vehicle's acceleration capabilities (C4) Apply mathematical equations and formulas to calculate and interpret acceleration performance metrics (C4) Modelling the acceleration of an electric scooter (C4): Develop a mathematical model that describes the acceleration behavior of an electric scooter (C4) Consider factors such as motor power, vehicle weight, aerodynamics, and rolling resistance in the acceleration model (C4) Incorporate control algorithms and motor characteristics to simulate the acceleration response of the electric scooter (C4) Validate the model against real-world test data and refine the model if necessary (C4) Modelling the acceleration of a small car (C4): Construct a mathematical model to represent the acceleration characteristics of a small car (C4) Consider parameters such as engine power, vehicle weight, transmission ratios, aerodynamics, and tire properties in the acceleration model (C4) Implement the model using numerical methods or simulation software to predict the car's acceleration performance under different conditions (C4) Compare the model predictions with empirical data or performance specifications to validate the accuracy of the model (C4)
2	Electric Vehicle Modelling (C4): Tractive Effort (C4): Understand the concept of tractive effort and its significance in electric vehicle performance (C4) Model and calculate the tractive effort based on parameters such as motor torque, gear ratio, and wheel radius (C4) Consider factors like vehicle weight, grade resistance, and tire characteristics in the tractive effort calculation (C4) Rolling Resistance Force (C4): Define and model the rolling resistance force acting on an electric vehicle (C4) Account for factors such as tire characteristics, vehicle weight, and road surface conditions in the rolling resistance model (C4) Calculate and analyze the impact of rolling resistance on the overall energy consumption and range of the electric vehicle (C4) Aerodynamic Drag (C4): Explain the concept of aerodynamic drag and its effect on electric vehicle

	performance (C4) Develop a mathematical model to estimate the aerodynamic drag force based on vehicle speed, frontal area, and drag coefficient (C4) Analyze the influence of aerodynamic drag on energy consumption and range of the electric vehicle (C4) Hill Climbing Force (C4): Describe the hill climbing force and its role in electric vehicle performance (C4) Model the hill climbing force taking into account the grade of the road, vehicle weight, and drivetrain efficiency (C4) Assess the impact of hill climbing on the energy consumption and range of the electric vehicle (C4) Acceleration Force (C4): Understand the relationship between acceleration and force in electric vehicles (C4) Develop a model to calculate the acceleration force based on vehicle mass, motor power, and drivetrain efficiency (C4) Evaluate the influence of acceleration on energy consumption and range of the electric vehicle (C4) Total Tractive Effort (C4): Combine the various forces, including tractive effort, rolling resistance, aerodynamic drag, hill climbing force, and acceleration force, to determine the total tractive effort (C4) Analyze the total tractive effort to assess the overall performance and energy requirements of the electric vehicle (C4) Modelling Electric Vehicle Range (C4): Driving Cycles (C4): Understand the concept of driving cycles and their importance in evaluating electric vehicle range (C4) Analyze and model different driving cycles, such as urban, highway, or standardized test cycles, to simulate real-world driving conditions (C4) Use driving cycles as inputs for range calculation models (C4) Range Modelling of Battery Electric Vehicles (C4): Develop mathematical models to estimate the range of battery electric vehicles based on factors like battery capacity, energy consumption, and efficiency (C4) Consider driving conditions, terrain, and driver behavior in the range calculation (C4) Validate the range model using real-world data or experimental results (C4) Constant Velocity Range Modelling (C4): Model the range of electric vehicles operating at constant velocities (C4) Take into account factors such as vehicle speed, energy consumption rate, and available energy capacity (C4) Analyze the impact of constant velocity driving on the range of the electric vehicle (C4) Range Modelling of Fuel Cell Vehicles (C4): Develop range models specifically for fuel cell vehicles, considering factors such as hydrogen consumption rate, fuel cell efficiency, and energy storage

	capacity (C4) Incorporate driving cycles and real-world conditions in the range estimation for fuel cell vehicles (C4) Compare and evaluate the range performance of fuel cell vehicles with other electric vehicle types (C4) Range Modelling of Hybrid Electric Vehicles (C4): Model the range of hybrid electric vehicles that combine multiple power sources, such as an internal combustion engine and electric motor (C4) Consider factors like fuel consumption, battery capacity, regenerative braking, and powertrain control strategies in the range estimation (C4) Assess the range performance of hybrid electric vehicles under different driving scenarios (C4)
3	Modelling and Characteristics of EV/HEV Powertrain Components (C4): ICE Performance Characteristics (C4): Understand the performance characteristics of internal combustion engines (ICE) used in hybrid electric vehicles (HEVs) (C4) Model and analyze the power, torque, and fuel consumption characteristics of the ICE (C4) Consider factors like engine speed, load, and efficiency in the performance modeling (C4) Electric Motor Performance Characteristics (C4): Understand the performance characteristics of electric motors used in electric vehicles (EVs) and HEVs (C4) Model and analyze the torque-speed relationship, power output, and efficiency of electric motors (C4) Consider factors like motor type, voltage, current, and control strategies in the performance modeling (C4) Battery Performance Characteristics (C4): Understand the performance characteristics of batteries used in EVs and HEVs (C4) Model and analyze the battery capacity, voltage, current, and energy efficiency (C4) Consider factors like battery chemistry, temperature, aging, and state of charge in the performance modeling (C4) Transmission and Drivetrain Characteristics (C4): Understand the characteristics and operation of transmissions and drivetrains in EVs and HEVs (C4) Model and analyze the gear ratios, power distribution, and efficiency of the transmission and drivetrain system (C4) Consider factors like gear shifting strategies, powertrain control, and regenerative braking in the modeling (C4) Regenerative Braking Characteristics (C4): Understand the principles and benefits of regenerative braking in EVs and HEVs (C4) Model and analyze the energy recovery during regenerative braking (C4) Consider factors like braking force, vehicle speed, and energy storage in the

	regenerative braking modeling (C4) Driving Cycles Modelling and Analysis (C4): Understand the concept of driving cycles and their relevance in analyzing the performance of EVs and HEVs (C4) Model and analyze different driving cycles, such as urban, highway, or standardized test cycles (C4) Consider factors like vehicle speed, acceleration, deceleration, and energy consumption in the driving cycle analysis (C4) Propulsion and Braking Analysis of Electric and Hybrid Electric Vehicles (C4): Model and analyze the propulsion characteristics of EVs and HEVs based on the combined performance of powertrain components (C4) Assess the energy consumption, power delivery, and efficiency of the propulsion system (C4) Model and analyze the braking characteristics, including regenerative braking, in EVs and HEVs (C4)
4	Analysis of Electric and Hybrid Electric Vehicles (C4): Develop simplified handling models for electric and hybrid electric vehicles (C4) Analyze the vehicle dynamics and handling characteristics of electric and hybrid vehicles (C4) Consider factors like vehicle weight, center of gravity, tire characteristics, and suspension systems in the analysis (C4) Energy/Power Allocation and Management (C4): Understand the importance of efficient energy and power management in electric and hybrid electric vehicles (C4) Develop power allocation strategies to optimize the distribution of power between different components (C4) Analyze and optimize the energy flow and power distribution in the vehicle's propulsion system (C4) Power/Energy Management Controllers (C4): Design and implement power and energy management controllers for electric and hybrid electric vehicles (C4) Develop control algorithms to regulate the power flow and energy usage in the vehicle's powertrain system (C4) Consider factors like vehicle speed, load, battery state of charge, and power demand in the controller design (C4) Rule-Based Control Strategies (C4): Implement rule-based control strategies for power and energy management in electric and hybrid electric vehicles (C4) Define a set of rules and conditions to govern the power allocation and energy usage based on system requirements (C4) Consider factors like driving conditions, battery capacity, and user preferences in the rule-based control strategies (C4) Optimization-Based Control Strategies (C4): Develop optimization-based control strategies for power and energy management in electric and hybrid electric vehicles (C4)

	Formulate optimization problems to maximize energy efficiency or minimize energy consumption in the vehicle (C4) Utilize optimization algorithms and techniques to find optimal power allocation and energy management solutions (C4)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	20
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	16
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

<table>
<tr><td colspan="3"></td></tr>
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2. Course Exit Survey</td></tr>
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2. Feedback between the semester through google forms.
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<tr><td></td><td colspan="2">1. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.
2. Amir Khajepour, Saber Fallah and Avesta Goodarzi, “Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach”, John Wiley & Sons Ltd, 2014.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition”, CRC Press, 2010.</td></tr>
</table>

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Modeling and Simulation of EHV Lab
Academic Year	IV
Semester	VII
Number of Credits	1
Course Prerequisite	Introduction to Electric and Hybrid Vehicles
Course Synopsis	This subject will help students to understand the modeling of electric vehicle performance parameters. It will also introduce students to model battery for electric vehicles and drive train characteristics. The concepts of energy management system and vehicle dynamic control systems will be explained at an introductory level.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Understand the modeling of vehicle performance parameters.
CO2	Model battery for electric vehicles.
CO3	Describe the drive train characteristics.
CO4	Apply the concepts of energy management system.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	3	0	1	1	3	2	3	1	2	2	1	1	3	2	-
CO2	3	2	2	1	3	0	2	0	0	0	1	3	3	1	1
CO3	3	2	3	2	3	1	2	1	0	0	0	2	3	1	1
CO4	3	2	1	0	2	0	1	0	1	1	1	2	3	2	-
Average	3.00	1.50	1.75	1.00	2.75	0.75	2.00	0.50	0.75	0.75	0.75	2.00	3	1.5	0.5

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week

0	0	2	2

Unit	**Content & Competencies**
1	To Simulate the battery electric vehicle by using MATLAB. (C1, C2, C3)
2	To Simulate the Motor performance of electric vehicle by using MATLAB. (C1, C2, C3)
3	To study about Modeling and Characteristics of EV/HEV Power trains Components. (C1, C2, C3)
4	To study about the acceleration performance of a car. (C1, C2, C3)
5	To study & Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking. (C1, C2, C3)
6	To study about energy management system of EVs. (C1, C2, C3)
7	To study about the MATLAB & Simu-link software for EVs. (C1, C2, C3)
8	To Study about control strategies of simulation. (C1, C2, C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	20
Seminar/Journal Club	--
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	VIVA
Viva-voce	Practical Examination & Viva-voce
--	University Examination

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
VIVA	✓	✓	✓	✓
Practical Log Book/ Record Book	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.
2. Amir Khajepour, Saber Fallah and Avesta Goodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2010.

FACULTY OF ENGINEERING AND TECHNOLOGY	
Name of the Department	Computer Science Engineering
Name of the Program	Bachelor of Technology
Course Code	
Course Title	Software Engineering
Academic Year	IV
Semester	VII
Number of Credits	3
Course Prerequisite	NIL
Course Synopsis	The aim of the course is to provide an understanding of the working knowledge of the techniques for estimation, design, testing and quality management of large software development projects.

Course Outcomes:

At the end of the course students will be able to:

CO1	Able to define software engineering process and practices, and demonstrate various process models
CO2	Able to identify different types of risks in software development.
CO3	Able to distinguish different testing strategies and it’s working
CO4	Able to Estimate the quality of software process and develop the SRS document for project.

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

Cos	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO 4**
CO1	3	2	1	2	2	-	-	-	1	-	1	1	-	1	1	-
CO2	3	3	1	2	-	-	-	-	1	-	1	1	1	1	1	-
CO3	3	3	1	2	2	2	-	2	1	-	1	1	1	1	1	-
CO4	3	2	1	2	2	2	-	2	1	-	1	-	-	1	1	-
Average	3	1.5	1	2	1.5	1	-	1	1	-	1	0.75	0.5	1	1	-

Course Content:

L (Hours/ Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3	**-**	**-**	**3**

Unit	Content & Competencies
1	Introduction to Software Engineering: Discuss the evolving role of software, changing nature of software, and software myths. (C2: Comprehension) Explain a Generic view of process and Software engineering layered technology. (C2: Comprehension) Generalize the concept of the capability maturity model integration (CMMI), Discuss the following terms: process patterns, process assessment, personal and team process models. (C2: Comprehension) Explain the following Process models: The waterfall model, incremental process models, evolutionary process models, the unified process. (C2: Comprehension)
2	Explain the characteristics and purpose of functional and non-functional requirements. (C2: Comprehension) Analyze user requirements to identify and prioritize software features that meet user needs. Recall the role and significance of system requirements in software development. Explain the importance of well-defined interfaces for software integration and interoperability. (C2: Comprehension) Recite the purpose and objectives of Feasibility studies, requirements elicitation and analysis, requirements validation, requirements management in the requirements engineering process. (C1: Knowledge) Describe the following System models: Context models, behavioral models, data models, object models, structured methods. (C2: Comprehension)
3	Design Engineering: Explain the importance of design quality in software engineering. (C2: Comprehension) Recall the fundamental design concepts and principles in software engineering. (C1: Knowledge) Explain how the design model represents the structure and behavior of a software system. (C2: Comprehension) Explain software architecture and architectural design: software architecture, data design, architectural styles and patterns, architectural design. (C2: Comprehension) Recall the purpose and components of the conceptual model in the Unified Modeling Language (UML). (C1: Knowledge) Discuss following terms: basic structural modeling, class diagrams, sequence diagrams, collaboration diagrams, use case diagrams, component diagrams. (C2: Comprehension) Illustrate strategic approaches to software testing.

	Explain following testing techniques in detail: black-box and white-box testing, validation testing, system testing, the art of debugging. (C2: Comprehension)
4	Outline Software quality and metrics for analysis model. (C1: Knowledge) Explain metrics for design model, metrics for source code, metrics for testing and metrics for maintenance. (C2: Comprehension) Explain following in Risk management: Reactive Vs proactive risk strategies, software risks, risk identification, risk projection, risk refinement, RMMM, RMMM plan. (C2: Comprehension) Discuss following Quality Management Concepts: Quality concepts, software quality assurance, software reviews, Explain formal technical reviews. (C2: Comprehension) Describe statistical software quality assurance and software reliability. (C2: Comprehension) Explain the ISO 9000 quality standards. (C2: Comprehension)

Learning Strategies and Contact Hours

Learning Strategies	Contact Hours
Lecture	30
Practical	
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	1
Problem Based Learning (PBL)	4
Case/Project Based Learning (CBL)	2
Revision	4
Others If any:	
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2
Objective Structured Clinical Examination (OSCE)	University Examination
Objective Structured Practical Examination	Dissertation

(OSPE)	
Quiz	Multiple Choice Questions (MCQ)
Seminars	Short Answer Questions (SAQ)
Problem Based Learning (PBL)	Long Answer Question (LAQ)
Journal Club	Practical Examination & Viva-voce
	Objective Structured Clinical Examination (OSCE)
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz	✓	✓	✓	✓
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test	✓	✓	✓	✓
Clinical assessment				
Clinical/Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student’s Feedback			

References:	Textbooks: 1.Software Engineering, A practitioner’s Approach- Roger S. Pressman, 6th edition, Mc Graw Hill International Edition. 2. Software Engineering- Sommerville, 7th edition, Pearson Education. 3. The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education.
	References: 1.Software Engineering, an Engineering approach- James F. Peters, Witold

	Pedrycz, John Wiley. 2. Software Engineering principles and practice- Waman S Jawadekar, The Mc Graw-Hill Companies. 3. Fundamentals of object-oriented design using UML Meiler page-Jones: Pearson Education

Faculty of Engineering and Technology	
Name of the Department	Computer Science Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Software Engineering Lab
Academic Year	IV
Semester	VII
Number of Credits	1
Course Prerequisite	Programming for Problem Solving
Course Synopsis	To have hands on experience in developing a software project by using various software engineering principles and methods in each of the phases of software development.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Able to Plan a software engineering process life cycle.
CO2	Able to elicit, analyze and specify software requirements.
CO3	Able to Analyze and translate a specification into a design.
CO4	Able to Built an SRS documents :Realize design practically, using an appropriate software engineering

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	P O 12	PSO 1	PSO 2	PSO3	PSO4
CO1	3	2	2	2	1	-	-	-	-	1	1	-	-	-	-	-
CO2	3	2	2	2	1	-	-	-	1	1	-	-	3	-	-	-
CO3	3	2	2	2	1	-	-	-	-	-	1	-	-	-	-	-
CO4	3	2	2	2	1	-	-	-	-	1	1	-	3	-	-	-
Average	3	2	2	2	1	-	-	-	0.25	0.75	0.75		1.5	-	-	-

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
0	0	2	2

Sr. No.	Content & Competencies

1	Draft a project plan for any Project. (C1: Knowledge)
2	Development of SRS document. (C1: Knowledge)
3	To draw different levels of DFD. (C1: Knowledge)
4	To draw an ER diagram (C1: Knowledge)
5	To draw a use case diagram. (C1: Knowledge)
6	To draw a sequence diagram and collaboration diagrams. (C1: Knowledge)
7	To draw a class diagram. (C1: Knowledge)
8	To draw a Gantt chart and network diagram. (C1: Knowledge)
9	To draw a structured chart. (C1: Knowledge)
10	Development of design Document. (C1: Knowledge)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	05
Case/Project Based Learning (CBL)	--
Revision	--
Others If any:	--
Total Number of Contact Hours	30

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

References:	Textbooks: **i)** Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th edition, Mc Graw Hill International Edition. **ii)** Software Engineering- Sommerville, 7th edition, Pearson Education. **iii)** The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education

SEMESTER - VIII

Course Code	Course Title
	Operation Research Techniques
Program Electives Course - VI	
	Design of Thermal Systems
	Advance Automotive Electronics
	Lean enterprise & Advanced Manufacturing Technologies
	Non-Destructive Evaluation & Testing
	Biomaterials
	Entrepreneurship & Digital Product Management
	Research Project/ Dissertation

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Operation Research Techniques
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	Industrial Engineering
Course Synopsis	Operation research is having many powerful tools to optimize the real-life problems. The study of this subject will give knowledge to the students regarding transportation and inventory related problems. This also describes the method of sequencing of jobs through different number of machines. Focus is also given to most common problems of waiting of either job/machines/peoples. Emphasis is given to decision models and replacement problems. So, the study of this subject will develop the capability among students to solve effectively many problems arising during their career.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Apply the concept of Linear model to solve various transportation problems.
CO2	Apply the concept of Sequencing and Networks to optimize the production
CO3	Apply the concept of inventory model to maximize the profit.
CO4	Apply the concept of Queuing Models and decision models to forecast the demand in the industry.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO 1	PSO2	PSO3
CO1	3	1	2	2	1	1	-	1	-	-	-	3	3	2	1
CO2	3	2	3	3	2	1	-	-	-	1	1	3	3	2	1
CO3	3	2	3	3	2	1	-	-	-	-	1	3	3	2	-
CO4	3	3	3	3	3	2	-	-	1	1	-	3	3	2	-
Average	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	3	2	0.5

Course Content:				
L (Hours/Week)		**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**
3		**0**	**0**	**3**
Unit	**Content & Competencies**			
1	Introduction to Operations Research (C2): Understand the basic concepts and principles of Operations Research (C2) Recognize the importance of optimization and decision-making in operations management (C2) Explore various techniques and methodologies used in Operations Research (C2) Linear Programming (C3): Learn about the mathematical formulation of linear programming problems (C3) Apply graphical methods to solve linear programming problems (C3) Understand the simplex method and its steps for solving linear programming problems (C3) Explore the duality concept and its applications in linear programming (C3) Understand the two-phase simplex method for solving linear programming problems (C3) Transportation Problems (C3): Understand the concept of transportation problems in Operations Research (C3) Learn about the Northwest Corner method and Vogel's Approximation method for solving transportation problems (C3) Explore the MODI (Modified Distribution) method for finding optimal solutions to transportation problems (C3) Transshipment Problems (C3): Understand the concept of transshipment problems in Operations Research (C3) Learn about the different approaches for solving transshipment problems (C3) Apply optimization techniques to find optimal solutions to transshipment problems (C3) Assignment Problems (C3): Understand the concept of assignment problems in Operations Research (C3) Learn about the different algorithms and methods for solving assignment problems (C3) Apply optimization techniques to find optimal assignments in assignment problems (C3) Introduction to Dynamic Programming and Nonlinear Programming (C2): Understand the basics of dynamic programming and nonlinear programming in Operations Research (C2) Explore the applications of dynamic programming and nonlinear programming in solving complex optimization problems (C2) Goal Programming (C2): Understand the concept of goal programming in Operations Research (C2) Apply goal programming techniques to handle multiple conflicting objectives in decision-making (C2)			

2	Sequencing (C3): Understand the sequencing problem with N jobs and 2 machines (C3) Learn Johnson's method and its application in solving sequencing problems (C3) Apply Johnson's method to determine the optimal sequence of jobs on 2 machines (C3) Sequencing with N Jobs and 3 Machines (C3): Understand the sequencing problem with N jobs and 3 machines (C3) Learn the modified Johnson's method for solving sequencing problems with 3 machines (C3) Apply the modified Johnson's method to determine the optimal sequence of jobs on 3 machines (C3) Sequencing with M Machines (C3): Understand the sequencing problem with N jobs and 'M' machines (C3) Learn the modified Johnson's method for solving sequencing problems with 'M' machines (C3) Apply the modified Johnson's method to determine the optimal sequence of jobs on 'M' machines (C3) Network Models (C2): Understand the basic concepts of network models in Operations Research (C2) Learn about the construction of networks and their representation (C2) Explore project networks and their applications in project management (C2) Understand the concepts of CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) (C2) Apply critical path scheduling techniques to determine project timelines (C2) Learn about crashing of networks and its impact on project schedules (C2)
3	Inventory Models (C2): Understand the concept of inventory and its importance in operations management (C2) Explore the various costs associated with inventory, such as holding costs, ordering costs, and shortage costs (C2) Learn about the Economic Order Quantity (EOQ) model and its application in determining optimal order quantity (C2) Understand deterministic inventory models, which assume known demand and lead time (C2) Study production models that integrate inventory management with production planning (C2) Learn about stochastic inventory models, which consider uncertain demand and lead time (C2) Explore the concept of buffer stock and its role in mitigating demand and lead time variability (C2)
4	Queuing Models (C3): Understand the concept of queuing theory and its applications in modeling waiting lines (C3) Study Poisson arrival process, which assumes arrivals occur randomly over time

	(C3) Explore exponential service time distribution, which represents the time taken to serve each customer (C3) Learn about single-channel queuing models, where there is only one server (C3) Study multi-channel queuing models, where there are multiple parallel servers (C3) Simulation (C3): Understand the concept of simulation and its uses in modeling real-world systems (C3) Explore the advantages and disadvantages of simulation as a decision-making tool (C3) Learn about random number generation and its importance in generating random inputs for simulations (C3) Study Monte Carlo simulation models, which use random sampling techniques to analyze probabilistic systems (C3) Decision Models (C4): Introduction to decision models and their role in decision-making (C4) Explore game theory and its application in analyzing strategic interactions between players (C4) Study two-person zero-sum games, where one player's gain is the other player's loss (C4) Learn about graphic solution methods for solving simple games (C4) Understand the concept of dominance and its application in simplifying decision problems (C4) Explore algebraic solution methods for solving games (C4) Replacement Models (C3): Study replacement models for items that deteriorate over time, such as machinery or equipment (C3) Learn about replacement models when the value of money changes over time (C3) Explore replacement models for items that fail completely, such as light bulbs or batteries (C3) Understand the concepts of individual replacement and group replacement policies (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	4
Small Group Discussion (SGD)	6
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5

Case/Project Based Learning (CBL)	--
Revision	4
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References: (List of reference books)

i) DS GUPTA ,PK HIRA(2015), Operation Research, S.CHAND PUBLISHER; 2011 edition (2015)**ISBN-10:** 121212184 **ISBN-13:** 978-1212121844, ISBN: 978-8-120- 30162-7.

ii) Hamdy Taha, (2008), Operations Research-An Introduction, 8th Edition, Pearson Education, ISBN:978-8-131-71104-0.

iii) R. Panneerselvan (2006), Operation Research, 2nd Edition, Prentice Hall of India Pvt Ltd ISBN:978-8-120-31743-7.

iv) J. K. Sharma (2013), Operation Research, 5th Edition, Macmillan Publications, ISBN: 978-9-350-59336-3.

v) Kanti Swarup, P.K. Gupta and Manmohan Lal (2010), Operations Research, 15th Edition, S. Chand & Sons, ISBN: 978- 8-180-54771-3.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Design of Thermal Systems**
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	Engineering Thermodynamics, Heat and Mass Transfer
Course Synopsis	The design of thermal systems requires an integrated approach that treats thermodynamics, fluid mechanics, and heat transfer as parts of one interconnected area, in which appropriate solutions to real-life design and analysis problems can be obtained only when all these aspects are considered simultaneously (after familiarity with the set here topics is achieved in previous dedicated courses.)This approach must be implemented through open-ended problems and design project oriented teaching. Topics related to thermal systems Include fluid flow networks, heat exchanger design, design and selection of pumps, fans and compressors, heat recovery systems, psychometrics, air-conditioning systems, electronic cooling systems, fuels and combustion, solar thermal systems, and power plant design. This course is specifically designed to allay the fear of ill-defined problems by teaching the skills to model and translate a physical situation into the relevant equations. The use of equation-solving software facilitates the implementation of this focus by reducing the effort involved in solving equations and affording the opportunity for more discourse on the approach toward modelling of thermal systems. The students will learn the effect of individual component design on overall systems through parametric optimization studies. Topics common to the design of all thermal systems will be taught briefly in an interactive lecture format, but the main emphasis will be on open-ended design problems to be formulated and solved in discussion format. The course will begin with the development of skills for the modelling and parametric investigation of individual thermal system components. As proficiency is gained in these exercises, the students will develop the capability to design overall thermal systems in projects of larger scope. The methodology of translating a problem statement into design tasks and executing them will be illustrated. The understanding of thermal component and system design will be encouraged by requiring the students to view the "solution"

	to the problem as the beginning rather than the end of a design. Discussion of the effects of changes in design conditions (flow rates, inlet temperatures, etc.) and component geometry (diameter, length, other features) on performance will be emphasized.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Students should be able to have knowledge of different aspects of designing of a thermal system.
CO2	Students should be able to identify and examine a design problem associated to a thermal system.
CO3	Students should be able to understand basics of modeling and their associated techniques,
CO4	Students should be able to explain economic aspect of designing and able to apply different

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	3	2	0	2	0	0	0	0	0	2	2	3	1
CO2	3	1	3	2	2	1	2	0	0	0	0	3	1	3	3
CO3	3	3	3	3	0	1	2	0	0	1	0	3	-	3	3
CO4	3	3	1	3	2	2	2	0	0	0	0	3	-	3	2
Average	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Content & Competencies

Unit	Content & Competencies
1	Requirements of Engineering Design (C3): Understand the importance of engineering design in creating solutions to problems (C3) Study the requirements and constraints that guide the design process (C3) Learn about the role of creativity, innovation, and problem-solving skills in engineering design (C3) Analysis (C3): Understand the concept of analysis in engineering design, which involves breaking down a complex problem into smaller components (C3) Learn various analytical techniques and tools used in engineering design, such

	as mathematical modeling, simulation, and numerical analysis (C3) Study the importance of analysis in evaluating the performance, feasibility, and optimization of design solutions (C3) Synthesis (C3): Understand the concept of synthesis in engineering design, which involves combining or creating new elements or systems to meet design requirements (C3) Learn about synthesis techniques such as brainstorming, concept generation, and system integration (C3) Study the importance of synthesis in developing innovative and effective design solutions (C3) Selection and Optimization (C4): Learn about the process of selecting the most suitable design alternatives from a set of options (C4) Understand the concept of optimization, which involves maximizing or minimizing certain design criteria or objectives (C4) Study optimization techniques such as mathematical programming, evolutionary algorithms, and heuristic methods (C4) Characteristics of a Thermal System (C2): Understand the fundamental principles and characteristics of thermal systems (C2) Study the transfer of heat and energy within thermal systems (C2) Learn about different types of thermal systems, such as HVAC systems, power plants, and heat exchangers (C2) Analyze the performance, efficiency, and control of thermal systems (C2) Formulation of the Design Problem (C2): Understand the process of formulating the design problem, which involves defining the objectives, constraints, and specifications of the design project (C2) Learn about problem statement development, stakeholder analysis, and requirement gathering techniques (C2) Study the importance of accurately formulating the design problem to ensure the success of the design process (C2) Conceptual Design and Steps in the Design Process (C3): Understand the concept of conceptual design, which involves generating and evaluating different design concepts and solutions (C3) Learn about the various steps involved in the design process, such as problem identification, research, concept development, prototyping, and testing (C3) Study the iterative nature of the design process and the importance of feedback and iteration in refining design solutions (C3) Computer-Aided Design (C4): Understand the role of computer-aided design (CAD) tools in the design process (C4) Learn about the various CAD software and technologies used for 2D and 3D modeling, simulation, and visualization (C4) Study the advantages of CAD in improving design efficiency, accuracy, and collaboration (C4)

	Material Selection (C3): Understand the importance of material selection in engineering design (C3) Study the properties and characteristics of different materials and their suitability for specific design applications (C3) Learn about material selection criteria, such as mechanical properties, cost, availability, and environmental impact (C3) Analyze the trade-offs and decision-making process involved in material selection (C3)
2	Modelling Basics (C2): Understand the importance of modelling in the design process (C2) Identify the basic features and characteristics of models (C2) Learn about different types of models, including analogue, mathematical, physical, and numerical models (C2) Mathematical Modelling (C3): Understand the general procedure for mathematical modelling in design (C3) Learn about the steps involved in developing a mathematical model, including problem formulation, assumptions, and equations (C3) Study the process of refining and validating the mathematical model (C3) Modelling Techniques (C3): Explore physical modelling techniques and the use of dimensional analysis in design (C3) Understand the concept of curve fitting and different methods for fitting curves to data (C3) Learn about exact and best fit curve fitting approaches (C3) Synthesis of Different Design Steps (C3): Understand the concept of synthesis in the design process, which involves combining and integrating different design steps (C3) Explore the initial design phase and the importance of defining design objectives and constraints (C3) Learn about commonly used design approaches and strategies (C3) Study the iterative design procedure and the role of feedback and iteration in refining design solutions (C3)
3	Economic Considerations (C3): Calculate interest using different methods, including simple interest, compound interest, continuous compounding, and effective interest rate (C3) Understand the concept of the time value of money and its implications in economic analysis (C3) Explore different types of payments, such as lump-sum payments, annuities, and installment payments (C3) Learn about bonds and stocks as financial instruments and their role in investment (C3) Understand the concepts of taxes and depreciation and their impact on the cost of an investment (C3) Perform cost comparisons and analyze the rate of return for different investment options (C3)

	Apply economic analysis techniques to thermal systems and evaluate the economic viability of such systems (C3)
4	Optimization (C3): Introduction to Optimization: Understand the need for optimization in engineering and design (C3) Familiarize with the basic concepts of optimization, including the objective function and constraints (C3) Learn how to formulate an optimization problem in mathematical terms (C3) Methods of Optimization: Explore different methods of optimization, including the calculus method, search method, and geometrical programming (C3) Understand the principles and techniques used in each method (C3) Apply these methods to solve optimization problems in engineering and design (C3) Practical Aspects of Optimal Design: Consider the choice of variables in the optimization process (C3) Perform sensitivity analysis to assess the impact of changes in variables on the optimal solution (C3) Understand the dependence of the optimal solution on the objective function (C3) Explore multi-objective optimization and the challenges associated with optimizing multiple conflicting objectives (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2

Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student’s Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Janna, William S. Design of Fluid Thermal Systems-SI Version. Cengage learning, 2010. ISBN- 13: 978-1305076075. ii) Rieder, W.G. and Busby, H.R. Introductory Engineering Modelling Emphasizing differential Models and Computer Simulation, Wiley, 1986. ISBN-13: 978-0471895374. iii) Collier, Courtland A., and William Burl Ledbetter. Engineering economic and cost analysis. Harper collins College Division, 1988. ISBN-13: 978-0060413330. iv) Fox, R.L. Optimization Methods for Engineering Design, Addison Wesley,

	1971. ISBN-13: 978-0201020786. v) Rao, Singiresu S., and S. S. Rao. Engineering optimization: theory and practice. John Wiley & Sons, 2009. ISBN: 978-1-119-45479-3.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Advanced Automotive Electronics
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	Basics of Electronics and Electrical Engineering
Course Synopsis	Automotive electronics are electronic systems used in vehicles, including engine management, ignition, radio, carburetors, telematics, in-car entertainment systems and others. Ignition, engine, and transmission electronics are also found in trucks, motorcycles, off-road vehicles, and other internal combustion-powered machinery such as forklifts, tractors, and excavators. Related elements for control of relevant electrical systems are found on hybrid vehicles and electric cars as well.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today's automotive industry
CO2	Understanding the advantages of electronic injection and ignition system
CO3	Develop and design of warning systems and indicators for alerting the driver.
CO4	To learn the importance of comfort, safety, software interface, and hardware in overall design and working of a vehicle.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	-	2	-	2	-	-	-	-	-	-	2	3	2	-
CO2	3	-	2	-	3	2	-	-	-	-	-	2	3	2	-
CO3	3	-	-	-	3	2	2	2	-	-	-	2	3	2	1
CO4	3	2	2	2	3	3	-	-	-	-	-	2	3	2	-

Average	3	0.5	1.5	0.5	2.75	1.75	0.5	0.5	0	0	0	2	3	2	0.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	**0**	**0**	**3**

Unit	Content & Competencies
1	Introduction to Automotive Sensors and Control Systems (C2): Gain an understanding of the role and importance of sensors in automotive systems (C2) Learn about the basic sensor arrangements used in vehicles (C2) Explore different types of sensors employed in automotive applications (C2) Study the functioning and significance of specific sensors like oxygen sensors, fuel metering/vehicle speed sensors, detonation sensors, and flow sensors (C2) Understand the operation and purpose of throttle position sensors (C2) Actuators and Control Systems (C2): Learn about actuators used in automotive systems such as solenoids, stepper motors, and relays (C2) Understand their role in controlling various components and functions in a vehicle (C2) Differentiate between open-loop and closed-loop control systems (C2) Explore the Engine Control Module (ECM) and its functions in controlling the engine (C2) Study engine cooling and warm-up control mechanisms (C2) Gain insights into the control of acceleration, detonation, and idle speed in an integrated engine system (C2) Learn about exhaust emission control engineering and the measures taken to reduce emissions (C2) Understand the concept of on-board diagnostics (OBD) and its importance in diagnosing vehicle issues (C2) Get an overview of future trends in automotive electronic systems (C2)
2	Introduction to Automotive Fuel Systems and Ignition Systems (C2): Gain an understanding of the basic principles and components of automotive fuel systems (C2) Learn about the feedback carburetor system (FBC) and its role in fuel delivery (C2) Explore different types of gasoline fuel injection systems, including throttle body injection and multi-port fuel injection (C2) Understand the control mechanisms and components involved in fuel injection systems (C2) Study the Robert Bosch gasoline fuel injection system controls (C2) Learn about fuel-air ratio sensing methods used in automotive fuel systems (C2) Understand the fuel system requirements and considerations for turbocharged engines (C2)

	Ignition Systems (C2): Explore the advantages of electronic ignition systems over conventional ignition systems (C2) Understand the principle of operation of electronic ignition systems (C2) Learn about high-energy ignition distributors and their role in the ignition process (C2) Study the simplified operational diagram for a distributorless ignition system (C2) Gain insights into electronic spark timing and control mechanisms (C2)
3	Brake Actuation Warning System (C3): Understand the purpose and operation of brake actuation warning systems in vehicles (C3) Learn about the components involved in the system, such as brake sensors and warning indicators (C3) Explore the activation criteria and signals that trigger the warning system (C3) Study the integration of the brake actuation warning system with other vehicle safety systems (C3) Trafficators and Flash System (C2): Gain an understanding of trafficators and their role in indicating vehicle turning signals (C2) Learn about the operation and control mechanisms of trafficators (C2) Explore the flash system used in modern vehicles for turn signal indication (C2) Understand the electrical circuitry and control signals involved in the flash system (C2) Oil Pressure Warning System (C3): Study the oil pressure warning system in vehicles and its importance for engine health (C3) Learn about the sensors, gauges, and warning indicators used in the system (C3) Understand the activation criteria and signals that trigger the oil pressure warning (C3) Explore the integration of the oil pressure warning system with engine control systems (C3) Engine Overheat Warning System (C3): Understand the engine overheat warning system and its role in preventing engine damage (C3) Learn about the temperature sensors, warning indicators, and cooling mechanisms involved (C3) Explore the activation criteria and signals that trigger the engine overheat warning (C3) Study the integration of the system with engine management systems for protection (C3) Air Pressure Warning System (C3): Gain an understanding of the air pressure warning system in vehicles, commonly used in air brake systems (C3) Learn about the sensors, gauges, and warning indicators used in the system (C3) Understand the activation criteria and signals that trigger the air pressure

	warning (C3) Explore the integration of the system with air brake control systems for safety (C3) Speed Warning System (C2): Study the speed warning system and its role in promoting safe driving habits (C2) Learn about the speed sensors, warning indicators, and control mechanisms used (C2) Understand the activation criteria and signals that trigger the speed warning (C2) Explore the integration of the system with vehicle speed control systems (C2) Door Lock Indicators and Gear Neutral Indicator (C2): Gain an understanding of door lock indicators and gear neutral indicators in vehicles (C2) Learn about the sensors, switches, and warning indicators used (C2) Understand the activation criteria and signals that trigger the indicators (C2) Explore the integration of the indicators with vehicle control systems (C2) Horn Design (C2): Study the design principles and considerations for vehicle horns (C2) Learn about the different types of horns, such as permanent magnet horns and air/music horns (C2) Understand the sound production mechanisms and electrical circuitry involved (C2) Explore the regulations and safety considerations for horn design (C2)
4	Car Radio and Stereo (C2): Understand the operation and features of car radio and stereo systems (C2) Learn about the components involved, such as the head unit, speakers, and antennas (C2) Explore the functions and controls of the radio and stereo system (C2) Study the integration of other audio sources, such as CD players and Bluetooth connectivity (C2) Courtesy Lamp, Time Piece, and Cigar Lamp (C2): Gain an understanding of courtesy lamps, time pieces, and cigar lamps in vehicles (C2) Learn about their location and function within the vehicle interior (C2) Explore the electrical circuitry and control mechanisms involved (C2) Understand their integration with other interior lighting systems (C2) Car Fan (C2): Study the car fan system and its role in providing ventilation and cooling (C2) Learn about the different types of car fans, such as radiator fans and cabin fans (C2) Understand the electrical circuitry and control mechanisms involved (C2) Explore the integration of the fan system with vehicle cooling systems (C2) Windshield Wiper and Window Washer (C2): Gain an understanding of the windshield wiper and window washer systems in vehicles (C2)

	Learn about the wiper motor, blades, washer fluid reservoir, and controls (C2) Explore the electrical circuitry and control mechanisms involved (C2) Study the integration of these systems with vehicle safety and visibility features (C2) Instrument Wiring System and Electromagnetic Interference Suppression (C3): Understand the wiring system for vehicle instruments and gauges (C3) Learn about the electrical connections, harnesses, and grounding methods (C3) Study the techniques used to suppress electromagnetic interference (C3) Explore the regulations and standards related to instrument wiring and EMC (C3) Wiring Circuits for Instruments and Electronic Instruments (C3): Gain an understanding of the wiring circuits used for vehicle instruments (C3) Learn about the connections, sensors, and control modules involved (C3) Study the integration of electronic instruments, such as digital displays and touchscreen interfaces (C3) Explore the programming and communication protocols used in electronic instruments (C3) Dashboard Illumination (C2): Study the illumination system for the vehicle dashboard (C2) Learn about the lighting sources, dimming controls, and color schemes (C2) Understand the electrical circuitry and control mechanisms involved (C2) Explore the integration of the dashboard illumination with other vehicle systems (C2) Seats, Mirrors, and Sunroofs (C2): Gain an understanding of the electrical controls and adjustments for seats, mirrors, and sunroofs in vehicles (C2) Learn about the motors, switches, and memory functions involved (C2) Explore the integration of these systems with driver comfort and convenience (C2) Central Locking and Electronic Windows (C2): Study the central locking system and electronic window controls in vehicles (C2) Learn about the actuators, switches, and control modules involved (C2) Understand the integration of these systems with security and convenience features (C2) Cruise Control (C2): Gain an understanding of the cruise control system and its role in maintaining a set speed (C2) Learn about the sensors, controls, and actuation mechanisms involved (C2) Explore the integration of cruise control with vehicle speed sensors and engine management systems (C2) In-Car Multimedia (C2): Study the multimedia systems in vehicles, such as infotainment displays and audio interfaces (C2) Learn about the connectivity options, media sources, and user interfaces (C2) Understand the integration of multimedia systems with other vehicle systems

	(C2) Security, Airbag, and Belt Tensioners (C2): Gain an understanding of security systems, airbags, and seat belt tensioners in vehicles (C2) Learn about the sensors, control modules, and deployment mechanisms involved (C2) Explore the integration of these systems with vehicle safety features (C2) Other Safety and Comfort Systems (C2): Study additional safety and comfort systems in vehicles, such as parking assist, blind-spot detection, and climate control (C2) Learn about the sensors, controls, and actuators involved (C2) Understand the integration of these systems with driver assistance and passenger comfort (C2) Advanced Comfort and Safety Systems (C2): Gain an understanding of advanced comfort and safety systems in modern vehicles, such as adaptive cruise control, lane-keeping assist, and automatic emergency braking (C2) Learn about the sensors, control algorithms, and actuators involved (C2) Explore the integration of these systems for enhanced vehicle safety and comfort (C2) New Developments in Comfort and Safety (C2): Stay updated on the latest advancements in comfort and safety systems for vehicles (C2) Learn about emerging technologies, such as gesture control, biometric sensing, and augmented reality displays (C2) Understand the potential benefits and challenges of integrating these new systems (C2) The System Approach to Control and Instrumentation (C3): Understand the importance of a system approach in control and instrumentation design for vehicles (C3) Learn about the interactions between different vehicle systems and their impact on control and instrumentation (C3) Study the methods and techniques used to optimize system performance and integration (C3) Antilock Braking System (ABS) (C2): Study the principles and operation of antilock braking systems in vehicles (C2) Learn about the sensors, control algorithms, and actuators involved (C2) Understand the benefits of ABS in improving vehicle stability and braking performance (C2) Electronic Ride Microprocessor Control (C2): Gain an understanding of electronic ride control systems in vehicles (C2) Learn about the sensors, control algorithms, and actuators involved (C2) Explore the integration of electronic ride control for improved suspension performance and comfort (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	28
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	2
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	8
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1
Viva-voce	Mid Semester Examination 2 (Mid Term 3 is optional)
Assignments	University End Term Examination
Student Seminar	Project
Problem Based Learning (PBL)	

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Assignment / Presentation	✓	✓	✓	✓
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback			

	2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Robert N. Brandy, "Automotive Computers & Digital Instrumentation", Prentice Hall Eaglewood, Cliffs, Reston Pub Co, ISBN: 0835902633 **ii)** Wiliam B. Ribbens- Understanding Automotive Electronics, Allied Publishers Pvt. Ltd., 5th Revised Edition, ISBN: 0750670088. **iii)** Tom Denton- Automobile Electrical & Electronic Systems, Allied Publishers Pvt. Ltd., 3rd Edition, 2004, ISBN: 0768014972

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Lean Enterprise & Advanced Manufacturing Technologies
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	Industrial Engineering, Manufacturing Processes and Technology
Course Synopsis	This is a course based on lean thinking, enterprise process re-engineering, and digital manufacturing are becoming more prevalent in the workplace, engineering and science professionals need to be prepared to address the enterprise as a holistic system of technologies, decision-making processes, and cultural components. The objective of this course to graduates with experience in manufacturing, engineering, design, or business who wish to develop their manufacturing expertise. This course is ideal for wishing to transfer smoothly and effectively to a career in the manufacturing sector and of industry.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To develop lean thinking and, enterprise process re-engineering concept.
CO2	To explain advanced production techniques methods for different applications.
CO3	To Explain Plastic Processing methods for different applications.
CO4	To Classify Press tools and apply it in various engineering applications.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	0	0	1	2	2	2	2	1	-	-
CO2	3	2	3	3	3	0	0	0	2	0	2	2	1	-	-

CO3	3	2	2	2	2	2	2	0	0	0	0	2	1	2	-
CO4	3	2	2	2	2	0	2	0	0	0	0	2	1	2	-
Average	3	2	2.25	2.25	2.25	0.5	1	0.25	1	0.5	1	2	1	1	-

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Introduction & Jidoka Concept (C1): Understand the concept of Jidoka and its significance in lean production systems (C1) Learn about the origins of the lean production system and its importance in improving efficiency (C1) Explore the concept of Jidoka as a quality control method that focuses on detecting and addressing issues immediately (C1) Understand the basic principles and benefits of Jidoka in achieving high-quality production (C1) The Mass Production System (C1): Study the mass production system and its historical development (C1) Learn about the characteristics and challenges of mass production (C1) Understand the need for a shift towards lean production systems (C1) Explore the reasons behind the lean revolution in Toyota and its impact on the manufacturing industry (C1) Systems and Systems Thinking (C2): Gain an understanding of systems thinking in the context of lean production (C2) Learn about the interdependencies and interactions between different components of a production system (C2) Explore the holistic approach of systems thinking in identifying and eliminating waste (C2) Understand how systems thinking contributes to the overall efficiency and effectiveness of lean production (C2) Basic Image of Lean (C2): Understand the fundamental principles and values of lean production (C2) Learn about the core concepts of lean, such as value, value stream, flow, pull, and perfection (C2) Explore the importance of customer focus in lean production (C2) Understand how lean principles contribute to waste reduction and process improvement (C2) Production Customer Focus and Muda (Waste) (C2): Study the concept of customer focus in lean production (C2)

	Understand the importance of aligning production processes with customer needs and preferences (C2) Learn about different types of waste (Muda) in manufacturing and their impact on efficiency and quality (C2) Explore strategies for identifying and eliminating waste in lean production (C2) Poka Concept and Poka-Yoke Systems (C2): Gain an understanding of the Poka concept and its application in lean production (C2) Learn about Poka-Yoke, also known as mistake-proofing, as a method for preventing errors and defects (C2) Study the different types and examples of Poka-Yoke systems (C2) Understand the implementation and benefits of Poka-Yoke in improving process reliability and quality (C2) Inspection Systems and Zone Control (C2): Learn about inspection systems and their role in quality control (C2) Understand the concept of zone control and its application in managing and monitoring production areas (C2) Study the importance of standardized work and visual management in inspection systems and zone control (C2) Explore the integration of inspection systems and zone control with Jidoka principles (C2) Types and Use of Poka-Yoke Systems (C2): Gain knowledge of different types of Poka-Yoke systems used in lean production (C2) Learn about the specific applications and benefits of each type of Poka-Yoke system (C2) Understand the selection criteria and considerations for implementing Poka-Yoke systems (C2) Explore case studies and examples of successful Poka-Yoke implementations (C2) Implementation of Jidoka (C2): Study the process of implementing Jidoka in lean production systems (C2) Understand the steps and considerations involved in integrating Jidoka principles (C2) Learn about the challenges and potential solutions in implementing Jidoka effectively (C2) Explore real-world examples of Jidoka implementation and its impact on production quality (C2)
2	Stability of Lean System & Just-In-Time Standards (C3): Understand the importance of stability in lean production systems (C3) Learn about the principles and techniques for achieving stability in production processes (C3) Study the concept of Just-In-Time (JIT) and its role in lean production (C3) Explore the benefits and challenges of implementing JIT standards in lean systems (C3) 5S System (C3):

	Learn about the 5S system and its significance in lean production (C3) Understand the five principles of 5S: Sort, Set in Order, Shine, Standardize, and Sustain (C3) Study the implementation process and benefits of the 5S system in improving workplace organization and efficiency (C3) Explore case studies and examples of successful 5S implementations (C3) Total Productive Maintenance (TPM) (C3): Gain an understanding of Total Productive Maintenance and its role in lean production (C3) Learn about the principles and strategies for implementing TPM (C3) Study the benefits of TPM in reducing equipment downtime and improving overall equipment effectiveness (C3) Explore the relationship between TPM and standardized work in lean systems (C3) Elements of Standardized Work (C3): Learn about the key elements of standardized work in lean production (C3) Understand the importance of standardizing work processes and job instructions (C3) Study the elements of standardized work, including work sequence, work-in-process, and takt time (C3) Explore strategies for developing and maintaining standardized work in lean systems (C3) Charts to Define Standardized Work (C3): Gain knowledge of different types of charts used to define standardized work (C3) Learn about the purpose and benefits of each chart type, such as process flowcharts, work combination charts, and standard work charts (C3) Understand how these charts help in visualizing and communicating standardized work processes (C3) Explore examples and case studies of chart-based standardized work definitions (C3) Manpower Reduction and Overall Efficiency (C4): Understand the relationship between manpower reduction and overall efficiency in lean production (C4) Learn about the strategies and techniques for optimizing manpower utilization (C4) Study the concept of multi-skilling and its role in reducing manpower requirements (C4) Explore case studies and examples of successful manpower reduction initiatives in lean systems (C4) Kaizen & Layouts (C4): Gain an understanding of Kaizen, the philosophy of continuous improvement in lean production (C4) Learn about the principles and techniques of Kaizen, including PDCA (Plan-Do-Check-Act) cycles (C4) Study the importance of efficient layouts in lean systems and their impact on

	workflow and productivity (C4) Explore the application of Kaizen and layout optimization in achieving continuous improvement in lean production (C4) Principles of JIT (C3): Learn about the principles of Just-In-Time (JIT) in lean production (C3) Understand the concept of JIT as a demand-driven production system (C3) Study the principles of JIT, including Kanban, production leveling, pull systems, and value stream mapping (C3) Explore the benefits and challenges of implementing JIT in lean systems (C3) JIT System and Kanban (C4): Gain an understanding of the JIT system and its components (C4) Learn about Kanban, a key element of the JIT system, and its role in controlling production flow (C4) Study the rules and techniques for implementing Kanban systems (C4) Explore case studies and examples of successful JIT and Kanban implementations (C4) Expanded Role of Conveyance and Production Leveling (C4): Understand the expanded role of conveyance in lean production systems (C4) Learn about the techniques and strategies for optimizing material flow and conveyance processes (C4) Study the concept of production leveling and its benefits in reducing waste and improving efficiency (C4) Explore case studies and examples of effective conveyance and production leveling in lean systems (C4) Pull Systems and Value Stream Mapping (C4): Gain knowledge of pull systems and their importance in lean production (C4) Learn about the principles and techniques for implementing pull systems, such as Just-In-Time and Kanban (C4) Understand the concept of value stream mapping and its role in identifying and eliminating waste (C4) Explore the application of pull systems and value stream mapping in lean production environments (C4)
3	Introduction to Plastics Processing (C1): Understand the basics of plastics processing and its importance in manufacturing (C1) Learn about the different processing methods used for plastics (C1) Study the advantages and limitations of each plastics processing method (C1) Explore the applications of plastics in various industries (C1) Injection Molding (C2): Learn about the injection molding process for plastics (C2) Understand the equipment and machinery used in injection molding (C2) Study the steps involved in the injection molding process, including mold design, material selection, and part production (C2) Explore the advantages and considerations of injection molding (C2) Compression Molding and Transfer Molding (C2):

	Gain knowledge of compression molding and transfer molding techniques for plastics (C2) Understand the differences between compression molding and injection molding (C2) Study the process steps and equipment used in compression molding and transfer molding (C2) Explore the applications and advantages of compression molding and transfer molding (C2) Extrusion, Casting, Calendaring, Machining, and Welding (C2): Learn about extrusion, casting, calendaring, machining, and welding methods for plastics processing (C2) Understand the principles and equipment used in each of these methods (C2) Study the applications and considerations for extrusion, casting, calendaring, machining, and welding of plastics (C2) Fabrication Methods and Applications of Plastics (C2): Gain an understanding of different fabrication methods for plastics (C2) Learn about techniques such as bending, forming, joining, and assembly of plastic components (C2) Study the applications of plastics in various industries, including automotive, packaging, electronics, and healthcare (C2) Explore the advantages and challenges of using plastics in different applications (C2) Shear Action in Die Cutting Operation and Cutting Forces (C3): Understand the shear action involved in die cutting operations for plastics (C3) Learn about the principles and mechanics of cutting forces in die cutting (C3) Study the factors that affect cutting forces, such as material properties, die clearance, and angular clearance (C3) Explore techniques for optimizing die cutting operations and reducing cutting forces (C3) Press Working Operations (C3): Learn about various press working operations for sheet metal and plastics (C3) Understand the principles and techniques of blanking, piercing, forming, lancing, cutting-off, notching, trimming, embossing, and other press working operations (C3) Study the line sketches and terminology used in press working operations (C3) Explore the applications and considerations of press working operations in plastics processing (C3)
4	Press Tools Introduction (C1): Understand the importance of press tools in manufacturing processes (C1) Learn about the various types of presses used in industry, including hand, power, gap, inclinable, adjustable, horn, straight side, and pillar presses (C1) Study the functions and features of different types of presses (C1) Gain an overview of the constructional details and components of a power press (C1) Press Size and Constructional Details of a Power Press (C2): Understand the factors to consider when determining the appropriate press size

	for a specific application (C2) Learn about the constructional details of a power press, including its frame, bed, ram, clutch, and drive mechanism (C2) Study the principles and mechanics of power press operation (C2) Explore the safety considerations and regulations associated with power press usage (C2) Press Tools and Components (C2): Gain knowledge of the different components of press tools, including punches, dies, stops, pilots, strippers, knockouts, and pressure pads (C2) Understand the functions and applications of each component in press tooling (C2) Study the design considerations and material selection for press tools (C2) Explore techniques for maintaining and servicing press tools to ensure their optimal performance (C2) Shear Action in Die Cutting Operation and Cutting Forces (C3): Understand the shear action involved in die cutting operations (C3) Learn about the principles and mechanics of cutting forces in die cutting (C3) Study the factors that affect cutting forces, such as punch and die clearance, angular clearance, and centre of pressure (C3) Explore techniques for optimizing die cutting operations and reducing cutting forces (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	25
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	5
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	**Summative**
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term

Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Lean Manufacturing: Tools, Techniques, and How to Use Them (Resource Management) Hardcover–by William MFeld, ISBN-13: 978-1574442977. **ii)** Industrial Engineering & Operations management by S.K. Sharma & Savita Sharma, Kataria publishersISBN:1412918057

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	Non-Destructive Testing and Evaluation
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	Automation in Manufacturing
Course Synopsis	This course provides students a synopsis of non-destructive evaluation and testing methods used in Evaluation of welds. This includes understanding the basic principles of various NDT methods with importance, applications and limitations.

Course Outcomes:

At the end of the course, students will be able to:

CO1	To identify different welding defects through non-destructive examination/testing.
CO2	To identify and use of each non-destructive testing equipment with their applications.
CO3	To select the specific Code, Standard, or Specification related to each testing method.
CO4	Have the knowledge and essential skills to identify strengths and weaknesses in materials used in fabrication.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	2	1	1	1	1	2	3	3	3	2	1
CO2	3	1	2	3	1	1	1	1	2	1	2	2	3	2	2
CO3	3	2	2	2	2	1	2	1	2	1	2	2	3	1	2
CO4	3	2	1	1	2	2	1	2	3	2	3	3	3	2	1
Average	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5

Course Content:

L (Hours/Week)	**T (Hours/Week)**	**P (Hours/Week)**	**Total Hour/Week**

3	0	0	3

Unit	**Content & Competencies**
1	Introduction to Non-Destructive Testing (C2): Understand the concept and importance of non-destructive testing (NDT) in evaluating the integrity and quality of materials and structures without causing damage (C2) Recognize the role of NDT in ensuring safety, reliability, and cost-effectiveness in various industries (C2) Comparison with Destructive Testing, Advantages, Applications, and Limitations (C3): Compare non-destructive testing with destructive testing methods in terms of their purpose, benefits, and limitations (C3) Evaluate the advantages of NDT, such as the ability to inspect components without causing damage, reduced downtime, and cost savings (C3) Explore the wide range of applications of NDT in industries such as aerospace, automotive, manufacturing, oil and gas, and construction (C3) Understand the limitations of NDT techniques, including their reliance on skilled personnel, equipment limitations, and the inability to detect certain types of defects (C3) Dye Penetration Test (C2): Learn about the dye penetration test method, also known as liquid penetrant testing or dye penetrant inspection (C2) Understand the principles and procedure of the test, which involves applying a liquid dye to the surface of a component and observing for indications of surface-breaking defects (C2) Recognize the advantages and limitations of dye penetration testing (C2) Magnetic Particle Testing (C2): Explore the magnetic particle testing method, which is used to detect surface and near-surface defects in ferromagnetic materials (C2) Understand the principles and procedure of magnetic particle testing, involving the application of magnetic fields and magnetic particles to detect indications of defects (C2) Recognize the advantages and limitations of magnetic particle testing (C2) Ultrasonic Testing (C3): Learn about ultrasonic testing, a widely used NDT method based on the propagation of high-frequency sound waves through materials (C3) Understand the principles of ultrasonic testing, including pulse-echo and through-transmission techniques, and the use of transducers and ultrasonic equipment (C3) Explore the applications of ultrasonic testing in detecting internal defects, measuring material thickness, and evaluating material properties (C3) Recognize the advantages of ultrasonic testing, such as its ability to provide detailed information about the size, shape, and location of defects (C3) Eddy Current Testing (C3): Study eddy current testing, a technique used for detecting surface and near-

	surface defects in conductive materials (C3) Understand the principles and applications of eddy current testing, which relies on the interaction between alternating electrical currents and magnetic fields (C3) Recognize the advantages and limitations of eddy current testing (C3) Radiography Testing (C3): Explore radiographic testing, a widely used NDT method that utilizes X-rays or gamma rays to inspect the internal structure of materials (C3) Understand the principles and procedures of radiographic testing, including the use of film or digital detectors to capture and analyze the transmitted radiation (C3) Recognize the advantages and limitations of radiographic testing, including its ability to detect both surface and internal defects (C3)
2	Liquid Penetrate Testing (C2): Understand the principles of liquid penetrate testing (LPT), also known as liquid penetrant inspection or dye penetrant testing (C2) Learn about the types and properties of liquid penetrants, including visible and fluorescent penetrants, as well as the selection of developers for enhancing indications (C2) Evaluate the advantages and limitations of different LPT methods, such as sensitivity, ease of application, and suitability for various materials and surface conditions (C2) Familiarize yourself with the testing procedure for LPT, including surface preparation, application of penetrant, removal of excess penetrant, application of developer, and inspection (C2) Understand the interpretation of test results in LPT, including the identification and evaluation of indications (C2) Magnetic Particle Testing (C3): Gain an understanding of the theory of magnetism and its application in magnetic particle testing (C3) Learn about the inspection materials used in magnetic particle testing, including ferromagnetic materials and magnetic particles (C3) Explore different methods of magnetization in magnetic particle testing, such as direct magnetization and indirect magnetization (C3) Understand the principles and techniques for the interpretation and evaluation of test indications in magnetic particle testing (C3) Familiarize yourself with the methods of demagnetization used to remove residual magnetism after testing (C3) Gain knowledge of the importance of controlling residual magnetism and the potential impact on subsequent inspections or component performance (C3)
3	Thermography (C3): Understand the principles of thermography, which involves the detection and measurement of infrared radiation emitted by objects (C3) Differentiate between contact and non-contact inspection methods in thermography (C3) Learn about techniques for applying liquid crystals as temperature-indicating

	materials in thermography (C3) Evaluate the advantages and limitations of thermography, including its non-destructive nature, ability to detect surface and subsurface defects, and limitations related to surface conditions and material properties (C3) Gain knowledge of infrared radiation and infrared detectors used in thermography, including the principles of thermal imaging and the types of detectors employed (C3) Familiarize yourself with the instrumentation and methods used in thermography, such as infrared cameras and image processing techniques (C3) Explore various applications of thermography, including defect detection in materials, monitoring of thermal processes, and non-destructive testing in industries such as aerospace, automotive, and building inspections (C3)
4	Principle, interaction of X-Ray with matter (C2): Understand the basic principles of X-ray generation and the interaction of X-rays with matter (C2) Learn about the various types of X-ray interactions, such as photoelectric effect, Compton scattering, and coherent scattering (C2) Explore the factors that influence the interaction of X-rays with matter, including energy of the X-rays, atomic number of the material, and thickness of the material (C2) Imaging, film and filmless techniques (C2): Gain knowledge of different imaging techniques used in X-ray imaging, including traditional film-based radiography and digital imaging techniques (C2) Understand the advantages and limitations of film-based radiography and digital imaging systems (C2) Learn about the principles and working mechanisms of filmless techniques such as computed radiography (CR) and digital radiography (DR) (C2) Types and use of filters and screens (C2): Understand the role of filters in X-ray imaging, including their use for beam quality control and patient dose reduction (C2) Learn about different types of filters used in X-ray systems, such as aluminum, copper, and molybdenum filters (C2) Explore the use of screens in X-ray imaging, including their role in intensifying the X-ray image and reducing patient exposure (C2) Geometric factors, Penetrameters, Exposure charts, Radiographic equivalence (C2): Understand the geometric factors that affect X-ray imaging, such as source-to-object distance, object-to-image distance, and object orientation (C2) Learn about the use of penetrameters, exposure charts, and radiographic equivalence in X-ray imaging for quality control and image interpretation (C2) Fluoroscopy, Xeroradiography, Computed Radiography, Computed Tomography (C2): Gain knowledge of fluoroscopy, including its principles and applications for real-time imaging and interventional procedures (C2) Learn about Xeroradiography, a specialized imaging technique that uses

	charged particles to create X-ray images (C2) Understand the principles of Computed Radiography (CR) and Computed Tomography (CT), which involve the use of digital imaging and cross-sectional imaging techniques, respectively (C2)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	Contact Hours
Lecture	30
Practical	--
Seminar/Journal Club	5
Small Group Discussion (SGD)	--
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	5
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	Mid Semester Examination 2
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Dissertation
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:	(List of reference books)
	i) Baldev Raj, T. Jayakumar, M. Thavasimuthu (2009), "Practical Non-Destructive Testing", WoodHeadPublishing,ISBN:1855736004 ii)RaviPrakash(2010),"NonDestructiveTestingTechniques",NewAgeInternationalPrivate Limited;1st edition,ISBN:8122425887

Faculty of engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Biomaterials**
Academic Year	IV
Semester	VIII
Number of Credits	3
Course Prerequisite	**Material Engineering & Technology**
Course Synopsis	A biomaterial is any matter, surface, or construct that interacts with biological systems. This course covers basic synthesis, analysis and design of biomaterials used for bioengineering, including biotechnology, tissue engineering, medical imaging and clinical applications. Topics include interactions between bio and synthetic molecules and surfaces; design, synthesis, and processing approaches for materials that control cell functions; and application of state-of-the-art biomaterial approaches to problems in tissue engineering.

Course Outcomes:

At the end of the course students will be able to:

CO1	Understand common use biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology.
CO2	Understand the various applications of biomaterials as an implant.
CO3	Understand and account for methods for categorization of biomaterials.
CO4	Apply and account for methods to characterize interactions between materials and tissue.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	0	0	0	2	3	2	0	0	0	3	2	3	1
CO2	3	2	3	2	2	2	3	0	0	0	0	2	1	3	3
CO3	3	2	2	3	2	2	3	0	0	0	0	2	-	3	3

CO4	3	2	2	3	2	2	3	0	0	0	0	2	-	3	2
Average	3	1.75	1.75	2	1.5	2	3	0.5	0	0	0	2.25	0.75	3	2.25

Course Content:

L (Hours/Week)	T (Hours/Week)	P (Hours/Week)	Total Hour/Week
3	0	0	3

Unit	Content & Competencies
1	Definition of Biomaterials (C1): Understand the concept and definition of biomaterials (C1) Learn how biomaterials are used in various medical and biological applications (C1) Recognize the importance of biomaterials in improving healthcare and quality of life (C1) Requirements and Classification of Biomaterials (C2): Understand the essential requirements and criteria for biomaterials, such as biocompatibility, mechanical properties, and stability (C2) Learn about the classification of biomaterials based on their origin, function, and application (C2) Study the different types of biomaterials, including metals, ceramics, polymers, and composites (C2) Gain an overview of the advantages and limitations of each biomaterial type (C2) Comparison of Properties of Common Biomaterials (C3): Compare the physical, mechanical, and chemical properties of common biomaterials, such as stainless steel, titanium, hydroxyapatite, polyethylene, and silicone (C3) Analyze the strengths and weaknesses of different biomaterials for specific applications (C3) Understand the factors that influence the selection of biomaterials for medical devices and implants (C3) Effects of Physiological Fluid on Biomaterial Properties (C3): Learn about the interactions between biomaterials and physiological fluids (C3) Understand the effects of physiological fluid on the degradation, corrosion, and wear of biomaterials (C3) Study the importance of designing biomaterials that can withstand the challenges of the physiological environment (C3) Biological Responses to Biomaterials (C2): Explore the biological responses that occur when biomaterials are introduced into the body, both in the extravascular and intravascular systems (C2) Understand the immune response, inflammation, tissue integration, and biocompatibility considerations related to biomaterials (C2) Learn about the factors that influence the biological responses to biomaterials,

	such as surface properties, degradation products, and host factors (C2) Surface Properties, Physical Properties, and Mechanical Properties of Biomaterials (C2): Study the importance of surface properties, such as roughness, chemistry, and topography, in influencing the interactions between biomaterials and biological systems (C2) Understand the physical properties of biomaterials, including density, porosity, and thermal conductivity (C2) Analyze the mechanical properties of biomaterials, such as strength, stiffness, and elasticity (C2) Learn how the surface, physical, and mechanical properties of biomaterials can be tailored to meet specific requirements (C2)
2	Stainless Steel, Co-based Alloys, Ti and Ti-based Alloys (C3): Understand the properties and characteristics of stainless steel, cobalt-based alloys, titanium, and titanium-based alloys (C3) Compare the mechanical, chemical, and corrosion resistance properties of these biomaterials (C3) Recognize the applications and advantages of each material in the field of biomedical implants (C3) Importance of Stress-Corrosion Cracking (C4): Understand the concept of stress-corrosion cracking and its significance in biomaterials (C4) Learn about the factors that contribute to stress-corrosion cracking, such as tensile stresses, corrosive environments, and material susceptibility (C4) Recognize the impact of stress-corrosion cracking on the mechanical integrity and reliability of biomaterials (C4) Host Tissue Reaction with Biomaterials (C3): Study the biological response of host tissues to bio-metals, including the immune response, inflammation, and tissue integration (C3) Understand the factors influencing the host tissue reaction, such as surface properties, chemical composition, and degradation products (C3) Explore the importance of biocompatibility and the design of biomaterials to minimize adverse tissue reactions (C3) Corrosion Behavior and Importance of Passive Films for Tissue Adhesion (C4): Learn about the corrosion behavior of biomaterials and the factors influencing their corrosion resistance (C4) Understand the formation and significance of passive films on the surface of biomaterials for tissue adhesion and biocompatibility (C4) Explore the techniques used to enhance the formation and stability of passive films on biomaterial surfaces (C4) Hard Tissue Replacement Implants: Orthopedic and Dental Implants (C3): Study the design, materials, and manufacturing processes involved in orthopedic implants, such as hip and knee replacements (C3) Learn about dental implants, including the different types, materials, and considerations for successful integration (C3) Understand the biomechanical aspects and challenges associated with hard

	tissue replacement implants (C3) Soft Tissue Replacement Implants: Percutaneous and Skin Implants, Vascular Implants, Heart Valve Implants (C3): Explore the use of percutaneous and skin implants for soft tissue replacement, such as breast implants or facial prosthetics (C3) Study the design and materials used in vascular implants, such as stents and grafts (C3) Understand the challenges and considerations in designing and using heart valve implants (C3) Tailor-Made Composite in Medium (C4): Learn about the concept of tailor-made composites for biomedical applications (C4) Understand the design and fabrication of composite materials with specific properties for soft tissue replacement (C4) Explore the potential applications and advantages of tailor-made composites in the biomedical field (C4)
3	Definition of Bioceramics (C2): Understand the concept and definition of bioceramics as materials used in biomedical applications (C2) Recognize the unique properties and characteristics of bioceramics that make them suitable for use in medical and dental implants (C2) Learn about the importance of biocompatibility and bioactivity in bioceramics (C2) Common Types of Bioceramics: Aluminum Oxides, Glass Ceramics, Carbons (C3): Explore different types of bioceramics commonly used in biomedical applications, such as aluminum oxides, glass ceramics, and carbon-based materials (C3) Understand the properties, advantages, and limitations of each type of bioceramic (C3) Recognize the specific applications and considerations for each type of bioceramic (C3) Bioresorbable and Bioactive Ceramics (C3): Learn about bioresorbable ceramics that can be absorbed by the body over time, such as calcium phosphates (C3) Understand the concept of bioactive ceramics that can bond with surrounding tissues and promote tissue growth, such as hydroxyapatite (C3) Recognize the advantages and applications of bioresorbable and bioactive ceramics in biomedical engineering (C3) Importance of Wear Resistance and Low Fracture Toughness (C3): Understand the significance of wear resistance in bioceramics to ensure long-term durability and functionality of implants (C3) Recognize the challenges associated with low fracture toughness in bioceramics and the need for appropriate design and material selection (C3) Learn about strategies to enhance wear resistance and fracture toughness in bioceramic materials (C3)

	Host Tissue Reactions: Importance of Interfacial Tissue Reaction (C3): Study the interaction between bioceramics and host tissues, particularly the interfacial tissue reaction at the ceramic/bone interface (C3) Understand the importance of promoting proper tissue integration and minimizing adverse reactions, such as inflammation or fibrous encapsulation (C3) Explore surface modification techniques and materials selection to enhance interfacial tissue reactions in bioceramic implants (C3) Composite Implant Materials: Mechanics of Property Improvement (C3): Learn about composite materials used in biomedical applications, including bioceramic composites (C3) Understand the principles and mechanics behind property improvement by incorporating different elements, such as fibers or fillers, into bioceramic matrices (C3) Recognize the advantages and challenges associated with composite implant materials (C3) Composite Theory of Fiber Reinforcement: Short and Long Fibers, Fiber Pull-Out (C4): Study the composite theory of fiber reinforcement, including the role of short and long fibers in improving mechanical properties (C4) Understand the concept of fiber pull-out and its significance in load transfer and toughening mechanisms in bioceramic composites (C4) Explore the design and fabrication considerations for effective fiber reinforcement in composite implant materials (C4) Polymers Filled with Osteogenic Fillers: Hydroxyapatite (C3): Learn about polymers filled with osteogenic fillers, such as hydroxyapatite, to promote bone regeneration and tissue integration (C3) Understand the advantages and applications of polymer-based composites filled with osteogenic fillers in orthopedic and dental implants (C3) Recognize the importance of host tissue reactions and biocompatibility in these composite implant materials (C3)
4	Polyolefins, Polyamides, Acrylic Polymers, Fluorocarbon Polymers, Silicon Rubbers, Acetyls (C2): Understand the classification of polymers into thermosets, thermoplastics, and elastomers (C2) Learn about specific polymer types such as polyolefins, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, and acetyls (C2) Recognize the key properties, applications, and characteristics of each polymer type (C2) Viscoelastic Behavior: Creep, Recovery, Stress Relaxation, Strain Rate Sensitivity (C3): Explore the viscoelastic behavior of polymers, including creep, recovery, stress relaxation, and strain rate sensitivity (C3) Understand the importance of molecular structure in determining the viscoelastic properties of polymers (C3) Recognize the significance of viscoelastic behavior in polymer processing,

	material performance, and durability (C3) Importance of Molecular Structure, Surface Properties, Additive Migration, Aging, and Environmental Stress Cracking (C3): Learn about the influence of molecular structure on the properties and behavior of polymers (C3) Understand the hydrophilic and hydrophobic surface properties of polymers and their impact on interactions with the environment (C3) Recognize the potential migration of additives, the effects of aging, and the susceptibility to environmental stress cracking in polymers (C3) Physicochemical Characteristics of Biopolymers and Biodegradable Polymers for Medical Purposes (C3): Study the physicochemical characteristics of biopolymers, including their origin, structure, and properties (C3) Explore the applications and benefits of biodegradable polymers in medical purposes, such as drug delivery systems and tissue engineering (C3) Understand the considerations and challenges associated with the use of biodegradable polymers in biomedical applications (C3) Biopolymers in Controlled Release Systems and Synthetic Polymeric Membranes (C3): Learn about the use of biopolymers in controlled release systems, such as drug delivery devices and implants (C3) Understand the principles and design considerations of synthetic polymeric membranes for various biological applications, such as filtration and separation (C3) Recognize the advantages and limitations of using biopolymers and synthetic membranes in biomedical applications (C3)

Teaching - Learning Strategies and Contact Hours

Teaching - Learning Strategies	**Contact Hours**
Lecture	26
Practical	--
Seminar/Journal Club	2
Small Group Discussion (SGD)	10
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	2
Case/Project Based Learning (CBL)	--
Revision	5
Others If any:	--
Total Number of Contact Hours	45

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	Mid Semester Examination 1,2, End term
Viva-voce	--
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	Multiple Choice Questions (MCQ)
Seminars	Multiple Choice Questions (MCQ)
Problem Based Learning (PBL)	Short Answer Questions (SAQ)
Journal Club	Long Answer Question (LAQ)
	Practical Examination & Viva-voce
	Objective Structured Practical Examination (OSPE)

Mapping of Assessment with COs

Nature of Assessment	**CO1**	**CO2**	**CO3**	**CO4**
Quiz				
VIVA				
Assignment / Presentation	✓	✓	✓	✓
Unit test				
Practical Log Book/ Record Book				
Mid Semester Examination 1	✓	✓	✓	✓
Mid Semester Examination 2	✓	✓	✓	✓
University Examination	✓	✓	✓	✓
Feedback Process	1. Student's Feedback 2. Course Exit Survey			

Students Feedback is taken through various steps

1. Regular feedback through Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of semester.

References:

i) Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.

ii) Amar K. Mohanty, ManjusriMisra and Lawrence T. Drzal (2005), Natural Fibers, Biopolymers,and Bio composites, First Edition, CRC Press. ISBN: 978-0-849-31741-5.

iii) JB Park and RS Lakes (2010), Biomaterials - An Introduction, Springer. ISBN: 978-1-441-92281-6.

Faculty of Engineering and Technology	
Name of the Department	Mechanical Engineering
Name of the Program	B. Tech.
Course Code	
Course Title	**Entrepreneurship and Digital Product Management**
Academic Year	IV
Semester	VIII
Number of Credits	2
Course Prerequisite	NIL
Course Synopsis	This course provides students with an in-depth understanding of entrepreneurship and the principles of digital product management. It explores the process of ideation, innovation, and development of digital products, while also focusing on the key aspects of starting and managing a successful entrepreneurial venture in the digital era. Students will learn essential skills and strategies for identifying market opportunities, designing and launching digital products, and effectively managing product lifecycles.

Course Outcomes:

At the end of the course, students will be able to:

CO1	Identify and evaluate market opportunities
CO2	Develop and manage digital product strategies.
CO3	Implement effective product development and launch processes.
CO4	Analyze and optimize digital product performance.

Mapping of Course Outcomes (COs) to Program Outcomes (POs)& Program Specific Outcomes:

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	2	-	3	3	-	-	-	1	3	1	3	2	`1
CO2	2	3	2	2	-	2	-	-	-	1	2	3	3	2	2
CO3	2	3	2	-	-	3	-	-	-	1	1	3	3	2	2

CO4	2	3	3	2	3	2	-	-	-	1	2	3	3	2	1
Average	2	3	2	1	1.5	2.5	-	-	-	1	2	2.5	3.0	2.0	1.5

Course Content:

L (Hours/Week)	**T** (Hours/Week)	**P** (Hours/Week)	**Total Hour/Week**
0	**0**	**4**	**4**

Sr. No.	**Content & Competencies**
1	Introduction to Entrepreneurship in the Digital Era (C1) Definition and significance of entrepreneurship in the digital era (C1) Exploring the impact of digital technologies on entrepreneurial opportunities (C1)
2	Overview of Digital Product Management Principles and Practices (C1-C2) Understanding the key principles and practices of digital product management (C1) Identifying the role of product managers in digital product development (C2) Examining the importance of customer-centric approaches in digital product management (C2)
3	Market Research and Opportunity Identification(C2-C4) Conducting market research to identify target audiences and customer needs (C2) Evaluating market trends, competition, and market opportunities for digital products (C3) Assessing and validating market opportunities through market analysis and customer feedback (C4)
4	Product Development and Management (4 weeks) (C3-C5) Product lifecycle management: from concept development to launch and beyond (C3) Agile project management methodologies for efficient digital product development (C4) User experience design and usability testing for enhancing product quality (C5) Development and implementation of digital marketing strategies to drive product success (C5)
5	Entrepreneurial Finance and Business Models (C2-C4) Financial planning and budgeting considerations for startups (C2) Funding options and strategies for entrepreneurial ventures (C3) Business model canvas and value proposition design for creating sustainable business models (C4)
6	Scaling and Growth Strategies (C3-C4) Strategies for scaling digital products and startups (C3)

	Sales and marketing strategies for achieving growth and market penetration (C4) Managing teams and organizational culture to support growth and scalability (C4)
7	Risk Management and Legal Considerations(C2-C3) Identifying and mitigating risks in entrepreneurship and digital product management (C2) Understanding intellectual property rights and legal considerations for digital products (C3)
8	Ethical and Social Responsibility in Digital Entrepreneurship (C2) Addressing ethical considerations in digital product development and entrepreneurship (C2) Exploring the social impact and sustainability aspects of digital entrepreneurship (C2)
9	Case Studies and Industry Insights (C3-C5) Analyzing real-life case studies of successful digital product launches (C3) Guest lectures and industry insights from experienced entrepreneurs and product managers (C4) Drawing lessons and best practices from industry examples (C5)
10	Final Project and Presentation (C4-C6) Application of course concepts to develop and present a digital product business plan (C4) Incorporating research, analysis, and strategic thinking into the final project (C5) Demonstrating advanced expertise in developing a comprehensive and viable digital product business plan (C6)

Teaching - Learning Strategies and Contact Hours

Teaching-Learning Strategies	**Contact Hours**
Lecture	--
Practical	15
Seminar/Journal Club	--
Small Group Discussion (SGD)	15
Self-Directed Learning (SDL) / Tutorial	--
Problem Based Learning (PBL)	15
Case/Project Based Learning (CBL)	15
Revision	--
Others If any:	--
Total Number of Contact Hours	60

Assessment Methods:

Formative	Summative
Multiple Choice Questions (MCQ)	--
Viva-voce	Practical Examination & Viva-voce
Objective Structured Practical Examination (OSPE)	University Examination
Quiz	--
Seminars	--
Problem Based Learning (PBL)	--
Journal Club	--

Mapping of Assessment with COs

Nature of Assessment	CO1	CO2	CO3	CO4
Quiz				
VIVA	✓	✓	✓	✓
Assignment / Presentation				
Unit test				
Practical Log Book/ Record Book	✓	✓	✓	✓
Mid-Semester Examination 1				
Mid-Semester Examination 2				
University Examination	✓	✓	✓	✓

Feedback Process	1. Student's Feedback 2. Course Exit Survey

Students Feedback is taken through various steps

1. Regular feedback through the Mentor Mentee system.
2. Feedback between the semester through google forms.
3. Course Exit Survey will be taken at the end of the semester.

References:	(List of reference books)
	i) "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries. ISBN-13: 978-0307887894

	ii) "Hooked: How to Build Habit-Forming Products" by Nir Eyal. ISBN-13: 978-1591847786 **iii)** "The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company" by Steve Blank and Bob Dorf. ISBN-13: 978-0984999309

9. MAPPING OF COURSE OUTCOMES, PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Sem.	Course Code	Course Title	C	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
I		Engineering Mathematics-I	3	3	1.75	-	-	-	-	-	-	-	-	-	1	1	-	1
I		Programming for Problem-Solving	2	1	1.25	0.5	1	0.5	-	-	-	0.75		0.5	0.5	1		1
I		Engineering Workshop	1	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5
I		Design Thinking & Innovation Lab	2	2	3	2.5	0.8	1.5	2.5	-	-	-	-	2	2.5	3.0	2.0	1.5
I		Programming for Problem-Solving Lab	2	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5
I		Engineering Workshop Lab	2	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	1.3	2.5	3.0	2.0	0.5
II		Engineering Mathematics-II	3	3	1.75	1	2	-	-	-	-	-	-	-	1	1	0.75	1
II		Basics of Electrical & Electronics Engineering	2	1.75	-	1	-	-	0.75	-	-	-	-	-	2	-	0.25	0.5
II		Engineering Graphics and Design	1	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1
II		New Age Skills Lab	2	2	1	1	0.75	3	-	-	-	-	2	1	1	3.0	2.0	1
II		Basics of Electrical &	2	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1

		Electronics Engineering Lab																
II		Engineering Graphics and Design Lab	2	2	0.75	1	0.75	3	-	-	-	-	2	-	-	3.0	2.0	1
III		Engineering Mechanics	3	3	2.75	2.25	2	1.75	0.75	0.5	0.25	-	0.25	2	-	3	2.75	2.25
III		Engineering Thermodynamics	3	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25
III		Refrigeration & Air Conditioning	3	3	2.5	3	3	1.75	2	1.75	-	-	-	-	2.5	3	3	2.25
III		Automobile Engineering	3	3	2.25	2.75	2.5	1.5	1	-	-	0.5	0.5	0.5	2.25	0.75	3	2.25
III		Numerical Methods	3	3	2.25	1.75	2.25	2	1.5	-	-	-	-	2	2.75	0.75	1.25	0.5
III		Product Design for Manufacturing	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
III		Composite Materials	3	3	2.25	2.25	1.75	1	0.5	1.75	-	1	0.25	1	2.25	2.5	3	1.5
III		SEC-I (SolidWorks)	2	3	2.75	2.75	2.25	3	1	0.5	0.25	-	1	1	1	3	2.75	0.5
III		Engineering Mechanics Lab	1	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	0.25	0.25	2.25
III		Summer Internship	1	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	2	2	2.5
III		Robotics Engineering & Applications	3	3	1.75	1.75	1.75	1.25	1	-	-	-	-	-	2	2.25	2	2
III		Robotics Engineering & Applications Lab	1	3	1.75	1.75	1.75	1.25	1	-	-	-	-	-	2	2.25	2	2
III		Introduction to Hybrid and Electric Vehicles	3	3	1.5	1.75	1	2.75	0.75	2	0.5	0.75	0.75	0.75	2	3	1.75	0.5
III		Introduction to Hybrid and	1	3	1.5	1.75	1	2.75	0.75	2	0.5	0.75	0.75	0.75	2	3	1.75	0.5

		Electric Vehicles Lab															
III		Object-Oriented Programming	3	3	2.5	0.75	1	-	-	-	-	0.5	-	-	-	1	0.5	1
III		Object-Oriented Programming Lab	1	3.0	1.8	2.3	0.8	1.0	0.5	-	-	-	-	-	-	3.0	2.0	0.5
IV		Strength of Materials	3	3	2.75	2.75	2.75	1.5	-	-	-	-	-	-	2.5	3	2.75	2.75
IV		Material Engineering & Technology	3	3	2	1.75	2.5	1.75	1.5	2	-	-	0.5	-	2.25	2.75	2.75	2
IV		Manufacturing Processes	3	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	0.75	3	2.25
IV		Steam Power Generation	3	3	1.75	2.5	2.25	1.5	1.25	1.5	-	-	-	1.5	2.5	0.75	3	2.25
IV		Total Quality Management	3	3	1.25	-	1.75	-	1.75	1.75	1.75	1.75	1.75	2.5	2.75	3	1.5	0.5
IV		Production Planning & Control	3	3	-	-	-	2	2	2	2	3	2	3	3	1	1	-
IV		Mechanical Vibration	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
IV		Tool Design	3	3	2	2.5	2.25	2	-	-	-	-	-	1.25	2.5	0.75	3	2.25
IV		SEC-II (ANSYS)	2	3	2.75	2.75	2.25	3	1	0.5	0.25	-	1	1.5	1.5	3	2.75	0.5
IV		Strength of Materials Lab	1	3	3	3	3	3	0	2	0	0	0	0	2	2.5	2.75	2
IV		Material Engineering & Technology Lab	1	3	2	1.75	2.5	1.75	1.5	2	-	-	0.5	-	2.25	2.75	2.75	2
IV		Manufacturing Processes Lab	1	3	2.4	2	1.6	1.4	1	0.6	-	1	0.8	1.4	2	3	1.2	1
IV		Mobile Robots	3	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	3	2	1.75
IV		Mobile Robots Lab	1	3	2.25	2.5	2.5	2.5	2	-	-	-	-	1	1.5	3	1.5	1.5
IV		Battery Management	3	3	1.75	2	2	1.5	2	0	0	0	0	0	2	3	1.75	0.5

		System															
IV		Battery Management System Lab	1	3	1.75	2	2	1.5	2	0	0	0	0	0	2	3	1.75	0.5
IV		Database Management System	3	3	3	0.5	1	-	-	-	-	-	-	-	-	0.5	0.5	-
IV		Database Management System Lab	1	3	3	3	1.5	1.5	-	-	-	-	-	-	-	3	2	0.5
V		Kinematics of Machines	3	3	2.4	2.6	2.4	2.2	0.6	0.4	0.2	0.4	0.2	0.6	2.4	3	2.4	2.6
V		Fluid Mechanics	3	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25
V		Applied Thermodynamics	3	3	2.25	2.75	2.25	1.75	1.25	1.25	0.25	0	0.25	0.25	2.5	1	3	2.5
V		Biology for Engineers	3	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25
V		Power Plant Engineering	3	3	1.75	2	2.25	1.5	2	2	-	-	-	2	2.25	0.75	3	2.25
V		Hydrogen and Fuel Cells	3	3	1	2	3	2	3	3	1	-	-	-	3	3	1.5	0.5
V		Non-Conventional Machining	3	3	2.25	2.5	2.5	2.25	1.25	-	-	-	-	-	2.5	1.75	1.25	-
V		Plant Layout and Material Handling	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
V		Industrial Safety Engineering	3	3	-	-	-	-	2	2	2.25	2.5	2.5	2.25	2.5	0.75	3	2.25
V		SEC-III (MATLAB)	2	3	2.75	2.75	2.25	3	0.5	-	0.25	-	1	1.5	1.5	3	2.75	0.25
V		Kinematics of Machines Lab	1	3	2.4	2.6	2.4	2.2	0.6	0.4	0.2	0.4	0.2	0.6	2.4	2.25	2.75	1.5
V		Fluid Mechanics Lab	1	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25
V		Applied Thermodynamics	1	3	2.25	2.75	2.25	1.75	1.25	1.25	0.25	0	0.25	0.25	2.5	1	3	2.5

		Lab																
V		Industrial Training - I	1	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	2	2	2.5
V		Mechanics of Robot	3	3	1.5	1.75	1.25	1.75	0.75	1.5	-	-	-	-	2.25	3.0	2.0	1
V		Mechanics of Robot Lab	1	3	2	2	2	1	1	1	1	-	-	1	3	3.0	2.0	0.5
V		Power train Design	3	3	1.75	2.5	2.5	2.5	-	1.5	-	-	-	1.5	2.25	3	2	0.25
V		Power train Design Lab	1	3.00	2.67	2.50	2.50	2.50	1.00	1.75	-	-	-	1.00	2.25	3	2	0.25
V		Data Structure & Algorithm	3	3	3	1	2.25	2.25	-	-	1	2.25	2.25	1	1	3	2	1
V		Data Structure & Algorithm Lab	1	3	0.25	1.75	1.25	0.25	0.5	-	-	-	-	-	-	3	1	0.5
VI		Dynamics of Machines	3	3	2.25	2.5	2.25	2	0.5	0.25	-	0.5	0.25	0.75	2.25	3	2.5	0.25
VI		Fluid Machines	3	3	2.5	2.5	2.25	1.75	0.75	0.25	-	0.5	0.25	-	1	3	2.75	-
VI		Design of Machine Elements	3	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25
VI		Instrumentation and Control Engineering	3	3	3	3	3	3	3	2	1	1	1	1	3	-	3	2
VI		Fluid Power System	3	3	1.75	2.5	2	2.25	-	-	-	-	-	-	2	0.75	3	2.25
VI		Design for Manufacturing & Assembly	3	3	2.7	2.7	2.3	2.0	-	-	-	-	-	-	2.5	3	0.75	0.75
VI		Supply Chain and Logistic Management	3	3	-	-	-	1.5	2.5	-	2.5	2.25	1	3	2.25	1	-	-
VI		Finite Element Methods	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
VI		Nano-Technology and Surface Engineering	3	3	1.5	2	2	2.25	1	0.5	0	0.25	0	1.25	2.75	0.75	3	2.25
VI		SEC-IV (Digital	2	3	2.75	2.75	2.25	3	0.5	0.5	0.25	-	0.5	1	1	3	2.75	0.5

		Manufacturing)																
VI		Dynamics of Machines Lab	1	3	2.25	2.5	2.25	2	0.5	0.25	-	0.5	0.25	0.75	2.25	3	2.5	0.25
VI		Fluid Machines Lab	1	3	2.5	2.5	2.25	1.75	0.75	0.25	-	0.5	0.25	-	1	3	2.75	-
VI		Design of Machine Elements Lab	1	3	2.25	2.25	2.25	1.5	1	1	1	1	1	1	2.5	0.75	3	2.25
VI		Instrumentation and Control Engineering Lab	1	3	2	2.75	2.75	2	1.25	-	0.25	0.25	0.5	0.5	3	0.75	3	2.25
VI		Robot Operating and Control Systems	3	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	0.75	3	2.25
VI		Robot Operating and Control Systems Lab	1	3	2	2	1.75	2	1	-	-	-	1	-	2.75	2.75	2.75	2
VI		EV Charging Infrastructure Technology	3	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.75	0.5
VI		EV Charging Infrastructure Technology Lab	1	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.75	0.5
VI		Data Visualization	3	3	2	1	0.5	-	-	-	-	-	-	-	1	0.5	1	0.5
VI		Data Visualization Lab	1	3	2	1	0.5	0.5	-	-	-	-	-	-	1	0.5	0.5	1
VII		Industrial Engineering	3	3	-	-	-	1.75	2	1	2	3	3	3	2.5	3	2	0.25
VII		Heat and Mass Transfer	3	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25
VII		Automation in Manufacturing	2	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5
VII		Machine Learning for Mechanical Engineering	1	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5
VII		Renewable Energy	3	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25

VII		Rapid Manufacturing Technologies	3	3	1.5	1.25	1.5	2.75	1.5	0.5	0.25	-	-	0.75	2.25	3	1.25	0.25
VII		Work Study	3	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	1	-	-
VII		Mechatronics	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
VII		Chassis Design	3	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25
VII		Heat and Mass Transfer Lab	1	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	0.75	3	2.25
VII		Automation in Manufacturing Lab	2	3	2.25	1.5	1.5	1.75	1	1	1	1.75	1.25	2.25	2.25	3	1.75	0.5
VII		Machine Learning for Mechanical Engineering Lab	2	3	2.25	1.5	1.5	1.75	-	-	-	1.75	2	2.7	2.25	3	1.75	0.5
VII		Industrial Training-II	1	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	2	2	2.5
VII		Capstone Project	2	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	2	2	2.5
VII		Cognitive Robotics	3	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1	0.25
VII		Cognitive Robotics Lab	1	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1	0.25
VII		Modelling and Simulation of EHV	3	3.0	1.5	1.8	1.0	2.8	0.8	2.0	0.5	0.8	0.8	0.8	2.0	3	1.5	0.5
VII		Modelling and Simulation of EHV Lab	1	3.00	1.50	1.75	1.00	2.75	0.75	2.00	0.50	0.75	0.75	0.75	2.00	3	1.5	0.5
VII		Software Engineering	3	3	1.5	1	2	1.5	1	-	1	1	-	1	0.75	0.5	1	1
VII		Software Engineering Lab	1	3	2	2	2	1	-	-	-	0.25	0.75	0.75		1.5	-	-
VIII		Operation Research Techniques	3	3	2	2.75	2.75	2	1.25	0	0.25	0.25	0.5	0.5	3	3	2	0.5
VIII		Design of Thermal Systems	3	3	2	2.5	2.5	1	1.5	1.5	0	0	0.25	0	2.75	0.75	3	2.25

VIII		Advance Automotive Electronics	3	3	0.5	1.5	0.5	2.75	1.75	0.5	0.5	0	0	0	2	3	2	0.25
VIII		Lean enterprise & Advanced Manufacturing Technologies	3	3	2	2.25	2.25	2.25	0.5	1	0.25	1	0.5	1	2	1	1	-
VIII		Non-Destructive Evaluation & Testing	3	3	1.75	1.5	2	1.75	1.25	1.25	1.25	2	1.5	2.5	2.5	3	1.75	1.5
VIII		Biomaterials	3	3	1.75	1.75	2	1.5	2	3	0.5	0	0	0	2.25	0.75	3	2.25
VIII		Entrepreneurship & Digital Product Management	2	2	3	2	1	1.5	2.5	-	-	-	1	2	2.5	3.0	2.0	1.5
VIII		Research Project/ Dissertation	12	3.0	2.5	2.5	2.3	1.5	-	1.3	0.5	1.3	1.0	1.8	2.3	2	2	2.5

Annexure I
(Program Name)
Course Plan

<table>
<tr><td>Course Title:</td><td colspan="3"></td><td>Course Code:</td><td></td></tr>
<tr><td>Total Credits:</td><td>L</td><td>T</td><td>P</td><td>CL</td><td>Hour/Week</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Course Content:</td></tr>
<tr><td>Unit</td><td colspan="2">Content</td><td>No. of Hours</td><td colspan="2">Mode of Delivery</td></tr>
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<tr><td colspan="3" align="right">Total Hours</td><td></td><td colspan="2"></td></tr>
</table>

Note – L: Lecture Hour/week, T: Tutorial Hour/week, P: Practical Hour/week, CL: Clinical Hour/week

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Annexure II

Entry, Exit Points

To bring major reforms in the Higher Education System, National Education Policy (NEP) 2020 has provided a system of multiple entry and exit in academic programs. In this system the students shall be free to choose their programs and academic pathways in Higher Education that will support the Academic Bank of Credit (ABC). Multiple Entry and Exit System (MEES) are the fundamental recommendations of University Grants Commission (UGC), to encourage flexible learning in Higher Education Institutions (HEIs) which is important for life- long learning of the students and to choose their academic path leading to the award of certificate, diploma and degree.

Hence the Entry, Exit points for our program will be as per the guidelines laid down by UGC and will be subjected to change in future as per UGC decisions.