COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHEME
And
SYLLABUS

B. TECH PROGRAMME

in

MECHANICAL ENGINEERING

(2023 Admission onwards)

B.TECH. DEGREE PROGRAMME IN MECHANICAL ENGINEERING

VISION

The Mechanical Engineering Division strives to be recognized globally for outstanding education and research leading to well-qualified engineers, who are innovative, entrepreneurial and successful in advanced fields of engineering and research

MISSION

Imparting quality education to the students and enhancing their skills to make them globally competitive mechanical engineers.

Maintaining vital, state-of-the-art research facilities to provide its students and faculty with opportunities to create, interpret, apply and disseminate knowledge.

To develop linkages with world-class R&D organizations and educational institutions in India and abroad for excellence in teaching, research and consultancy practices.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO-1. PREPARATION: To prepare students to excel in postgraduate programmes or to succeed in industry/technical professions through global rigorous education.

PEO-2. CORE COMPETENCE: To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve engineering problems and also to pursue higher studies.

PEO-3. BREADTH: To train students with good scientific and engineering breadth so as to comprehend, analyze, design and create novel products and solutions for real-life problems.

PEO-4. PROFESSIONALISM: To inculcate in students professional and ethical attitudes, effective communication skills, teamwork skills, multidisciplinary approach and an ability to relate engineering issues to broader social context.

PROGRAMME OUTCOMES (POS)

PO-1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO-2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO-3 Design/Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PO-4 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.

PO-5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modem engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO-6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO-7 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.

PO-8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO-9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO-10 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.

PO-11 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.

PO-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.

PROGRAMME SPECIFIC OUTCOMES

PSO-1 Excel in product design, thermal and fluid engineering, and manufacturing systems with the acquired knowledge in mathematics, science, and engineering disciplines.

PSO-2 Be competent to analyze, interpret, and solve real-life mechanical engineering problems.

PSO-3 Have the managerial skills to work effectively in a team and a society by following ethical and environmental practices.

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4
Imparting quality education to the students and enhancing their skills to make them globally competitive mechanical engineers.	3	3	2	2
Maintaining vital, state-of-the-art research facilities to provide its students and faculty with opportunities to create, interpret, apply and disseminate knowledge.	3	3	2	2
To develop linkages with world-class R&D organizations and educational institutions in India and abroad for excellence in teaching, research and consultancy practices.	3	3	2	2

1-Slightly; 2-Moderately; 3-Substantially

Stream A: Civil Engineering, Mechanical Engineering and Safety and Fire Engineering (I and II Semesters)

Categories of Courses with the Breakup of Credits

Sl. No	Category of Courses	Credit breakup
1	Humanities and Social Sciences including Management Courses	11
2	Basic Science courses	18
3	Engineering Science Courses including workshop, drawing, basics of electronics/electrical/mechanical/computer etc.,	30
4	Professional Courses	74
5	Professional elective courses relevant to the chosen specialization/discipline	18
6	Open subjects-Electives from other technical and /or emerging subjects	6
7	Project work, seminar and internship in industry or elsewhere	13
8	Mandatory courses	(non-credit)
	Total	170

SEMESTER I [Stream – A]

Code No.	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total
						CA	SEE	
23-200-0101A	Calculus	3	1	0	3	50	50	100
23-200-0102A	Engineering Chemistry	3	0	1	3	50	50	100
23-200-0103A	Engineering Graphics	2	0	3	3	50	50	100
23-200-0104A	Basic Civil Engineering	3	1	0	4	50	50	100
23-200-0105A	Basic Mechanical Engineering	3	1	0	4	50	50	100
23-200-0106A	Environmental and Life Sciences	3	0	0	3	50	50	100
23-200-0107A	Civil Engineering Workshop	0	0	3	1	25	25	50
23-200-0108A	Mechanical Engineering Workshop	0	0	3	1	25	25	50
	TOTAL	**17**	**3**	**10**	**22**			

CA – Continuous Assessment, SEE – Semester End Examination

SEMESTER II [Stream A]

Code No.	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total
						CA	SEE	
23-200-0201A	Computer Programming and Problem Solving	3	1	0	4	50	50	100
23-200-0202A	Engineering Physics	3	0	1	3	50	50	100
23-200-0203A	Engineering Mechanics	3	1	0	4	50	50	100
23-200-0204A	Basic Electrical Engineering	3	0	0	3	50	50	100
23-200-0205A	Basic Electronics Engineering	3	0	0	3	50	50	100
23-200-0206A	Soft Skills Development	2	0	0	2	50	0	50
23-200-0207A	Computer Programming Laboratory	0	0	3	1	25	25	50
23-200-0208A	Basic Electrical and Electronics Engineering Laboratory	0	0	3	1	25	25	50
23-200-0209A	Language Laboratory	0	0	2	1	25	25	50
23-200-0210A	NSS/Nature Conservation Activities/Yoga	0	0	2	0	0	0	0
	TOTAL	**17**	**2**	**11**	**22**			

SEMESTER III

Code No.	Subject	L H/ W	T H/W	P/D H/W	C	Marks		Total
						CA	SEE	
23-200-0301A*	Linear Algebra and Transform Techniques	3	1	0	3	50	50	100
23-205-0302	Electrical Technology	3	1	0	3	50	50	100
23-205-0303	Mechanics of Solids	3	1	0	3	50	50	100
23-205-0304	Fluid Mechanics and Hydraulic Machinery	3	1	0	3	50	50	100
23-205-0305	Metallurgy and Materials Science	3	1	0	3	50	50	100
23-205-0306	Machine Drawing	3	1	0	3	50	50	100
23-205-0307	Strength of Materials Laboratory	0	0	3	1	25	25	50
23-205-0308	Fluid Mechanics Laboratory	0	0	3	1	25	25	50
23-205-0309	Internship-I	0	0	0	1	50	0	50
	TOTAL	**18**	**6**	**6**	**21**			
Minor in Mechanical Engineering								
23-205-0310	Computer-Aided Machine Drawing	3	0	0	3	50	50	100
23-205-0311	Introduction to Materials and Processing	3	0	0	3	50	50	100

* Common for CE, ME and SE

Internship-I of a minimum duration of two weeks (10 working days) must be completed during the summer vacation after the II Semester, and evaluation will take place during the III Semester. For Lateral Entry students, a mini project carried out can be considered equivalent to Internship I.

SEMESTER IV

Code No.	Subject	L H/ W	T H/W	P/D H/ Week	C	Marks		Total
						CA	SEE	
23-200-0401A*	Complex Variables and Partial Differential Equations	3	1	0	3	50	50	100
23-205-0402	Metrology and Instrumentation	3	1	0	3	50	50	100
23-205-0403	Mechatronics	3	1	0	3	50	50	100
23-205-0404	Applied Thermodynamics	3	1	0	3	50	50	100
23-205-0405	Principles of Management and Industrial Engineering	3	1	0	3	50	50	100
23-205-0406	Manufacturing Processes	3	1	0	3	50	50	100
23-200-0407**	Universal Human Values	2	1	0	3	25	25	50
23-205-0408	Metrology and Automation Laboratory	0	0	3	1	25	25	50
23-205-0409	Hydraulic Machinery Laboratory	0	0	3	1	25	25	50
	TOTAL	**20**	**7**	**6**	**23**			
Minor in Mechanical Engineering								
23-205-0410#	MOOC**:** Broad Area- Thermal and Fluid Engineering	0	0	0	3	0	0	100
Honours in Mechanical Engineering								
23-205-0411	Multibody Dynamics	3	0	0	3	50	50	100
23-205-0412#	MOOC: Broad Area- Advanced Thermal and Fluid Engineering	0	0	0	3	0	0	100

* Common for CE, ME and SE

Students should take Massive Open Online Courses (MOOCs) approved by the concerned Division/Board of Studies (BoS)

SEMESTER V

Code No.	Subject	L H/ W	T H/W	P/D H/ W	C	Marks		Total
						CA	SEE	
23-200-0501A*	Numerical and Statistical Methods	3	1	0	3	50	50	100
23-205-0502	Mechanics of Machinery	3	1	0	3	50	50	100
23-205-0503	Machine Tools	3	1	0	3	50	50	100
23-205-0504	Thermal Engineering	3	1	0	3	50	50	100
23-205-0505	Advanced Manufacturing Technology	3	1	0	3	50	50	100
23-205-05**	Professional Elective – I (MOOC)	0	0	0	3	0	0	100
23-205-0510	Computational Methods Laboratory	0	0	3	1	25	25	50
23-205-0511	Machine Shop- I	0	0	3	1	25	25	50
23-205-0512	Internship- II	0	0	0	1	50		
	TOTAL	**15**	**5**	**6**	**21**			
Minor in Mechanical Engineering								
23-205-0513#	MOOC: Broad Area- Mechanical Design and Development	0	0	0	3	0	0	100
Honours in Mechanical Engineering								
23-205-0514	Theory of Plasticity and Metal Forming	3	0	0	3	50	50	100
23-205-0515#	MOOC: Broad Area- Advanced Manufacturing	0	0	0	3	0	0	100

* Common for CE, ME and SE

Students should take Massive Open Online Courses (MOOCs) approved by the concerned Division/Board of Studies (BoS)

Internship-II, which has a minimum duration of two weeks (10 working days), must be completed during the summer vacation after the IV Semester, and evaluation will take place during the V Semester.

23-205-0506 to 0509: PROFESSIONAL ELECTIVE – I (MOOC)	
Course Code	**Broad Area**
23-205-0506 **(IE)**	Additive Manufacturing
23-205-0507	Operations Management
23-205-0508	Advanced Thermodynamics
23-205-0509	Advanced Mechanics of Solids

SEMESTER VI

Code No.	Subject	L H/ W	T H/W	P/D H/ W	C	Marks		Total
						CA	SEE	
23-205-0601	Dynamics of Machinery	3	1	0	3	50	50	100
23-205-0602	Design of Machine Elements- I	3	1	0	3	50	50	100
23-205-0603	Compressible Fluid Flow	3	1	0	3	50	50	100
23-205-0604	Heat and Mass Transfer	3	1	0	3	50	50	100
23-205-0605	Computer-Aided Design and Analysis	3	1	0	3	50	50	100
23-205-06**	Professional Elective- II	3	1	0	3	50	50	100
23-205-0610	Machine Shop- II	0	0	3	1	25	25	50
23-205-0611	Thermal Engineering Laboratory	0	0	3	1	25	25	50
	TOTAL	**18**	**6**	**6**	**20**			
Minor in Mechanical Engineering								
23-205-0612#	MOOC**:** Broad Area- Manufacturing and Production Management	0	0	0	3	0	0	100
23-205-0613	Mini Project	3	0	0	3	100	0	100
Honours in Mechanical Engineering								
23-205-0614#	MOOC: Broad Area- Advanced Design and Analysis	0	0	0	3	0	0	100

Students should take Massive Open Online Courses (MOOCs) approved by the concerned Division/Board of Studies (BoS)

23-205-0606 to 0609: PROFESSIONAL ELECTIVE – II	
23-205-0606	Advanced Fluid Mechanics
23-205-0607	Artificial Intelligence and Machine Learning for Mechanical Engineers
23-205-0608	Finite Element Methods for Engineers
23-205-0609 (**IE**)	Quality Engineering and Management

SEMESTER VII

Code No.	Subject	L H/ W	T H/W	P/D H/ W	C	Marks		Total
						CA	SEE	
23-205-0701	Refrigeration and Air Conditioning	3	1	0	3	50	50	100
23-205-0702	Vibration and Noise Control	3	1	0	3	50	50	100
23-205-0703	Design of Machine Elements II	3	1	0	3	50	50	100
23-205-07**	Professional Elective-III	3	1	0	3	50	50	100
23-205-07**	Open Elective-I	3	0	0	3	50	50	100
23-205-0712	Heat and Mass Transfer Laboratory	0	0	3	1	25	25	50
23-205-0713	CAD and Analysis Laboratory	0	0	3	1	25	25	50
23-205-0714	Entrepreneurship Development	0	0	2	1	50	0	50
23-205-0715	Project Phase I	0	0	3	2	50	0	50
23-205-0716	Internship-III	0	0	0	1	50	0	50
	TOTAL	**15**	**4**	**11**	**21**			
Honours in Mechanical Engineering								
23-205-0717	Introduction to Statistical Thermodynamics and Molecular Dynamics	3	0	0	3	50	50	100

****** Electives

A student should opt for at least one open elective offered by a Division other than their branch of study in the 7th or 8th semester.

Internship-III, which has a minimum duration of two weeks (10 working days), must be completed during the summer vacation after the VI Semester, and evaluation will take place during the VII Semester.

23-205-0704 to 0707: PROFESSIONAL ELECTIVE – III	
23-205-0704 (**IE**):	Automobile Engineering
23-205-0705	Robot Kinematics and Dynamics
23-205-0706	Supply Chain Management
23-205-0707	Aerospace Engineering

23-205-0708 to 0711: OPEN ELECTIVE – I	
23-205-0708	Energy Conservation and Environmental Protection
23-205-0709	Project Management
23-205-0710	HRD and Organisational Behaviour
23-205-0711	Fundamentals of Combustion And Pollution

SEMESTER VIII – Regular Track

Code No.	Subject	L H/ W	T H/W	P/D H/ W	C	Marks		Total
						CA	SEE	
23-205-08**	Professional Elective - IV	3	1	0	3	50	50	100
23-205-08**	Professional Elective - V	3	1	0	3	50	50	100
23-205-08**	Professional Elective - VI	3	1	0	3	50	50	100
23-205-08**	Open Elective - II	3	0	0	3	50	50	100
23-205-0818	Seminar	0	0	3	1	50	0	50
23-205-0819	Project Phase - II	0	0	12	6	200	0	200
23-205-0820	Comprehensive Viva Voce	0	0	0	1	0	50	50
	TOTAL	**12**	**3**	**15**	**20**			

SEMESTER VIII – Internship Track*

Code No.	Subject	L H/ W	T H/W	P/D H/ W	C	Marks		Total
						CA	SEE	
23-205-08**	Professional Elective - IV	3	1	0	3	50	50	100
23-205-08**	Elective(Professional/Open)	3	1	0	3	50	50	100
23-205-0818	Seminar	0	0	3	1	50	0	50
23-205-0819	Project Phase - II	0	0	12	6	200	0	200
23-205-0820	Comprehensive Viva Voce	0	0	0	1	0	50	50
23-205-0821	Internship-IV	0	0	0	6	200		200
	TOTAL	**12**	**3**	**15**	**20**			

23-205-0801 to 0804: PROFESSIONAL ELECTIVE – IV	
23-205-0801	Mechanical Behaviour of Materials
23-205-0802	Operations Research
23-205-0803	Cryogenic Engineering
23-205-0804	Hydraulic and Pneumatic Drives

23-205-0805 to 0808: PROFESSIONAL ELECTIVE - V	
23-205-0805	Materials Management
23-205-0806	Nano Technology and Surface Engineering
23-205-0807	Convection and Two-Phase Flows
23-205-0808	Propulsion Engineering

23-205-0809 to 0812: PROFESSIONAL ELECTIVE - VI	
23-205-0809	Energy Engineering
23-205-0810	Nondestructive Testing Techniques
23-205-0811	Computational Fluid Dynamics
23-205-0812	Mechanical Estimation and Costing

23-205-0813 to 0816 and 23-200-0817: OPEN ELECTIVE – II	
23-205-0813	Corrosion Engineering
23-205-0814	Engineering Economics, Estimation and Costing
23-205-0815	Renewable Energy Engineering
23-205-0816	Smart Materials
23-200-0817*	Constitutional Law

*Common to all branches

List of Courses for Minor in Mechanical Engineering

Code No	Subject	L H/ W	T H/ W	P/D H/ W	C	Marks		Total Marks	Semester in which offered	Mode of Learning
						CA	**SEE**			
23-205-0310	Computer-Aided Machine Drawing	3	0	0	3	50	50	100	III	Class Room
23-205-0311	Introduction to Materials and Processing	3	0	0	3	50	50	100	III	Class Room
23-205-0410	MOOC-I	0	0	0	3	0	0	100	IV	Online
23-205-0513	MOOC-II	0	0	0	3	0	0	100	V	Online
23-205-0612	MOOC-III	0	0	0	3	0	0	100	VI	Online
23-205-0613	Mini Project	3	0	0	3	100	0	100	VI	-

List of suggested MOOCs for Minor in Mechanical Engineering

MOOC-1

Broad Area: Thermal and Fluid Engineering

MOOC-II

Broad Area: Mechanical Design and Development

MOOC-III

Broad Area: Manufacturing and Production Management

List of Courses for Honours

Code No	Subject	L H/ W	T H/ W	P/D H/ W	C	Marks		Total Marks	Semester in which offered	Mode of Learning
						CA	**SEE**			
23-205-0411	Multibody Dynamics	3	0	0	3	50	50	100	IV	Class Room
23-205-0412	MOOC-I	0	0	0	3	0	0	100	IV	Online
23-205-0514	Theory of Plasticity and Metal Forming	3	0	0	3	50	50	100	V	Class Room
23-205-0515	MOOC-II	0	0	0	3	0	0	100	V	Online
23-205-0614	MOOC-III	0	0	0	3	0	0	100	VI	Online
23-205-0717	Introduction to Statistical Thermodynamics and Molecular Dynamics	3	0	0	3	50	50	100	VII	Class Room

List of suggested MOOCs for Honours in Mechanical Engineering

MOOC-I

Broad Area: Advanced Thermal and Fluid Engineering

MOOC-II

Broad Area: Advanced Manufacturing

MOOC-III

Broad Area: Advanced Design and Analysis

Industry Based Electives

Industry-based Electives are offered in the 5th, 6th and 7th Semesters and listed among the Professional Electives with the notation (IE) and the subject code. A student should opt for at least one Industry-based elective during the B. Tech programme.

Open Electives

Open Electives are offered in the 7th and 8th Semesters. A student should opt for at least one Open Elective offered by any Division/Department other than their branch of study.

MOOC

Every student shall undergo at least one MOOC of a minimum 12 weeks duration during the programme (preferably before the final semester) as per the University Regulations for conducting online courses (MOOC)

SEMESTER VIII- Internship Track

Students who intend to go for the Internship Track should inform the division head concerned before the commencement of the 8th Semester. The student will be given the option to change the track within

30 days from the commencement of the 8th Semester. Students opting for the Internship Track have to do Project Phase II and appear for the Comprehensive Viva-Voce.

The interns may opt for courses recommended by the division from the list of NPTEL/SWAYAM courses approved by the BoS.

The students opting for the divisional courses must fulfil the Continuous Assessment (CA) and Semester End Examination (SEE) requirements.

One elective from the Open Elective pool is mandatory if they have not completed one mandatory Open Elective in the seventh semester.

Project Phase II is the continuation of Project Phase I in the seventh semester or a separate one approved by the division

The Internship-IV, of a minimum six weeks duration, must be done in an Industry approved by either the Placement Cell or the respective Department based on a valid MOU or in any Government organization or any organization approved by the division.

The Internship-IV is equivalent to two 3-credit courses for a total of 200 marks.

The progress of Internship-IV will be evaluated twice during the semester, along with the Continuous Assessment tests and finally after the completion of the internship.

Evaluation Pattern for Theory and Practical Courses

1. Theory Courses

Types of questions for Semester End Examination (SEE)

Part A $(\mathbf{5 \times 2 = 10\ marks})$

Question No. I (a) to (e) – Five short answer questions of 2 marks each with at least one question from each of the four modules.

Part B $(\mathbf{4 \times 10 = 40\ marks})$

Questions nos. II, III (from Module I) of 10 marks each with the option to answer either II or III. The questions may have sub-sections (a) and (b)

Questions nos. IV, V (from Module II) of 10 marks each with the option to answer either IV or V. The questions may have sub-sections (a) and (b)

Questions nos. VI, VII (from Module III) of 10 marks each with the option to answer either VI or VII. The questions may have sub-sections (a) and (b)

Questions nos. VIII, IX (from Module IV) of 10 marks each with the option to answer either VIII or IX. The questions may have sub-sections (a) and (b)

2. Practical Courses

50% of marks are earmarked for Continuous Evaluation, and 50% of marks are for Semester End Examination. A minimum of two examiners will conduct the semester-end examination.

Pass Requirements

A candidate has to obtain a minimum of 50% marks for Continuous Assessment and Semester End Examination, put together with a minimum of 40% marks in the Semester End Examination for a pass in theory and laboratory courses.

In the case of theory/laboratory/other courses having only Continuous Assessment, a candidate has to obtain a minimum of 50% marks in Continuous Assessment for a pass.

23-200-0101A: CALCULUS

Course Outcomes:

On completion of this course, the student will be able to:

1. Solve ordinary differential equations and linear differential equations of higher orders with constant coefficients and apply them to engineering problems
2. Determine the maxima and minima of multi-variable functions.
3. Convert line integrals into surface integrals and surface integrals into volume integrals
4. Illustrate the physical meaning and application of gradient, divergence and curl.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2								
CO2	3	3	3	2	2	2	2								
CO3	3	3	3	2	2	2	2								
CO4	3	3	3	2	2	2	2								

1-Slightly; 2-Moderately; 3-Substantially

Module I

Ordinary differential equations:
First-order differential equations - exact differential equations, Bernoulli's equations--Methods of solution and Simple applications.
Linear differential equations of higher orders with constant co-efficient-Methods of solution of these equations. Cauchy's linear differential equations. Simultaneous linear differential equations- Simple applications of linear differential equations in engineering problems –Electrical Circuits, Mechanical Systems.

Module II

Partial differentiation: Partial Differentiation-Concept of partial derivative - Chain rule- Total derivative- Euler's theorem for homogeneous functions, Differentials and their applications in errors and approximations, Jacobians - Maxima minima of functions of two variables (Proof of the result not required)-Simple applications.
Coordinate systems: Rectangular coordinates-Polar coordinates- In-plane and in Space-Cylindrical polar coordinates-Spherical polar coordinates.

Module III

Integral calculus:
Application of definite integrals: Area, Volume, Arc length, Surface area.
Multiple integrals: Evaluation of double integrals-Change of order of integration. Evaluation of triple integrals-Change of Variables in integrals.
Applications of multiple integrals. Plane Area, Surface area &Volumes of solids

Module IV

Vector calculus: scalar and vector point functions, gradient and directional derivative of a scalar point function, divergence and curl of vector point functions, their physical meaning. Evaluation of line integral, surface integral, and volume integrals, Gauss's divergence theorem, Stoke's theorem (No proofs), conservative force fields, and scalar potential.

References:

1. Sastry, S.S. Engineering Mathematics: Vol1. (Fourth edition). PHI Learning, New Delhi. (2008).
2. Erwin Kreyzig. Advanced Engineering Mathematics (Tenth edition). John Wiley& Sons, Hoboken, NJ. (2011)
3. Veerarajan, T. Engineering Mathematics. (Third edition). Tata McGraw Hill Publishers, New Delhi. (2011)

4. Grewal, B.S. Higher Engineering Mathematics. (Forty-third Edition). Khanna Publishers, New Delhi. (2013).

23-200-0102A: ENGINEERING CHEMISTRY

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain the basic concepts of chemical thermodynamics and quantum chemistry.
2. Illustrate the spectroscopic methods in characterizing materials.
3. Develop electrochemical methods to protect different metals from corrosion.
4. Interpret the chemistry of a few important engineering materials and their industrial applications.
5. Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2												
CO2	3	2	3												
CO3	1	1	1												
CO4	1	1	1												
CO5	2	2	3												

1-Slightly; 2-Moderately; 3-Substantially

Module I

Chemical Thermodynamics: Fundamentals. The first law of thermodynamics, the Molecular interpretation of internal energy, enthalpy and entropy. Heat of reaction. Kirchoff's equations. Dependence on pressure and temperature. Gibbs-Helmholtz equation. Free energy changes and equilibrium constant. Chemical potential and fugacity. Thermodynamics of biochemical reactions.

Phase Rule: Terms involved in phase rule and examples, Application of phase rule to one component water system, Application of phase rule to two-component systems. (Simple eutectic systems).

Module II

Quantum Chemistry: Schrodinger wave equation – significance of Ψ, well-behaved functions, Postulates of quantum mechanics, Application of quantum mechanics to simple systems - particle in 1 D box, normalization of wave function, Forms of hydrogen atom wave functions and the plots of these functions to explore their spatial variations, Quantum numbers.

Module III

Spectroscopy: Principles of spectroscopy and selection rules. Electronic spectroscopy. Vibrational and rotational spectroscopy of diatomic molecules. Applications. 1H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting - coupling constant - applications of NMR- MRI.

Module IV

Electrochemistry: Cell EMF- its measurement and applications. Nernst Equation and application, the relation of e.m.f. with thermodynamic functions (ΔH, ΔF and Δ S). Lead storage battery. Corrosion; causes, effects and its prevention.

Polymers- Classifications- Thermoplastics and thermosetting plastics- A brief account of conducting polymers (polypyrrole and polythiophene) and their applications.

Lubricants- Introduction solid and liquid lubricants- Properties of lubricants- viscosity index- flash and fire point- cloud and pour point- aniline value.

Refractories: Classifications – Properties of refractories.

Laboratory Experiments to be conducted in the virtual lab mode

List of Experiments (Minimum six experiments shall be conducted)

Determination of the partition coefficient of a solute in two immiscible liquids.

Phase diagram of two-component System (Naphthalene-diphenylamine)

Conductometric titration of Strong acids with Strong base.

Potentiometric titration: Fe2+ vs KMNO4

Heat of neutralization

Verification of Beer-Lamberts law

Determination of rate constant of a reaction.

Determination of total hardness of water by EDTA method.

Determination of COD of water sample.

Determination of alkalinity of water.

Determination of chloride content of water by Mohr's method.

Determination of dissolved oxygen in given water sample.

Determination of acidity of water sample.

Determination of adsorption of acetic acid by charcoal.

Determination of acidity of water sample

References:

1. B. H. Mahan and R. J. Meyers. University Chemistry, 4th Edition, Pearson publishers. (2009).
2. Peter W. Atkins, Julio de Paula, and James Keele. Physical Chemistry, 11th Edition, Oxford Publishers. (2018).
3. M. J. Sienko and R. A. Plane. Chemistry: Principles and Applications, 3rd Edition, McGraw-Hill Publishers. (1980).
4. C. N. Banwell. Fundamentals of Molecular Spectroscopy, 5th Edition, McGraw-Hill Publishers. (2013).
5. B.L. Tembe, M.S. Krishnan and Kamaluddin. Engineering Chemistry (NPTEL Web Course).
6. Shashi Chawla. A Textbook of Engineering Chemistry. Dhanpat Rai & Co, New Delhi. (2013).

Pattern of Continuous Assessment

Test – I for the theory portions: 15 marks

Test -II for the theory portions: 15 marks

Assignment from the theory portions: 5 marks

Laboratory record and Viva -voce: 10 marks (5 + 5)

Attendance: 5 marks

The students are required to submit the laboratory record.

23-200-0103A: ENGINEERING GRAPHICS

Course Outcomes:

On completion of this course, the student will be able to:

1. Visualize and draw orthographic projections of straight lines and planes and solids
2. Understand the development of the surface of different geometric shapes
3. Construct isometric scale, isometric projections and views.
4. Obtain Multiview projections and solid models of objects using CAD tools

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2		1				1	2					
CO2	2	3	2		1				1	2					
CO3	2	2	2		1				1	2					
CO4	2	2	2		1				1	2					

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to engineering graphics. Drawing instruments and their use. Familiarisation with the current Indian Standard Code of Practice for general engineering drawing, scales and geometric curves. Introduction to orthographic projections- plane of projection- principles of first angle and third angle projections, projection of points in different quadrants.
Orthographic projection of straight lines parallel to one plane and inclined to the other plane- straight lines inclined to both the planes- true length and inclination of lines with reference planes- traces of lines. Projection of plane laminae of geometrical shapes in oblique positions.

Module II

Projection of polyhedra and solids of revolution- frustum, projection of solids with axis parallel to one plane and parallel or perpendicular to another plane- projection of solids with axis inclined to both the planes- projection of solids on auxiliary planes.
Section of solids by planes inclined to horizontal or vertical planes- true shape of sections.

Module III

Development of the surface of cubes, prisms, cylinders, pyramids and cones
The intersection of surfaces- methods of determining lines of intersection - the intersection of prism in prism and cylinder in cylinder.

Module IV

Introduction to isometric projection- isometric scales, isometric views- isometric projections of prisms, pyramids, cylinders, cones and spheres.
Introduction to perspective projections: visual ray method and vanishing point method- perspective of circles- perspective views of prisms and pyramids.

Note: A minimum of two exercises from each module shall be done using suitable drafting software.

References:

1. Bhat, N.D. Engineering Drawing. 54th Edition, Charotar Publishing House, Anand. (2023)
2. John, K.C. Engineering Graphics. PHI Learning, New Delhi. (2013)
3. Anilkumar, K.N., Engineering Graphics, 10th Edition, Adhyuth Narayan Publishers. (2016).
4. Gill P.S. Geometric Drawing. B.D Kataria & Sons, Ludhiana. (2012)
5. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI. (2009).

Pattern of Question Paper for the Semester-End Examination

Two questions of 12.5 marks each from all four modules. Answer one question from each module.

23-200-0104A BASIC CIVIL ENGINEERING

Course Outcomes

On completion of this course, the student will be able to:

1. Summarize the types, uses and properties of various building materials
2. Explain the different components of the building and the types of foundations
3. Recognize the fundamental aspects and services in the field of civil engineering
4. Discuss the surveying techniques and solve problems related to levelling
5. Prepare a site plan based on the Kerala Panchayath and Municipality Building Rules

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					1		1				1			
CO2	2					1		1				1			
CO3	2					1		1				1			
CO4	1					1		1				1			
CO5	2					1		1				1			

1-Slightly; 2-Moderately; 3-Substantially

Module I

Overview of Civil Engineering - Civil Engineering contributions to the welfare of Society – Specialized sub-disciplines in Civil Engineering – Structural, Construction, Geotechnical, Environmental, Transportation and Water Resources Engineering.

Engineering Materials: Cement - varieties and grades of cement and their uses. Steel- types of steel for reinforcement bars, and steel structural sections. Brick- varieties, tests on bricks. Aggregates, Concrete, water cement ratio, workability, batching, mixing, transportation, placing, compaction and curing of concrete.

Module II

Construction: Components of a building-Foundation- types of foundations- isolated footing, combined footing, raft, pile & well foundation.

Superstructure: Brick masonry, English bond and Flemish bond, Stone Masonry-Ashlar masonry-Rubble masonry. Roofing- Steel trusses, roofing for industrial buildings.

Module III

Surveying: Basic Principles of Surveying, instruments, methods, and Measurements- linear measurements works

Levelling: Levelling instruments, reduction of levels by height of collimation method. Introduction to Total Station.

Module IV

Site planning as per Building Rules-Selection of the site- Site plan preparation for buildings- general provisions regarding site and building requirements- set back, coverage and Floor Area Ratio as per Kerala Panchayath and Municipal Building Rules.

Basic concepts of Intelligent Buildings and Green Buildings, Roads- Classification of Rural and Urban Roads, Sources of Water - Water Supply- Quality of Water-Rain water harvesting.

References:

1. Mamlouk, M. S., and Zaniewski, J. P., Materials for Civil and Construction Engineering, Pearson Publishers (2011)
2. Chudley, R., Construction Technology, Vol. I to IV, Longman Group, England (2011).
3. 3.McKay, W. B. and McKay, J. K., Building Construction, Vol. 1 to 4, Pearson India Education Services. (2013)
4. Rangwala, S.C and Dalal, K.B, Building Construction, Charotar Publishing House (2017).
5. Kerala Panchayath and Municipal Building Rules (Latest revision)

23-200-0105A BASIC MECHANICAL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. Summarize the role of mechanical engineering, different energy sources, and basic thermodynamic laws
2. Illustrate the principles and types of power-generating and power-producing devices
3. Explain the working of power transmission systems, electric and hybrid vehicles and modern fuel injection systems.
4. Demonstrate the types and classification of composite and smart materials and joining processes
5. Summarize the machine tools operations and advanced manufacturing systems
6. Explain the concepts of Mechatronics, Robotics, and Automation in IoT

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3					1	2			1		1			
CO2	3					1	1			1		1			
CO3	3					1	1			1		1			
CO4	3					1	1			1		1			
CO5	3					1	1			1		1			
CO6	3					1	1			1		1			

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Role of Mechanical Engineering in Industries and Society- Emerging Trends and Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors.

Introduction to thermodynamic laws, power generating devices: Boilers, Turbines (Steam & Gas), IC engines: Components and Working Principles of two-stroke petrol engines and 4-Strokes Petrol and Diesel Engines, and Application of IC Engines. (Elementary ideas only no numerical problems).

Introduction to power consuming devices: Refrigerator, types and properties of refrigerants, working of domestic refrigerators, Air-conditioning systems, Windows and Split systems (only elementary ideas, no numerical problems)

Module II

Introduction to power transmission systems: Belts, chain, and Gear drives, types and application, (numerical problems related to simple power calculations only).

Energy: Introduction and applications of Energy sources like Fossil fuels, nuclear fuels, Hydel, Solar, wind, and bio-fuels, Environmental issues like Global warming and Ozone depletion.

Modern fuel injection systems in CI and SI engines: CRDi, MPFI systems, cooling and lubricating systems in two-stroke and four-stroke engines. (Only elementary ideas with block diagrams).

Insight into Future Mobility: Electric and Hybrid Vehicles, Components of Electric and Hybrid Vehicles. Advantages and disadvantages of EVs and Hybrid vehicles.

Module III

Introduction to engineering materials: composite and smart materials.
Joining Processes: Soldering, Brazing and Welding, Definitions, classification of the welding process, Arc welding, Gas welding and types of flames.
Machine Tool Operations: Working Principle of lathe, Lathe operations: Turning, facing, knurling. Working principles of Drilling Machine, drilling operations: drilling, boring, reaming. Working of Milling Machine, Milling operations: plane milling and slot milling.
(No sketches of machine tools, sketches to be used only for explaining the operations).
Introduction to Advanced Manufacturing Systems: Introduction, components of CNC, advantages and applications of CNC, 3D printing.

Module IV

Introduction to Mechatronics and Robotics: open-loop and closed-loop mechatronic systems. **Classification based on robotics configuration:** polar cylindrical, Cartesian coordinate and spherical. Application, Advantages and Disadvantages.
Automation in industry: Definition, types – Fixed, programmable and flexible automation, basic elements with block diagrams, advantages.
Introduction to IOT: Definition and Characteristics, Physical design, protocols, Logical design of IoT, Functional blocks, and communication models.

References:

1. Jonathan Wickert and Kemper Lewis. An Introduction to Mechanical Engineering, Third Edition, Cengage Learning (2012).
2. Hazra Choudhry and Nirzar Roy. Elements of Workshop Technology (Vol. 1 and 2), Media Promoters and Publishers Pvt. Ltd. (2010).
3. V. Ganesan. Internal Combustion Engines, 4th edition, Tata McGraw Hill Education (2017).
4. Appu Kuttan K. K., Robotics Volume 1, I K. International Publishing House Pvt Ltd (2013).
5. SRN Reddy, Rachit Thukral and Manasi Mishra. Introduction to Internet of Things: A Practical Approach, ETI Labs (2021).

23-200-0106A: ENVIRONMENTAL AND LIFE SCIENCES

Course Outcomes

On completion of this course, the student will be able to:

1. Identify the global environmental issues
2. Examine the types of pollution in society along with their sources
3. Elucidate the basic biological concepts via relevant industrial applications and case studies.
4. Evaluate the principles of design and development, for exploring novel bioengineering projects.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2				3	3								
CO2	2	2				2	3								
CO3	2	2				2	2								
CO4	2	2				2	2								

1-Slightly; 2-Moderately; 3-Substantially

Module -I

Environment, Ecosystems and Biodiversity: Definition, scope and importance of environment — need for public awareness — concept of an ecosystem — structure and function of an ecosystem — producers, consumers and decomposers — energy flow in the ecosystem — ecological succession — food chains, food webs and ecological pyramids — Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) — Introduction to biodiversity definition: genetic, species and ecosystem diversity — biogeographical classification of India — value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values — Biodiversity at global, national and local levels — India as a mega-diversity nation — hot-spots of biodiversity — threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts — endangered and endemic species of India — conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of common plants, insects, and birds; Field study of simple ecosystems — pond, river, hill slopes, etc.

Module -II

Natural Resources: Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people — Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems — Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies — Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies — Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. case studies — Land resources: Land as a resource, land degradation, man-induced landslides, soil erosion and desertification — the role of an individual in conservation of natural resources. The concept of sustainable development.
Environmental Pollution: Definition — causes, effects and control measures of (a) Air pollution (b) Water pollution (c) Soil pollution (d) Noise pollution. Management of e-waste.

Module – III

Biomolecules and their Applications (Qualitative): Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogues, Plant-based proteins), Lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

Nature-Bioinspired Materials and Mechanisms (Qualitative): Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircraft), Lotus leaf effect

(Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Sharkskin (Friction reducing swimsuits), Kingfisher beak (Bullet train). Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbons (PFCs).

Module -IV

Human Organ Systems and Bio Designs (Qualitative): Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease). Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye). Heart as a pump system (architecture, electrical signalling – ECG monitoring and heart-related issues, reasons for blockages of blood vessels, design of stents, pacemakers, defibrillators). Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine). Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems). Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).
Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods.

References:

1. Rajagopalan, R. Environmental Studies: From Crisis to Cure. Oxford University Press, New Delhi, (2015).
2. Erach Bharucha. Textbook of Environmental Studies and Ethics. Universities Press (India), Hyderabad, (2013).
3. Thyagarajan S., Velmurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K. Biology for Engineers, Tata McGraw-Hill, New Delhi, (2012).
4. Arthur T. Johnson. Biology for Engineers, CRC Press, Taylor and Francis, (2019).
5. Sohini Singh and Tanu Allen. Biology for Engineers, Vayu Education of India, New Delhi, (2020).
6. Ibrahim Ozbolat. 3D Bioprinting: Fundamentals, Principles and Applications, Academic Press, (2016).

23-200-0107A: CIVIL ENGINEERING WORKSHOP

Course Outcomes:

On completion of this course, the students will be able to:

1. Identify various building materials and simple plumbing and sanitary fittings
2. Construct brick walls using English Bond and Flemish Bond
3. Set out a building as per a given building plan using surveying instruments
4. Compute the various quantities of materials required for a building

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1					1	1	1	1		1			
CO2	1						1	1	1			1			
CO3	1						1	1	1	1		1			
CO4	1	1					1	1	1	1		1			

1-Slightly; 2-Moderately; 3-Substantially

Building Materials:

Familiarization with building materials and their testing.

Plumbing:

Introduction to simple plumbing and sanitary fittings.

Masonry:

Construction of English bond and Flemish bond – wall junction – one brick – one and a half brick – and two brick thick

Surveying:

Surveying and levelling instruments
Setting out of the building (single room only) as per the given building plan using surveying instruments
Demonstration of Total Station
Computation of area and/or volume of various features of a building/structure such as door and window size, number of bricks required to construct a wall of a building, diameter of bars used in windows, RCC construction etc. (to create an awareness of measurements and units)

Assignment: *Students shall collect the list of various building materials used for the construction of a building including their market rate.*

23-200-0108A MECHANICAL ENGINEERING WORKSHOP

Course Outcomes:

On completion of this course, the student will be able to:

1. Identify and use tools, and make different types of joints used in carpentry, fitting, and sheet metal shop.
2. Compare basic fabrication techniques of different types of welding.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1					2			2					2	
CO2	1					2			2					2	

1-Slightly; 2-Moderately; 3-Substantially

Preliminary exercises for beginners in all the following shops. Specific models may be designed by the teachers.

1) Fitting Shop
2) Sheet Metal Shop
3) Foundry Shop
4) Welding Shop
5) Carpentry Shop
6) Familiarization with wheel replacement, automobile battery charging, identification of different dashboard indications, IC engine parts, refrigerators, nuts, bolts and their specifications.

23-200-0201A: COMPUTER PROGRAMMING AND PROBLEM-SOLVING

Course Outcomes:

On completion of this course, the student will be able to:

1. Elucidate the basic architecture and functionalities of a computer and also recognize the hardware parts.
2. Apply programming constructs of C language to solve real-world problems.
3. Explore user-defined data structures like arrays in implementing solutions to problems like searching and sorting.
4. Explore user-defined data structures like structures, unions and pointers in implementing solutions.
5. Design and Develop Solutions to problems using modular programming constructs using functions.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	3										
CO2	3	2	2	2	3										
CO3	2	2	2	2	3										
CO4	2	2	2	2	3										
CO5	2	2	2	2	3										

1-Slightly; 2-Moderately; 3-Substantially

Module I

Basics of Computer and Information Technology: Digital Computer System (CPU, Memory, I/O devices)- Working of a digital computer-Hardware and Software: Definition - Categories of Software, Application of Computers.

Problem-Solving Methodology: Problem statement, Analysis, Design a solution, Implement/Coding the solution, Test the solution, Design tools (Algorithm, Flowchart, Pseudo-code)- Develop algorithms for simple problems.

Programming Languages: Types of programming languages-Compiler–Interpreter-Linker–Loader–Execution of program.

Module II

Basics of C: Character set- Identifier- Keywords- Constants –Data Types- Variables and declaration – Operators and Expressions – Operator precedence and associativity – Expression Evaluation (Simple Examples) - Input and output functions – Simple computational problems involving the above constructs.
Control Statements: Selection, Conditional operator, Iteration (for, while, do-while), Branching (switch, break, continue, goto), Nesting of control statements- Problems using control statements.

Module III

Arrays and Strings:1D and 2D arrays –Searching (Linear and Binary) - Sorting (Bubble, Selection) – Matrix manipulation programs – Strings and basic operations on strings – Strings functions -Programs on string manipulation.
Functions: Definition – Calling – Declaration – Parameter Passing (by value and by reference) – Recursion –Programs based on functions.
User-defined data types: Structure – Union - Enumerated data type - Programs involving structure and union.

Module IV

Pointers: Declaration, Initialization – Operations on pointers- Pointers and arrays – Pointers and Structures- Command line arguments- Dynamic memory allocation — Programs involving the above concepts.
Files: File concept – File pointer – File handling operations (open, close, read, write etc.) on sequential and random-access files. Programs on file manipulations using fgetc(), fgets(), fseek().

References:

1. Pradip Dey and Manas Ghosh. Computer Fundamentals and Programming in C, Second Edition, Oxford University Press (2013).
2. Reema Thareja. Computer Fundamentals and Programming in C, Second Edition, Oxford University (2016).
3. Byron Gottfried. Programming with C, Second edition, Tata McGraw-Hill (2006).
4. Brian W. Kernighan and Dennis M. Ritchie. The C Programming Language, Second Edition, Pearson Education, (2001).
5. E. Balagurusamy. Programming in ANSI C, 8th Edition, Tata McGraw-Hill (2017).
6. Kanetkar Y. Let Us C: Authentic guide to C programming language, 19th Edition, BPB Publications (2022).

19-200-0202A: ENGINEERING PHYSICS

Course Outcomes:

On completion of this course, the student will be able to:

1. Interpret modern devices and technologies based on lasers and optical fibres.
2. Explain the basic principles of crystal physics
3. Summarize the characteristics and applications of superconducting materials nanomaterials and smart materials
4. Illustrate the theory of semiconductors and magnetic materials
5. Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2												
CO2	3	1	1												
CO3	3	2	1												
CO4	2	2	2												
CO5	3	2	2												

1-Slightly; 2-Moderately; 3-Substantially

Module I

Laser-properties-interaction of radiation with matter-absorption, spontaneous and stimulated emission-principle of laser--Einstein coefficients- population inversion- metastable state -Basic components of a laser- construction and working of Ruby laser and He-Ne laser -Applications.
Fibre optics - Basic structure - principle- step-index fibre and graded index fibre- single mode and multimode- Numerical aperture (no derivation) -acceptance angle and acceptance cone-propagation-Applications.

Module II

Crystallography – Space lattice- Basis- Unit cell-Bravais lattices- cubic lattices-SC, BCC, and FCC-Number of atoms per unit cell- Co-ordination number- Atomic radius-Packing factor- Relation between density and crystal lattice constants- Lattice planes and Miller indices-
X-rays- Production, Properties, characteristic and continuous X-rays, Moseley's law; Diffraction of X-rays- Bragg's law (derivation), Bragg's Spectrometer

Module III

Superconductor-transition temperature-Meissner effect-effect of current- isotope effect- Type 1 and type 2 superconductors –BCS theory (basic idea only)- Applications.
Nanomaterials- nanoparticle, nano ring, nanorod, nanoshells, fullerenes- surface occupancy-quantum confinement effect- optical, electrical, magnetic and mechanical properties - Applications.
Smart materials-Liquid crystals, Metallic glasses, Shape memory alloys- optical, electrical magnetic and mechanical properties-applications.

Module IV

Magnetic Materials-Magnetic pole strength, magnetic moment, the intensity of magnetization, magnetic field, magnetic induction, magnetic susceptibility, magnetic permeability, classification. Hard and soft-Paramagnetic materials-properties, Diamagnetic materials-properties, Ferromagnetic properties-Antiferromagnetic materials, Ferrimagnetic materials- Applications
Semiconductor-Properties-Energy band description-effect of temperature-intrinsic, extrinsic semiconductors-n-type and p-type semiconductors-Majority and minority carriers.

Laboratory Experiments to be conducted in the virtual lab mode

List of Experiments (Minimum six experiments shall be conducted)

1. Transmission grating: To find the wavelength of the laser beam
2. Determination of NA of an optical fibre
3. Laser beam divergence and spot size
4. Determination of Grain size and lattice parameter using Bragg's X-ray spectrum
5. Lattice planes from X Y Z intercepts
6. LCR circuits to find the resonance frequency and quality factor.
7. Diode characteristics
8. Ohms law
9. LED circuits to find cutting voltage.
10. Determination of the Energy band gap of a given semiconductor material
11. Magnetic field along the axis of a circular coil carrying current
12. Deflection Magnetometer

References:

1. S. Mani Naidu, A Textbook of Engineering Physics, Pearson. (2010)
2. A.S. Vasudeva, Modern Engineering Physics, S. Chand & Co. (2013)
3. Prabir K. Vasu and Hrishikesh Dhasmana, Engineering Physics, Ane Books Pvt. Ltd. (2010)
4. S.O. Pillai and Sivakami, Applied Physics, New Age International (P) Ltd., Second Edition. (2008)
5. G.S. Raghuvanshi, Engineering Physics, Prentice Hall of India. (2008)

Pattern of Continuous Assessment

Test - I for the theory portions: 15 marks
Test - II for the theory portions: 15 marks
Assignment from the theory portions: 5 marks
Laboratory record and Viva-voce: 10 marks (5 + 5)
Attendance: 5 marks

The students are required to submit the laboratory record.

23-200-0203A: ENGINEERING MECHANICS

Course Outcomes:
On completion of this course, a student will be able to

1. Explain principles and theorems related to rigid body mechanics
2. Identify the components of a system of forces acting on the rigid body
3. Apply the conditions of equilibrium to various practical problems involving different force systems.
4. Choose appropriate theorems, principles or formulae to solve problems of mechanics.
5. Solve problems involving rigid bodies, applying the properties of distributed areas and masses

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3													
CO2	2	3													
CO3	2	3													
CO4	2	3													
CO5	2	3													

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to Mechanics: Definition and classification of mechanics – rigid body (statics and dynamics) and deformable body mechanics.
Forces and Force systems: Force and its characteristics, Principles of statics – concept of resultant and equilibrant, Composition and resolution of forces, force systems.
Coplanar Concurrent force system: Equilibrium of two, three and more than three forces, Moment of a force, Varignon's theorem of moments, Equations of equilibrium, Friction and its effects on bodies, Engineering applications.
Coplanar Parallel Force System: Two parallel forces, General case of parallel forces in a plane, Centre of parallel forces, Centre of gravity, Centre of mass, Centroids of curves, areas and volumes – regular and composite, Pappus's theorems, Equilibrium of distributed forces in a plane, Applications of the concept of centroid in engineering practice.

Module II

Moment of Inertia: Concept of moment of inertia and second moment of area, Moment of inertia of regular and composite solids, Second moment of area of regular and irregular surfaces, Polar moment of inertia / second moment of area, Product of inertia, Principal moments of inertia and principal axes, Applications of the concepts in engineering practice.
Coplanar non-concurrent force system: Resultant of a general case of force system in a plane, Equilibrium equations, Applications in engineering practice.
Analysis of Plane trusses and frames: Concept of load carrying mechanism in trusses and frames – internal (axial) forces, two force and multi force members, Analysis of plane trusses by Method of joints and Method of sections, Analysis of Plane frames by Method of members, Applications of trusses and frames in structures.

Module III

Introduction to Dynamics: Definitions, Units, Divisions – Kinematics, Kinetics.
Rectilinear translation: Kinematics of rectilinear motion – displacement, velocity, acceleration, Kinetics – Differential equations of motion, D'Alembert's principle in rectilinear translation and its applications, Motion of a particle due to a constant force, Motion of a particle due to a force proportional to displacement – Simple harmonic motion, Momentum and impulse, Work and energy, Conservation of energy, Collision of two bodies – direct central impact.

Module IV

Curvilinear translation: Kinematics of curvilinear translation – components of displacement, velocity and acceleration, normal and tangential acceleration, Kinetics – Differential equations of motion, Motion of a projectile – projection on horizontal and inclined surfaces, D'Alembert's principle in curvilinear motion and its applications, Moment of momentum, Work and energy in curvilinear motion.
Rotation of a rigid body: Kinematics of rotation – angular displacement, velocity and acceleration, RPM, Relations of kinematic parameters of linear and angular motions, Kinetics – Equation of motion of a rigid body rotating about a fixed axis, Rotation under the action of a constant moment, Rotation proportional to angular displacement.

References:

1. Timoshenko and Young. Engineering mechanics. McGraw Hill Book Company, Singapore. (1956)
2. Beer, F. P. and Johnston, E. R. Mechanics for Engineers (Vol. 1: Statics and Vol.2: Dynamics). Tata McGraw Hill, New Delhi. (2004).
3. Merriam, H. L. and Kraige, L. G. (2003). Engineering Mechanics (Vol. 1: Statics and Vol.2: Dynamics). John Wiley and Sons, Somerset, N.J. (2003)
4. Hibbeller, R.C. Engineering mechanics. Vol. 1: Statics, Vol. 2: Dynamics. (Twelfth edition). Pearson Education Asia Pvt. Ltd., New Delhi (2010).
5. Rajasekaran, S.and Sankarasubramanian, G. Fundamentals of Engineering Mechanics. (Third edition). Vikas Publishing House Pvt. Ltd., New Delhi. (2010)

23-200-0204A: BASIC ELECTRICAL ENGINEERING

Course Outcomes:
On completion of this course, the student will be able to:
1. Explain the concepts of various energy sources and electric circuits.
2. Apply the basic electrical laws to solve circuits.
3. Discuss the construction and operation of various electrical machines.
4. Identify a suitable electrical machine for practical implementation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	0	1	1	1								
CO2	3	3	2	1	1	1	0								
CO3	3	2	1	1	1	1	1								
CO4	3	2	2	1	0	1	1								

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Conventional and non-conventional energy resources; General structure of electrical power systems using a single-line diagram approach.
Power Generation: Hydel, Nuclear, Solar & wind power generation (Block Diagram approach).
DC Circuits: Ohm’s Law and its limitations. Kirchhoff's Current and Voltage Laws (KCL and KVL), series, parallel, series-parallel circuits. Faraday's law, Lenz’s law, Induced emf. Simple Numerical.

Module II

A.C. Fundamentals: Equation of AC Voltage and current, waveform, time period, frequency, amplitude, phase, phase difference, average value, RMS value, form factor, peak factor. (Only definitions)
Voltage and current relationship with phasor diagrams in R, L, and C circuits. Concept of Impedance. Analysis of R-L, R-C, R-L-C Series circuits. Concepts of active power, reactive power and apparent power. Concept of power factor. (Simple Numerical).

Three Phase Circuits: Generation of Three-phase AC quantity, advantages and limitations; star and delta connection, relationship between line and phase quantities (excluding proof)

Module III

DC Machines:

DC Generator: Principle of operation, constructional details, induced emf expression, types of generators. Relation between induced emf and terminal voltage. Simple numerical.

DC Motor: Principle of operation, back emf and its significance. Torque equation, types of motors, characteristics and speed control (armature & field) of DC motors (series & shunt only). Applications of DC motors. Simple numerical.

Module IV

Transformers: Necessity of transformer, principle of operation, Types and construction of single-phase transformers, EMF equation, losses (physical concepts and applications), variation of losses with respect to load. Efficiency and simple numerical.

Three-phase induction Motors: Concept of the rotating magnetic field, Principle of operation, constructional features of motor, types – squirrel cage and wound rotor. Slip and its significance. (Qualitative aspects only).

Equipment Safety Measures: Working principle of Fuse and Miniature circuit breaker (MCB).

Personal safety measures: Electric Shock, Earthing and its types, Safety Precautions to avoid shock.

References:

1. Cotton, H. Electrical Technology. (Seventh edition). CBS Publishers and Distributors, New Delhi (2005).
2. D. P. Kothari and I. J. Nagrath. Basic Electrical Engineering,4th edition, Tata McGraw Hill (2019).
3. Rajendra Prasad. Fundamentals of Electrical Engineering. Third edition. PHI Learning, New Delhi (2014).
4. D C Kulshreshtha. Basic Electrical Engineering, First Edition, Tata McGraw Hill (2019).

23-200-0205A: BASIC ELECTRONICS ENGINEERING

Course Outcomes:

On successful completion of this course, the student will be able to:

1. Illustrate the concept of diode in rectifiers, filter circuits and wave shaping,
2. Interpret the functioning of oscillators and operational amplifiers.
3. Explain the principle of embedded systems and sensors
4. Summarise the functioning of a communication system and different modulation technologies.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				2										
CO2	2				2										
CO3	2				2										
CO4	2				2										

1-Slightly; 2-Moderately; 3-Substantially

Module I

Semiconductor devices and applications: p-n junction diode - Characteristics and Parameters, Half-wave rectifier, Full-wave rectifiers and filters, voltage regulators, Output resistance and voltage regulation, Voltage multipliers. (Only concepts and working and principle. No mathematical derivations).

Amplifiers – Types of amplifiers, Gain, Input and output resistance, Frequency response, Bandwidth, Phase shift, negative feedback, and multi-stage amplifiers. (Only elementary ideas. Mathematical treatment is not envisaged)

Module II

Oscillators – Barkhausen criterion, sinusoidal and non-sinusoidal oscillators, Multivibrators, crystal-controlled oscillators (Only qualitative concepts, working principle, waveforms and applications).

Operational amplifiers -Operational amplifier parameters, Operational amplifier characteristics, Operational amplifier configurations, Operational amplifier circuits (Only qualitative concepts, working principle and applications). Elementary concepts of logic gates.

Module III

Introduction to Embedded Systems – Definition, Embedded systems vs general computing systems, Classification of Embedded Systems, Major application areas of Embedded Systems, Elements of an Embedded System, Core of the Embedded System, Microprocessor vs Microcontroller, RISC vs CISC (Elementary concepts only).

Sensors and Interfacing – Instrumentation and control systems (Elementary concepts only), Working principle and applications of Transducers, Sensors, Actuators, LED, and 7-Segment LED Display.

Module IV

Communication Schemes – Modern communication system scheme, Information source, An input transducer, Transmitter, Channel or Medium – Hardwired and Soft wired, Noise, Receiver, Multiplexing, Types of communication systems. Types of modulation (only concepts. No mathematical derivations) – AM, FM, Concept of Radio wave propagation (Space, sky)
Elementary concepts of satellite, mobile, and fibre optic communication.

References:

1. Mike Tooley. Electronic Circuits, Fundamentals & Applications, 4th Edition, Elsevier (2015).
2. K V Shibu. Introduction to Embedded Systems, 2nd Edition, McGraw Hill Education (India), Private Limited (2016).
3. S L Kakani and Priyanka Punglia. Communication Systems, New Age International Publisher, (2017).

23-200-0206A SOFT SKILLS DEVELOPMENT

Course Outcomes:

On completion of this course, the student will be able to:

1. Use English language at the formal and informal levels for daily conversations, presentations, group discussions and debates.
2. Demonstrate the ability to read, comprehend and answer questions based on literary, scientific and technological texts.
3. Develop self-motivation, raised aspiration, belief in one's own abilities and commitment to achieving one's goal.
4. Demonstrate emotional maturity and emotional health.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1		2	2	3					
CO2						2		2	2	3					
CO3						1		2	2	2					
CO4						1		2	3	2					

1-Slightly; 2-Moderately; 3-Substantially

Module I

Role and importance of verbal communication, Everyday active vocabulary, Common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension- skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Two types of meaning- literal and contextual. Constructive criticism of speeches and explanations.

Module II

Fundamental grammar, Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open-ended and close-ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships.

Module III

Kinesics, Proxemics, Haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same.
Different types of interviews, and presentations - oral, poster, PPT. Organizing ideas for group discussions, the difference between GD and debates.
Effective listening and seeking to understand others' perspectives. Non-violent negotiation and persuasion, communicating across age groups, cultures or identity groups.
Higher order thinking and evaluation, information-seeking, research, independent learning, synthesis, creativity, problem analysis and problem-solving. Decision-making, Self-reflection and learning from experience.

Module IV

Developing positive self: Understanding oneself, A realistic awareness of oneself and one's abilities, strengths and potential, Self-esteem, Self-efficacy, and steps for improvement.
Intra-personal skills – Self-control, emotional regulation and self-discipline, conscientiousness, dutifulness, reliability, truthfulness, honesty and trustworthiness. Goal orientation and initiative. Time management – prioritising work.

Interpersonal skills – cross-cultural competence and valuing diversity of perspectives, respecting and expressing concern for others. Empathy and ability to notice the effect of one's actions on others, tolerance for disagreement, conflict management and resolution.
Civic engagement and social responsibility – Global and local awareness (issues, challenges, priorities). Vision is the ability to imagine something new or improved. Social responsibility and willingness to take constructive action.

References:

1. Duck, Steve and David T. McMahan. Communication in Everyday Life. 3rd Ed. Sage, (2017).
2. Gamble, Kawl Teri and Michael W. Gamble. The Public Speaking Playbook. Sage, (2015).
3. Raman, Meenakshi and Sangeetha Sharma. Technical Communication: Principles and Practice, Oxford University Press, (2015).
4. Coleman, D. Emotional intelligence: Why it can matter more than IQ, Bantam Books, New York (2006).
5. Devadas Menon. Stop sleepwalking through life, Yogi Impressions Books Pvt. Ltd, Mumbai (2012).
6. Barun K Mitra. Personality Development and Soft Skills, Oxford University Press (2012).

ASSESSMENT

1. 'Soft Skills Development' is a practical and activity-oriented course which has a continuous assessment for 50 marks based on classroom interaction, activities, and assignments. The activities may include 'Just a Minute' (JAM) sessions, group discussion, role-play, debate, and extempore speech.
The weightage for the different components shall be as follows:
Classroom interaction – 10 marks
Activities – 30 marks
Assignments (from Modules I and II) – 10 marks
2. Semester End Examination is not envisaged.
3. A student should secure a minimum of 50% marks in continuous assessment for a pass in the course.

23-200-0207A: COMPUTER PROGRAMMING LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Solve problems efficiently by choosing loops and decision-making statements in C programming.
2. Demonstrate different operations on arrays.
3. Solve problems using functions and recursion.
4. Develop C programs using the concepts of structure, pointers and files.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3														
CO2	2														
CO3	3														
CO4	2														

1-Slightly; 2-Moderately; 3-Substantially

Cycle I

Application Packages:

Text Editor

1. To create a Word document like an advertisement.

Spread Sheet

2. To create a spreadsheet to analyse the marks of the students of a class and also to create appropriate charts.

Presentation Software

3. To create a presentation for the department using PowerPoint.

C Programming Basics:

4. To write a program to calculate and display areas of rectangles and triangles.

Decision Making:

5. To write a program for electricity bill preparation.
6. To write a program to find the roots of a quadratic equation.
7. To write a simple menu-driven calculator program using switch statements.
8. To write a program to find the sum of digits of a given number.

Cycle II

Looping:

9. To write a program to print all the prime numbers of a given range.
10. To write a program to print the sine and cosine series.
11. To write a program to print Pascal's triangle.

Arrays:

12. To write a program to print the sum and average of elements in an array.
13. To write a program to sort the given numbers using bubble sort.
14. To write a program to perform Matrix addition and matrix multiplication.

String:

15. To write a program to perform string manipulation functions like string concatenations, comparison, find the length and string copy without using library functions.
16. To write a program to arrange names in alphabetical order.

Cycle III

Functions:

17. To write a C program to calculate the mean, variance and standard deviation using functions.
18. To write a C program to perform sequential and binary search using functions.

Recursion:

19. To write a program to print the Fibonacci series using a recursive function.
20. To write a program to print the factorial of the given number using a recursive function.

Structure:
21. To print the mark sheet of n students using structures.
Pointers:
22. To write a program using pointers to access the elements of an array and count the number of occurrences of the given number in the array.
Files:
23. To write a program to count the number of characters, and lines in a file.

References:

1. Pradip Dey and Manas Ghosh, Computer Fundamentals and Programming in C, Second Edition, Oxford University Press, (2013).
2. Smarajit Ghosh, All of C, PHI Learning Pvt. Ltd, (2009).
3. Byron Gottfried, Programming with C, 2nd edition, Tata McGraw-Hill, (2006).
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Second Edition, Pearson Education, (2001).
5. Sukhendu Dey, Debobrata Dutta, Complete Knowledge in C, Narosa Publishing House, New Delhi, (2009).

23-200-0208A: BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:
1. Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols
2. Develop the connection diagram, and identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings
3. Identify and test various electronic components
4. Draw circuit schematics with EDA tools
5. Assemble and test electronic circuits on boards

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3														
CO2	2														
CO3	3														
CO4	2														
CO5	2														

1-Slightly; 2-Moderately; 3-Substantially

List of Exercises / Experiments

(Any 9 exercises to be carried out)

1. a) Demonstrate the precautionary steps adopted in case of Electrical shocks.
b) Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELC Band MCCB with ratings.
2. Wiring of simple light circuit for controlling light/ fan point (PVC conduit wiring)
3. Wiring of light/fan circuit using two-way switches. (Staircase wiring)
4. Wiring of Fluorescent lamps and light sockets (6A) with a power circuit for controlling the power device. (16A socket)
5. Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.
6. a) Identify different types of batteries with their specifications.

b) Demonstrate the Pipe and Plate Earthing Schemes using Charts/Site Visits.
7. Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)
8. Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or X Circuit), Interpreting data sheets of discrete components and ICs, Estimation and costing.
9. Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Screwdrivers, Tweezers, Crimping tool, Hot air soldering and de-soldering station etc.]
10. Measurement of input and output parameters of a transistor in CE, CB and CC configuration.
11. Design of a centre tap full wave rectifier circuit.
12. Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using a multimeter.]
13. Measurement of voltage and current in a series RLC circuit using a multimeter
14. Realization of basic gates
15. Inhouse substation visit.

23-200-0209A LANGUAGE LABORATORY

Course Outcomes:
On completion of this course, the student will be able to:
1. Test pronunciation skills through stress on word accent, intonation, and rhythm.
2. Use the English language effectively for writing business letters, resumes, minutes of meetings and reports.
3. Use the English language effectively to face interviews, group discussions, and public speaking.

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

1-Slightly; 2-Moderately; 3-Substantially

The following exercises are prescribed for the **Language Laboratory** sessions:

1. Introduction to the Sounds of English- Vowels, Diphthongs & Consonants.
2. Introduction to Stress and Intonation.
3. Preparing business letters
4. Preparing a resume
5. Conducting a meeting and writing the minutes
6. Writing a report
7. Situational Dialogues / Role Play.
8. Oral Presentations- Prepared and Extempore.
9. 'Just A Minute' Sessions (JAM).
10. Describing Objects / Situations / People.
11. Debate
12. Group discussion

23-200-0210A: NSS/NATURE CONSERVATION ACTIVITIES/YOGA

NATIONAL SERVICE SCHEME (NSS)

Course Outcomes:

On completion of this course, the student will be able to:

1. Identify the community in which they work
2. Utilize their knowledge in finding practical solutions to individual and community problems
3. A student enrolling as a member of NSS will have to complete 10 hours of training / social service.

NATURE CONSERVATION ACTIVITIES

Course Outcomes:

On completion of this course, the student will be able to:

1. Demonstrate the message of sustainable lifestyles
2. Explain the importance of green plants in mitigating global environmental problems
3. Identify suitable waste management practices for the local community
4. A student enrolling as a member of the Nature Conservation Club will have to complete 10 hours of campus cleaning and greening activities.

YOGA

Course Outcomes:

On completion of this course, the student will be able to:

1. Demonstrate the use of yoga for stress management
2. Illustrate the different yogic postures for physical and mental well-being.
3. Identify suitable methods of strengthening physical, emotional, and intellectual aspects of “self” based on the principles and practices of Yoga and positive psychology

23-200-0301A: LINEAR ALGEBRA AND TRANSFORM TECHNIQUES

(Common for CE, ME and SE)

Course Outcomes:

1. Classify vector spaces, subspaces, spanning sets, linear dependence/independence, basis, and dimension of vector spaces.
2. Apply concepts of linear algebra like rank, Eigenvalues, eigenvectors, diagonalization of matrices, inner products, Gram-Schmidt process and linear transformations to solve problems.
3. Analyze a system of linear equations for existence, uniqueness and general form of solutions using rank, inverse and Cayley Hamilton theorem.
4. Evaluate and solve differential and integral equations using Fourier analysis, Fourier transforms, and Laplace transforms.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3					1		1	3	3	1
CO2	3	3	3	3	3					1		1	3	3	1
CO3	3	3	3	3	3					1		1	3	3	1
CO4	3	3	3	3	3					1		1	3	3	1

Module I

Linear Algebra 1: Rank of a Matrix, Solution of a Linear System of Equations, Existence, Uniqueness, General Form, Eigenvalues and Eigenvectors, Properties of Eigenvalues, Diagonalization of a Matrix, Cayley-Hamilton Theorem (without proof), Verification, Finding Inverse and Power of a Matrix Using It, Quadratic Form, Orthogonal Reduction of Quadratic Form to Canonical Form. Applications of Linear Algebra in Machine Learning and Data Science.

Module II

Linear Algebra 2: Vector Space, Subspace, Linear Dependence and Independence, Spanning of a Subspace, Basis and Dimension, Inner Product, Inner Product Spaces, Orthogonal and Orthonormal Basis, Gram-Schmidt Orthogonalization Process, Linear Transformation. Applications of Linear Algebra in Computer Graphics and Optimization.

Module III

Fourier Analysis: Periodic Function, Fourier Series, Functions of Arbitrary Period, Even and Odd Functions, Half-Range Expansion, Harmonic Analysis, Complex Fourier Series, Fourier Integrals, Fourier Cosine and Sine Transform, Fourier Transform. Applications of Fourier Analysis in Signal Processing and Image Reconstruction.

Module IV

Laplace Transforms: Gamma Functions and Beta Function, Definition and Properties, Laplace Transforms, Inverse Laplace Transform, Shifting Theorem, Transform of Derivative and Integrals, Solution of Differential Equation and Integral Equation Using Laplace Transform, Convolution, Unit Step Function, Second Shifting Theorem, Laplace Transform of Periodic Function, Applications of Laplace Transforms in Control Systems and Electronic Circuits.

The students should be introduced to Computer Algebra Systems (CAS) such as Matlab/Python (utilizing NumPy, SymPy, and SciPy) for both symbolic and numerical calculations. Homework and assignments should be given with the integration of CAS.

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, (2022).
2. Grewal, B. S., Higher Engineering Mathematics, 45th Edition, Khanna Publishers, (2023).

3. Hoffman K. and Kunze, R., Linear Algebra, Second Edition, Pearson, (1971).
4. Venkataraman M. K., Linear Algebra, The National Publishing Co., (2018).

23-205-0302: ELECTRICAL TECHNOLOGY

Course Outcomes:

1. Explain the basic working principles and constructional features of DC machines, transformers and AC machines.
2. Analyze the performance, characteristics and testing methods of DC generators, DC motors, transformers and AC machines.
3. Evaluate different methods of power generation and analyse various aspects of transmission and distribution systems.
4. Design simple electrical circuits and solve numerical problems related to DC and AC machines.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

DC machines: Basic principle of operation of DC Generator, construction, EMF equation, types of generators, armature reaction and commutation, characteristics, losses and efficiency.
DC Motor: working principle, Concepts of motoring and generating action, Torque equation, Types of motors, characteristics, starting, speed control, losses and efficiency, brake test, Swinburne's test, applications.

Module II

Transformers: Working principles and elementary theory of an ideal transformer, Constructional features of single phase transformer, EMF equation, turns ratio, vector diagram, equivalent circuit, impedance transformation, transformer losses, flux leakage, efficiency, open circuit and short circuit test, load test. Autotransformer – working principle and saving copper, the basic idea of current transformer and potential transformer, distribution and power transformer, applications, standard rating, IS specifications.

Module III

AC Machines: Alternator- rotating field, speed and frequency, effect of distribution of winding, coil span, characteristics, EMF equation, losses and efficiency, regulation (EMF method only), applications, synchronous motor principles of operation, over excited and under excited, starting, applications, synchronous capacitor.
Induction Motor: Induction motor, principles of operation, constructional features of squirrel cage and slip ring motors, torque-slip characteristics, starting, speed control, losses and efficiency.

Module IV

Generation, transmission & distribution of electrical energy: Different methods of power generation, hydro-electric, nuclear, diesel, gas turbine stations (general idea only), electrical equipment in power stations, concept of bus bar, load dispatching, methods of transmission, transmission lines, overhead lines and insulators, corona and skin effect of DC & AC distribution, substation (elementary idea only).

The students may be given familiarisation with the following experiments on Electrical Machines

1. Determination of the efficiency of the single-phase transformer by direct loading.
2. Determination of the Equivalent circuit of a transformer by open and short circuit test calculation of efficiency and regulation at various loads and power factors.

3. Starting the cage induction motor using a star-delta switch and plotting the performance characteristics.
4. Conducting the no load and blocked rotor tests on slip ring induction motor –determining equivalent circuit and calculating torque-slip characteristics.
5. Plotting OCC of a D.C. shunt generator at rated speed – determining the critical resistance.
6. Conducting load test on D.C. shunt generator and plotting external characteristics – deducting internal characteristics.
7. Conducting load tests on the D.CL Series motor and plotting the performance characteristics.

References

1. Hughes, K, Electrical Technology, English Language Book Society, (2022).
2. Cotton, H., Advanced Electrical Technology, CBS Publishers and Distributors, New Delhi, (2022).
3. Nagrath, I. J, Kothari D.P, Electrical Machines, Tata McGraw Hill Publishing Co. Limited, (2022).
4. Bimbra, F. S., Electrical Machines, 8th Edition, Khanna Publishers, (2022).
5. Gupta B.R and Vandana Singhal, Fundamentals of Electric Machines, D. K Publishers, (2022).
6. Vincent Del Toro, Electrical Machines & Power Systems, Prentice Hall, (2022).
7. Chapman, S. J, Electric Machines & Power Systems, McGraw Hill, (2022).

23-205-0303: MECHANICS OF SOLIDS

Course Outcomes:

On completion of the course, the student will be able to:
1. Define the concepts of stresses and strains and relate them with material constants.
2. Interpret the results and plot the stress-strain, shear force, and bending moment diagrams.
3. Apply the static equilibrium equations and compatibility conditions and formulate a given problem.
4. Analyse a structural member under axial, torsional, and flexural loads and calculate the stresses, strains, deformations, and deflections.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Concepts of Stress and Strain: Stress at a Point: Stress Tensor - Equality of Cross Shear. Cauchy's Equation. Strain Tensor: Displacement Field, Strain-Displacement Relations (Small Strain Only), Plane Stress, and Plane Strain. Introduction to Cartesian Tensor Notation.
Axially Loaded Members: Normal Stress and Strain, Stress-Strain Diagrams, Linear Elasticity, and Generalized Hooke's Law. Bulk Modulus, Relationship Between Modulus of Elasticity and Bulk Modulus.
Deflections of Axially Loaded Members: Statically Indeterminate Problems, Compatibility Conditions, Temperature and Pre-Strain Effects, Strain Energy in Axial Loading, Allowable Stresses, and Factor of Safety. Stress Concentration.

Module II

Analysis of Plane Stress and Plane Strain: Transformation Equations for Plane Stress and Plane Strain. Principal Stresses and Maximum Shear Stresses. Mohr's Circle for Plane Stress and Stresses in Spherical and Cylindrical Pressure Vessels.
Torsionally Loaded Members: Shear Stress and Strain, Torsion Formula for Circular Shafts, Pure Shear, Power Transmission. Relation Between Modulus of Elasticity and Modulus of Rigidity. Strain Energy in Torsion.

Module III

Flexurally Loaded Members - Beams: Classification, Shear Force and Bending Moment. Relationship Among Load, Shear Force, and Bending Moment. Shear Force and Bending Moment Diagrams.
Stresses in Beams: Pure Bending of Beams, Normal Stress and Normal Strain in Beams. Flexure Formula, Shear Stresses in Beams with Rectangular, I, and T Sections. Combined Axial, Flexural, and Torsional Loads. Strain Energy in Bending.

Module IV

Deflections of Beams: Differential Equations of the Deflection Curve, Deflections by Integration. Macaulay's Method, Moment Area Method. Deflections of Non-Prismatic Beams. Deflections of Statically Indeterminate Beams - Propped Cantilevers and Fixed Beams.
Columns: Buckling and Stability. Euler's Equations for Columns with Different Support Conditions.
Theories of Failure: Various Theories of Failure and Their Applications to Ductile and Brittle Materials.

References:

1. Gere and Timoshenko, Mechanics of Materials, 2nd Edition, CBS Publishers, (2004).
2. Popov, E.P, Introduction to mechanics of solids, Pearson Education, (1998).
3. Beer and Johnston, Mechanics of Solids, 8th Edition, Mc Graw Hill, (2020).
4. Shames and Pittaresi, Introduction to Solid Mechanics, 8th Edition, Pearson, (2015).
5. Mott and Untener, Applied strength of materials, 6th Edition, CRC Press, (2016).
6. Carl T. F. Ross, Strength of Materials and Structures, 4th Edition, Blackwell Publishers, (1999).

23-205-0304: FLUID MECHANICS AND HYDRAULIC MACHINERY

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the basics of fluid statics, kinematics and dynamics. Understand and use the continuity equation, momentum equation, energy equation and their vector and tensor representation.
2. Understand and apply the basics of one-dimensional and two-dimensional flow.
3. Understand dimensional analysis and similitude.
4. Understand and apply the principles of turbines, pumps and other hydraulic machinery and equipment

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Properties of fluids, density, pressure, viscosity, surface tension, capillarity, vapour pressure. Fluid statics, basic equations of fluid statics, variation of pressure in a fluid, manometry, forces on surfaces and bodies in fluids, floatation, stability of bodies in fluid, metacentric height and its measurement, fluids in rigid body motion.
Fluid kinematics, Eulerian and Lagrangian description, local and material rates, deformation of a fluid element, strain rate-velocity relations, graphical description of flow, streamlines, path lines, streak lines, and stream tube.

Module II

Fluid dynamics: The concept of the control volume, Reynold's transport theorem, Integral and differential forms of the continuity, momentum and energy equations (introduce vector and tensor

representation). The physical meaning of important dimensional groups of fluid mechanics and their practical use.
One-dimensional flow through pipes, the non-viscous equation for the flow through a stream tube and along a streamline, Euler's equation, Bernoulli's equation. Applications of the one-dimensional equations: velocity and flow measuring devices and quasi-steady problems, Laminar flow through pipes, Hagen-Poiseuille equation, Darcy-Weisbach equation, pipe friction-Moody's chart, minor losses in pipes.

Module III

Impact of jets: The dynamic action of fluid, the impact of jets, the flow of an incompressible fluid over fixed and moving vanes, work done and efficiency.
Hydraulic turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine, their constructional features, velocity triangles, performance characteristics, specific speed, unit speed, unit power, theory of draft tubes, speed regulation of turbines

Module IV

Pumps, general features of positive displacement and rotodynamic pumps, centrifugal pumps, the principle of working, velocity diagrams, work done, efficiency, minimum speed, specific speed, losses in pumps, priming, Cavitation and its significance. Reciprocating pumps, single-acting and double-acting pumps, slip, acceleration head, effect of friction, use of air vessel, efficiencies, and pump characteristics.
Hydraulic Press, hydraulic ram, hydraulic intensifier, hydraulic lift, hydraulic accumulator, hydraulic crane, hydraulic coupling, hydraulic torque converter, surge

References:

1. Shames, I. H., Mechanics of fluids, Mc Graw Hill Book Co., (2002).
2. Frank M. White, Fluid Mechanics, 7th Edition, Tata Mc Graw Hill, New Delhi, (2008).
3. Cengel Y. A., Cimbala J. M., Fluid Mechanics-Fundamentals and Applications, Tata McGraw Hill, (2006).
4. Som S. K., and Biswas G., Fluid Mechanics and Fluid Machines, 2nd Edition., Tata McGraw Hill, (2004).
5. Cohen and Kundu, Fluid Mechanics, 6th Edition, Elsevier, (2015).
6. Shepherd, D.G., Principles of turbomachinery, MacMillan & Co. Ltd., (1957).
7. Vallentine, Applied hydrodynamics, Newness- Butterworths, London, (1969).
8. Herbert Addison, A treatise on applied hydraulics, 5th Edition, Chapman & Hall, (1972).
9. Stepanov, A. J., Centrifugal and axial flow pumps, Wiley, New York, (1957).

23-205-0305: METALLURGY AND MATERIAL SCIENCE

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain fundamental concepts of crystallography, solidification, defects, diffusion and phases in metals.
2. Analyze phase diagrams, heat treatment processes, deformation mechanisms and causes of failure in metals.
3. Evaluate the microstructures and properties of different ferrous and non-ferrous alloys.
4. Design heat treatment processes for given applications and select appropriate materials based on their structure-property correlation.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1				1		1		1	3	3	1
CO2	3	3	3	2				1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	2				1		1		1	3	3	1

Module I

Crystallography: crystal structure, space lattice, crystal systems, miller indices of crystal planes and directions, the atomic density of crystallographic planes and lines, atomic packing factor, coordination number, and interplanar spacing.

Solidification of metals: homogenous and heterogeneous nucleation, crystal growth, grains and grain boundaries, equiaxed and columnar grains, dendritic pattern, polymorphism.

Crystal imperfections: point defect, line defect, edge dislocation, screw dislocation, the interaction between dislocation, planar defects, stacking faults, grain boundary, twist and twin boundaries, and volume defects.

Diffusion: mechanism of diffusion in crystals, types of diffusion, factors affecting diffusion, Fick's law of diffusion, metallurgical application of diffusion.

Module II

Phase: Equilibrium between phases, Gibb's phase rule, solid solution, interstitial, substitutional, ordered and disordered types, Hume – Rothery rules, equilibrium phase diagrams of binary alloys complete solid solubility, partial solid solubility, no solid solubility, eutectic, peritectic and eutectoid reactions, Cu- Ni, Cd-Bi, Pb-Sn, Ag-Pt, and Fe-C systems as examples.

Heat treatment of steel: Definition and aims of heat treatment, T-T-T diagram, isothermal and continuous cooling, annealing, normalising, hardening, tempering, austempering, martempering, hardenability of steels, Jominy test, surface treatments – case hardening, carburising, cyaniding, nitriding, flame hardening, induction hardening, metal coating- hot dipping, electroplating, metal cladding, impregnation, metal spraying.

Module III

Deformation of metals: Elastic, anelastic and viscoelastic behaviour, plastic deformation; mechanism of slip, slip planes and slip directions; mechanism of twinning; strengthening mechanisms; work hardening, grain boundary hardening, precipitation hardening, cold working, hot working, recovery, recrystallisation and grain growth.

Failure of metals: creep, mechanism of creep, creep curves, creep resistant materials, fracture, brittle fracture, Griffith's theory, ductile fracture, ductile-brittle transition, protection against fracture, fatigue.

Module IV

Applications of ferrous and non-ferrous alloys steel - low, medium, high carbon steels, Stainless steels ferritic, austenitic, martensitic, duplex steels, tool steels cast iron, grey, white, ductile cast irons, copper and its alloys, aluminium and its alloys, magnesium and alloys, titanium and its alloys, refractories - super alloys, ceramics, composite and glasses, shape memory alloys, Nanomaterials, biomaterials, Optical fibres.

References:

1. Van Vlack, L.W., Elements of material science and Engineering, 7th Edition, Prentice Hall, (2022).
2. Reed Hill, Physical metallurgy principles, 4th Edition, Affiliated East-West Press, New Delhi, (2022).
3. William D Callister, Material Science & Engg, Wiley, 12th edition (2022).
4. Raghavan, V., Material science and engineering, 6th Edition, Prentice Hall, (2022).
5. Narula, Material Science, 2nd Edition, Tata McGraw Hill, (2022).
6. Agarwal, B.K., Introduction to engineering materials, 2nd Edition, McGraw Hill Education, (2022).

23-205-0306: MACHINE DRAWING

Course Outcomes:

On completion of this course, the student will be able to:

1. Convert pictorial views of machine components into orthographic projections using conventional methods and CAD tools.
2. Construct conventional representations of threaded fasteners, joints and couplings used in machine components using conventional methods and CAD tools.
3. Draw detailed assembly drawings of bearings, valves, I.C. engines and other mechanical systems using conventional methods and standard CAD software.
4. Apply linear and geometric dimensions, tolerances, and symbols for surface topology and conditions to drawings. Learn and apply the basics of sheet metal drawing.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	3			1		1		1	3	3	1
CO2	1	1	1	1	3			1		1		1	3	3	1
CO3	1	1	1	1	3			1		1		1	3	3	1
CO4	2	2	2	2	2			1		1		1	3	3	1

Module I

Introduction to Computer-Aided Design (CAD) Packages like Autodesk Fusion-360, FreeCAD, SolidWorks etc.
Introduction to Machine Drawing: Conversion of pictorial views to orthographic views.
Screwed fastenings: Screw thread forms, V and Square threads, Conventional representation of threads, Hexagonal headed bolt and nut, Square headed bolt, Nut locking arrangements, Foundation bolts- ray bolt and Lewis's foundation bolt.
Cotter and Pin joints: Socket and Spigot joints, Gib and Cotter joint for rectangular rods, Sleeve and Cotter joints, Knuckle joint.

Module II

Pipe joints: Coupler joints, Nipple joints, Union, Socket and Spigot joints, Integral flanged joints and Hydraulic joints.
Couplings: Parallel and tapered sunk keys, Saddle keys, Feather keys and Pin keys, Muff coupling, Protected type flange coupling, Pin type flexible coupling.

Bearings: Solid journal bearings, Bushed bearings, Plummer block, Footstep bearing, Thrust bearings.

Module III

Assembly of machine parts: Machine Vice, Tail-Stock of Lathe Steam Engine parts: Stuffing box, Crosshead.
I.C. engine: Piston and Connecting rod.
Valves: Steam stop valve, Spring loaded safety valve, Lever safety valve, Ramsbottom safety valve.
Give the students assignments/homework/practice sessions with CAD packages.

Module IV

Representation of linear and geometric dimensions and tolerances in engineering drawings: Symbols and indication of tolerances for form, orientation, location, runout and position, Interpretation of tolerance applied to features involving datums, its importance and implications. Representation of surface finish, surface treatment and material conditions using symbols and visual aids. Indication of machining marks, heat treatment, plating, surface finish etc. as per standards. Introduction to sheet metal design. Symbols and conventions used to represent sheet metal features like bends, holes etc. Basic sheet metal operations - bending, punching, cutting etc. Sheet metal component drawing with fold lines, bend allowances etc.

Give the students assignments/homework/practice sessions with CAD packages.

References:

1. Bhatt, N.D., Elementary engineering drawing, 37th Edition, Charotar publishing house, (2023).
2. Parkinson, First year engineering drawing, Pitman, London, (2023).
3. Gill, P.S., Machine drawing, 21st Edition, Kataria & Sons, (2023).
4. John, K.C., Text Book of Machine Drawing, 3rd Edition, PHI Learning, (2023).
5. Basudeb Bhattacharyya, Machine drawing, Oxford University Press, (2023).

Note: The Semester End Examination is 4 hours

Pattern of Questions for Semester-End Examination

Two questions from each module with an option to answer one of the questions, each carrying 12.5 marks (sub-sections are allowed).

23-205-0307: STRENGTH OF MATERIALS LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Design the required experiments.
2. Conduct different experiments on the specimens to find out the material properties using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			2	3	3		1	1	3	3
CO2	3	3	3	3	1			2	3	3		1	1	3	3
CO3	3	3	3	3	1			2	3	3		1	1	3	3
CO4	3	3	3	3	1			2	3	3		1	1	3	3

Experiments

1. Shear test on M.S.Rod.
2. Vicker's pyramid hardness test.
3. Brinnel Hardness test.
4. Tension test on M.S.Rod.
5. Impact test.
6. Spring test.
7. Bonding test on R.S.J. Beam.
8. Rockwell hardness test.
9. Compression test on concrete cubes and cylinders (300 T machine)
10. Preparation of cubes and cylinders.
11. Testing of cubes and cylinders.
12. Torsion test.

23-205-0308: FLUID MECHANICS LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Design the required experiments
2. Conduct different fluid flow experiments using theoretical knowledge.
3. Tabulate the data and use the necessary theoretical knowledge to find out the results.
4. Interpret the results.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			2	3	3		1	1	3	3
CO2	3	3	3	3	1			2	3	3		1	1	3	3
CO3	3	3	3	3	1			2	3	3		1	1	3	3
CO4	3	3	3	3	1			2	3	3		1	1	3	3

Experiments

1. Study of pipe fittings and plumbing tools
2. Experiment on notches
3. Pipe friction apparatus
4. Determination of minor losses
5. Metacentric height
6. Venturimeter
7. Orifice meter
8. Flow through orifice
9. Heleshaw experiment
10. Reynolds experiment
11. Free & forced vortex apparatus
12. Verification of Bernoullis equation

23-200-0309: INTERNSHIP-I

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the real-time technical/managerial skills required and relevant to the subject area of the internship
2. Initiate a habit of proper daily diary writing with adequate and quality information recorded, drawing and sketches and data, thought process and the proper organisation of the information gained during the internship.
3. Conceive the pros and cons of working in a real-time industrial/ incubation/ innovation /entrepreneurship/lab environment and the wonderful results that could evolve through teamwork.
4. Present and defend a self-prepared and corrected internship report (with the help of the internship guide) of a self-created work to a peer audience.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1				1	2	3	1	1			3
CO2	1	1	1	1				1	2	3	1	1			3
CO3	1	1	1	1				1	2	3	1	1			3
CO4	1	1	1	1	3			1	2	3	1	1			3

Internship Guidelines

During the summer vacations, after the 2nd Semester, students are required to be involved in Inter/ Intra Institutional Activities viz; Training with higher Institutions; Soft skill training organized by the Training and Placement Cell of the University; contribution to incubation/ innovation /entrepreneurship cell of the University; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/ Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute's Innovation Council e.g.: IPR workshop/Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos etc.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member at the level of Associate Professor or above will carry out the final review. Training Certificate from the Inter/ Intra Institutional Activities from the concerned department/lab as mentioned above for the prescribed period shall be submitted at the end of the internship which can be considered as evidence for the the Internship-1.

Guidelines for evaluation:

1.	Regularity and progress of work	10
2.	Work knowledge and Involvement	10
3.	Semester End presentation and oral examination	10
4.	Level of completion of the internship	10
5.	Internship Report – Presentation style and content	10
Total		**50** Marks

23-200-0401A: COMPLEX VARIABLES AND PARTIAL DIFFERENTIAL EQUATIONS

(Common for CE, ME and SE)

Course Outcomes:

On completion of this course, the student will be able to:

1. Apply complex analysis principles in engineering scenarios, understanding key concepts like analytic functions, Cauchy's theorem, and contour integration.
2. Employ linear algebra techniques, such as eigenvalues and linear transformations, to solve engineering problems and model real-world systems effectively.
3. Solve partial differential equations using various methods and apply the solutions to analyze phenomena in engineering, machine learning, and computational biology.
4. Utilize advanced differential equations, including wave and heat equations, Alembert's solution, and Fourier series, for modelling and analyzing complex engineering problems.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3					1		1	3	3	1
CO2	3	3	3	3	3					1		1	3	3	1
CO3	3	3	3	3	3					1		1	3	3	1
CO4	3	3	3	3	3					1		1	3	3	1

Module I

Analytic Function: Analytic function, Cauchy-Riemann equation (Cartesian and polar), Harmonic function, Construction of analytic function given real or imaginary parts, Conformal mapping of standard elementary function and bilinear transformation. Applications of Analytic Functions in Signal Processing and Image Analysis.

Module II

Complex Analysis: Cauchy's integral theorem, Cauchy's integral formula and for derivatives, Taylor's and Laurent's expansion (without proof), Singularities, Residues, Cauchy's Residues theorem, Contour integration involving unit circle. Applications of Complex Analysis in Engineering.

Module III

Partial Differential Equations: Formation of partial differential equation eliminating arbitrary constants and function, Solution of the first-order equation, Four standard types, Lagrange's equation, Linear homogeneous partial differential equation with constant coefficient. Applications of Partial Differential Equations in Engineering and Machine Learning.

Module IV

Advanced Topics in Differential Equations: One-dimensional wave equation, Alembert's solution and one-dimensional heat flow equation, Solution by the method of separation of variables, Application of Fourier series solution, Solution of Laplace's equation over a rectangular region by the method of separation of variables. Applications of Wave and Heat Equations in Signal Processing and Materials Science.

The students should be introduced to Computer Algebra Systems (CAS) such as Matlab/Python (utilizing NumPy, SymPy, and SciPy) for both symbolic and numerical calculations. Homework and assignments should be given with the integration of CAS.

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, (2022).
2. Grewal, B. S., Higher Engineering Mathematics, 45th Edition, Khanna Publishers, (2023).

3. Churchill, R.V. and Brown, J.W., Complex Variables and Applications, 10th Edition, McGraw Hill, (2021).
4. Stroud, K.A. and Booth, D.J., Advanced Engineering Mathematics, 6th Edition, Palgrave Macmillan, (2019).

23-205-0402: METROLOGY AND INSTRUMENTATION

Course Outcomes:

On completion of this course, the student will be able to:

1. Identify and explain various measurement systems, concepts, standards, fits, tolerances, and gauges.
2. Use appropriate methods and tools to Measure angles, tapers, and surface finish parameters.
3. Analyze functional elements, mathematical models, and static and dynamic characteristics of measuring instruments and systems.
4. Evaluate and select appropriate instruments for the measurement of strain, force, torque, temperature, air pollution, and acoustical parameters.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1						1		1	3	3	1
CO2	1	3	1	1						1		1	3	3	1
CO3	3	3	1	1						1		1	3	3	1
CO4	3	3	1	2						1		1	3	3	1

Module I

General measurement concepts: precision and accuracy, Methods for estimating accuracy and precision, measuring errors.
The general principle of measurements: line and end measurements, standards; linear measurements, basic units, and quantities for displacement, mass, time, temperature, optics; Limits, Fits & Tolerance: systems of limits and fits, Hole basis and shaft basis system of representation; tolerances for linear dimensions, calculation of tolerance grade, representation.
Gauges*:* classification, types of gauges, gauge maker's tolerances, wear allowance, gauges, materials.

Module II

Measurement of angles and tapers: sine bars, angle gauges: auto collimator, clinometer, and spirit level; taper gauges, bevel protractors.
Measurement of surface finish: surface structure, integrity, texture, roughens, waviness, lay, RMS & CLA values, and roughness values produced by machining processes.
Optical measuring instruments: interferometry, optical flats, optimeters, optical projectors, tool maker's microscope, limitations.

Module III

Applications of measuring instruments-functional elements of an instrument-instrument as transducer-generalized measuring instrument-generalized mathematical model of measuring systems order, first order and second order instruments-classification of instruments- input output configurations-methods of correction for spurious inputs -static calibration and determination of bias systematic error and random error-static and dynamic characteristics, potentiometer transducer as a zero-order instrument-analysis of its loading error- mercury in glass thermometer as a first order instrument-step, ramp, frequency response-seismic instrument as a second order instrument.

Module IV

Measurement of strain: strain gauge classification –unbonded and bonded strain gauges-gauge factor-strain rosettes-temperature compensation-calibration. Measurement of force: multiple lever system for

weighing- load cells-temperature sensitivity calibration- ballistic weighing- hydraulic and pneumatic load cells. Measurement of Torque: water break-Heenan and Froude hydraulic dynamometer-beam and strain gauge transmission dynamometer. Measurement of Temperature: pressure thermometer-RTDs-compensation for lead resistance thermocouples- five laws of thermocouples and their applications-series and parallel connected thermocouples-pyrometry-optical pyrometer-infrared pyrometry-total radiation pyrometers.
Air pollution measurements: gas chromatography-ORSAT's apparatus. Nuclear instrumentation: Gieger Muller Counter-ionization chamber-scintillation counter.
Acoustical measurements: basic acoustical parameters-sound pressure-sound pressure levelpower-intensity-power level-microphones-sound.

References:

1. Doebelin, E. O., Measurement Systems: Application and Design, 7th Edition, McGraw Hill, (2022).
2. Beckwith, Marangoni, & Lienhard, Mechanical Measurements, 8th Edition, Prentice Hall, (2022).
3. Mahajan, M., A Textbook of Metrology, Dhapat Rai and Co., 5th Edition, (2022).

23-205-0403: MECHATRONICS

Course Outcomes:

On completion of the course, the student will be able to:
1. Understand the basics of sensors and transducers and the working of different mechatronics systems
2. Model the first and second-order mechatronic systems
3. Analyse first and second-order systems for their time and frequency domain responses and stability.
4. Design a mechatronics system for simple applications and familiarise with software tools for modelling and simulation of mechatronic systems.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3	3			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Module 1

Introduction to Mechatronics, scope, sensors and transducers, classification, thermal, electrical, optical, acoustic, pneumatic, magnetic and piezoelectric sensors. Actuation Systems: pneumatic and hydraulic systems, direction control valves, pressure control valves, servo and proportional control valves, cylinders, and rotary actuators. Mechanical actuation systems: kinematic chains, cams, gears, ratchet and pawl, belt and chain drives, bearings. Electrical actuation systems: Mechanical switches (relays), solid-state switches, solenoids, DC motors, PWM and speed control, AC motors, stepper motors, DC and AC servo motors, tacho generators, synchros.

Module 2

Open loop and closed loop control systems, continuous and discrete processes, servo mechanism, principles, components, error detectors, potentiometers, types. System modelling, mathematical models, mechanical, electrical, fluid and thermal system building blocks; electrical and mechanical analogous systems; transfer function, block diagram reduction; signal flow graph, state-space representation, dynamic response of systems, first and second order systems, time constant, rise time, peak time, peak overshoot, settling time. Closed loop controllers, proportional, derivative and integral controls, and PID controller

Module 3

Stability analysis: Concepts of stability, characteristic equations, stability analysis, determination of stability by Routh-Hurwitz criterion, Root locus-concept, procedure, parameter design, lag, lead, lag-lead compensators, frequency response using Bode plot and stability from Bode plot, Nyquist criteria.

Module 4

Stages in designing mechatronic systems, traditional and mechatronic design, possible design solutions, digital logic circuits, microprocessors and Microcontrollers, architecture, programmable logic controllers, and ladder diagrams. Automatic control and real-time systems, robot position and proximity sensing, tactile sensing, and man-machine interface. Case studies of mechatronic systems, pick and place robots, automatic car park systems, and engine management systems.

References:

1. Bolton, W., Mechatronics, Pearson Education Limited, 8th edition (2022).
2. Rolf Isermann, Mechatronic Systems: Fundamentals, Springer, 2nd edition (2022).
3. Singh & Joshi, Mechatronics, PHI, 4th edition (2021).
4. Dorf & Bishop, Modern Control Systems, 14th Edition, Pearson Education, (2022).
5. Ogata K, Modern Control Engineering, 7th Edition, Prentice Hall Inc., (2021).
6. Kuo, B.C., Automatic Control Systems, 10th Edition, Wiley, (2022).

23-205-0404: APPLIED THERMODYNAMICS

Course Outcomes:

On completion of this course, the student will be able to:

1. Apply laws of thermodynamics to analyze various thermodynamic cycles, processes and systems involving ideal gases and steam power cycles.
2. Evaluate the performance of steam power cycles and components, including modern steam generators, nozzles and turbines.
3. Using thermodynamic principles, analyze combustion reactions, fuels, and air standard cycles, including Otto, Diesel, and Brayton cycles.
4. Assess the concepts of availability, irreversibility, and entropy generation in various thermodynamic processes.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

The first and second law of thermodynamics, Carnot theorem, Thermodynamic temperature scale, Internal Energy and entropy, Clausius inequality, entropy change in various thermodynamic processes of ideal gases, Application of first and second law of thermodynamics for steady flow processes, reversibility, irreversibility and Availability, TdS equations, (Helmholtz, Gibbs function and Maxwell relations) Clausius-Clapeyron equations. Pure substance: PV, PT and TS systems, PVT surface.

Module II

Properties of steam: Steam table and Mollier diagram, Analysis of vapour process, Thermodynamic analysis of steam power cycles- Rankine, reheat, and regenerative, Binary vapour cycles, Organic Rankine cycle- Kalina cycle, modern steam generators, performance calculations of boilers.

Ideal, perfect and real gases, Properties of Mixtures of Gases and gas and vapours: Dalton’s law of

Partial pressure, Amagat's law of partial volume. Volumetric and Gravimetric analysis of Gas mixtures, Gibb's Dalton law, Mean value of the gas constant, Equivalent Molecular weight, Density, specific volume, specific heat and Molar heat capacity of gas mixtures.

Module III

Steam nozzles: Mass flow rate, throat pressure for maximum discharge, throat area, the effect of friction, supersaturated flow, and the effect of back pressure. Steam turbines: Fundamental principles of turbine-impu1se and reaction, condensing and noncondensing turbines, turbine compounding. Nomenclature and parts of a turbine, simple features and construction, velocity diagram, force on blades, work done by blades, blade or diagram efficiency, effect of friction on blades. Turbine Plant Auxi1iaries: Condenser, its classification, function and its construction. Circulating water pumps, Condensate and feed water system extraction, pumps, drain cooler, feed heaters, steam traps, and deaerator.

Module IV

Fuels and combustion: Calorific value, combustion equation, air-fuel ratio, gravimetric and volumetric analysis of fuel, excess air, enthalpy and internal energy of combustion, application of first law of thermodynamics to chemical reaction (combustion), adiabatic flame temperature, application of second law of thermodynamics to chemical reaction.

References:

1. Spalding D.B. & Cole, E.H., Engineering Thermodynamics, Edward Arnold, London, 4th Edition, (2022).
2. Holman, J. P., Thermodynamics, 8th Edition, McGraw Hill Inc., (2022).
3. Nag, P. K., Engineering Thermodynamics, 7th Edition, Tata McGraw Hill, (2022).
4. Bacon, Engineering Thermodynamics, Newnes- Butterworth, 3rd Edition, (2022).
5. Van Wylen, G. J., Borgnakke, C., & Sonntag R. E., Fundamentals of Thermodynamics, 8th Edition, John Wiley & Sons, (2022).

23-205-0405: PRINCIPLES OF MANAGEMENT AND INDUSTRIAL ENGINEERING

Course Outcomes:

On completion of this course, students will be able to:

1. Explain the management concepts and functions, organisational structures, and the role of HRM in organisations.
2. Understand the finance management concept, functions, role in industrial performance, and marketing techniques.
3. Understand the work measurement techniques, plant layouts, location selection factors, and material handling systems.
4. Apply the principles of inventory control and quality control for the overall performance improvement of an organisation.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1		1		1	3	3	1
CO2					1			1		1	3	1	3	3	1
CO3	3	3	2		1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Management Principles: Functions of Management - Planning, Organizing, Staffing, Directing, Controlling, Scientific Management. Organization Structure and Design – Line, Functional, Divisional, Matrix, Team-based, Centralization vs Decentralization, Delegation of Authority. Human Resource Management: Job Analysis, Human Resource Planning, Recruitment and Selection, Training and Development, Performance Appraisal Systems, Wage and Salary Administration, Labour Turnover, Employee Retention Strategies, Industrial Relations and Dispute Handling.

Module II

Bookkeeping and Accountancy: Trial balance, Preparation of profit and loss account, and Balance sheet. Financial Management: Role, Objectives, and Functions, Sources of Finance, Financial Statements, Ratio Analysis, Cost Concepts, Cost Classification and Control Techniques, Capital Budgeting Decisions - Payback Period Method, NPV, IRR, Capital Types, Estimating Working Capital Requirements. Marketing Management: Marketing Process and Concepts, Marketing Research - Data Analysis, Market Segmentation, Positioning, Understanding Consumer Buying Behaviour, Product Life Cycle, Distribution Channels, Pricing- Objectives and Strategies, Marketing Mix Formulation.

Module III

Work Study: Productivity and Productivity Improvement Techniques, Method Study - Development, Analysis, and Simplification using Process Charts, Flow Diagrams, and Work Measurement Techniques. Time Study: Work Sampling, Standard Data, Performance Rating, Allowances - Personal, Fatigue, Contingency. Plant Layout: Need, Objectives, and Types of Plant Layout, Factors affecting Location Selection, Systematic Layout Planning (SLP), Activity Relationship Analysis, Ergonomics-Space requirements for Men, Machines, and Material Handling. Material Handling Principles, Equipment Selection and Analysis.

Module IV

Materials Management: Purchasing Process, Vendor Evaluation and Selection, Inventory Types and Costs, EOQ Model, Quantity Discounts, Safety Stock, Perpetual and Periodic Inventory Control Systems, Just-in-Time Purchasing. Quality Control: Statistical Process Control - Control Charts for Variables and Attributes, Acceptance Sampling - Single, Double, Sequential Sampling Plans, Total

Quality Management, Quality Circles, Benchmarking, Six Sigma. Maintenance and Replacement Management, Types of Maintenance- Breakdown, Preventive, Scheduled and Predictive Maintenance, Reliability, Maintainability, and Availability.

References:

1. Koontz, H. and Weihrich, H., Principles of Management, 16th Edition, McGraw-Hill (2015).
2. Chandra, P., Financial Management: Theory and Practice, 9th Edition, Tata McGraw Hill (2021).
3. Khanna, O.P., Industrial Engineering and Management, S. K. Kataria & Sons (2016).
4. Heizer, J. and Render, B., Operations Management: Sustainability and Supply Chain Management,

23-205-0406: MANUFACTURING PROCESSES

Course Outcomes:

On completion of this course, the student will be able to:

1. Learn foundry materials, processes and techniques involved in metal casting, bulk-forming operations and various metal joining methods.
2. Comprehend the fundamental principles and workings of different manufacturing processes, including metal casting, bulk-forming and welding techniques.
3. Apply the concepts of solidification, plastic deformation, and metalworking theory to analyse casting design, bulk-forming loads and welding parameters.
4. Select appropriate manufacturing processes for component production based on considerations such as materials, quality requirements, joint design and testing methods.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Foundry: foundry materials, moulding and core sand, binders, additives, sand preparation, pattern and pattern making, pattern allowances and their calculations, mould and core making, types of cores, buoyancy force calculation on cores, chaplets, mould assembly, melting furnaces, pouring and fettling, solidification of pure metals and alloys, calculation of solidification time, grain growth.

Module II

Casting processes: sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting, casting design, gateway system design, riser design –(Caine's method, Modulus method, shrinkage volume consideration method, simple problems), casting defects, inspection and testing (destructive and non-destructive), casting alloys, economics of casting.

Module III

Yield criteria of metals (Von Mises, Tresca), isotropic hardening, kinematic hardening, plastic stress-strain relationship, metal forming operations, principle, process and equipment for punching, drawing, extrusion, rolling and forging, load calculation for punching, drawing, extrusion, rolling and forging, punch size and die size calculation for blanking and punching operations.

Module IV

Metal joining: Classification, Welding heat sources, Arc welding machines, Arc production characteristics, metal transfer, welding electrode, optimum voltage, current, and arc length calculation,

duty cycle and current relations, design of weld bead(no. of electrodes, welding speed, number of passes, welding time), Gas welding (TIG, MIG), Resistance welding, Thermit welding, Ultrasonic welding, Electron beam welding, Laser beam welding, Forge welding, Friction welding, Diffusion welding, Explosion welding, Gas and arc cutting, Welding metallurgy, Weldability of ferrous and non-ferrous metals, design of weldments, joint design, residual stresses and distortion, testing of welded joints, brazing and soldering.

References:

1. Campbell, J.S., Complete Casting Handbook: Metal Casting Processes, Techniques and Design, 3rd Edition, Butterworth-Heinemann, (2021).
2. Heine, R.W., Loper Jr., C.R., and Rosenthal, P.C., Principles of Metal Casting, 3rd Edition, American Foundry Society, (2003).
3. Rowe, G.W., Elements of Metalworking Theory, CRC Press, (2018).
4. Little, R.L., Welding and Welding Technology, McGraw-Hill Education, (1983).
5. Patte, H.E., Technological Advances in Welding and Other Joining Processes, Battelle Press, (1982).
6. Kalpakjian, S. and Schmid, S.R., Manufacturing Processes for Engineering Materials, 6th Edition, Pearson, (2020).

23-200-0407: UNIVERSAL HUMAN VALUES
(Common to all the branches)

Course Outcomes:

On completion of this course, the student will be able to:

1. Recognize needs, basic guidelines, content and process of value education, and explore the meaning of happiness and prosperity.
2. Understand human beings as the co-existence of two realities, self and body and harmony at the individual level.
3. Verify the possibility of ensuring the naturally acceptable feelings and express those to others with an expectation of mutual happiness and mutual prosperity.
4. Identify the harmony in society, nature and existence and ensure them through the effort to fulfil the human goal.
5. Apply the understanding of ethical human conduct to formulate strategies for ethical life and profession.

Mapping of Course Outcomes with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1			2	2	1	2	2	2	2
CO2			1			2	3	1	3	1	2	2
CO3			1			2	2	3	3	3	2	2
CO4			1			3	3	3	3	3	3	3
CO5			2			3	3	3	3	3	3	3

Module I: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education.

Purpose and motivation for the course, recapitulation from Universal Human Values-I.
Self-Exploration–what is it? – Its content and process; 'Natural Acceptance' and experiential Validation- as the process for self-exploration.
Continuous Happiness and Prosperity – A look at basic Human Aspirations.
Right understanding, Relationship and Physical Facility – the basic requirements for the fulfilment of aspirations of every human being with their priority.
Understanding Happiness and Prosperity rightly- A critical appraisal of the current Scenario.
Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human beings as the innate acceptance for

living with responsibility (living in relationship, harmony and co-existence) rather than arbitrariness in choice based on liking-disliking.

Module II: Understanding Harmony in the Human Being - Harmony in Myself.

Understanding human beings as a co-existence of the sentient 'I' and the material 'Body'.
Understanding the needs of Self ('I') and 'Body' - happiness and physical facility.
Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer).
Understanding the characteristics and activities of 'I' and harmony in 'I'.
Understanding the harmony of I with the Body: Self-regulation (*Sanyam)* and Health; correct appraisal of Physical needs, the meaning of Prosperity in detail.
Programs to ensure Self-regulation (*Sanyam)* and Health.

Include practice sessions to discuss the role others have played in making material goods available to oneself, identifying from own life. Differentiate between prosperity and accumulation. Discuss a program for ensuring health vs dealing with a disease.

Module III: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationships.

Understanding values in a human-human relationship; the meaning of Justice (nine universal values in relationships) and the program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship.
Understanding the meaning of Trust; Difference between intention and competence.
Understanding the meaning of Respect, the difference between respect and differentiation; the other salient values in a relationship.
Understanding the harmony in the society (society being an extension of the family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals.
Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real-life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Module IV: Understanding Harmony in Nature and Existence – Whole Existence as Coexistence.
Understanding the Harmony in Nature.
Interconnectedness and mutual fulfilment among the four orders of nature – recyclability and self-regulation in nature.
Understanding Existence as Co-existence of mutually interacting units in all-pervasive space.
Holistic perception of harmony at all levels of existence.
Include practice sessions to discuss human beings as the cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Implications of the above Holistic Understanding of Harmony on Professional Ethics: Natural acceptance of human values, Definitiveness of Ethical Human Conduct.

Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order.
Competence in professional ethics: a. Ability to utilize professional competence for augmenting universal human order, b. Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for the above production systems.
Case studies of typical holistic technologies, management models and production systems.
Strategy for the transition from the present state to Universal Human Order: a. At the level of the individual: as socially and ecologically responsible engineers, technologists and managers, b. At the level of society: as mutually enriching institutions and organizations.
Sum up.
Include practice exercises and case studies to discuss the conduct as an engineer or scientist etc.

Textbook:

1. Human Values and Professional Ethics (3rd revised edition) by R. R. Gaur, R Asthana, G P Bageria, Excel Books, New Delhi, (2022).

Reference Books:

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 3rd Edition, (2022).
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 5th Edition, (2022).

23-205-0408: METROLOGY AND AUTOMATION LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Measure dimensions, angles, and surface finish parameters using vernier callipers, micrometres, CMMs, surface profilometers and other metrology equipment.
2. Analyze measurement data to determine the accuracy, repeatability and calibration status of inspection tools and instruments.
3. Develop pneumatic, hydraulic and motor control circuits using actuators, valves, drivers and controllers to analyse system performance.
4. Select appropriate sensors, data acquisition and analysis methods for automated electromechanical systems and process monitoring.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				2	3	3		1	1	3	3
CO2	3	3	3	3				2	3	3		1	1	3	3
CO3	3	3	3	3				2	3	3		1	1	3	3
CO4	3	3	3	3	3			2	3	3		1	1	3	3

Experiments: Metrology

1. Measurement of lengths, heights, and diameters of engineering components using vernier callipers, micrometres, height gauges, etc. Determining accuracy and precision of measurements.
2. Measurement of angles using bevel protractors, sine bars, and clinometers. Calibration of devices.
3. Measurement of surface finish and roughness using talysurf and other surface profiling instruments.
4. Measurement of gear tooth profiles and parameters using gear tooth vernier callipers and comparators.
5. Measurement of screw thread parameters using two-wire/three-wire methods, optical projectors. Calibrating thread gauges.
6. Measurement of alignment and deflection of machine tool guides, spindles, etc., using dial indicators and autocollimators.
7. Use of coordinate measuring machines (CMM) for measurement of dimensions and profiles.
8. Use of optical flats and interferometers to measure surface accuracies.
9. Measurement of cutting tool forces using piezoelectric dynamometers during machining experiments.
10. Experiments with strain gauges for measurement of static and dynamic loads, strains and stresses.

Experiments: Automation

1. Basic pneumatic and hydraulic circuit design and control using actuators and valves
2. Motion control of AC, DC and stepper motors using drivers and motor controllers. Measurement of speed-torque characteristics.
3. Closed loop position and speed control of servo motors using PID feedback
4. Interfacing commonly used industrial sensors like potentiometers, LVDTs, load cells, proximity sensors, etc., with data acquisition systems

5. Data acquisition and analysis of sensor inputs using LabVIEW
6. Introduction to Programmable Logic Controllers (PLC) - Basic ladder logic programming
7. Development of process control circuits on PLC involving - logical controls, timers, counters, comparison and computations
8. Monitoring and control of AC motor drives through SCADA and PLC

23-205-0409: HYDRAULIC MACHINERY LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain the working principles and constructional features of hydraulic machines, including pumps and turbines.
2. Determine efficiency, input/output power, and performance characteristics of hydraulic machines by conducting experiments as per standard test codes.
3. Analyze test data to calculate losses, optimise operating parameters and evaluate machine performance.
4. Recommend suitable pumps or turbines for given applications based on the interpretation of characteristic curves and performance parameters.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				2	3	3		1	1	3	3
CO2	3	3	3	3				2	3	3		1	1	3	3
CO3	3	3	3	3				2	3	3		1	1	3	3
CO4	3	3	3	3				2	3	3		1	1	3	3

Experiments

1. Pelton Wheel
2. Francis Turbine
3. Kaplan Turbine
4. Centrifugal Pump
5. Variable Speed Centrifugal Pump
6. Reciprocating Pump
7. Plunger Pump
8. Gear Pump
9. Impact of Jets
10. Hydraulic Ram
11. Subsonic Wind Tunnel
12. Study of cut models of pumps and turbines

23-200-0501A: NUMERICAL AND STATISTICAL METHODS

(Common for CE, ME and SE)

Course Outcomes:

On completion of this course, the student will be able to:

1. Comprehend foundational concepts in numerical analysis, statistical methods, and machine learning, including understanding the importance of numerical methods and statistical techniques in problem-solving.
2. Apply various numerical methods and statistical tests to solve algebraic and transcendental equations, analyse data, and draw inferences about populations and samples.
3. Evaluate and compare the efficiency of numerical techniques in solving engineering problems, demonstrating analytical skills in differentiation, integration, and solving ordinary differential equations.
4. Apply advanced statistical and machine learning techniques using Pandas for data exploration and processing, showcasing proficiency in descriptive statistics, regression analysis, and the implementation of basic machine learning models.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3					1		1	3	3	1
CO2	3	3	3	3	3					1		1	3	3	1
CO3	3	3	3	3	3					1		1	3	3	1
CO4	3	3	3	3	3					1		1	3	3	1

Module I

Fundamentals of Numerical Analysis: Understanding Numerical Methods, Importance in Problem Solving, Error Analysis and Approximations. Numerical solution of algebraic and transcendental equations: Bisection, Newton-Raphson, Secant and Successive Iteration Method. System of Equations: Gauss-Seidel Iteration (Convergence without proof). Interpolation and Approximation: Polynomial, Lagrange, Newton's Forward/Backward/Divided-Difference, and Least Squares.

Module II

Numerical Differentiation at Tabulated Points: Forward, Backward, Central Differences. Numerical Integration: Trapezoidal, Simpson's, Gaussian Quadrature. Ordinary Differential Equations (ODEs): Initial Value Problems- Euler's Method, Taylor Series Method, and Runge-Kutta (2nd & 4th Order). Boundary Value Problems-Finite Difference Method (First & Second Order BVPs).

Module III

Statistical Concepts and Tests: Random Variables, Expectation, Mean, Variance. Probability Distributions: Binomial, Poisson, Normal. Statistical Inference: Population, Sample, Sampling Distributions (Mean & Variance). Hypothesis Testing: Level of Significance, Z-Test, Chi-Square Tests (Variance & Goodness of Fit), F-Test.

Module IV

Descriptive Statistics and Regression Analysis. Overview of Descriptive Statistics. Regression Analysis of Numerical Data. Regression Analysis of Categorical Data. Visualization of Data Trends. Basic Concepts of Machine Learning: Introduction to Supervised Learning, Overview of Classification and Regression, Introduction to Unsupervised Learning: Clustering. Utilize Pandas for data exploration and processing.

The students should be introduced to Computer Algebra Systems (CAS) such as Matlab/Python (utilizing NumPy, SymPy, and SciPy) for both symbolic and numerical calculations. Homework and assignments should be given with the integration of CAS.

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, (2022).
2. Grewal, B. S., Higher Engineering Mathematics, 45th Edition, Khanna Publishers, (2023).
3. R.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 7th Edition, New Age International Publishers, (2022).
4. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 10th Edition, Cengage Learning, (2023).
5. Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, 3rd Edition, O'Reilly Media, (2022).
6. Andreas C. Muller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, 2nd Edition, O'Reilly Media, (2021).

23-205-0502: MECHANICS OF MACHINERY

Course Outcomes:

On completion of the course, the student will be able to:

1. Understand the principles of different kinematic chains and their inversions.
2. Apply the principles of mechanics and analyse the planar mechanisms for position, velocity, acceleration, geometry, and forces.
3. Synthesize planar four-bar and slider crank mechanisms for specified kinematic conditions.
4. Identify a mechanism for a specific application and design the mechanism.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3	2			1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module 1

Introduction: Machines and mechanisms, lower and higher pairs, kinematic chains, kinematic inversions of four bar, slider crank and double slider crank chains, equivalent linkages, Lower pairs - Pantograph, Paucellier mechanism, Thomson indicator mechanism, Watt mechanism, Geneva mechanism, Steering mechanism, Hooke's joint.

Kinematic analysis of plane mechanisms: a review of rotation of rigid bodies, compound pendulum, resultant inertia force and centre of percussion. The general case of plane motion, and Instantaneous centre. Arnold Kennedy’s theorem, velocity analysis using the instantaneous centre method, velocity and acceleration diagrams, and Coriolis component of acceleration.

Module 2

Spur gear: gear terminology, conjugate gears, the involute arc of motion, generation of gear teeth profiles, interference, cycloidal and involute gear characteristics, the law of gearing, length of the path of contact, length of the arc of contact, contact ratio, interchangeable gears, standard and non-standard tooth profiles, description of various types of gears like a helical, bevel, worm and their applications

Gear Trains: Analysis of simple, compound, reverted and epicyclic gears, solution of epicyclic gear train problems, gear train in differentials.

Module 3

Cams: Classification of cams and followers, geometry of radial cams, displacement diagrams, follower motion, uniform velocity, simple harmonic, uniform acceleration and retardation, cycloidal, parabolic,

graphical layout of cam profiles, displacement, velocity, acceleration and jerk relations, pressure angle, analysis of tangent cam, convex sided cams with roller follower and flat faced followers.
Dynamometer – Types of dynamometers, Prony brake dynamometer, Rope brake dynamometer, Belt transmission dynamometer, Torsion dynamometer

Module 4

Friction: Laws of friction, Limiting angle of friction, Flat pivot bearing, Flat collar bearing, Conical pivot bearing, Efficiency of the inclined plane, Screw friction, Screw Jack, Efficiency of a screw jack
Friction clutches – Single disc clutch, Multiple disc clutch, Cone clutch, Centrifugal clutch.
Introduction to synthesis: synthesis of slider crank mechanism, crank and rocker mechanism. Optimum transmission angle, synthesis of four bar links, three and four position synthesis. Chebychev accuracy points, overlay method, coupler curve synthesis, Freudenstein's equations for Four bar and Slider crank mechanism

References:

1. S.S. Rattan, Theory of Machines, 6th Edition, McGraw Hill Education, (2023)
2. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, 4th Edition, Affiliated East-West Press Private Ltd., (2023)
3. David H. Myszka, Machines and Mechanisms: Applied Kinematic Analysis, 5th Edition, Pearson, (2023)
4. C. E. Wilson and P. Sadler, Kinematics and Dynamics of Machinery, 3rd Edition, Pearson, (2023)
5. Robert L. Norton, Design of Machinery, 8th Edition, McGraw-Hill Education, (2022)
6. V. P. Singh, Theory of Machines: Kinematics and Dynamics, 3rd Edition, New Age International Publishers, (2022)
7. Robert L. Norton, Machines and Mechanisms: Applied Kinematic Analysis, 5th Edition, Pearson, (2023)
8. Kenneth J. Waldron and Gary L. Kinzel, Kinematics, Dynamics, and Design of Machinery, 3rd Edition, Wiley, (2023)

23-205-0503: MACHINE TOOLS

Course Outcomes:

On completion of this course, the student will be able to:
1. Explain the mechanics of chip formation, tool materials, tool wear mechanisms, thermal effects in machining, economics of machining, and basic concepts of machine tools.
2. Describe engine lathes, shaping/slotting/planning machines, drilling/boring machines, milling machines and grinding machines including their specifications, features and capabilities.
3. Analyze the working principles, configuration, structural and control features of CNC machine tools including turning centres and machining centres.
4. Create CNC part programs with motions and contours for 2 and 3-axis CNC systems using manual programming, G/M codes and CAM software.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	2	1						1		1		1	3	3	1
CO3	3	1						1		1		1	3	3	1
CO4	3	3	3	2	3			1		1		1	3	3	1

Module I

Theory of Machining: Single point and multi-point machining, Chip formation: mechanism, chip types, chip control, Tool geometry: Single point, specifications in different systems, selection of tool angles, orthogonal and oblique machining, Mechanics of single point orthogonal machining: Merchant's circle,

force, velocity, shear angle and power consumption relations, Cutting tool wear and tool life: wear mechanisms, wear criterion, Taylor's tool life equation, variables affecting to life, machinability and its measures

Module II

General Purpose Machine Tools- Lathe: Principle of operation, construction details, specification, machining time calculation, Drilling machine: Principle of operation, construction details, specification, Twist drill geometry, Milling Machines: Features, Milling Cutter geometry, Types of Cutters, indexing methods, Grinding Machines: Abrasives, Selection of grinding wheels shaping, slotting and planing machines, material removal rate calculations.

Module III

Computer Numerical Control: Basic theory and working principles of CNC systems; Advantages over conventional methods; Classification and configuration of CNC machine tools including turning centres and machining centres. Machine Tool Design: Structural and control features - guideways, drives, feedback systems, automatic tool changers and power chucks/tailstocks to match the capabilities of CNC systems. CNC Tooling: Cutting tool materials, inserts and tool holders for mills and lathes to suit operations; Turret and magazine-based tool storage systems. Automatic Pallet Changers (APC).

Module IV

CNC part programming: Manual programming, G and M codes, ISO/EIA codes, machine zero, axes nomenclature, zero offsets, tool offset canned cycles, common industrial CNC controllers from Siemens, Fanuc and Haas, preparation of part programs with motions, contours for 2 and 3-axis CNC systems. Computer Aided Programming, CNC program generation by CAM software, multi-axes programming.

References:

1. Richard R. Kibbe, Roland O. Meyer, Machine tool practices, 11th Edition, Prentice Hall, (2021).
2. Rao, P. N., Manufacturing Technology, Volume 2, 5th Edition, Tata McGraw Hill, (2022).
3. Donaldson, Lecain, & Goold, Tool Design, 4th Edition, Tata McGraw Hill, (2020).
4. Esposito, A., Fluid Power with Applications, 9th Edition, Pearson, (2022).
5. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, 5th Edition, Pearson, (2022).
6. Kundra T. K., Rao P. N. and Tiwari N. K., CNC Machine Tools and Computer-aided Manufacturing, 3rd Edition, Tata McGraw-Hill Education, (2020).
7. Jha, B. K., CNC Programming Made Easy, 2nd Edition, Vikas Publishing House, (2020).

23-205-0504: THERMAL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand thermodynamic cycles and processes associated with IC engines to evaluate engine performance and efficiencies
2. Examine various systems and components of IC engines, including fuel, combustion, ignition, cooling, lubrication, and emissions control
3. Evaluate the working principles, components and applications of gas turbine systems for power generation, including combined cycles and cogeneration
4. Assess coal-based thermal power plants ranking cycle improvements and cogeneration systems for steam and gas turbines and IC engines

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Air standard cycles- Otto, Diesel, Dual and Brayton cycle. Actual cycles of four-stroke and two-stroke IC engines, valve timing diagram, engine testing, performance and characteristics of constant speed and variable speed engines, heat balance test, Morse test, retardation test, effect of dissociation, variable specific heats and heat losses, scavenging - objectives, effects and methods, efficiencies (thermal, mechanical and volumetric efficiencies).

Module II

Systems and components of IC engines, fuel systems, ignition systems, cooling, starting, and lubrication. Combustion in IC engines, flame propagation, normal and abnormal combustion, detonation, pre-ignition, after burning, fuel rating, additives in petrol, combustion chambers of SI engines, combustion in CI engines, phase of normal combustion, diesel knock, the effect of engine variables on diesel knock, cetane number, additives in diesel, combustion chambers of CI engines. MPFI Engines, CRDI Engines, VVT Engines.

Module III

Air compressors - General Aspects, Classification: Reciprocating (single and double stages only), Rotary, Centrifugal and Axial flow compressors (simple numerical problems). Comparison between Reciprocating, Rotary, Centrifugal and Axial flow compressors.

Gas turbines: Open cycle single shaft and twin shaft arrangements, Closed cycles, Aircraft propulsion, Industrial applications, Shaft power cycles, Ideal cycles, Comparative performance of practical cycles, Combined cycles and cogeneration schemes (simple numerical problems only).

Module IV

Coal-Based Thermal Power Plants: Basics of typical power plant utilities, Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system, steam rate and heat rate, mean temperature of heat addition, Rankine cycle improvements, Superheat, Reheat, Regeneration, Supercritical, AFBC/PFBC, computation of per unit cost of power generation from coal/biomass. Cogeneration systems: steam turbine, gas turbine, and IC engine-based cogeneration systems.

References:

1. Cengel, Y.A. and Boles, M.A., Thermodynamics: An Engineering Approach, 9th Edition, McGraw Hill, (2022).
2. Eastop, T.D. and McConkey, A., Applied Thermodynamics for Engineering Technologists, 5th Edition, Pearson, (1993).
3. Ferguson, C.R. and Kirkpatrick, A.T., Internal Combustion Engines: Applied Thermosciences, 4th Edition, Wiley, (2020).
4. Moran, M.J. and Shapiro, H.N., Fundamentals of Engineering Thermodynamics, 7th Edition, Wiley, (2011).
5. Rakopoulos, C.D. and Giakoumis, E.G., Diesel Engine Transient Operation: Principles of Operation and Simulation Analysis, Springer, (2009).
6. Woodruff, E.B., Lammers, H.B. and Lammers, T.F., Steam Plant Operation 9th Edition, McGraw-Hill, (2004).
7. Brown, R.N., Compressors: Selection and Sizing, 3rd Edition, McGraw Hill, (2005).

23-205-0505: ADVANCED MANUFACTURING TECHNOLOGY

Course Outcomes:

On completion of this course, the student will be able to:

1. Analyze different manufacturing systems such as job shops, cellular manufacturing, flexible manufacturing systems etc. in terms of automation levels, benefits and drawbacks.
2. Compare capabilities and applications of non-traditional machining processes including EDM, ECM, AJM, USM, EBM, LBM and PAM.
3. Evaluate the powder metallurgy process for the manufacture of products including mixing, compacting, sintering and secondary operations along with advantages and limitations.
4. Assess rapid prototyping techniques like stereolithography, selective laser sintering, fused deposition modelling and 3D printing in terms of basic principles, relative advantages and suitability for different applications.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3				3			1		1		1	3	3	1

Module I

Introduction to Advanced Manufacturing Technology Manufacturing Systems and Automation: Job shop, Flow lines, Transfer lines, Project shop, Continuous processes, Cellular manufacturing system, Flexible Manufacturing System. Automation: Degree of automation and their justified application in different levels of production, benefits and drawbacks of employing automation, examples of conventional non-automatic, semi-automatic and automatic machine tools, and the extent of automation in transfer machines. Integrated Manufacturing System: Steps involved in implementation, forming the linked-cell factory and Introduction to Robotics for its implementation in manufacturing.

Module II

Non-traditional machining processes: Principles, machining unit, process characteristics and applications of Electro Discharge Machining, Electro Chemical Machining, Abrasive Jet Machining, Ultrasonic Machining, Electron Beam Machining, Laser Beam Machining, and Plasma Arc Machining-capability analysis of non-traditional processes

Module III

Powder Metallurgy: Definition and basic concept of the powder metallurgy process, powder manufacture, characteristics of metal powders, mixing and blending, compacting, pre-sintering, sintering, hot pressing, secondary P/M operations like infiltration, impregnation, sizing, properties of P/M products, product applications, advantages & disadvantages.

Module IV

Rapid Prototyping- Overview of Rapid Prototyping, Basic Process- CAD Model Creation, Conversion to STL format, Slice, Layer by Layer Construction, Clean and Finish. Principles, systems, relative advantages and applications of the common RP methods: Stereolithography (SLG), selective laser sintering (SLS), fused deposition modelling (FDM), laminated objects manufacturing (LOM), and 3-D Inkjet Printing.

References:

1. Groover, M.P., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, John Wiley & Sons, (2022).
2. Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, (2022).
3. Mishra, P.K., Non-Conventional Machining, 2nd Edition, Narosa Publishing House, (2018).
4. Kalpakjian, S, Schmid, S.R. and Kok, C.W, Manufacturing Processes for Engineering Materials, 7th Edition, Pearson, (2022).
5. Gibson, I., Rosen, D. and Stucker, B., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 3rd Edition, Springer, (2021).
6. El-Hofy, H., Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, 2nd Edition, McGraw Hill Education, (2019).
7. Benedict, G.F., Non-traditional Manufacturing Processes, 2nd Edition, CRC Press, (1987).
8. McGeough, J.A., Micromachining of Engineering Materials, 1st Edition, CRC Press, (2001).

23-205-0510: COMPUTATIONAL METHODS LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain the fundamentals of C programming, including pointers, arrays, functions and data file handling.
2. Apply numerical methods to solve polynomial, transcendental equations, linear algebraic equations, integration problems, and ordinary differential equations.
3. Analyze boundary value problems using numerical techniques like Finite Difference Method.
4. Create C programs to implement numerical methods like Bisection, Gauss Elimination, Euler's, and Runge-Kutta methods.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3			2	3	3		1	1	3	3
CO2	3	3	3	3	3			2	3	3		1	1	3	3
CO3	3	3	3	3	3			2	3	3		1	1	3	3
CO4	3	3	3	3	3			2	3	3		1	1	3	3

Review of fundamentals of C programming: Pointers-pointer declaration-pointers and one-dimensional arrays-pointers and functions, data files- opening and closing a data file, creating a data file- processing a data file.

Numerical Techniques: Preparation of computer programs for the solution of polynomial and transcendental equations, Bisection method, False Position Method (or) Regula Falsi Method, Successive Iteration method, Newton Raphson method.

Solution of system linear algebraic equations: Gauss elimination, Gauss Jordan method, Matrix Inversion, Gauss-Seidel method.

Numerical integration: Trapezoidal Rule, Simpson’s 1/3 rule, Gauss Quadrature formulae.

Numerical solution of ordinary differential equations: Taylor Series method, Runge-Kutta method.

Numerical solution of boundary value problems: Finite Difference Method (FDM).

References:

1. Chapra, S.C. and Canale, R.P., Numerical Methods for Engineers, 8th Edition, McGraw Hill, (2021).
2. Froberg, C.E., Introduction to Numerical Analysis, 3rd Edition, Dover Publications, (2021).
3. Kandaswamy, P., Numerical Methods, 4th Edition, S. Chand & Company, (2022).
4. Jain M.K., Iyengar S.R.K., Jain R.K., Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International Publishers, (2018).

23-205-0511: MACHINE SHOP-I

Course Outcomes:

On completion of this course, the student will be able to:

1. Identify different types of machine tools, mechanisms, accessories and parameters related to various machining operations.
2. Operate lathe machines to perform cylindrical turning, taper turning, facing and thread-cutting operations.
3. Analyze the working of machine tools, including shapers, slotters, grinders and drilling machines.
4. Measure the machined components for linear and geometric dimensions.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							2	3	3		1	1	3	3
CO2	3							2	3	3		1	1	3	3
CO3	3							2	3	3		1	1	3	3
CO4	3							2	3	1		1	1	3	1

Introduction to machine tools:

Types of machine tools, spindle drive, work holding devices, tool holders, tool movement, selection of speeds, feed and depth of cut, use of cutting coolants, principle of thread cutting, V-thread and square thread, thread standards, cutting tool types, grinding of tools, selection of cutting speeds.

Practical:

Exercises on the lathe, cylindrical turning, taper turning, facing, shoulder turning and curve turning, thread cutting, and internal thread cutting.

Exercises on shaping and slotting machines.

Exercises on grinding machines.

Exercises on radial drilling machines.

Measurement of linear and geometric dimensions of the machined components.

Measurement of surface finish in various machining operations.

References:

1. HMT, Production Technology, Tata McGraw Hill, (2001).
2. Wilson, F.W. and ASTME, Tool Engineer's Handbook, McGraw Hill, (1959).
3. Boguslavsky, B.L., Automatic and Semi-Automatic Lathes, Peace Publications, (1963).
4. ASTME, Fundamentals of Tool Design, Prentice Hall, 5th edition, (2017).

23-205-0512: INTERNSHIP-II

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the real-time technical/managerial skills required and relevant to the subject area of the internship
2. Initiate a habit of proper daily diary writing with adequate and quality information recorded, drawing and sketches and data, thought process and the proper organisation of the information gained during the internship.
3. Conceive the pros and cons of working in a real-time industrial environment and the wonderful results which could evolve through teamwork.
4. Present and defend a self-prepared and corrected internship report (with the help of an internship guide/industry mentors) of a self-created work to a peer audience.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1				1	2	3	1	1			3
CO2	1	1	1	1				1	2	3	1	1			3
CO3	1	1	1	1				1	2	3	1	1			3
CO4	1	1	1	1	3			1	2	3	1	1			3

Internship Guidelines

- An internship plan has to be prepared by the interns incorporating the job description/internship duties, name of the project, if any internship schedule and expected learning outcomes in consultation with the industry supervisor/mentor and institute faculty.
- A detailed training report in the prescribed format shall be submitted at the end of the internship.
- Training Certificates from the industry for the prescribed period shall be submitted at the end of the internship.
- The work shall be reviewed and evaluated periodically.
- Orientation of interns, resource requirement of interns, and monitoring of intern's progress daily shall be carried out by the industry offering the internship in addition to ensuring the safety and welfare of the interns.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member at the level of Associate Professor or above will carry out the final review.

Guidelines for evaluation:

1.	Regularity and progress of work	10
2.	Work knowledge and Involvement	10
3.	Semester End presentation and oral examination	10
4.	Level of completion of the internship	10
5.	Internship Report – Presentation style and content	10
Total		**50** Marks

PROFESSIONAL ELECTIVE – I

23-205-0506(IE): ADDITIVE MANUFACTURING

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain the fundamentals of various additive manufacturing processes and compare them in terms of part quality, cost, speed, etc.
2. Design parts and select suitable additive manufacturing processes, materials and parameters for the production of end-use functional parts.
3. Prepare 3D models, configure machine parameters, and build prototypes/parts using additive manufacturing processes.
4. Post-process, test and evaluate additive manufactured parts to ensure quality.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3	3			1			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3				1			1		1		1	3	3	1

Module I

Introduction and Processes: Additive Manufacturing, Fundamentals, advantages, limitations, applications; Classification of processes; Comparison with traditional processes; Working principles, materials, characteristics of VAT Photopolymerization, Material Jetting, Binder Jetting, Material Extrusion processes

Module II

Powder Bed Processes and Sheet Lamination: Working principles, part quality characteristics, suitable materials and applications of Powder Bed Fusion and Directed Energy Deposition processes; Sheet Lamination process

Module III

Design, System Hardware and Software: Design rules and considerations; Lattice structures and design optimisation; Support structures and build orientation selection; AM system hardware components; Part preparation software, STL file manipulation; Machine configuration and build preparation software

Module IV

Post-processing, Applications and Economics: Part removal and cleanup; Heat treatment; Benchmarking and testing additive manufactured parts; Quality assurance; Applications in aerospace, automotive, medical and other industries; AM economics; Supply chain considerations; Sustainability

References:

1. Gibson, I., Rosen, D. W., & Stucker, B., Additive Manufacturing Technologies, Springer, (2021).
2. Thompson, M. K., Moroni, G., Vaneker, T., Fadel, G., Campbell, R. I., Gibson, I., ... & Martina, F., Design for Additive Manufacturing: Trends, opportunities, considerations, and constraints, CIRP Annals, (2016).
3. Gao, W., Zhang, Y., Ramanujan, D., Ramani, K., Chen, Y., Williams, C. B., ... & Zavattieri, P. D., The status, challenges, and future of additive manufacturing in engineering, Computer-Aided Design, (2015).

23-205-0507: OPERATIONS MANAGEMENT

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand different network techniques and forecasting methods
2. Learn production planning and control as well as inventory control techniques.
3. Study the concepts of aggregate planning and scheduling
4. Get the basic knowledge of plant location and layout and material handling

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			1			1		1		1	3	3	1
CO2	3	3	2		1			1		1		1	3	3	1
CO3	3	3	2		1			1		1		1	3	3	1
CO4	3	2	2		1			1		1		1	3	3	1

Module I

Operations Management: Characteristics and functions, Production process: Nature and importance of production function, relationship with other business activities; Network techniques: Basic concept of network construction, critical path, slack and float, CPM, crashing, PERT, multi-time estimate; Forecasting: Importance in operations management, methods of forecasting - time series, moving average, exponential smoothening.

Module II

Production planning and control: Scopes, objectives and functions of production planning and control; Product Design: Process and functions, guiding principles, consumption cycle, product life cycle, factors affecting product design, simplification, standardization, specialisation, inter-changeability; Inventory control: Structure of inventory problems, relevant costs, basic EOQ models, stores ledger, materials requisition sheet, materials return note, material transfer note, bin cards, just in time and lean management.

Module III

Aggregate Planning: Role and need of aggregate planning, graphical and reaction rate methods of aggregate planning; Scheduling: Definition and scheduling decisions, Gantt charts, indexing methods, critical ratio method of loading and scheduling; Sequencing: Basic concepts and importance of sequencing, one-machine-n-jobs, 2-machine-n-jobs, m-machines-n jobs problems.

Module IV

Plant Location: Factors influencing location, and significance of sites in urban,semi-urban and rural areas. Plant Layout: Types, need for layout, layout design process- factors, determination of equipment and employee requirement, production rate determination, space determination, block plan, systematic layout planning.
Material handling: The principles of materials handling, classification of equipment and its selection factors. Maintenance and replacement: Different types of maintenance, merits and demerits, operational and economic aspects. Replacement of equipment, methods, and concept of depreciation.

References:

1. Riggs, J.L., Economic Decision Models for Engineers and Managers, 5th Edition, McGraw Hill, (2021).
2. Moder, J.J., Phillips, C.R. and Davis, E.W., Project Management with CPM, PERT and Precedence Diagramming, 4th Edition, Van Nostrand Reinhold, (2021).
3. Harris, F.W., Inventory Management and Production Planning and Scheduling, 4th Edition, Wiley, (2022).

4. Russell, R.S. and Taylor III, B.W., Operations Management: Quality and Competitiveness in a Global Environment, 10th Edition, Wiley, (2021).
5. Heragu, S.S., Facilities Design, 5th Edition, Industrial Press Inc., (2020).
6. Bhadury, B., Total Modern Maintenance Program Management: A Strategic and Implementable Strategy with Tactics to Enhance Reliability Centered Maintenance, 1st Edition, Industrial Press Inc., (2022).

23-205-0508: ADVANCED THERMODYNAMICS

Course Outcomes:

On completion of this course, students will be able to:

1. Apply integral and differential forms in the analysis of thermodynamic processes, considering both local and global equilibrium.
2. Evaluate the thermodynamic properties of pure fluids and mixtures, including the stability and phase equilibrium of these systems.
3. Create solutions to complex problems in irreversible thermodynamics, considering entropy production and Onsager relations in the analysis of reacting systems.
4. Apply the basic concepts of statistical thermodynamics to analyse simple systems, utilising ensembles, probability distributions, and the partition function.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

General Principles of Classical Thermodynamics, Overview of Microscopic Thermodynamics, First Law Analysis, Integral and Differential Forms, Second Law and Entropy Evaluation, Local and Global Equilibrium, Maximum Entropy and Minimum Energy Principles, Availability Analysis Including Chemical Availability.

Module II

Postulatory Thermodynamics: Postulates for Simple Systems, Entropy and Energy-Based Equations, State Relationship for Real Gases and Liquid, Two and Three-Parameter Equations of State, Thermodynamic Properties of Pure Fluids and Their Evaluation, Thermodynamic Properties of Mixtures, Phase Equilibrium and Stability.

Module III

Chemically Reacting Systems, Combustion and Thermochemistry, Mass Conservation and Mole Balance Equations, Reaction Direction and Chemical Equilibrium, First and Second Law Analysis of Reacting Systems, Adiabatic Flame Temperature and Isothermal Combustion, Introduction to Irreversible Thermodynamics, Entropy Production, and Onsager Relations.

Module IV

Basic Concepts of Statistical Thermodynamics, Ensembles and Their Significance, Probability Distributions in Statistical Thermodynamics, The Partition Function and Thermodynamic Properties, Statistical Interpretation of Entropy and the Second Law, Applications to Simple Systems, Introduction to Quantum Statistical Mechanics.

References:

1. K. Annamalai and I. K. Puri, *Advanced Thermodynamics Engineering*, 3rd ed. CRC Press, (2021).
2. M. W. Zemansky, M. M. Abbot, and H. C. Van Ness, *Basic Engineering Thermodynamics*, 3rd ed. McGraw-Hill, (2020).
3. M. A. Saad, *Thermodynamics for Engineers*, 2nd ed. Prentice Hall of India, (2001).
4. K. Wark Jr., *Advanced Thermodynamics for Engineers*, 4th ed. McGraw-Hill, 2015.
5. J. P. O' Connell and J. M. Haile, *Thermodynamics – Fundamentals for Applications*, 2nd ed. Cambridge University Press, (2019).
6. P. Atkins and J. de Paula, *Atkins' Physical Chemistry*, 11th ed. Oxford University Press, (2017).

23-205-0509: ADVANCED MECHANICS OF SOLIDS

Course Outcomes:

On completion of the course, the student will be able to:

1. Transform a stress/strain tensor in cartesian and polar coordinates and evaluate the principal stresses and strains.
2. Formulate the differential equations of equilibrium, boundary conditions, and compatibility conditions in cartesian and polar coordinates.
3. Apply these principles to 2D, 2D axisymmetric, and 3D problems and calculate stresses and strains.
4. Analyse problems of bending and twisting of un-symmetrical and non-circular sections.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Stress at a point: Stress tensor - Equality of cross shear. Cauchy's equation. Strain Tensor: Displacement field, strain-displacement relations (small-strain only), 2D problems in Cartesian co-ordinates, plane stress and plane strain, measurement of surface strains, construction of Mohr circle for stress and strain, strain rosettes, differential equations of equilibrium, boundary conditions, compatibility equations, stress function. solution by polynomials, St. Venant's principle,

Module II

2D problems in polar coordinates: General equations in polar coordinates. Stress distribution - symmetrical about an axis, strain components in polar coordinates, displacement for symmetrical stress distribution, rotating disks, thick cylinders, pure bending of curved bars.

Module II

Analysis of stress and strain in 3D - principal stresses, stress ellipsoid, stress invariants, maximum shearing stress, homogenous deformation. differential equations of equilibrium and compatibility.
Energy methods: principle of virtual work, reciprocal theorems, strain energy methods, Castigliano's theorems.

Module IV

Unsymmetric bending, shear flow, shear centre. Torsion of straight bars with elliptic cross sections. Membrane analogy, Torsion of thin tubes, open and closed sections.

References :

1. Sadd, M.H., Elasticity: Theory, Applications, and Numerics, 4th Edition, Academic Press, (2022).
2. Solecki, R. and Conant, R.J., Advanced Mechanics of Materials, 4th Edition, Oxford University Press, (2024).
3. Srinath, L.S., Advanced Mechanics of Solids, 6th Edition, McGraw Hill, (2023).
4. Kazimi, S.M.A., Solid Mechanics, 4th Edition, McGraw Hill, (2023).
5. Boresi, A.P., Schmidt, R.J., Advanced Mechanics of Materials, 8th Edition, Wiley, (2023).

23-205-0601: DYNAMICS OF MACHINERY

Course Outcomes:

On completion of the course, the student will be able to:

1. Recall the concepts of free body diagrams, principles of statics and dynamics
2. Use graphical and/or analytical methods to perform the force analysis of planar mechanisms.
3. Apply these concepts in different machine elements for the evaluation of forces and moments
4. Analyze the dynamics of different mechanisms and machine elements and evaluate the various forces and torques.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module 1

Force analysis of plane motion mechanism: Static force analysis, analysis of four bar chain, slider crank mechanism, static force analysis with friction. Dynamic force analysis: D'Alembert's principle, inertia forces, dynamic force analysis of four bar and slider crank mechanism, Shaking forces, Dynamics of reciprocating engines, equivalent masses, inertia force in single engine, bearing loads in single cylinder engine.

Module 2

Flywheels: Inertia torque-turning moment diagrams for multi-cylinder engines, steam engines, coefficient of fluctuation of speed and energy, flywheel mass calculation. Balancing: Static and dynamic balancing, balancing of several masses in a plane, balancing of rotating masses in several planes, balancing of several masses in several planes. Condition of complete balancing of an engine, reciprocating and rotating parts, Multi-cylinder inline engines, Radial and V-engines, Balancing machines and principles of working.

Module 3

Gyroscopes: motion of a rigid body in 3 dimensions, Gyrodynamics, gyroscope and gyroscopic couple, Gyroscopic effects on ships, aircraft and automobiles. Governors: Watt governor, Porter governor, Proell governor, Hartnell governor, Sensitiveness, Hunting, Isochronism, Effort of the governor, Controlling force. Force analysis of spur, helical and bevel gears.

Module 4

Belt, Rope and Chain drives: Types of belt drives, Velocity ratio, Slip, Creep, Length of belt, Power transmitted, Ratio of tensions, Angle of contact, Centrifugal tension, Maximum tension, Initial tension, V belt drive, Ratio of Tensions in V belt and Rope drives, Kinematics of chain drive, Classifications of chains, Chain length.

Brakes – Types of brakes, Block brake, Band brake, Band and Block brake, Internal expanding brake, Condition of self-locking, Power transmitted and Heat generated

References:

1. Rattan, S.S., Theory of Machines, 5th Edition, McGraw Hill, (2022).
2. Ambekar, A.G., Mechanism and Machine Theory, 2nd Edition, PHI Learning, (2022).
3. Uicker, J.J., Pennock, G.R. and Shigley, J.E., Theory of Machines and Mechanisms, Oxford University Press, (2022).
4. Myszka, D.H., Machines and Mechanisms: Applied Kinematic Analysis, 5th Edition, Pearson, (2021).
5. Norton, R.L., Design of Machinery, 6th Edition, McGraw Hill, (2022).
6. Bevan, T., The Theory of Machines, Routledge, (2021).
7. Ghosh A. and Mallick A.K., Theory of Mechanisms and Machines, Affiliated East-West Press, (1996).
8. Norton, Kinematics and Dynamics of Machinery, McGraw Hill, (2009).

23-205-0602: DESIGN OF MACHINE ELEMENTS- I

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand fundamental principles in machine element design, including materials, tolerances, fits, and standards.
2. Apply design principles to analyse and design detachable joints, power screws, keys, and couplings, considering thread stresses, pre-loading, and fatigue.
3. Analyze and design various joints (riveted, bolted, welded) under different loads (direct, eccentric, fluctuating).
4. Apply knowledge of mechanical springs and shaft design to calculate stresses, deflections, and critical speeds, considering functional requirements and constraints.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3						1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Basic Requirements of Machine Elements, steps in the design process, design factors, and the use of standards in design. Selection of preferred sizes, aesthetic considerations in design, ergonomic considerations in design, concurrent engineering. Tolerances, types of fits, BIS system of fits and tolerances, selection of fits. Selection of materials, strength of mechanical elements, theories of failure, impact load, shock load, fatigue loading, effects of surface, size, temperature and stress concentration.

Module II

Detachable joints: design of screws, standards, thread stresses, pre-loading of bolts, fatigue and shock load, eccentric loading. Power screws: forms of threads, terminology of power screw, torque requirements, self-locking screw, efficiency of square threaded screw, collar friction, torque and overall efficiency. Types of keys: stresses in keys, design of socket and spigot joint, gib and cotter joints, and knuckle joints. Couplings: design of rigid couplings, design of flexible couplings.

Module III

Design of riveted joints, design of bolted assembly for direct loading and eccentric loading. Welded joints, including types of welded joints, stresses, and design considerations for welded joints subjected to axial, torsional, and bending loads. Additionally, addressing welds under fluctuating loads.

Module IV

Design of mechanical springs, stresses and deflections of helical springs, extension springs, compression springs, springs for fatigue loading, energy storage capacity, leaf springs, helical torsion springs, and flat spiral springs. Design of solid and hollow shafts for strength and rigidity, design of shafts for combined bending, torsion, and axial loads, and critical speed of shafts.

Data Book

1. Mahadevan, K. and Balaveera Reddy, K., Design Data Handbook for Mechanical Engineers, 5th Edition, CBS Publishers, (2022).
2. PSG College of Technology, PSG Design Data Book, Revised 13th Edition, DPV Printers, (2022).
3. Lingaiah, K. and Narayana Iyengar, B.R., Machine Design Data Handbook, Vol. 1 and 2, 2nd Edition, McGraw Hill, (2022).

References:

1. Norton, R.L., Machine Design, 6th Edition, Pearson, (2020).
2. Bhandari, V.B., Design of Machine Elements, 4th Edition, McGraw Hill, (2021).
3. Juvinall, R.C. and Marshek, K.M., Fundamentals of Machine Component Design, 7th Edition, Wiley, (2021).
4. Shigley, J.E., Mischke, C.R., and Budynas, R.G., Mechanical Engineering Design, 11th Edition, McGraw Hill, (2020).
5. Singh, S., Machine Design, S. K. Kataria & Sons, (2022).
6. Sharma, C.S. and Purohit, K., Design of Machine Elements, 3rd Edition, PHI Learning, (2022).
7. Pandya, K.C. and Shah, S.P., Machine Design, Charotar Publishing House, (2022).
8. Spotts, M.F., Shoup, T.E., and Hornberger, L.E., Design of Machine Elements, 9th Edition, Pearson, (2022)

23-205-0603: COMPRESSIBLE FLUID FLOW

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the significance of governing equations such as continuity, momentum and energy equations in fluid flows with density variation and get concepts of adiabatic flow, isentropic flow, static and stagnation conditions existing in a compressible flow
2. Analyze the occurrence of normal shocks, oblique shocks and expansion waves in propulsive devices
3. Apply the influence of friction and heat transfer in the behaviour of the flow through ducts
4. Get exposed to the devices used for the measurement of pressure, velocity, flow, density, Mach number and temperature

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Introduction to gas dynamics: System and Control Volume approach, Conservation of Mass, Momentum and Energy, Steady Flow Energy Equation, Entropy changes in fluid flow, Stagnation state, Critical state, Mach number, Effect of Mach number on compressibility, Classification of fluid flow based on Mach number, Acoustic wave propagation speed, Mach cone.

Isentropic flow with variable area: Isentropic flow of an ideal gas, Comparison of isentropic and adiabatic processes, Mach number variation with Area, Mass flow rate, Critical state, Geometric

choking, Area ratio as a function of Mach number, Impulse function, Isentropic flow through Convergent nozzle and Convergent Divergent nozzle, Isentropic flow through diffusers.

Module II

Normal Shocks: Fundamental relations for normal shock, Prandtl Meyer relation for normal shock, Rankine-Hugoniot relation for normal shock, Change in entropy across a shock, Impossibility of shock in subsonic flow, Strength of a shock, Variation of flow properties across a normal shock.
Oblique Shocks and Expansion waves: Fundamental relations, Prandtl's relation and Rankine-Hugoniot relation for oblique shock, θ-β-M diagram, Reflected shocks, Variation of flow parameters, Expansion of supersonic flow, Supersonic flow around a convex corner, Prandtl Meyer angle, Mach Waves.

Module III

Fanno flow: Adiabatic flow in constant area duct with friction, Fanno line, Fanno relation for perfect gas, Friction choking, Variation of Mach number with duct length, Variation of flow properties.
Rayleigh flow: Frictionless flow in constant area duct with heat transfer, Rayleigh line, Rayleigh equations for a perfect gas, Thermal choking, Maximum heat transfer, Variation of flow properties.

Module IV

Methods of flow measurements: Methods of measurement of pressure, temperature, density and velocity, Pitot tube, Prandtl Pitot static tube, Supersonic Pitot tube, Shock tube, Rayleigh Supersonic Pitot formula, Temperature recovery factor, Hot wire anemometer, Working principle of Shadowgraph, Velocimeter, Schlieren apparatus and Interferometer, Wind Tunnels – Subsonic and Supersonic Wind tunnels.

Note: *Standard Gas Tables are permitted for the examination*

References:

1. Anderson, J.D., Modern Compressible Flow: With Historical Perspective, 4th Edition, McGraw-Hill, (2022).
2. Oosthuizen, P.H. and Carscallen, W.E., Introduction to Compressible Fluid Flow, 3rd Edition, Taylor & Francis, (2021).
3. Babu, V., Fundamentals of Compressible Fluid Dynamics, 2nd Edition, PHI Learning, (2022).
4. John, J.E.A. and Keith, T.G., Gas Dynamics, 4th Edition, Pearson, (2022).
5. Yahya, S.M., Fundamentals of Compressible Flow, 3rd Edition, New Age International Publishers, (2017).
6. Shapiro, A.H., The Dynamics and Thermodynamics of Compressible Fluid Flow, Volume 1, The Ronald Press Company, (1953).

23-205-0604: HEAT AND MASS TRANSFER

Course Outcomes:

On completion of this course, the student will be able to:

1. Apply Fourier's law and heat diffusion equation for analyzing conduction heat transfer in solids, including critical insulation thickness and extended surfaces.
2. Evaluate convective heat transfer coefficients for laminar and turbulent flows using empirical relations and analyze natural convection and phase change processes.
3. Assess thermal radiation concepts, laws and heat exchange between surfaces using shape factors, resistances and electrical analogy.
4. Design parallel and counter flow heat exchangers using LMTD and NTU methods and detailed design of shell and tube exchangers.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Introduction to heat transfer: basic modes of heat transfer, conduction heat transfer, Fourier law of heat conduction, temperature dependence of thermal conductivity, derivation of general heat conduction equation in Cartesian coordinates. Expressions for cylindrical and spherical coordinates heat conduction equation. Boundary conditions, one-dimensional steady-state conduction, critical insulation thickness, one-dimensional steady conduction, extended surfaces, conduction shape factor, unsteady state heat conduction in one-dimension, lumped heat capacity system, introduction to numerical methods in conduction.

Module II

Convective heat transfer: Newton’s law of cooling, Prandtl number. Laminar forced convection heat transfer flow over flat plates, fully developed laminar flow in pipes, empirical relations for turbulent forced convection inside and outside pipe flows, bank of tubes inline and staggered arrangement. Natural convection- natural convection heat transfer from vertical plates and horizontal tubes, vertical tubes, condensation and boiling, film and dropwise condensation, film boiling and pool boiling, introduction to multiphase flow and heat transfer. Diffusion and convective mass transfer, Fick's law of diffusion.

Module III

Radiative transfer: electromagnetic radiation spectrum, thermal radiation, radiation properties, black body, grey body, monochromatic and total emissive power, Planck’s law, Stefan-Boltzmann law, Wien’s displacement law, Kirchhoff's identity, shape factor- reciprocity relation, heat exchange between non-black bodies, surface and shape resistances, electrical network analogy, heat transfer between parallel plates, cylinders and spheres, radiation shields.

Module IV

Heat Exchangers: Type of heat exchangers, overall heat transfer coefficient, fouling factors, Logarithmic mean temperature difference (LMTD), derivation of LMTD for parallel flow heat exchangers, LMTD correction factor, effectiveness, NTU method of heat exchanger analysis, effectiveness, derivation for parallel flow heat exchanger. Design of parallel flow, counterflow, cross flow heat exchangers. Design of shell and tube heat exchangers. Design codes, Detailed design procedure for shell and tube heat exchangers, Bell Delaware Method of Design. Estimation of the number of tubes

The approved data book is to be specified in the question paper.

References:

1. Cengel, Y.A., Heat and Mass Transfer: A Practical Approach, 5th Edition, McGraw Hill, (2020).
2. Bergman, T.L., Incropera, F.P., DeWitt, D.P., Lavine, A.S., Fundamentals of Heat and Mass Transfer, 9th Edition, Wiley, (2022).
3. Holman, J.P., Heat Transfer, 12th Edition, McGraw Hill, (2021).
4. Kreith, F., Manglik, R.M., Bohn, M.S., Principles of Heat Transfer, 8th Edition, Cengage Learning, 2016.
5. Rajput, R.K., Heat and Mass Transfer, 5th Edition, S. Chand, (2022).
6. Gebhart, B., Jaluria, Y., Mahajan, R.L., Sammakia, B.G., Fundamentals of Thermal-Fluid Sciences, 5th Edition, McGraw Hill, (2021).
7. Nag, P.K., Heat and Mass Transfer, 5th Edition, McGraw Hill, (2022).
8. Arthur P Fraas, Heat exchanger design, Wiley, 1989.

Data Book:

1. C.P. Kothandaraman and S. Subramanyan, Heat and Mass Transfer Data Book, 7th Edition, New Age International Publishers, (2019).
2. Domkundwar and Domkundwar, Heat Transfer Data Book, 2nd Edition, Dhanpat Rai Publications, (2021).

23- 205-0605: COMPUTER-AIDED DESIGN AND ANALYSIS

Course Outcomes:

On completion of this course, students will be able to:

1. Explain basic concepts of computer-aided design and analysis and their role in engineering.
2. Create CAD models using different modelling techniques and generate drawings.
3. Learn the basics of FEA and apply FEA to solve 1-D problems.
4. Analyze engineering problems using finite element analysis methods.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3	3	3	3	3			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Module I:

Introduction to Computer-Aided Design (CAD): Role of computers in design, advantages, applications, CAD packages; Computer graphics: Vector vs raster graphics, homogeneous representation, transformations, numerical problems using matrices, data standards, data exchange between CAD packages and Computer Aided Manufacturing (CAM) and Computer Aided Engineering (CAE) packages.

Module II:

CAD Modelling concepts: Wireframe, surface, solid modelling; Introduction to CAD packages: Basic skills, parametric modelling, sketching, extrude, revolution, sweep, loft; Orthographic projections from CAD models. Dimensioning: linear and geometric dimensions. Representation of surface topography and surface condition.

Module III:

Introduction to Finite Element Analysis (FEA): Basic concepts, analysis types; FEA process: Pre-processing, solution, post-processing; Element types: 1D, 2D, 3D; Analysis types: Structural, thermal,

dynamic. FEA Software: Capabilities, limitations, popular packages; Integrating modelling and analysis: CAD to FEA data exchange; Some numerical problems for structural and thermal analysis using FEA packages.

Module IV:

Finite element analysis of one-dimensional problems, procedure, I-D elements and interpolation functions. Weighted Residual and Energy methods, Analysis of one-dimensional second and fourth-order equations, derivation of element equations, assembly, application of boundary conditions, solution, approximation errors in FEA, and computer implementation.

References:

1. Zeid, Ibrahim, CAD/CAM Theory and Practice, McGraw Hill, (2021).
2. Rao, P.N., Computer-Aided Design, McGraw Hill, (2019).
3. Hutton, David V., Fundamentals of Finite Element Analysis, McGraw Hill, (2004).
4. Reddy, J.N., An Introduction to Finite Element Method, McGraw Hill, (2005).

23-205-0610: MACHINE SHOP-II

Course Outcomes:

On completion of this course, students will be able to:

1. Understand the basics of milling operations and milling tools and operate the milling machines to produce engineering components.
2. Learn the basics of CNC programming and operation and gain practical experience in CNC Turning Centre and Machining Centre operations.
3. Use Coordinate Measuring Machines (CMM) to make linear and geometric measurements.
4. Learn the basics of Robot programming and operation and use the robots to perform simple tasks.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2							2	3	3		1	1	3	3
CO2	3	3	2	2	3			2	3	3		1	1	3	3
CO3	3	3	1	1	3			2	3	3		1	1	3	3
CO4	3	3	3	3	3			2	3	3		1	1	3	3

Introduction to Milling and Practical Applications

Overview of Milling: Understanding the basics of milling, including the milling process, types of milling operations, and the distinction between up-milling and down-milling. Milling Machine Types: Introduction to various milling machines, their structures, and functionalities.
Milling Tools: Exploration of different milling tools, their applications, and selection criteria.
Practical Hands-on Experience: Application-based practical sessions involving hands-on experience in milling to reinforce theoretical concepts.

CNC Machines and Advanced Machining Techniques

Introduction to CNC Machines: Understanding the principles and components of CNC machines, emphasizing their role in modern machining. Referencing and Offsets: In-depth exploration of referencing, zero offsets, and tool offsets in CNC machining. G and M Codes: Learning the programming languages essential for CNC machining operations. Modular Tools and Fixtures: Examination of modular tools and fixtures used in CNC machining centres. Practical Exposure: Hands-on sessions on CNC turning centres and machining centres, allowing students to apply CNC principles in real-world scenarios.

Coordinate Measuring Machines (CMM) and Precision Machining

Introduction to CMM: Understanding the principles and applications of Coordinate Measuring Machines in precision machining. Linear and Geometric Machining: Exposure to techniques for achieving precision in machining, covering both linear and geometric dimensions. Practical Applications: Application-based sessions using CMM to measure and validate machined components, ensuring accuracy and quality in production.

Robotics in Machining and Practical Programming

Introduction to Robotics: Overview of robotic configurations, components, and their applications in machining processes. Robot Programming: Understanding the basics of robot programming for machining applications. Practical Exposure: Hands-on sessions involving the programming and operation of robots in a machining environment, providing practical insights into automated manufacturing processes.

References:

1. Mehta, N.K., Fundamentals of CNC Machining, 1st Edition, McGraw Hill, (2017).
2. Smid, P., CNC Programming Handbook: A Comprehensive Guide to Practical CNC Programming, 3rd Edition, Industrial Press, (2008).
3. Bowman, M., CNC Milling in the Workshop, 1st Edition, Crowood Metalworking Guides, (2011).
4. Hocken, R.J. and Pereira, P.H., Coordinate Measuring Machines and Systems, 2nd Edition, CRC Press, (2011).
5. Hughes, C. and Hughes, T., Robot Programming: A Guide to Controlling Autonomous Robots, 1st Edition, Que Publishing, (2016).
6. Fitzpatrick, M., Machining and CNC Technology, 3rd Edition, McGraw Hill, (2013).
7. Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Prentice Hall, (2015).

23-205-0611:THERMAL ENGINEERING LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Design the required experiments.
2. Conduct different performance tests on engines and refrigeration equipment using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3					2	3	3		1	1	3	1
CO2	3	3	3					2	3	3		1	1	3	1
CO3	3	3	3					2	3	3		1	1	3	1
CO4	3	3	3					2	3	3		1	1	3	1

Practicals:

1. Determination of flash and fire points of fuels and oils
2. Viscosity of fuels and oils and its variation with temperature
3. Determination of Calorific values of fuels
4. Performance of simple journal bearings
5. Valve timing diagrams of I.C. engines

6. Performance test on Petrol and Diesel engine
7. Forced convection heat transfer for tube flow
8. Performance test on air compressors
9. Test on air conditioning equipment and refrigeration equipment.

PROFESSIONAL ELECTIVE – II

23-205-0606: ADVANCED FLUID MECHANICS

Course Outcomes:

1. Understand and apply continuity, momentum and energy equations using vector/ tensor notations and inviscid incompressible flows
2. Understand and apply knowledge of Navier-stokes equations, Dimensional analysis and similitude
3. Understand and apply principles of boundary layer theory, boundary layer separation and control
4. Understand and apply principles of turbulent flows and its governing equations

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Stress analysis in fluids: Stress components in a real fluid, Translational motion of fluid element, Rate of strain quadric and principal stresses. Incompressible inviscid flows: Vorticity, Circulation, Irrotational flow, velocity potential, stream function, relation between stream function and potential function in ideal flows, Uniform flow, Source and Sink, Vortex flow, Doublet, Flow about a cylinder without circulation, Lift and drag for flow past a cylinder without circulation, Flow about a rotating cylinder, Karman Vortex street, Magnus effect, Lift and drag for flow about a rotating cylinder.

Module II

Viscous incompressible flow: Navier-Stokes equations in cartesian and cylindrical coordinates, representation of continuity and Navier-Stokes equations using vector and tensor notations. Exact solutions of Navier–Stokes equations, Parallel flow in a straight channel, Couette flow between two parallel flat plates, Plane Poiseuille flow. Dimensional Analysis: Rayleigh's method, Buckingham's Pi theorem, principles of similitude, geometric, kinematic and dynamic similarities, and model studies.

Module III

Laminar boundary layer: Wall Shear and boundary layer thickness, Prandtl boundary layer theory, Blasius solution, Characteristic boundary layer parameters, Karman integral equations. Karman-Pohlhausen method, Separation of boundary layer, Control of boundary layer separation, Mechanism of boundary layer transition.

Module IV:

Turbulent flow: Characteristics of turbulent flow, turbulent flow near a wall, laminar-turbulent transition, Turbulence production and cascade, Mean motion and fluctuations, Derivation of governing equations for turbulent flow, Reynolds averaging, RANS equation turbulent boundary layer equations, Boussinesq approximation.

References

1. Graebel, W.P., Advanced Fluid Mechanics, 3rd Edition, Academic Press, (2021).

2. Shames, I.H., Mechanics of Fluids, 5th Edition, McGraw Hill Education, (2021).
3. Schlichting, H., Gersten, K., Boundary-Layer Theory, 9th Edition, Springer, (2016).
4. Mohanty, A.K., Fluid Mechanics, 4th Edition, Phi Learning Private Limited, (2022).
5. Som, S.K. and Biswas, G., Introduction to Fluid Mechanics and Fluid Machines, 4th Edition, McGraw Hill Education, (2022).
6. White, F.M., Fluid Mechanics, 8th Edition, McGraw-Hill Education, (2020).
7. Kundu, P.K., Cohen, I.M. and Dowling, D.R., Fluid Mechanics, 6th Edition, Academic Press, (2020).
8. Pope, S.B., Turbulent Flows, 2nd Edition, Cambridge University Press, (2020).
9. Biswas, G. and Eswaran, V., Turbulent Flows, 3rd Edition, Alpha Science International Ltd., (2021).

23-205-0607: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MECHANICAL ENGINEERS

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain basic concepts of artificial intelligence, machine learning and their applications in mechanical engineering.
2. Understand different types of machine learning algorithms like supervised, unsupervised and reinforcement learning.
3. Apply machine learning techniques like regression, classification and clustering to solve problems in mechanical engineering.
4. Develop machine learning models using libraries like TensorFlow, PyTorch, and scikit-learn for mechanical engineering tasks.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1						1		1		1	3	3	1
CO2	3	3	1	3				1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Module I

Introduction to AI and ML: Introduction to artificial intelligence and machine learning; AI and mechanical engineering; Types of machine learning - supervised, unsupervised, semi-supervised and reinforcement learning; Model evaluation metrics; Overfitting and regularisation.

Module II

Supervised Learning: Linear regression, Logistic regression, Decision trees, Support vector machines, Neural networks, Model selection, and hyperparameter tuning.

Module III

Unsupervised Learning and Reinforcement Learning: Clustering algorithms like k-means clustering and hierarchical clustering; Dimensionality reduction techniques like PCA; Introduction to reinforcement learning and applications; Q-Learning; Deep Q Networks.

Module IV

AI and ML Applications in Mechanical Engineering: Predictive maintenance and fault diagnosis; Design optimisation; Robot control; Computer vision for quality inspection and process monitoring; Natural language processing for documentation.

References

1. Gardner, M.W. and Dorling, S.R., Artificial intelligence in the mechanical engineering industry, Nature Machine Intelligence, (2022).
2. Sutton, R.S. and Barto, A.G. Reinforcement learning: An introduction. MIT Press, (2018).
3. Geron, A. Hands-on machine learning with Scikit-Learn, Keras and TensorFlow, O'Reilly Media, (2019).
4. Russell, S. J. and Norvig, P. Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, (2020).
5. Goodfellow, I., Bengio, Y. and Courville, A. Deep Learning, MIT Press, (2016).

23-205-0608: FINITE ELEMENT METHODS FOR ENGINEERS

Course Outcomes:

On completion of this course, the student will be able to:

1. Utilize linear vector spaces, transformations, and functionals in the context of finite element analysis.
2. Proficiently conduct finite element analysis for one-dimensional problems, implementing I-D elements and interpolation functions.
3. Apply finite element analysis to solve two-dimensional problems, addressing mesh generation and boundary conditions and analysing specific cases.
4. Investigate alternative formulations, eigenvalue problems, and non-linear scenarios in finite element analysis, including 3-D elements and complex equations.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Module I

Linear vector spaces- Linear transformations and functionals- linear, bilinear and quadratic forms- theory of normed spaces- theory of inner products spaces- concepts from variational calculus- variational methods of approximation- Ritz method- weighted residual method- Galerkin method- subdomain method-collocation method.

Module II

Finite element analysis of one-dimensional problems- procedure- I-D elements and interpolation functions-analysis of one dimensional second and fourth order equations- approximation errors in FEM- computer implementation.

Module III

Finite element analysis of two-dimensional problems- 2-D elements and interpolation functions- 2^{nd} order equations involving a scalar-valued function- comments on mesh generation and composition of boundary condition- analysis of plane elasticity and incompressible fluid flow problems- time dependent problems - transient heat transfer- isoparametric elements and numerical integration.

Module IV

Alternative formulations - the least square formulations- the mixed formulation- eigenvalue problem- non-linear problems- 3-D elements and interpolation functions- formulation of 3-D problems (2 and 3-D Navier Stokes equations, 3D heat transfer equations).

References:

1. Reddy J. N., An Introduction to Finite Element Method, 5th Edition, McGraw Hill, (2022).
2. Reddy J. N., Applied Functional Analysis and Variational Methods in Engineering, 2nd Edition, McGraw Hill, (2010).
3. Zienkiewicz, O., Finite Element Method, 6th Edition, Butterworth Heinemann, (2017).
4. Huebner K. H., The Finite Element Method for Engineers, 4th Edition, John Wiley, (1991).
5. Saeed Moaveni, Finite Element Analysis, 3rd Edition, Prentice Hall, (2021).
6. Rao, S. S., The Finite Element Method in Engineering, 6th Edition, Elsevier, (2018).

23-205-0609(IE): QUALITY ENGINEERING AND MANAGEMENT

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand and apply fundamental concepts related to quality, probability theory, and reliability in a diverse range of industrial scenarios.
2. Analyze and differentiate between various quality management principles, control chart techniques, and acceptance sampling methods.
3. Apply advanced tools and methodologies, such as Total Quality Management (TQM), Six Sigma, and life testing analysis, to enhance quality and reliability.
4. Evaluate and integrate comprehensive approaches for ensuring product quality, process control, and system reliability within the broader context of organizational performance.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1		1		1	3	3	1
CO2	1	3		3				1		1		1	3	3	1
CO3	3	3	1					1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Product quality: Quality definitions, Quality in manufacturing and service organizations, Quality of design, Cost of quality- failure cost, appraisal cost, prevention cost, Total quality management (TQM)-evolution and principles, Quality improvement and employees- Quality circles, KAIZEN, PDCA cycle. Tools for identifying quality problems and causes, ISO 9001:2015.

Module II

Shewhart's control chart for variables: Fundamentals of the theory of probability and probability distributions, Variables, Attributes, Relationship between sample parameters and Universe parameters, X bar and R charts-control limits, process in control and out of control; Process Capability-Six sigma. Control chart for fraction defectives: selection of subgroups, choice between p-chart and np-chart, control limits, Sensitivity of the P-chart. Control charts for defects: C-chart and U-chart- control limits, preparation and uses.

Module III

Acceptance sampling: Sampling methods, Operating characteristics curve (OC curve)-producers risk, consumers risk, AQL, RQL, LTPD, AOQL. Selection of sampling plans: Average Total Inspection (ATI), Choice to minimise ATI, ATI curves for double and sequential sampling plans.

Module IV

Life testing and Reliability: Reliability definition and concept, Life test analysis, failure distribution, probability of equipment failure-conventional model, failure rate, MTBF, MTTF, MTTR, Exponential

reliability function, Series, Parallel and Combinational reliability, Redundant system, Maintainability and Availability.

References:

1. Grant, E. L., Statistical Quality Control, 10th Edition, McGraw Hill, (2022).
2. Srinath, L.S., Reliability Engineering: Principles and Practice, 3rd Edition, East West Press, (2021).
3. Mahajan, Statistical Quality Control: Concepts and Applications, Dhanpat Rai Publications, (2019).
4. Montgomery, D. C., Introduction to Statistical Quality Control, 8th Edition, Wiley, (2023).
5. Pyzdek, T., The Six Sigma Handbook, 5th Edition, McGraw Hill, (2020).
6. ISO, ISO 9001:2015 Quality Management Systems – Requirements, International Organization for Standardization, (2015).

23-205-0701: REFRIGERATION AND AIR CONDITIONING

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the basics of different refrigeration cycles.
2. Study the vapour compression and vapour absorption refrigeration cycles- both theoretical and practical cycles, properties of refrigerants, and selection criteria for refrigerants.
3. Understand the different components of refrigeration systems.
4. Get knowledge of psychrometry, and air-conditioning systems and will be able to do the cooling load calculation

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3					1		1		1	3	3	1
CO2	3	3	3					1		1		1	3	3	1
CO3	3	3	3					1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Principles of refrigeration: Unit of refrigeration, capacity, coefficient of performance. Refrigeration systems: Carnot refrigeration cycle, steam jet refrigeration, thermoelectric refrigeration, vortex tube, pulse tube, air refrigeration cycle bootstrap and bootstrap evaporative cooling. Thermodynamic analysis of the Bell-Coleman cycle.

Module II

Vapour compression system: Theoretical and practical cycles, simple and multi-pressure systems. Thermodynamic analysis. Vapour absorption system: The principle of operation of aqua-ammonia and lithium bromide-water systems. Electrolux system. Comparison between vapour compression and absorption systems. Refrigerants: Thermodynamic, physical, and chemical properties of refrigerants. Environment-friendly refrigerants and their properties. Selection criteria of refrigerants.

Module III

System components: Compressors, reciprocating compressors, single and multistage compressors; rotary compressors, centrifugal and axial flow compressors; screw type and vane type compressors. Hermetic, semi-hermetic, and open compressors. Condensers: Water-cooled and air-cooled condensers, evaporative condensers. Expansion devices: Capillary tube, thermostatic expansion valve, float valves. Evaporators: Natural convection and forced convection coils, flooded evaporators, and direct expansion coils.

Module IV

Psychrometry: Psychrometric properties and processes. Determination of air entering the conditioned space. Air conditioning systems: Summer and winter air conditioning systems, central and unitary

systems. Human comfort: Comfort chart and limitations, effective temperature, factors governing effective temperature. Cooling load calculation: Various heat sources. Design of air conditioning systems: Duct design, air distribution systems, heating systems.

Note: Refrigeration Data Books are permitted for examination

1. Domkundwar, A.V. and Domkundwar, V.M., Refrigeration and Air Conditioning Data Book, 7th Edition, Snow White Publication Pvt Ltd, (2021).

References:

1. Dossat, R.J. and Horan, T.J., Principles of Refrigeration, 7th Edition, Pearson, (2022).
2. Stoecker, W.F., Jones, J.W. and Harahap, F., Refrigeration and Air Conditioning, 4th Edition, McGraw Hill, (2021).
3. Whitman, W.C, Johnson, W.M. and Tomczyk, J., Refrigeration and Air Conditioning Technology, 8th Edition, Cengage Learning, (2015).
4. Arora, C.P., Refrigeration and Air Conditioning, 5th Edition, PHI Learning, (2021).
5. McQuiston, F.C., Parker, J.D. and Spitler, J.D., Heating, Ventilating, and Air Conditioning: Analysis and Design, 8th Edition, Wiley, (2021).
6. Arora, R.C. and Domkundwar, S., A Textbook of Refrigeration and Air Conditioning, 2nd Edition, Dhanpat Rai & Co., (2022).

23-205-0702: VIBRATION AND NOISE CONTROL

Course Outcomes:

On completion of this course, the student will be able to:

1. Model a given physical system using spring, mass, and damping elements.
2. Formulate the governing differential equations of single-dof, multi-dof, and continuous systems.
3. Solve the governing equations and interpret the results.
4. Understand the effects of noise and the control measures adopted.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Introduction to mechanical vibrations: Free vibrations, Response of single degree of freedom system, Viscous damping, under-damped, critically-damped and over-damped vibrations, Forced vibrations, Transmissibility, Vibration isolation, Support excited motion, Rotating Unbalance, Coulomb damping.

Module II

Multi-degree freedom systems: two degrees of freedom and three degrees of freedom spring-mass systems, Matrix formulation, Eigenvalue problems, Mode shapes, Coordinate Coupling, Lagrange's equations. Torsional vibratory systems, Torsionally equivalent shaft, Two rotor system, Three rotor system, Geared system, Location of Nodes, Frequency of torsional vibration.
Measurement of vibration - Accelerometer and Seismometer.

Module III

Transverse vibration of shafts, Whirling speed of shafts, Approximate methods to analyse vibratory system: Rayleigh's energy method, Dunkerley's method.
The vibration of continuous systems: exact methods, boundary value problem, Eigenvalue problem, Axial vibration of rods, Transverse vibration of beams.

Module IV

Noise, Sound level meter scales, Octave bands, Psychophysical indices, Overall sound pressure level, Sound intensity level, Sound power level, Noise and loss of hearing, Normal hearing and hearing loss, Temporary hearing loss from continuous noise, Permanent hearing loss from continuous noise, Physiological effects of noise, Specific effects of noise, Noise exposure limits, Continuous and intermittent noise, Impulse noise, Annoyance of noise, Jet noise, Noise control; control at the source, control at the receiver, control along the path, Cylindrical and spherical acoustic waves.

References:

1. Rao, S.S., Mechanical Vibrations, 6th Edition, Pearson, (2016).
2. Sanders, M.S. and McCormick, E.J., Human Factors in Engineering and Design, 12th Edition, McGraw-Hill Education, (2022).
3. Thomson, W.T. and Dahleh, M.D., Theory of Vibration with Applications, 6th Edition, Pearson, (2021).
4. Tongue, B.H., Principles of Vibrations, 2nd Edition, Oxford University Press, (2010).
5. Shabana, A.A., An Introduction to Mechanical Vibrations, Cambridge University Press, (2022).
6. Fletcher, N.H. and Rossing, T.D., The Physics of Musical Instruments, 3rd Edition, Springer, (2021).
7. Nag, D. and Abhijit, S., Mechanical Vibrations and Condition Monitoring, 2nd Edition, CRC Press, (2022).

23-205-0703: DESIGN OF MACHINE ELEMENTS - II

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand fundamental principles in mechanical design, encompassing clutches, brakes, belts, gears, bearings, and lubrication systems.
2. Apply design principles to create and calculate mechanical components, demonstrating proficiency in the design of clutches, brakes, belts, gears, bearings, and lubrication systems.
3. Analyze stress factors, load-bearing capacity, and critical design aspects in mechanical components, critically evaluating the strength, durability, and performance under diverse operating conditions.
4. Optimize designs for manufacturing considering the ease of production, material selection, and cost-effectiveness. Create detailed working drawings with specifications, tolerances, and surface finish requirements

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3					1		1		1	3	3	1

Module I

Design of Clutches: Classification of clutches, positive clutches, single and multi-plate friction clutches, cone clutch, torque analysis of plate/disc clutch, uniform wear and uniform pressure theories, centrifugal clutches. Design of brakes: Design of internal expansion elements, assumptions, design of external contraction elements, band-type brakes.Design of belt and chain drives: flat belts, V-belts, and roller chains.

Module II

Design of Gears: Classification of gears, spur, helical, bevel and worm gears, general profiles of gear tooth, terms used in gears, and gear materials. Methods of gear drives, beam strength of a gear tooth,

velocity factor, allowable stresses, design stresses, bending strength of gear teeth, dynamic tooth load, wear tooth load, endurance strength, heat dissipation, design for strength and wear**,**

Module III

Bearings and lubrication: types of lubrication, viscosity, journal bearing with perfect lubrication, hydrodynamic theory, design factors, bearing load, bearing dimensions, and journal bearing design. Ball and roller bearings, bearing life, static and dynamic capacity, selection of bearings with axial and radial loads, bearing materials used. Thrust bearings, lubrication, wear of metal, adhesive wear, abrasive wear, corrosion wear, fatigue and impact wear, measurement of friction and wear.

Module IV

Design for manufacturing: Introduction, selection of materials and shapes, general design recommendations for casting, bulk deformation processes like rolled sections, forgings, Design for sheet metal forming processes, design for machining, design for powder metallurgy, screw machine parts, parts produced on milling machines, welded parts, design for assembly, design for reliability and quality. Modification of design for manufacturing easiness for typical products.

Data books allowed for Examination:

1. Mahadevan, K. and Balaveera Reddy, K., Design Data Handbook for Mechanical Engineers, 5th Edition, CBS Publishers, (2017).
2. PSG College of Technology, PSG Design Data Book, 12th Edition, DPV Printers, (2022).
3. Mahadevan, K. and Balaveera Reddy, V., Design Data Handbook for Mechanical Engineers in SI and Metric Units, 4th Edition, McGraw Hill Education, (2019).

References:

1. Budynas, R.G. and Nisbett, J.K., Shigley's Mechanical Engineering Design, 11th Edition, McGraw-Hill Education, (2020).
2. Boothroyd, G., Dewhurst, P. and Knight, W.A., Product Design for Manufacture and Assembly, 3rd Edition, CRC Press, (2011).
3. Bhandari, V.B., Design of Machine Elements, 4th Edition, McGraw Hill Education, (2021).
4. Juvinall, R.C. and Marshek, K.M., Fundamentals of Machine Component Design, 7th Edition, Wiley, (2020).
5. Mott, R.L., Machine Elements in Mechanical Design, 6th Edition, Pearson, (2018).
6. Pandya, S.H. and Shah, T.H., Machine Design, Charotar Publishing House, (2022).
7. Kumar, K.L., Machine Design, 2nd Edition, Vikas Publishing House, (2021).
8. Rajoria, M. and Gupta, R., Machine Design, Laxmi Publications, (2021).

23-205-0712:HEAT AND MASS TRANSFER LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:
1. Design the required experiments
2. Conduct different heat transfer experiments using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				2	3	3		1	1	3	1
CO2	3	3	3	3				2	3	3		1	1	3	1
CO3	3	3	3	3				2	3	3		1	1	3	1
CO4	3	3	3	3				2	3	3		1	1	3	1

Introduction to fundamentals of heat transfer - condensation and boiling heat exchanges experimental techniques in thermal sciences

Practicals:

1. Performance studies on a shell and tube heat exchanger
2. Performance studies on parallel and counter flow arrangements in a concentric pipe heat exchanger
3. Emissivity measurement of a radiating surface
4. Measurement of solar radiation
5. Thermal conductivity of a metal rod
6. Measurement of unsteady state conduction heat transfer
7. Experimental study on forced convection heat transfer
8. Experimental study of dropwise and filmwise condensation
9. Experiments on boiling heat transfer
10. Measurement of critical heat flux.

23-205-0713: CAD AND ANALYSIS LABORATORY

Course Outcomes:

On completion of this course, the student will be able to:

1. Create parametric CAD models using best practices and generate complete engineering drawings documenting designs
2. Perform basic stress, vibration, thermal, and fluid analyses
3. Select appropriate analysis methods for engineering problems
4. Interpret analysis results and evaluate design performance

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	3			1		1		1	3	3	1
CO2	3	3	3	3	3			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Computer-Aided Design (CAD)

Introduction to CAD Packages: Overview of packages: FreeCAD, SolidWorks, Fusion 360, NX, CATIA, Parametric modelling concepts, Sketching and solid/surface modelling, Drawings and Documentation: Drafting standards, dimensioning, tolerances, annotations, surface finish specifications. Sheet Metal and Assembly Modelling.

Computer Aided Analysis (CAE)

Introduction to CAE Software: Packages like ANSYS, Abaqus, NASTRAN, analysis concepts and methods, meshing, boundary conditions, CAD/CAE data exchange, importing and exporting between software, and format considerations. Engineering Analysis: Structural (stress) analysis types, linear, non-linear, contact, buckling; Dynamic analysis types, modal, harmonic, transient; Thermal analysis types: Steady-state and transient; Fluid flow analysis

Laboratory Projects:

1. Parametric Part Modelling
2. Drawing Creation
3. Sheet Metal
4. Assembly
5. Stress Analysis
6. Thermal Analysis
7. Modal Analysis
8. Fluid Analysis

References:

1. Rao, S.S., Mechanical Vibrations, 6th Edition, Pearson, (2016).
2. Hoffman, C.M. and Ananthasuresh, G.K., Computational Fluid Dynamics for Engineers, Cambridge University Press, (2018).
3. Logan, D., A First Course in the Finite Element Method, 6th Edition, Cengage Learning, (2016).
4. Kurowski, P., Engineering Analysis with SolidWorks Simulation, SDC Publications, (2014).
5. Planchard, J.H. and Planchard, M.P., Engineering Drawing and Design, 7th Edition, McGraw-Hill, (2012).
6. Bethune, J., CAD Fundamentals for Architecture, Routledge, (2013).

7. Mattson, C.A., Introduction to Mechanical System Simulation Using Adams, SDC Publications, (2019).
8. Zeid, I., CAD/CAM Theory and Practice, 2nd Edition, McGraw-Hill, (2021).
9. Tickoo, S., CATIA V5-6R2020 for Designers, 17th Edition, CADCIM Technologies, (2020).
10. Sokovic, M. and Kopac, J., RE (Reverse Engineering), Springer-Verlag, (2006).

23-205-0714: ENTREPRENEURSHIP DEVELOPMENT

Course Outcomes:

On completion of this course, the student will be able to:
1. Develop awareness about the importance of entrepreneurship opportunities available in the society
2. Get acquainted with the challenges faced by the entrepreneur

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1					1			1	1	1		1	1	1	2
CO2					1			1	1	1		1	1	1	2

Exercises:

1. To study the types of entrepreneurs and the factors affecting entrepreneurial growth.
2. To assess the major motives influencing an entrepreneur
3. To make an overview of the various stress management techniques
4. How to identify and select a good business opportunity?
5. Preparation of a techno-economic feasibility report for a given project
6. Preparation of a preliminary project report for a given project
7. To identify the various sources of finance and management of working capital
8. Carry out the costing and break-even analysis of a proposed project
9. Preparation of a PERT / CPM chart for the various activities involved in a project
10. To make a study of the various causes and consequences of sickness in small businesses and identify corrective measures.
11. To analyze logistics and supply chain processes for a proposed business venture.

References:

1. Rajeev, R., Entrepreneurship, 5th Edition, Oxford University Press, (2022).
2. Gordon, E. & Natarajan, K., Entrepreneurship Development, 6th edition, Himalaya Publishing House, (2022).
3. Coulter, M.K., Entrepreneurship in Action, 5th edition, Pearson Education, (2021).
4. Jain, P.C., Handbook for New Entrepreneurs, 2nd Edition, McGraw Hill Education, (2019).
5. Khanka, S.S., Entrepreneurial Development, 12th edition, S. Chand Publishing, (2020).

Note: *There will only be continuous evaluation for this course. The evaluation will be based on the performance of the student in the exercises given above. A minimum of 50% marks is required for a pass.*

23-205-0715: PROJECT PHASE I

Course Outcomes:

On completion of the Project, the student will be able to:

1. Conduct a comprehensive literature survey to identify and analyze a specific problem statement in Mechanical Engineering.
2. Formulate a well-structured project proposal by synthesizing literature insights and engaging with industry experts and academic mentors.
3. Develop a detailed execution plan for Phase II, including resource allocation, timeline, and risk management strategies.
4. Demonstrate technical communication skills through a properly formatted thesis document and professional PowerPoint presentations.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1			1	2	2	1	1	3	3	1
CO2	3	2	1	1	1	1	1	1	3	2	1	1	3	3	1
CO3	3	3	1	1	1	1	1	1	3	2	1	1	3	3	1
CO4					3			1	3	2	1	1	3	3	1

This course aims to equip undergraduate students in Mechanical Engineering with the essential skills and knowledge required to successfully navigate through the initial phases of a project. Students will learn to conduct a comprehensive literature survey, identify and focus on a specific problem, formulate a project proposal, develop an execution plan for Phase II, and enhance their technical communication skills through thesis preparation and presentation techniques.

Topics to be Covered

Introduction to Literature Survey and Problem Identification: Understanding the significance of literature survey in research, Techniques for conducting a thorough literature review, identifying relevant areas of study within Mechanical Engineering, and Narrowing down to a specific problem statement.

Formulating a Project Proposal: Guidelines for structuring a project proposal, the importance of consultation with industry experts and academic mentors, incorporating insights from the literature survey into the proposal, Developing a clear and concise problem statement and objectives

Project Execution Planning: Principles of project management and planning, developing a detailed execution plan for Phase II of the project, identifying resources, timeline, and milestones.

Enhancing Presentation Skills: Understanding the elements of effective presentations, Techniques for engaging and communicating technical information, Hands-on practice sessions on preparing and delivering technical presentations, and Peer feedback and improvement strategies.

Technical Communication: Thesis Preparation- Structure and format of a thesis document, Guidelines for writing thesis chapters- introduction, literature review, methodology, results, discussion, conclusion, Typesetting using Word or LaTeX for professional thesis formatting. Prepare PPTs for technical presentation.

Assessment:

Guidelines for evaluation:		Marks
1	Attendance and Regularity	10
2	Literature Survey and Problem Identification	10
3	Project Proposal	10
4	Project Execution Plan	10

Guidelines for evaluation:		Marks
5	Thesis and Presentation Skills Assessment	10
	Total	50

Note: Points (1)-(3) are to be evaluated by the respective project guides and project coordinator based on continuous evaluation. (4)-(5) to be evaluated by the final evaluation team comprising of 3 internal Examiners.

References:

1. Jesson, J., Matheson, L., and Lacey, F. M., Doing Your Literature Review: Traditional and Systematic Techniques, Sage Publications Ltd, (2011).
2. Machi, L. A., and McEvoy, B. T., The Literature Review: Six Steps to Success, Corwin Press, (2016).
3. Friedland, A., and Folt, C., Writing Successful Science Proposals, Yale University Press, (2009).
4. Duarte, N., Slide:ology: The Art and Science of Creating Great Presentations, O'Reilly Media, (2008).
5. Joyner, R. L., Rouse, W. A., and Glatthorn, A. A., Writing the Winning Thesis or Dissertation: A Step-by-Step Guide, Corwin Press, (2013).

23-205-716: INTERNSHIP-III

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the real-time technical/managerial skills required and relevant to the subject area of the internship
2. Initiate a habit of proper daily diary writing with adequate and quality information recorded, drawing and sketches and data, thought process and the proper organisation of the information gained during the internship.
3. Conceive the pros and cons of working in a real-time industrial environment and the wonderful results which could evolve through teamwork.
4. Present and defend a self-prepared and corrected internship report (with the help of an internship guide/industry mentors) of a self-created work to a peer audience.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1				1	2	3	1	1			3
CO2	1	1	1	1				1	2	3	1	1			3
CO3	1	1	1	1				1	2	3	1	1			3
CO4	1	1	1	1	3			1	2	3	1	1			3

Internship Guidelines

- An internship plan has to be prepared by the interns incorporating the job description/internship duties, name of the project, if any internship schedule and expected learning outcomes in consultation with the industry supervisor/mentor and institute faculty.
- A detailed training report in the prescribed format shall be submitted at the end of the internship.
- Training Certificates from the industry for the prescribed period shall be submitted at the end of the internship.
- The work shall be reviewed and evaluated periodically.
- Orientation of interns, resource requirement of interns, and monitoring of intern's progress daily shall be carried out by the industry offering the internship in addition to ensuring the safety and welfare of the interns.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member at the level of Associate Professor or above will carry out the final review.

Guidelines for evaluation:

1.	Regularity and progress of work	10
2.	Work knowledge and Involvement	10
3.	Semester End presentation and oral examination	10
4.	Level of completion of the internship	10
5.	Internship Report – Presentation style and content	10
Total		**50** Marks

PROFESSIONAL ELECTIVE-III

23-205-0704 (IE): AUTOMOBILE ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:
1. Compare the working of various types of automobiles.
2. Learn the functions and workings of different engine components
3. Appreciate the use of alternate fuels.
4. Understand the latest technology used in the field of automobile

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Automotive engine classification, S.I. & C.I. engines, combustion chamber types, engine balancing, multi-cylinder arrangements. Multi-axle vehicles. Automobile engine parts: Cylinder block, cylinder head, crankcase, oil pan, cylinder liners, piston, arrangements to control piston slap, piston rings, connecting rod, crankshaft, valves, materials used, valves layout, valve and port timing diagrams, valves actuating mechanism, Variable Valve Timing, Method used to effect variable Valve Timing, Electromagnetic Valves, Cam less engine actuation, wheel balancing, engine tuning, energy balance sheet, cooling curves.

Module II

Fuel supply system: Simple carburettor, constant choke, constant vacuum carburettor, types of carburettor, mixture strength requirements, fuel pumps for petrol engines, petrol injections, diesel fuel pump and fuel injector for diesel engines, Multi-Point Fuel Injection systems, Common Rail Direct Injection systems, Alternate fuels, CNG, advantages, Characteristics of CNG with relation to conventional fuels. Ignition System: Battery ignition system, comparisons between battery ignition and magnetic ignition system, ignition advance methods, electronic ignition. Cooling System: Necessity, Properties of coolants, methods of cooling, Liquid cooled system, Thermosyphon system, Pressure cooling system. Lubrication System: Objectives, properties of lubricants, systems of engine lubrication, Mist lubrication system, Wet sump and dry sump lubrication, Crankcase ventilation.

Module III

Gearbox: sliding mesh gearbox, constant mesh gearbox, synchromesh gearbox, epicyclic gearbox, overdrive, torque converter, automatic transmission an overview, AMT and CVT vehicles. Universal coupling, propeller shaft, final drive, Steering mechanisms, wheel suspension. Factors for wheel alignment: camber, caster, kingpin inclination, toe–in, toe–out. Brakes: Types of brakes, Braking requirements, drum brake and disc brakes, brake efficiency, stopping distance, fading of brakes, Mechanical, Hydraulic and Pneumatic brakes, external calliper brakes, Power-assisted brakes. Anti-lock braking systems. Electrical systems: Electrical lighting system, brake lighting system, warning system and indicators. Exhaust: catalytic converters, emission standards and test, BS-VI norms.

Module IV

Introduction to Hybrid Electric Vehicles: Hybrid Electric Drive-trains and Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles. Battery, Fuel Cell, Super Capacitor and Flywheel energy storage and its analysis, Hybridization of different energy storage devices

References:

1. Newton, Steed, and Garrett, Motor Vehicle Technology, 4th edition, Butterworth-Heinemann, (2020).
2. Kirpal Singh, Automobile Engineering, Vol 1 & Vol 2, 12th edition, Standard Publishers Distributors, (2022).
3. Crouse, Anglin, Automotive Mechanics, 11th Edition, McGraw Hill, (2022).
4. Giri, N.K., Automobile Mechanics, 12th edition, Khanna Publishers, (2022).
5. Giles, K.G., Steering, Suspension and Tyres, 4th edition, Routledge, (2003).
6. Gupta, R.B., Automobile Engineering, 12th edition, Satya Prakashan, (2022).
7. Young, A.P. and Griffiths, Automotive Electrical Systems, Elsevier, 5th edition, (2022).
8. Husain, Iqbal, Electric and Hybrid Vehicles: Design Fundamentals, 3rd edition, CRC Press, (2021).
9. Ehsani, M., Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 4th edition, (2022).
10. Larminie, J. and Lowry, J., Electric Vehicle Technology Explained, Wiley, 3rd Edition, (2022).
11. Mi, C., Hybrid Electric Vehicles, Wiley, 2nd edition, (2022).

23-205-0705: ROBOT KINEMATICS AND DYNAMICS

Course Outcomes:

On completion of this course, the student will be able to:

1. Analyze the fundamentals of robotics, including components, classifications, coordinate frames and transformations
2. Apply kinematic principles to model and analyze the motion of robotic manipulators
3. Formulate and solve robot manipulation problems using analytical methods like inverse kinematics
4. Derive dynamic models of robots using Lagrangian and Newton-Euler formulations

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	3			1		1		1	3	3	1
CO4	3	3	3	3	3			1		1		1	3	3	1

Module I

Robotics Fundamentals: Introduction, Components and Mechanisms of a Robotic System, Robot Classifications, Position and Orientation of Objects, Objects Coordinate Frame, Rotation Matrix, Euler Angles, Roll, Pitch and Yaw Angles, Coordinate Transformations, Joint Variables and Position of End Effectors.

Module II

Kinematics: Dot and Cross Products, Coordinate Frames, Rotations, Homogeneous Coordinates, Link Coordinates, D-H Representation, Transformation Between Two Adjacent Coordinate Frames, Forward Position Kinematics of Robots, and The ARM Equation, Direct Kinematic Analysis for Four-Axis, SCARA Robot and Six-Axis Articulated Robots.

Module III

Motion Planning: The Inverse Kinematics Problem, General Properties of Solutions, Tool Configuration, Inverse Kinematics of Four-Axis SCARA Robot and Six-Axis Articulated Robot, Workspace Analysis, Work Envelope of a Four-Axis SCARA Robot and Five-Axis Articulated Robot Workspace Fixtures, The Pick and Place Operations, Continuous Path Motion, Interpolated Motion, Straight-Line Motion.

Module IV

Dynamics: Introduction, Lagrange's Equation of Kinetic and Potential Energy, Link Inertia Tensor, Link Jacobian Manipulator Inertia Tensor, Gravity, Generalized Forces, Lagrange-Euler Dynamic Model, Dynamic Model of a Two-Axis Planar Robot, Newton Euler Formulation, Lagrange-Euler Formulation.

References:

1. Theory of Applied Robotics Kinematics, Dynamics, and Control, 2nd Edition, Reza N. Jazar, Springer, (2014)
2. Fundamentals of Robotics: Analysis and Control, Robert J. Schilling, Wiley, (2022)
3. Introduction to Robotics: Analysis, Systems, Applications, Saeed B. Niku, Wiley, (2020)
4. Robot Modelling and Control, Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Wiley (2020)
5. Introduction to Robotics: Mechanics and Control, 4th Edition, John J. Craig, Pearson, (2017)
6. Industrial Robotics: Technology, Programming, and Applications, Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, McGraw Hill (2022)

23-205-0706: SUPPLY CHAIN MANAGEMENT

Course Outcomes:

On completion of this course, the student will be able to:

1. Define key concepts related to supply chain management, including drivers, performance measures, inventory control, transportation modes and network design.
2. Apply analytical techniques to solve problems related to inventory management, facility location, capacity allocation and transportation planning across the supply chain network.
3. Analyze supply chain dynamics such as the bullwhip effect and determine appropriate strategies to improve integration, reduce inefficiencies and optimize costs.
4. Evaluate supply chain performance through metrics like customer service, cost tradeoffs and strategic fit; synthesize remedial strategies for issues like the bullwhip effect.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1					1		1		1	3	3	1
CO2	3	3	3					1		1		1	3	3	1
CO3	3	3	3					1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Introduction and a Strategic View of Supply Chains: Evolution of Supply Chain Management (SCM), Importance of the Supply Chain, Decision Phases in a Supply Chain, Process Views of Supply Chain, Enablers of Supply Chain Performance. Supply Chain Performance in India: Challenges in Maintaining Supply Chain in India, Supply Chain Strategy and Performance Measures. Competitive and Supply Chain Strategies: Customer Service and Cost Tradeoffs, Achieving Strategic Fit, Supply Chain Performance Measures, Enhancing Supply Chain Performance.

Module II

Supply Chain Drivers: A Framework for Structuring Drivers. Introduction to Inventory Management: Types of Inventory, Inventory-Related Costs, Managing Inventories in a Supply Chain. Single-Stage Inventory Control: Inventory Control Policies, Periodic Review, and Continuous Review. Deterministic and Probabilistic Models: Managing Cycle Stock, Safety Stock, and Seasonal Stock

Module III

Drivers of Transportation Decisions: Modes of Transportation, Choices, and Comparison of Their Performance Measures. Devising a Strategy for Transportation. Distribution Network Design Options for a Transportation Network: Cross-Docking Practices. Network Design and Operation Decisions: The Role of Network Design in the Supply Chain, Factors Influencing Network Design Decisions, The Framework for Network Design Decisions

Module IV

Models for Facility Location and Capacity Allocation: Network Optimization Models, Capacitated Plant Location Models, Gravity Location Models, Network Operations Models, and Strategic Role of Units in the Network. Innovations in Supply Chains: Supply Chain Integration (Internal and External). Bullwhip Effect: Quantifying the Bullwhip Effect, Remedial Strategies for Coping with the Bullwhip Effect.

References

1. Shah, J., Supply Chain Management: Strategy, Planning and Operation, Pearson, 8th Edition, (2022).
2. Chopra, S., and Meindl, P., Supply Chain Management: Strategy, Planning and Operation, Pearson, 7th Edition, (2022).
3. Levi, D.S., Designing and Managing the Supply Chain: Concepts, Strategies and Cases, Tata McGraw Hill, 4th Edition, (2020).
4. Aquilano, N.J., Operation Management: An Integrated Approach, Wiley, 6th Edition, (2022).
5. Shapiro, J.F., Modeling the Supply Chain, Wadsworth Publishing, 3rd Edition, (2021).
6. Vollmann, T.E., Manufacturing Planning and Control for Supply Chain Management, McGraw Hill, 7th Edition (2022).

23-205-0707: AEROSPACE ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:
1. Know the variations of properties in the international standard atmosphere.
2. Gain knowledge of 2D viscous flow over bodies.
3. Understand aircraft performance and stability.
4. Learn about the principles of wind tunnel testing.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

The atmosphere: International standard atmosphere, characteristics of the troposphere, stratosphere, ionosphere, pressure – temperature - density variations in the atmosphere.
Review of basic fluid dynamics**:** continuity, momentum, and energy equations for compressible and incompressible flows, static, dynamic and stagnation pressure, stagnation enthalpy, temperature, Area – velocity relationship, and Area variation as a function of Mach number.

Module II

Aerodynamics: 2D viscous flow over bodies, 2D airfoils, nomenclature and classification, pressure distribution in viscid and real flows, circulation theory of airfoils, centre of pressure and aerodynamic centre, 2D airfoil characteristics, aspect ratio, induced drag, calculation of induced drag from momentum considerations, skin friction and form drag – Drag divergence - Propellers - Blade element theory, propeller coefficients and charts.

Module III

Aircraft performance**:** Flight envelops, v-n diagrams for manoeuvres, straight and level flight, gliding and climbing, rate of climb, service and absolute ceilings, gliding angle and speed of flattest glider take off, landing performance and length of runway required, range and endurance of aeroplanes, charts for piston and jet engine aircraft, aircraft instruments, Qualitative ideas of stability.

Module IV

Aircraft engines: thrust equations- thrust power, propulsive power, propulsive efficiency, the principle of turbojet engines, engine performance characteristics – Rocket engines.

Principles of wind tunnel testing: open and closed types of wind tunnels, wind tunnel balances, pressure and velocity measurements, supersonic wind tunnels.

Note: *The standard Atmospheric table is permitted in the exam hall.*

References:

1. John D Anderson, "Introduction to Flight," 8th Edition, McGraw Hill, (2019).
2. Kermode, A. C., "Mechanics of Flight," 12th Edition, Prentice Hall, (2017).
3. Francis J. Hale, "Aircraft Performance Selection & Design," 2nd Edition, John Wiley & Sons, (2005).
4. Houghton & Brock, "Aerodynamics for Engineering Students," 3rd Edition, Hodder & Stoughton Educational, (1989).
5. Piercy, N. A. V., "Aerodynamics," 5th Edition, The English Universities Press, (1976).
6. Dommasch, D. O., Sherby S. S., Connolly T. F., "Airplane Aerodynamics," 2nd Edition, Pitman Publishing, (1981).
7. Hill P., & Peterson C., "Mechanics and Thermodynamics of Propulsion," 3rd Edition, Addison Wesley, (1992).

OPEN ELECTIVE – I

23-205-0708: ENERGY CONSERVATION AND ENVIRONMENT PROTECTION

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the overview of World Energy Scenario and energy economics
2. Study the Importance of energy management and energy auditing
3. Learn about renewable energy sources
4. Understand the Environmental Impacts of energy use

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3						3	1		1		1	3	3	1
CO2	3	2					3	1		1		1	3	3	1
CO3	3						3	1		1		1	3	3	1
CO4	3						3	1		1		1	3	3	1

Module I

Overview of world energy scenario: Fossil fuel reserves, estimates, country energy balance construction, examples, trends in energy use patterns. Energy economics: Simple payback period, IRR, NPV, life cycle costing.

Module II

Importance of energy management. Energy auditing: Methodology, analysis of past trends in plant data. Steam systems: Boiler efficiency testing, excess air control. Steam distribution and use: Steam traps, condensate recovery, flash steam utilization. Thermal insulation. Energy conservation in pumps, fans (flow control), compressed air systems, refrigeration and air conditioning systems. Waste heat recovery.

Module III

Cogeneration: concept, options (steam/gas turbines/diesel engine based), selection criteria. Heat exchanger networking: Concept of pinch, target setting, composite curves. Renewable energy sources: Overview of solar, wind, tidal, geothermal, and nuclear energy sources.

Module IV

Environmental impacts of energy use - Air pollution: SOx, NOx, CO, particulates. Solid and water pollution: Formation of pollutants, sources of emissions. Exhaust emission test procedures, standards, and legislation. Environmental audits. Emission factors and global warming: CO2 emissions, impacts. Water pollution.

References:

1. Nakicenovic, N., Grubler, A. and McDonald, A., Global Energy Perspectives, 2nd Edition, Cambridge University Press, (2021).
2. Tester, J.W., Drake, E.M., Driscoll, M.J., Golay, M.W. and Peters, W.A., Sustainable Energy: Choosing Among Options, 2nd Edition, MIT Press, (2012).
3. Klemes, J., Friedler, F., Bulatov, I. and Varbanov, P., Sustainability in the Design, Synthesis and Analysis of Chemical Engineering Processes, 2nd Edition, Butterworth-Heinemann, (2020).
4. Smith, C.B., Energy Management Principles: Applications, Benefits, Savings, 2nd Edition, Fairmont Press, (2019).
5. Cengel, Y.A., Boles, M.A. and Kanoglu, M., Thermodynamics: An Engineering Approach, 9th Edition, McGraw-Hill Education, (2022).
6. Kalogirou, S.A., Solar Energy Engineering: Processes and Systems, 2nd Edition, Academic Press, (2013).
7. Davis, M.L. and Cornwell, D.A., Introduction to Environmental Engineering, 5th Edition, McGraw Hill Higher Education, (2013).
8. El-Halwagi, M.M. and Gabriel, F., Synthesis of Optimal Heat Exchanger Networks, 2nd Edition, Butterworth-Heinemann, (2022).

23-205-0709: PROJECT MANAGEMENT

Course Outcomes:

On completion of this course, students will be able to:

1. Explain the fundamental concepts of project management and its importance in the engineering industry.
2. Develop project plans, schedules, and budgets using various project management tools and techniques.
3. Apply project management principles and methodologies to manage and control project resources, risks, and stakeholder expectations.
4. Analyze and optimize project performance through effective communication, leadership, and team management.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1	2	1	3	1	3	3	1
CO2	3	3	3	3				1	2	1	3	1	3	3	1
CO3	3	3	3	3	1			1	2	1	3	1	3	3	1
CO4	3	3						1	2	3	3	1	3	3	1

Module I

Introduction to Project Management: Definition, importance, and scope of project management; Project life cycle; Project organization and stakeholders; Project manager's roles and responsibilities; Project management frameworks and methodologies (e.g., PMBOK, PRINCE2, Agile); Project management process groups (initiating, planning, executing, monitoring, and closing); Project management information systems and tools.

Project Initiation and Selection: Project selection criteria and techniques; Project feasibility analysis; Project charter and initiation documents; Stakeholder identification and analysis; Project governance and organizational structures; Project management office (PMO) and its functions.

Module II

Project Planning and Scheduling: Project scope management; Work breakdown structure (WBS); Scope definition and scope creep management; Project schedule development using techniques such as Gantt charts, critical path method (CPM), and program evaluation and review technique (PERT); Resource planning and management; Resource levelling and smoothing; Project budgeting and cost estimation techniques (top-down, bottom-up, parametric, etc.); Cost-benefit analysis; Project risk management; Risk identification, analysis, and mitigation strategies; Qualitative and quantitative risk analysis techniques.
Project Procurement and Contracts: Procurement planning and processes; Contract types and selection criteria; Contract negotiation and administration; Supplier management and performance evaluation; Outsourcing and subcontracting in projects; Legal and ethical aspects of project procurement.

Module III

Project Execution and Control: Project execution and control processes; Project monitoring and control techniques; Earned value management (EVM); Project performance measurement and reporting; Project change management; Integrated change control; Quality management in projects; Quality planning, assurance, and control; Communication management in projects; Communication planning and stakeholder management; Team management and leadership; Conflict resolution and negotiation in project teams; Project human resource management.
Project Closure and Evaluation: Project closure processes; Project documentation and knowledge management; Project evaluation and lessons learned; Continuous improvement in project management; Project management best practices and case studies; Project auditing and review processes.

Module IV

Advanced Topics in Project Management: Agile project management; Lean project management; Project management for engineering and construction projects; Project management for research and development projects; Project management for information technology and software development projects; Project portfolio management; Program management; Project management certifications and professional development.

References:

1. Kloppenborg, Timothy J., Contemporary Project Management, Cengage Learning, (2021).
2. Schwalbe, Kathy, Information Technology Project Management, Cengage Learning, (2019).
3. Larson, Erik W., and Clifford F. Gray, Project Management: The Managerial Process, McGraw-Hill Education, (2021).
4. A Guide to the Project Management Body of Knowledge (PMBOK Guide), Project Management Institute, (2021).
5. Wysocki, Robert K., Effective Project Management: Traditional, Agile, Extreme, John Wiley & Sons, (2019).

23-205-0710: HRD AND ORGANISATIONAL BEHAVIOUR

Course Outcomes:

On completion of this course, the student will be able to:

1. Apply the principles and techniques as professionals for developing human resources in an organization.
2. Understand and integrate human resource functions into business management effectively.
3. Develop insight into various individual phenomena observed at the workplace leading to human behaviour.
4. Explore the effects of individual behaviour and attitude on organizational behaviour.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1	1	1		1	3	3	1
CO2	2	2						1	1	1		1	3	3	1
CO3	2	2						1	1	1		1	3	3	1
CO4	2	2						1	1	1		1	3	3	1

Module I

Human Resource Development: An Introduction; Historical Development; Concept of HRD; Characteristics of HRD; Objectives of HRD; Need for HRD; HRD as a total system; Functions of HRD; HRD and Personnel Management.

Module II

Human Resource Management: Role, Objectives and functions of human resource management. Training and Development: Introduction; Training as System; Components of Training development; Benefits of training and development. Motivating Human Resources: Introduction; Motivation at Work; Basic Process; Different Theories; Relationship Between Motivation and Performance.

Module III

Performance Management System: Stakeholder in Performance System; Multi-Source Assessment and Feedback; Balanced Scoreboard; Performance Appraisal; Behaviourally Anchored Rating Scale (BARS). HRM in Mergers and Acquisitions: Introduction to Mergers and Acquisitions; Culture Mixing; Challenge in Managing Human Resource.

Module IV

Definition and Scope of Organizational Behavior, Disciplines contributing to Organizational Behavior, Models of OB. Foundations of Individual Behavior: Biological foundations of behaviour, Causes of Human behaviour, Environmental effects on behaviour, Behavior as an input-output system. Attitudes: Nature of Attitudes, Components of Attitudes, Functions of Attitudes, Changing Attitudes and ways of changing work-related attitudes.
Values: Meaning, Importance and relevance of values to OB, Types of values.

References:

1. Dayal Raghubir, Dynamics of Human Resource Development, Mittal Publications, (2015).
2. Bhatia B.S., Emerging Dimensions of HRD: Role and Orientation, Deep & Deep Publications, (2013).
3. Rao T.V., Readings In Human Resource Development, Oxford University Press, (2010).
4. Stephans Robbins, Organizational Behavior, 18th Edition, Pearson, (2021).
5. Davis, Keith, Organizational Behavior: Human Behavior at Work, 16th Edition, McGraw-Hill Education, (2020).
6. G. Moorhead & Griffith, Organizational Behavior, 12th Edition, Pearson, (2019).

23-205-0711: FUNDAMENTALS OF COMBUSTION AND POLLUTION

Course Outcomes:

Upon completion of this course, the student will be able to:

1. Understand the principles of combustion processes in various systems.
2. Analyze combustion efficiency and pollutant formation in combustion systems.
3. Propose and design methods for pollution control in combustion processes.
4. Apply knowledge to address real-world environmental and energy challenges.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Fundamentals of Combustion: Introduction to combustion: Definition, types, and applications. Basics of chemical reactions in combustion. Thermodynamics of combustion: Enthalpy, internal energy, and entropy. Combustion chemistry: Stoichiometry, equilibrium, and reaction kinetics. Flame structure and temperature distribution.

Module II

Combustion Analysis and Efficiency: Analysis of combustion products and pollutants. Combustion efficiency and performance metrics. Measurement techniques for temperature, pressure, and species concentration. Heat transfer in combustion systems. Case studies on the analysis of combustion processes.

Module III

Pollutants in Combustion: Formation mechanisms of pollutants: Nitrogen oxides (NOx), sulphur oxides (SO_x), carbon monoxide (CO), and particulate matter. Emission standards and regulations. Impact of combustion pollutants on the environment and health. Methods for the reduction of pollutants in combustion processes. Case studies on pollution control technologies.

Module IV

Alternative Fuels and Future Trends: Introduction to alternative fuels: biofuels, hydrogen, and synthetic fuels. Combustion of alternative fuels: Challenges and opportunities. Role of combustion in sustainable energy solutions. Future trends in combustion technology and pollution control. Research and development in clean combustion technologies.

References:

1. Turns, S. R., An Introduction to Combustion: Concepts and Applications, 5th Edition, McGraw-Hill, (2023).
2. Baukal, C. E., Industrial Combustion Pollution and Control, 2nd Edition, CRC Press, (2020).
3. Glassman, I., Combustion, 5th Edition, Academic Press, (2022).
4. Law, C. K., Combustion Physics, 2nd Edition, Cambridge University Press, (2021).
5. Environmental Protection Agency (EPA) publications on combustion and pollution control (latest editions).

23-205-0818: SEMINAR

Course Outcomes:

On completion of this course, the student will be able to:

1. Identify and familiarize with some of the good publications and journals in their field of study.
2. Acquaint oneself with the preparation of independent reports, name them based on a central theme and write abstracts, main body, conclusions and references identifying their intended meaning and style.
3. Understand effective use of tools of presentation, generate confidence in presenting a report before an audience and improve their skills in the same.
4. Develop skills like time management, leadership quality and rapport with an audience.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1				1			1		3			1	1	1
CO2	1	1			2			3		3			1	1	1
CO3					3					3			1	1	1
CO4								1		3	1		1	11	1

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Mechanical Engineering. The reference shall include standard journals, conference proceedings, reputed magazines and textbooks and technical reports. The references shall be incorporated in the report following International standards reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal experts comprising of 3 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

23-205-0819: PROJECT PHASE II

Course Outcomes:

On completion of this course, the student will be able to:

1. Realize various steps involved in conducting a project work, like literature survey, the methodology adopted – field study/survey/experiments / numerical work, analysis of the data to arrive at final results and conclusions, etc.
2. Initiate a habit of proper report writing with all of its major components, proper style of writing and preparation of distinct abstract and carved-out conclusions.
3. Conceive the pros and cons of working in a team and the wonderful results which could evolve through teamwork.
4. Present and defend a self-prepared and corrected report (with the help of a project guide) of a self-created work to a peer audience.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1			1	3	3	2	1	3	3	3
CO2	1	2	1	1	2			1	3	3	2	1	3	3	3
CO3	3	3	1	1	1			1	3	3	2	1	3	3	3
CO4					3			1	3	3	2	1	3	3	3

Each batch of students shall develop the project designed during the VII semester. The implementation phase shall proceed as follows:

1. A detailed project report in the prescribed format shall be submitted at the end of the semester. All test results and relevant design and engineering documentation shall be included in the report.
2. The work shall be reviewed and evaluated periodically

A committee consisting of the Project Coordinator (appointed by the Head of the Department / Division), project guide and at least one senior faculty member will carry out the assessment based on at least one interim review and a final review just before the submission of the project report.

The final evaluation of the project shall include the following.

1. Presentation of the work
2. Oral examination
3. Demonstration of the project against design specifications
4. Quality and content of the project report.

Guidelines for evaluation:		***Marks***
1.	Regularity and progress of work	20
2.	Work knowledge and Involvement	50
3.	Semester End presentation and oral examination	50
4.	Level of completion and demonstration of Functionality / Specifications	50
5.	Project Report – Presentation style and content	30
Total		**200**

Note: *Points (1) and (2) are to be evaluated by the respective project guide and the project coordinator based on continuous evaluation. (3)-(5) to be evaluated by the final evaluation team.*

23-205-0820:COMPREHENSIVE VIVA-VOCE

Course Outcomes:

The student will be able to:
1. Refresh all the subjects covered during the programme
2. Gain good knowledge of theory and practice
3. Develop oral communication skills and a positive attitude
4. Face technical interviews with confidence

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1					1		1		1	3	3	1
CO2	3	3	1					1		1		1	3	3	1
CO3	3	3						1		3		1	3	3	1
CO4	3	3						1		3		1	3	3	1

Each student is required to appear for a comprehensive viva voce examination at the end of the complete coursework. The examination panel shall comprise of a minimum of one internal examiner and one external examiner, both appointed by the University. The examiners shall evaluate the students in terms of their conceptual grasp of the entire course of study and practical/analysis skills in the field.

PROFESSIONAL ELECTIVE – IV

23-205-0801: MECHANICAL BEHAVIOUR OF MATERIALS

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the elastic deformation of materials and viscoelasticity.
2. Learn about the permanent deformation and slip line field theory.
3. Study dislocations and plastic deformation in single and polycrystalline materials.
4. Learn about the high-temperature deformation of crystalline materials.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Elastic deformation-Description of stress at a point-state of stress in two and three dimensions-stress tensor-Mohr's circle-description of strain at a point-Mohr's circle of strain- hydrostatic and deviator component of stress-elastic stress-strain relations-strain energy-anisotropy of elastic behaviour-rubber elasticity-viscoelasticity-mechanical damping.

Module II

Permanent deformation-Flow curve- True stress and true strain-yielding criteria for ductile metals-combined stress tests- yield locus-anisotropy in yielding-yield surface and normality-octahedral shear stress and shear strain-Invariants of stress and strain-Plastic stress–strain relations-Two dimensional plastic flow-slip line field theory.

Module III

Dislocations-Edge, screw and mixed dislocations-Properties of dislocations-dislocation stress fields, energies, forces between dislocations, kinks in dislocations, dislocation velocities-Dislocation geometry and crystal structure-slip systems-partial dislocations, interaction of dislocations, dislocation density and macroscopic strain-Plastic deformation in single and polycrystalline materials-initiation of plastic flow in single crystals-stress strain behaviour of single crystals-plastic flow in polycrystals.

Module IV

High-temperature deformation of crystalline materials- creep mechanism, creep in two-phase alloys, independent and sequential processes- deformation mechanism map- Engineering aspects of creep design –creep resistance as related to n\material properties and structure, estimates of creep behaviour, strain rate sensitivity and superplasticity, mechanisms of superplasticity.

References:

1. Dieter, G. E., Mechanical Metallurgy, 3rd Edition, McGraw Hill, (2019).
2. Courtney, T. H., Mechanical Behaviour of Materials, 3rd Edition, Waveland Press Inc., (2018).
3. Hertzberg R. W., Deformation and Fracture Mechanics of Engineering Materials, 5th Edition, John Wiley & Sons, (2019).
4. McClintock F. A. and Argon A. S., Mechanical Behavior of Materials, 2nd Edition, Addison-Wesley Publications, (1975).
5. Reed Hill R. E., Physical Metallurgy Principles, 4th Edition, Affiliated East-West Press, (2015).
6. Honeycombe R. W. K., Plastic Deformation of Metals, 3rd Edition, Edward Arnold, (2006).

23-205-0802: OPERATIONS RESEARCH

Course Outcomes:

On completion of this course, the student will be able to:
1. Solve problems using optimisation methods
2. Develop mathematical skills to approach real-life industrial problems
3. Inculcate ideas to solve problems on transportation and Queueing models
4. Import and analyse case studies to solve future problems

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Operations Research models, Phases of OR study; Optimization Problems, Programming Problems, Linear Programming – formulation, graphical solution, multiple, unbounded and infeasible solutions, application of LP in industry.

Module II

Simplex method – Big M method, two-phase method, unbounded solution, alternate optima and degeneracy, Duality in LP, Economic interpretation of duality.

Module III

Transportation Problem – formulation and solution, degeneracy, Assignment Problem – formulation and solution, unbalanced problems, comparison with TP models.

Module IV

Dynamic Programming – characterisation, Bellman's principle of optimality, Problems with a finite number of concentric decisions; Queueing theory – generalised Poisson queueing models, steady state solution of single server models for infinite and finite queue sizes.

References:

1. Taha, H.A., Operations Research: An Introduction, 11th ed., Pearson Education Inc., (2021)
2. Kanti Swarup, Gupta and Manmohan, Operations Research, Sultan Chand and Sons Publishers, New Delhi, (2022).
3. Hillier, F.S., Lieberman, G.J., Introduction to Operations Research, 10th Ed., McGraw Hill (2015).
4. Ravindran, A., Philips, D.T., Solberg, J.J., Operations Research: Principles and Practice, 3rd Ed., John Wiley and Sons Inc., (2006).
5. Hadley, G., Linear Programming, Addison Wesley Narosa, Narosa Publishing House, (2002)

23-205-0803: CRYOGENIC ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand about the low-temperature properties of engineering materials.
2. Learn about the critical components of the gas liquefaction systems.
3. Study cryogenic fluid storage and transfer systems.
4. Get insight into the insulation and transportation of cryogenic storage vessels.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1						1		1		1	3	3	1
CO2	3	1						1		1		1	3	3	1
CO3	3	1						1		1		1	3	3	1
CO4	3	1						1		1		1	3	3	1

Module I

Introduction to Cryogenic Systems, Historical development, Low-Temperature properties of engineering materials, Mechanical properties, Thermal properties, Electric and Magnetic properties – Cryogenic fluids and their properties. Applications of Cryogenics: Applications in space, Food Processing, Super Conductivity, Electrical Power, Biology, Medicine, Electronics and Cutting Tool Industries.

Module II

Liquefaction systems: ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude and Cascaded System, Magnetic Cooling, Stirling Cycle Cryo Coolers.
Gas liquefaction systems: Introduction -Production of low temperatures-General Liquefaction systems-Liquefaction systems for Neon. Hydrogen and Helium – Critical components of Liquefaction systems.

Module III

Cryogenic Refrigeration systems: Ideal Refrigeration systems-Refrigeration using liquids and gases as refrigerant-Refrigerators using solids as working media, cryogenic fluid storage and transfer systems.

Module IV

Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, super-insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Pressure flow level and temperature measurements. Types of heat exchangers used in cryogenic systems. Cryo pumping applications.

References

1. Klaus D. Timmerhaus, Thomas M. Flynn, Cryogenic Process Engineering, Springer, (2021).
2. Randal F. Barron, Cryogenic Systems, McGraw Hill, (2021).
3. Robert P. Reed and Alvin F. Clark, Cryogenic Engineering, Springer Nature, (2021).
4. Flynn T. M., Cryogenic Engineering, Taylor and Francis Inc., (2021).
5. Mamata Mukhopadhyay, Fundamentals of Cryogenic Engineering, Prentice Hall, (2022).
6. Thipse, S. S., Cryogenics – A Textbook, Narosa Publishing House, (2022).

23-205-0804: HYDRAULIC AND PNEUMATIC DRIVES

Course Outcomes:

On completion of this course, the student will be able to:

1. Describe the operation of hydraulic and pneumatic system components such as actuators and control valves
2. Identify various components of Pneumatic and Hydraulic control systems
3. Develop simple circuits for hydraulic and pneumatic applications.
4. Design and troubleshoot hydraulic and pneumatic systems

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1						1		1		1	3	3	1
CO2	3	1						1		1		1	3	3	1
CO3	3	1	3					1		1		1	3	3	1
CO4	3	1	3					1		1		1	3	3	1

Module I

Introduction to oil hydraulics and pneumatics, their advantages and limitations, ISO symbols and standards in Oil Hydraulics and pneumatics, Recent developments, applications, Basic types and constructions of Hydraulic pumps and motors, Ideal pump and motor analysis, Practical pump and motor analysis, Performance curves and parameters.

Module II

Hydraulic Actuators, Hydraulic control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves, Series and parallel pressure compensation flow control valves, Flapper valve Analysis and Design, Analysis of valve controlled and pump controlled motor, Electro-hydraulic servo valves-specifications, selection and use of servo valves.

Module III

Electro-hydraulic servomechanisms – Electro-hydraulic position control servos and velocity control servos, Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Basic configurations of hydraulic power supplies – Bypass Regulated and Stroke Regulated Hydraulic Power Supplies, Heat generation and dissipation in hydraulic systems: Design and analysis of typical hydraulic circuits, Use of Displacement – Time and Travels-Step diagrams: Synchronization circuits and accumulator sizing. Meter-in, Meter-out and Bleed-off circuits: Fail Safe and Counterbalancing circuits.

Module IV

Components of pneumatic systems: Direction, flow and pressure control valves in pneumatic systems, Development of single and multiple actuator circuits, Valves for logic functions: Time delay valve, Exhaust and supply air throttling, Examples of typical circuits using Displacement – Time and Travel-Step diagrams, Will-dependent control, Travel-dependent control and Time-dependent control, combined control, Program Control, Electro-pneumatic control and air hydraulic control, Applications in Assembly, Feeding, Metalworking, materials handling and plastics working.

References:

1. Joji P., Pneumatic Controls, Wiley India Pvt. Ltd., (2010).
2. Anthony Esposito, Fluid Power with Applications, 8th Edition, Pearson, (2019).
3. Ernst W., Oil Hydraulic Power and its Industrial Applications, 3rd Edition, McGraw Hill, (1978).
4. Lewis E. E. and Stern H., Design of Hydraulic Control Systems, 2nd Edition, McGraw Hill, (1971).
5. Morse A. C., Electrohydraulic Servomechanisms, 3rd Edition, McGraw Hill, (1972).

6. Pippenger J. J. and Koff, R. M., Fluid Power Control Systems, 2nd Edition, McGraw Hill, (1970).
7. Fitch Jr. E. C., Fluid Power Control Systems, 2nd Edition, McGraw Hill, (1975).
8. Khaimovitch, Hydraulic and Pneumatic Control of Machine Tools, Pergamon Press, (1972).

PROFESSIONAL ELECTIVE – V

23-205-0805: MATERIALS MANAGEMENT

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the scope, objectives and phases of material management.
2. Get the concept of static inventory problems.
3. Study dynamic inventory problems under risk.
4. Learn about lot sizing in material requirement planning.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Introduction: Scope, objectives and phases in materials management.
Procurement: purchase procedure, tender, earnest money, security deposit, purchase order, vendor rating. Receipt: Invoice, cash memo, inspection. Storage: methods of storage.
Selective control techniques of inventory – ABC & VED analysis.
Inventory Theory: objectives of keeping an inventory, structure of inventory problems and their analysis, relevant cost.

Module II

Static inventory problems under risk: general characteristics, Christmas tree problem, total cost matrix, opportunity cost matrix, cost of risk, and mathematical formulation of discrete and continuous cases.
Dynamic inventory problems under certainty: general characteristics, optimal lot size models with constant demand and infinite delivery rate with and without back ordering, quantity discounts.

Module III

Dynamic inventory problems under risk: general characteristics, basic kinds of inventory control systems – demand probability distribution – approximate methods to find optimal P & Q systems of inventory, optimal selling policy with fluctuating prices.

Module IV

Material requirement planning: master production schedule, bill of materials, inventory stock, files, MRP process, logic and computational procedure using a simple example, lot sizing in MRP.

References:

1. Deb, A., Materials Management, Academic Publishers, India, (1974).
2. Starr, M. K., & Miller, D. W., Inventory Control: Theory and Practice, Prentice Hall, (1997).
3. Monks, G., Operations Management, 3rd Edition, McGraw-Hill, (1987).
4. Bedi, K., Production & Operations Management, 2nd Edition, Oxford University Press, (2007).

23-205-0806: NANO TECHNOLOGY AND SURFACE ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the structure and properties of nanomaterials
2. Get the concept of synthesis and preparation of nanomaterials
3. Apply surface engineering by material removal and addition
4. Explore advanced surface engineering practices

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				3			1		1		1	3	3	1
CO2	2	2			1			1		1		1	3	3	1
CO3	3				1			1		1		1	3	3	1
CO4	1	1			3			1		1		1	3	3	1

Module I

Atomic Structure and atomic size, emergence and challenges of nanotechnology, carbon age-new form of carbon (CNT to Graphene), the influence of nano over micro/macro, size effects and crystals, large surface-to-volume ratio, surface effects on the properties, Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three-dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties, Application of Nanomaterial: Ferroelectric materials, membrane-based application, polymer-based application.

Module II

Synthesis and preparation of Nanomaterials: Synthesis of bulk nanostructured materials - Sol-Gel processing- bulk and nanocomposite materials - Grinding - high energy ball milling – injection moulding - extrusion - melt quenching and annealing, Synthetic Technique (Physical and Chemical): Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self-assembly Electrochemical approaches: Thin films -Epitaxy –Lithography, One dimensional and Two-dimensional nanostructures: Nanowires and Nanotubes.

Module III

Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing/puffing (principle). Role and estimate of surface roughness, Surface engineering by material addition: From liquid bath - hot dipping (principle and its application). Surface engineering by material addition: Electro-deposition / plating (theory and application), Surface modification of steel and ferrous components: Pack carburizing (principle and application), Surface modification of ferrous and non-ferrous components: Aluminizing, calorizing, diffusional coatings, Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (diffusion from liquid state), Surface modification using gaseous medium, Nitriding, Carbonitriding (diffusion from gaseous state).

Module IV

Advanced surface engineering practices, Surface engineering by energy beams: General classification, scope and principles, types and intensity/energy deposition profile, Surface engineering by energy beams, Laser assisted micro-structural modification – surface melting, hardening, shocking and similar processes, Surface engineering by energy beams: Laser-assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys, Surface engineering by energy beams: Laser-assisted compositional modification – surface cladding, composite surfacing, Surface engineering by energy beams: Electron beam assisted modification and joining, Ion beam assisted microstructure and compositional modification, Surface engineering by spray techniques: Flame spray, Plasma coating.

References:

1. W. Gaddand, D. Brenner, S. Lysherski, and G. J. Infrate (Eds), Handbook of Nanoscience, Engineering, and Technology, CRC Press, (2018).
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, (2016).
3. J. George, Preparation of Thin Films, CRC Press, (2005).
4. Ghuzang G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, (2016).
5. Zhong Lin Wang, Handbook of Nanophase & Nanostructured Materials (Vol. I & II), Springer, (2019).
6. B.D. Cullity, Elements of X-ray Diffraction, 3rd Edition, Addison Wesley, (2001).
7. K.G. Budinski, Surface Engineering for Wear Resistance, Prentice Hall, Englewood Cliffs, (2002).
8. M. Ohring, The Materials Science of Thin Films, 2nd Edition, Academic Press Inc, (2002).

23-205-0807: CONVECTION AND TWO-PHASE FLOWS

Course Outcomes:

Upon completion of this course, the student will be able to:

1. Understand the principles of convection and two-phase flows.
2. Analyze and model heat transfer in different convection scenarios.
3. Apply knowledge to solve engineering problems related to convection and two-phase flows.
4. Design and evaluate systems involving convection and two-phase flows.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I:

Fundamentals of Convection: Introduction to convection and its significance in heat transfer. Classification of convection: natural, forced, and mixed convection. Boundary layers and velocity profiles in convection. Heat transfer correlations for forced and free convection. Thermal boundary layers and their impact on heat transfer. External and internal convection in practical applications.

Module II:

Two-Phase Flows: Introduction to two-phase flows and phase equilibrium. Types of two-phase flows: boiling, condensation, and gas-liquid flows. Flow regimes in two-phase systems. Void fraction and its measurement. Pressure drops and heat transfer in two-phase flows. Boiling and condensation heat transfer correlations.

Module III:

Heat Exchangers in Convection and Two-Phase Flows: Classification of heat exchangers and their applications. Analysis and design of heat exchangers for convection and two-phase flows. Performance parameters of heat exchangers. Special considerations in designing two-phase flow heat exchangers. Selection and optimization of heat exchangers for specific applications.

Module IV:

Applications and Case Studies: Practical applications of convection and two-phase flows in engineering systems. Case studies of heat exchangers, cooling systems, and other relevant applications. Design

projects involving convection and two-phase flows. Troubleshooting and optimization of systems in real-world scenarios.

References:

1. Incropera, F. P., & DeWitt, D. P., Introduction to Heat Transfer, 6th Edition, Wiley, (2019).
2. Kays, W. M., & Crawford, M. E., Convective Heat and Mass Transfer, 4th Edition, McGraw Hill, (2012).
3. Bergman, T. L., Lavine, A. S., Incropera, F. P., & DeWitt, D. P., Fundamentals of Heat and Mass Transfer, 8th Edition, Wiley, (2019).
4. Hewitt, G. F., Shires, G. L., & Bott, T. R., Process Heat Transfer, 2nd Edition, CRC Press, (1994).
5. Collier, J. G., & Thome, J. R., Convective Boiling and Condensation, 3rd Edition, Oxford University Press, (2017).

23-205-0808: PROPULSION ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:
1. Understand the different types of propulsive devices
2. Calculate the thrust and thrust power and also analyse the component efficiencies in various jet engines.
3. Get a concept and operating principles of rocket motors and their performance parameters
4. Explore the aspects of launching and boost dynamics

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Fundamentals of propulsion: Types of propulsive devices - Turboprop, Turbojet, Turbofan, Turboshaft, Ram jet, Scramjet, Pulse jet, Ram rocket, Comparative study of performance characteristics, Propellers, Advance ratio, Types of combustion chambers, Operating characteristics, Materials for turbine blades, Cooling of turbine blades, Surging in compressors and its control, Comparison of centrifugal and axial flow compressors.

Module II

Thrust equation, Calculation of thrust and thrust power, Propulsive efficiency, Thermal efficiency, Transmission efficiency, Overall efficiency of Turbo jet engines, Isentropic flow through nozzles, Thrust Augmentation methods, Analysis of turbojet engine cycle, Component efficiencies, Diffuser efficiency, Compressor efficiency, Burner efficiency, Turbine efficiency, Nozzle efficiency, Analysis of Ramjet engine cycles.

Module III

Rocket Propulsion: General operating principles of rocket motors, Performance parameters for rocket motors and their relationship, Rocket equation, Burn-out velocity, Specific Impulse, Specific Propellant Consumption, Characteristic Velocity, Solid propellant Rocket motor, Grain configuration, Propellant area ratio, Fuels and oxidizers for solid propellant rocket motors, Liquid fuels and oxidizers, Liquid monopropellants, Hybrid rockets, Nuclear, Solar and Electrical rockets.

Module IV

Liquid propellant Rocket engines, Gas pressure feed systems, Turbo-pump feed systems, Cryogenic rocket engines, Properties of cryogenic rocket propellants, Cryogenic fluids as rocket propellants, Injectors, Igniters – Pyrotechnic & Pyrogen Igniters, Cooling of Thrust Chambers – Radiation cooling, Ablative cooling, Regenerative cooling, Film cooling, Transpiration cooling, Aspects of Launching, Kepler's Law, Atmospheric Re-entry of Space vehicles.

Note: *A gas table is permitted in the exam hall.*

References:

1. Zucrow, P., Aircraft and Missile Propulsion, John Wiley, (1956).
2. Sutton, G. P., Rocket Propulsion Elements, 9th Edition, John Wiley & Sons, (2016).
3. Babu, V., Fundamentals of Propulsion, Ane Books Pvt. Ltd., (2015).
4. Hosny, H., Propulsion Systems, University of South Carolina Press, (1995).
5. Treager, I., Aircraft Gas Turbine Engine Technology, 4th Edition, Tata McGraw-Hill, (2008).
6. Cohen, H., and Rogers, G. F. C., Gas Turbine Theory, 7th Edition, Pearson, (2010).
7. Hill, P., & Peterson, C., Mechanics and Thermodynamics of Propulsion, 3rd Edition, Addison Wesley, (1992).
8. Yahya, S. M., Fundamentals of Compressible Flow, 6th Edition, New Age International Publishers, (2013).

PROFESSIONAL ELECTIVE - VI

23-205-0809: ENERGY ENGINEERING

Course Outcomes:

On completion of this course, students will be able to:

1. Explain types of power plants, working principles, flow diagrams, performance analysis, and environmental impacts.
2. Describe various energy storage systems, including battery technologies, fuel cells, and hydrogen storage.
3. Analyze renewable energy systems such as solar, wind, geothermal, ocean energy, and biomass power generation.
4. Design basic systems for power generation from conventional and non-conventional sources and energy storage systems.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3	2	2					1		1		1	3	3	1

Module I

Power Plants: Thermal Power Plants, working principle, schematic layout, flow diagrams, performance analysis, environmental impacts; Hydro Power Plants: classification, typical layouts, load characteristics; Nuclear Power Plants: working principle, nuclear fuel cycle, reactor types, safety mechanisms; Diesel and Gas Turbine Power Plants: plant layout, performance evaluation, applications; Combined Heat and Power Plants: principle, types, performance assessment

Module II

Energy storage systems: Battery storage, types, construction and working principle, performance parameters; Fuel cells: classification, structure and working, performance evaluation; Hydrogen

storage: importance, methods of storage, safety mechanisms; Other storage systems: Compressed air, flywheel, supercapacitors.

Module III

Non-Conventional Energy: Solar Energy, solar thermal systems, photovoltaic types, power generation methods; Wind Energy: windmill configurations, turbine types, system components; Ocean Energy: tidal, OTEC, wave energy conversion devices and systems; Geothermal Energy: resources, types of wells & power plants, working principle; Biomass Energy: sources, and methods of harnessing energy from biomass

Module IV:

System Design**:** Steam Power Plant, boiler, steam turbine, condenser, feed water systems; Hydroelectric Project: Water reservoirs, dams, turbines, power houses; Solar Photovoltaic System: solar panels, batteries, converters, and applications; Wind Electric Generator: wind turbines, electric generators, power electronics; Numerical Problems on the Design of Power Generation and Storage Systems.

References:

1. Nag, P.K., Power Plant Engineering, McGraw Hill, 3rd edition, (2014).
2. El-Wakil, M.M., Powerplant Technology, McGraw Hill, 2nd edition, (2018).
3. Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers, 5th edition, (2021).
4. Duffie, J.A., Beckman, W.A., Solar Engineering of Thermal Processes, Wiley, 4th edition, (2013).

23-205-0810: NONDESTRUCTIVE TESTING TECHNIQUES

Course Outcomes:

Upon completion of this course, the student will be able to:
1. Understand the principles of non-destructive testing (NDT) techniques.
2. Evaluate and select appropriate NDT methods for different materials and applications.
3. Perform NDT inspections using various techniques.
4. Analyze and interpret NDT results for defect detection and characterization.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3	1						1		1		1	3	3	1
CO3	3	1	1					1		1		1	3	3	1
CO4	3	3	3	2				1		1		1	3	3	1

Module I

Introduction to Non-Destructive Testing: Definition and Importance of Non-Destructive Testing. Classification of NDT Methods. Visual Inspection and Penetrant Testing: Basics of Visual Inspection and its Applications. Penetrant Testing Principles and Techniques. Magnetic Particle Testing Principles. Techniques and Equipment Used in Magnetic Particle Testing. Ultrasonic Testing: Nature of Sound Waves. Wave Propagation in Metals, Modes of Sound Wave Generation, Longitudinal, Transverse, Surface, and Lamb Waves. Velocity, Frequency, and Wavelength of Ultrasonic Waves. Ultrasonic Pressure, Intensity, and Impedance. Attenuation of Ultrasonic Waves, Reflection, Refraction, and Mode Convection. Snell's Law and Critical Angles. Fresnel and Fraunhofer Effects. Principle of the Pulse-Echo Method, Through Transmission Method, Resonance Method. Advantages and Limitations. Contact Testing, Immersion Testing, Couplants. Data Presentation: A, B, and C Scan Displays. Comparison of Contact and Immersion Methods.

Module II

Eddy Current Testing: Generation of Eddy Currents. Effect of Change of Impedance on Instrumentation. Properties of Eddy Currents. Eddy Current Sensing Elements, Probes, Types of Coil Arrangement. Factors Affecting Sensing Elements and Coil Impedance. Test Part and Test System. Signal to Noise Ratio. Radiographic Testing: Basics of Radiographic Testing and its Applications. Radiographic Equipment and Safety Measures. Computed Tomography. X-ray Detectors. CT Image Reconstruction Algorithm. Capabilities, Comparison to Other NDT Methods. Industrial CT Applications.

Module III

Principles of Thermography: Contact and Non-Contact Inspection Methods. Heat-Sensitive Paints. Heat-Sensitive Papers, Calibration, and Sensitivity. Non-Contact Thermographic Inspection. Advantages and Limitations. Infrared Radiation and Infrared Detectors. Instrumentations and Methods. Pulsed Thermography. Eddy Current Thermography. Applications. Acoustic Emission Techniques: Principles of Acoustic Emission Techniques. Advantages and Limitations. Instrumentation Applications. Acoustical Holography.

Module IV

Optical Holography and Speckle Metrology: Laser Fundamentals. Coherence. Types of Lasers. Holography. Recording and Reconstruction. Holographic Interferometry. Real-Time, Double-Exposure, and Time-Averaged Techniques. Holographic NDT. Methods of Stressing and Fringe Analysis. Typical Applications, Requirements, Advantages, and Disadvantages. Laser Speckle Metrology Basics. Electronic Speckle Pattern Interferometry (ESPI). Shearography Applications.

References:

1. Shull, P. J., Non-destructive Evaluation: Theory, Techniques, and Applications, CRC Press, (2014).
2. Baldev Raj, T. Jayakumar, M. Thavasimuthu, Non-Destructive Testing and Quality Management, Narosa Publishing House, (2010).
3. J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4th edition (1990).
4. Xavier PV Maldague, "Nondestructive evaluation of materials by infrared thermography", Springer Science & Business Media, (2012).
5. Joseph L. Rose, "Ultrasonic Guided Waves in Solid Media", Cambridge University Press, (2014).
6. ASTM E1316-20, Standard Terminology for Non-destructive Examinations, ASTM International, (2020).
7. Michael, M., Introduction to Non-destructive Testing: A Training Guide, ASNT, (2017).
8. Raghav, S., Practical Non-Destructive Testing, Woodhead Publishing, (2018).

23-205-0811:COMPUTATIONAL FLUID DYNAMICS

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the classifications of partial differential equations
2. Get an insight on consistency, stability, error analysis and finite difference formulations
3. Use numerical algorithms for solving Navier Stokes equations
4. Attain information on grid, domain, boundary conditions, solving equations and post-processing of the data

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Classification of partial differential equations, system of first and second-order partial differential equations, initial and boundary conditions, finite difference formulations, finite difference equations, finite difference approximation of mixed partial derivatives.

Module II

Parabolic partial differential equations, explicit methods, implicit methods, parabolic equation in two space dimensions, consistency, stability and error analysis of finite difference equations, artificial viscosity.

Module III

Elliptic equations, finite difference formulations, solution algorithms, finite difference formulations, splitting methods, multiple step methods.

Module IV

Scalar representation of the Navier-Stokes equations, model equations, numerical algorithms, incompressible Navier-Stokes equation, primitive variable and vorticity, stream function formulations, Poisson equation for pressure, numerical algorithms, boundary conditions, staggered grids.

Reference:

1. Anderson, Computational Fluid Dynamics, 3rd edition, McGraw Hill Education, (2021).
2. Hoffmann, Klaus, Computational Fluid Dynamics for Engineers vol. 2, Engineering Education System, (2021).
3. Malalasekera and Versteeg, Introduction to Finite Volume Method, Pearson, (2022).
4. Sundararajan, T., and Muralidhar, K., Computational Fluid Flow and Heat Transfer, Cengage, (2022).
5. Fletcher, C.A.J., Computational Techniques for Fluid Dynamics, 4th edition, Springer, (2022).
6. Patankar, Suhas, Numerical Heat Transfer and Fluid Flow, CRC Press, (2021).

23-205-0812: MECHANICAL ESTIMATION AND COSTING

Course Outcomes:

On completion of this course, students will be able to:

1. Explain the fundamental concepts of mechanical estimation and costing and their importance in the manufacturing industry.
2. Estimate the cost of materials, labour, and overhead expenses for various mechanical components and assemblies.
3. Apply cost accounting principles and techniques to calculate the total cost of production for mechanical products.
4. Analyze and optimize the cost factors involved in the design and manufacturing of mechanical systems.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3					1		1		1	3	3	1
CO2	3	3	3					1		1		1	3	3	1
CO3	3	3	3					1		1		1	3	3	1
CO4	3	3	3					1		1		1	3	3	1

Module I

Introduction to Mechanical Estimation and Costing: Definition, importance, and scope of mechanical estimation and costing; Cost components: direct and indirect costs, fixed and variable costs; Cost estimation techniques: analytical, parametric, analogous, and activity-based costing methods; Cost-benefit analysis; Cost-volume-profit analysis; Importance of cost estimation in product design and manufacturing decisions; Impact of cost on product competitiveness and profitability.

Module II

Materials Costing: Estimation of material costs for various mechanical components, such as castings, forgings, machined parts, and fabricated structures; Costing of raw materials, consumables, and auxiliary materials; Material wastage and scrap calculations; Material cost optimization through selection of appropriate materials, manufacturing processes, and design alternatives; Value engineering and design for manufacturing and assembly (DFMA) principles.

Module III

Labour Costing: Calculation of labour costs for different manufacturing processes, including machining, welding, assembly, inspection, and testing; Estimation of direct and indirect labour costs; Productivity analysis; Wage systems and incentive plans; Optimization of labour costs through process improvement, automation, and lean manufacturing principles; Time and motion study techniques; Work measurement and standard time calculation.

Module IV

Overhead Expenses: Estimation of overhead expenses, Allocation of overhead expenses to individual products or product lines using appropriate methods; Calculation of overhead rates and their application in cost estimation; Cost Analysis and Optimization: Cost analysis techniques, break-even analysis, life cycle costing, and target costing, lean manufacturing principles, and continuous improvement; Integrated cost management approaches, such as activity-based costing (ABC) and target costing; Impact of cost optimization on product quality, reliability, and customer satisfaction.

References:

1. Ostwald, Phillip F., and Jairo Munoz, Manufacturing Processes and Cost Estimation, Prentice Hall, (2021).
2. Jelen, Frederic C., Cost and Optimization Engineering, McGraw Hill, (2019).
3. Maynard, H.B., Industrial Engineering Handbook, McGraw Hill, (2004).
4. Niebel, Benjamin W., Motion and Time Study for Lean Manufacturing, Prentice Hall, (2005).

OPEN ELECTIVE – II

23-205-0813: CORROSION ENGINEERING

Course Outcomes:

Upon completion of this course, students will be able to:

1. Explain the fundamentals of corrosion including electrochemical reactions, corrosion kinetics, passivation and Roubaix diagrams.
2. Identify and analyze different forms of corrosion like galvanic, pitting, crevice, stress corrosion cracking and high-temperature corrosion.
3. Apply corrosion monitoring methods such as linear polarization, Tafel analysis, and electrochemical impedance spectroscopy.
4. Select appropriate materials, protective coatings and inhibitors to control corrosion in structural and industrial applications.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Introduction: Definitions; Types of corrosion; Thermodynamics, kinetics and mechanisms; Electrochemical reactions and cells; Passivation; Pourbaix diagrams; Factors influencing corrosion rates; Economic impacts

Module II

Corrosion Types: Uniform and localized corrosion; Galvanic, crevice, pitting and intergranular corrosion; Stress corrosion cracking; High-temperature oxidation and hot corrosion; Microbiologically influenced corrosion; Wear and fretting corrosion

Module III

Corrosion Measurement and Prevention Methods: Visual inspection methods; Gravimetric weight loss techniques; Electrochemical techniques - Tafel analysis, linear polarization and EIS; Corrosion probes and electrical resistance techniques; Protective coatings - electroplating, anodizing, metal claddings and organic coatings; Corrosion inhibitors; Material selection

Module IV

Corrosion Control and Design: Design considerations; Cathodic protection - sacrificial anodes and impressed current methods; Standards - NACE and ASTM; Corrosion failures and case studies; Corrosion challenges in automotive, power, petrochemical and aerospace industries

References:

1. Jones, D. A. (1996). Principles and prevention of corrosion. Prentice Hall.
2. Fontana, M. G. (2005). Corrosion engineering. Tata McGraw-Hill Education.
3. Shreir, L. L., Jarman, R. A., & Burstein, G. T. (2010). Corrosion (Vol. 2). Butterworth-Heinemann.

23-205-0814: ENGINEERING ECONOMICS, ESTIMATION AND COSTING

Course Outcomes:

On completion of this course, the students will be able to:

1. Define key economic principles and theories, including demand, supply, elasticity, and macroeconomic concepts.
2. Utilize linear programming, investment analysis, and forecasting in business decision-making.
3. Critically assess the post-independence growth, inclusion issues, and policy debates in the Indian economy.
4. Integrate estimation, measurement, rate analysis, and tender preparation for effective bidding in construction projects.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3	1						1		1		1	3	3	1
CO3	3	1						1		1		1	3	3	1
CO4	3	1						1		1		1	3	3	1

Module 1

Basic Principles and Methodology of Economics, Demand/Supply – elasticity –Government Policies and Application, Theory of the Firm and Market Structure, Basic Macro-economic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies, Aggregate Demand and Supply (IS/LM), Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes.
Public Sector Economics –Welfare, Externalities, Labour Market, Components of Monetary and Financial System, Central Bank – Monetary Aggregates; Commercial Banks and their functions; Capital and Debt Markets, Monetary and Fiscal Policy Tools and their impact on the economy – Inflation and Phillips Curve.

Module II

Elements of Business/Managerial Economics and forms of Organizations, Cost and cost Control – Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming, Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows), Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method.
Indian economy - Brief overview of the post-independence period – plans, Post reform Growth, Structure of productive activity, Issues of Inclusion – Sectors, States/Regions, Groups of people (M/F), Urbanization, Employment–Informal, Organized, Unorganized, Public, Private, Challenges and Policy Debates in Monetary, Fiscal, Social, External sectors.

Module III

Estimation / Measurements for various items- Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, Taking out quantities from the given requirements of the work, Comparison of different alternatives, Bar bending schedules, Mass haul Diagrams, Finishes, Interiors, MEP works; BIM and quantity take-offs; Adding equipment costs; Labour costs; Rate analysis; Material survey-Thumb rules for computation of materials requirement for different

applications, Percentage break-up of the cost, Cost-sensitive index, Market survey of basic materials, Use of computers in quantity surveying.
Specifications-Types, Requirements and importance, Detailed specifications for industrial structures.

Module IV

Rate Analysis, Importance and necessity of the same, Affecting factors, Task work, Daily output from different equipment/ productivity. Tender- Preparation of tender documents, Importance of inviting tenders, Contract types, Relative merits, Prequalification, General and special conditions, Termination of contracts, Extra work and changes, Penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, Claims, Price variation, etc. Preparing Bids- Bid Price buildup: Material, Labour, Equipment costs, Risks, Direct and indirect Overheads, Profits; Bid conditions, alternative specifications; Alternative Bids. Bid process management. Introduction to Acts pertaining to Minimum Wages, Workman's Compensation, Contracts, Arbitration, and Easement rights.

References:

1. Mankiw, G.N., Principles of Economics, Cengage Learning, (2021).
2. Mote, P.S., Managerial Economics, McGraw Hill Education, (2021).
3. Misra, S.K. and Puri, V.K., Indian Economy, Himalaya Publishing House, (2021).
4. Pareek, S., Textbook of Business Economics, Sunrise Publishers, (2021).
5. Chakravarty, M., Estimating, Costing Specifications and Valuation, Universal Book Stall, (2022).
6. Dutta, B.N., Estimating and Costing (Theory and Practice), UBS Publishers, (2022).

23-205-0815: RENEWABLE ENERGY ENGINEERING

Course Outcomes:

On completion of this course, students will be able to:
1. Explain fundamental principles and techniques used in various renewable energy systems.
2. Analyze efficiencies and performance characteristics of renewable energy technologies.
3. Assess feasibility and conduct economic analysis of renewable energy projects.
4. Examine the environmental impact of renewable and conventional energy sources.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3	2						1		1		1	3	3	1
CO3	3			2				1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Introduction to Renewable Energy: Overview of energy usage and sources; Limitations of fossil fuels; Fundamentals and social, political and economic influences of renewable energy technologies; Advantages, potential applications; Renewable energy policies and incentives.

Module II

Solar and Wind Energy: Basics of solar radiation data collection and analysis; Physics of PV cells; Types of PV materials and manufacturing; Solar photovoltaic systems - Applications, stand-alone vs grid connection, tracking systems; Concentrating solar power plants; Solar thermal systems; Principles of wind energy conversion; Wind speed characteristics and data analysis; Wind turbine components and configurations; Aerodynamic modelling of wind turbines; Offshore vs onshore wind farms; Wind farm design considerations; Hybrid solar-wind systems.

Module III

Hydro Power and Bioenergy: Principles and systems of hydroelectric power - Dams, run-of-river, tidal, wave power concepts; Assessment of hydropower potential; Geothermal energy - Geothermal fluids, power plant technologies, direct heating and cooling usage; Bioenergy resource assessment techniques; Biomass conversion processes.

Module IV

Renewable Energy Systems: Assessment of renewable energy potential for a location/region; Feasibility analysis; Environmental impacts; Microgrid design involving solar, wind and other renewables; Economic analysis - Life cycle costing, incentives, cash flow forecasting; Integrating renewable energy with existing power infrastructure; Hybrid renewable energy systems; Hydrogen systems and fuel cell technologies for energy storage.

References:

1. Boyle, G., "Renewable Energy," 3rd Edition, Oxford University Press, (2020).
2. Twidell, J. and Weir, T., "Renewable Energy Resources," 2nd Edition, Taylor & Francis, (2006).

23-205-0816: SMART MATERIALS

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain concepts, classification and operating principles of smart materials.
2. Characterize behaviours and model responses of different smart materials.
3. Evaluate smart material performance metrics for sensing and actuation.
4. Analyze engineering applications incorporating smart materials.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Piezoelectric Materials, Crystal structure and origin of piezoelectricity, Mathematical modelling - electromechanical coupling relations, Ceramic vs polymer piezo electrics, Sensing mechanisms: direct and indirect effects, Actuation mechanisms and transducer configurations, Considerations for sensors and actuators design, Applications: ultrasound, micropumps, micromanipulation

Module II

Shape Memory Alloys, Phases, phase transformations and microstructures, Thermomechanical response - twinning, dislocation movements, Shape memory effect, superelasticity, Training shape memory alloys - shape setting, Recovery stress generation and damping capacity, Fatigue, fracture toughening mechanisms, Biocompatibility - applications in biomedical devices.

Module III

Magnetostrictive Materials, Origin of magnetostriction- ferromagnetic domains, Sensitivities, figures of merit and conditions for maximizing, Mathematical models - single crystal, polycrystalline, magnetomechanical coupling factor, Incorporation into composites, tuning properties, Applications: sonar, vibration control, stress sensors

Module IV

Electroactive Polymers, Piezoelectric polymers - PVDF, odd nylons, Dielectric elastomer actuators - acrylics, silicones, Ionic polymer metal composites - Nafion, other ionomers, Conducting polymers – PPy, PANI, operation mechanisms, Mathematical models - static, dynamic responses, Actuator performance considerations and selection, Artificial muscles for biomimetics and soft robotics

References:

1. Tech, X.Y., Smart Materials and Structures, CRC Press (2010).
2. Schwartz, M. M., Encyclopaedia of Smart Materials, J. Wiley & Sons (2020).
3. Madhusudana, K. Smart Structures and Smart Materials, Cambridge University Press, (2021)
4. Harrison, J. and Ounaies Z., Piezoelectric Polymers, Springer (2018).

23-200-0817: CONSTITUTIONAL LAW

Course Outcomes:

On completion of this course, the student will be able to:

1. Configure the preamble and fundamental rights.
2. Actuate the governance and functioning of constitutional functionaries.
3. Describe the functions of legislative bodies.
4. Decipher the judiciary system and its role in governance.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1	1	1		1					1
CO2						1	1	1		1					1
CO3						1	1	1		1					1
CO4						1	1	1		1					1

Module I

Introduction: Constitution Law, Constitutional Assembly Debates, Constitution of India, Basic Features of Indian Constitution, Preamble, Structure and Content of Indian Constitution

Module II

Fundamental Rights: Rights, Fundamental Rights, Definition of State, Fundamental Rights under Indian Constitution, Right to Equality, Untouchability, Title, Right to Life Cultural and Educational Rights of Minorities, Enforcement of Fundamental Rights

Module III

Directive Principles of State Policy and Fundamental Duties: DPSP's, Relationship between DPSP and Fundamental Rights, Conversion of DPSP into Fundamental Rights, Role of Judiciary, Judicial Activism, PIL, Fundamental Duties

Module IV

Constitutional Organs: Legislative Organs, Parliament, Lok Sabha, Rajya Sabha, State Legislatures. Executive Organs, President, Vice President, Council of Ministers. Judicial Organs, Supreme Court and High Courts, Other Constitutional Bodies, Election Commission, Comptroller and Auditor General of India, etc.

References:

1. Durga Das Basu, Introduction to the Constitution of India, 25th Edition. Prentice–Hall of India, New Delhi, (2022).
2. D.C. Gupta, Indian Government and Politics, 9th Edition. Vikas Publishing House, (2023).
3. H.M. Sreevai, Constitutional Law of India, 5th edition in 3 volumes. Universal Law Publication, (2020).

Minor in Mechanical Engineering

23-205-0310: COMPUTER AIDED MACHINE DRAWING

Course Outcomes:

On completion of this course, the student will be able to:

1. Explain the principles of engineering drawing and its importance in mechanical design.
2. Create 2D drawings of mechanical components using CAD software.
3. Generate 3D CAD models of mechanical parts and assemblies.
4. Produce drawings, schematics and documentation to effectively communicate design.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				3			1		1		1	3	3	1
CO2	3				3			1		1		1	3	3	1
CO3	3	3	3		3			1		1		1	3	3	1
CO4	3				3			1		1		1	3	3	1

Module I

Introduction to Engineering Drawing: Drawing Standards, Conventions, Layout and Scaling. Orthographic and Isometric projections. Symbols and Representation of Components.

Module II

Computer Aided Design: Basic principles, CAD software packages. Creating 2D drawings using commands - Coordinate Systems, Snap Grids, Layers, Geometric Constraints. Editing commands - Scale, Trim, Extend, Fillet, Chamfer etc. Dimensioning and Text Annotation.

Module III

3D Modelling: Extrude, Revolve, Loft, Sweep. Assembly of parts. Surface and Solid Modelling. Rendering photorealistic images. Parametric Modelling.

Module IV

Detail and Assembly Drawings: Section views and sectional views. Threads, Springs, Bearings, Gears, Cams. Welding and Machining symbols. Part Lists, Ballooning using CAD. Layouts of mechanical assemblies. Exporting Drawings.

References:

1. Bhatt, N.D., Panchal, V.M. & Ingle, P.R., Machine Drawing, Charotar Publishing House, (2022).
2. Sham Tickoo and CADCIM Technologies, CATIA V5 for Engineers and Designers. CADCIM Technologies, (2022).
3. Jensen, C.H. and Helsel, J.D., Engineering Drawing and Design, 8th edition, McGraw-Hill, (2022).
4. Bertoline, G.R, Wiebe, E.N., Miller, C.L. and Nasman, L.O., Fundamentals of Graphics Communication, 8th edition, McGraw-Hill, (2020).

23-205-0410: INTRODUCTION TO MATERIALS AND PROCESSING

Course Outcomes:

On completion of this course, students will be able to:

1. Classify engineering materials based on structure, properties, processing methods, and applications.
2. Analyze material failure modes and prevention methods through concepts of fracture, fatigue, creep, corrosion etc.
3. Compare metal processing techniques including casting, metal forming, welding, and powder metallurgy based on process principles, equipment, defects and effect on properties.
4. Assess additive and subtractive manufacturing processes based on part quality, cost, speed and applications in automotive and aerospace industries.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3							1		1		1	3	3	1
CO2	3							1		1		1	3	3	1
CO3	3							1		1		1	3	3	1
CO4	3							1		1		1	3	3	1

Module I

Engineering Materials - Classification, crystal structures, defects; Properties - Physical, Mechanical, Thermal, Electrical, Optical; Testing standards. Materials Selection; Failure analysis and prevention - Fracture, fatigue, creep, corrosion, wear. Ceramics and Polymers - Classification; Traditional ceramics - Powder processing, clay, glass and cement production; Advanced ceramics - Engineering ceramics production and properties control, testing; Polymers and plastics - Polymerization, processing methods, testing; Rubber and elastomers; Composites.

Module II

Metal Processing Fundamentals - Physical principles; Metal Casting - Sand casting, investment casting, defects and inspection; Metal Forming - Hot and cold working of metals like rolling, extrusion, drawing; effect on properties. Metal joining- Classification, Welding heat sources, Arc welding, Gas welding (TIG, MIG), Resistance welding, Thermit welding, Ultrasonic welding, Electron beam welding, Laser beam welding, Forge welding, Friction welding

Module III

Subtractive Manufacturing: Basic concepts of machine tools: Tool–work motions, orthogonal and oblique cutting, tool nomenclatures, cutting tool materials, inserts, tool life, machine tools for various processes, and lathes. Shaping and slotting machines, drilling machines, milling machines, grinding machines.

Basic theory and working principles of CNC systems; Advantages over conventional methods; Classification and configuration of CNC machine tools, CNC part programming: Manual programming, G and M codes, ISO/EIA codes, machine zero, axes nomenclature, zero offsets, tool offset canned cycles, preparation of part programs with motions

Module IV

Additive Manufacturing - Materials, design considerations, powder bed fusion, material extrusion, VAT Photopolymerization, Material Jetting, Binder Jetting, Material Extrusion processes; Directed energy deposition; Post-processing of AM parts; Part removal and cleanup; Heat treatment; Benchmarking and testing additive manufactured parts, Applications in aerospace, automotive; Comparison based on part quality, cost, speed; Regulatory issues.

References:

1. Callister, W.D & Rethwisch, D.G., Materials Science and Engineering: An Introduction. 11th Ed.,

Wiley, (2021).
2. Ashby, M.F., Materials Selection in Mechanical Design. 5th Ed., Butterworth-Heinemann, (2017).
3. Groover, M.P., Fundamentals of Modern Manufacturing: Materials, Processes and Systems. 7th Ed., Wiley, (2022).
4. Kalpakjian, S & Schmid, S.R., Manufacturing Processes for Engineering Materials. 6th Ed., Pearson, (2016).
5. Mathews, F.L & Rawlings, R.D., Composite Materials: Engineering and Science. 2nd Ed., Chapman and Hall, (2021).
6. Burns, G.W., Automotive Engineering: Lightweight, Functional, and Novel Materials. 1st Ed., Taylor & Francis, (2008).
7. Gibson, I., Rosen, D.W., & Stucker, B., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. 2nd Ed., Springer, (2021).

23-205-0612: MINI PROJECT

Course Outcomes:

On completion of this course, the student will be able to:

1. Students will apply core mechanical engineering principles to devise innovative solutions for interdisciplinary challenges.
2. Students will collaborate effectively in diverse teams, integrating ideas from various disciplines to develop a comprehensive project that addresses both mechanical engineering principles and the needs of other disciplines.
3. Students will demonstrate proficiency in project management, including planning, resource allocation, and adaptability, ensuring the successful execution of the mini-project within specified constraints.
4. Students will communicate technical concepts clearly through well-structured reports and presentations, demonstrating their ability to convey the significance, methodology, and results of the mini-project.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1	3	1		1	3	3	3
CO2	3	3	3	3				1	3	1		1	3	3	3
CO3	3	3	3	3	3			1	3	3		1	3	3	3
CO4	3	3	3	3	3			1	3	3		1	3	3	1

Guidelines for Mini Project in Mechanical Engineering Minor Course

1. Team Formation: Encourage interdisciplinary teams; Aim for diverse skill sets in each group.
2. Project Proposal: Students propose project ideas aligned with mechanical engineering principles; The proposal must outline the problem, objectives, and relevance to their disciplines.
3. Project Scope: Clearly define the scope of the project to ensure it aligns with the minor course objectives; Ensure feasibility within the given time and resource constraints.
4. Project Deliverables: Technical Report: Including problem definition, design methodology, analysis, and results; Prototype/Model: If applicable.
5. Presentation: Demonstrating key aspects to the class.
6. Requirements: Integrate concepts from mechanical engineering into the project; Use relevant software/tools for simulations and analysis.
7. Adhere to safety guidelines; Mentorship: Assign a mentor or allow students to choose one from the mechanical engineering faculty; Regular check-ins to ensure project progress and offer guidance.

8. Documentation: Emphasize the importance of keeping detailed records of the design process, challenges faced, and solutions implemented.
9. Interdisciplinary Collaboration: Encourage collaboration with students from other disciplines; Assess the extent of integration of ideas from different fields.

Assessment Method

1. Project Proposal Evaluation (10%): Relevance to mechanical engineering principles; Clear problem definition and objectives.
2. Mid-term Progress Report (20%): Demonstration of progress compared to the initial proposal; Identification and resolution of challenges.
3. Prototype/Model (if applicable) (20%): Functional and realistic representation of the design; Application of mechanical engineering concepts.
4. Technical Report (30%): Clarity of writing and presentation; Depth of mechanical engineering concepts applied; Quality of analysis and results.
5. Final Presentation (20%): Ability to communicate technical details to a diverse audience; Handling of questions and feedback.

Honours in Mechanical Engineering

23-205-0412: MULTIBODY DYNAMICS

Course Outcomes:

By the end of this course students will be able to:

1. Compute kinematics of interconnected rigid body systems using appropriate coordinate systems
2. Formulate equations of motion for multibody systems using energy and momentum principles
3. Develop computational models for dynamic simulation of multibody mechanical systems
4. Analyze the dynamic behaviour of multibody engineering systems in applications such as robotics and vehicles

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Rigid Body Kinematics: Degrees of freedom analysis using Grübler's equation; Reference coordinate frames – inertial, translating, rotating frames; Displacement, velocity, acceleration – transport theorem; Rotation matrices, Euler angles – sequence transformations; Rotational kinematics: angular velocity, acceleration.

Module II

Principles of Dynamics: Work-energy equation for systems – conservative forces, dissipative forces; Newton-Euler equations of motion from F=ma; D'Alembert's principle and Lagrangian dynamics; Equations of motion in matrix form; Numerical integration methods – Runge Kutta, Newmark.

Module III

Advanced Modelling Techniques: Constraint equations and formulation using Lagrange multipliers; Friction and impact modelling using impulse-momentum theory; Flexibility modelling using the Finite Element Method; State-space form–eigenvalue analysis for stability; Automated dynamic simulation software.

Module IV

Applications: Modelling robotic manipulators – inverse vs forward dynamics; Vehicle suspension design – kinematic/dynamic analysis; Landing gears analysis – shimmy dynamics; Analogous control and testing of artificial limbs.

References:

1. Nikravesh, P.E., Computer-Aided Analysis of Mechanical Systems. Prentice Hall, (1988).
2. Magnus, K., Multibody System Dynamics, Robotics and Control. Springer, (2015).
3. Wittenburg, J., Dynamics of Systems of Rigid Bodies. Teubner, (1977).
4. Ambrósio, J., Multibody Systems Dynamics. Springer, (2004).

23-205-0514: THEORY OF PLASTICITY AND METAL FORMING

Course Outcomes:

By the end of this course students will be able to:

1. Understand the theoretical foundations of plasticity and its relevance to metal forming.
2. Analyze stress-strain relationships and deformation mechanisms in plastic materials.
3. Apply plasticity theories to predict material behaviour in different metal-forming processes.
4. Design and analyze metal forming processes based on plasticity principles.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3				1		1		1	3	3	1
CO2	3	3	3	3				1		1		1	3	3	1
CO3	3	3	3	3				1		1		1	3	3	1
CO4	3	3	3	3				1		1		1	3	3	1

Module I

Introduction to Plasticity: Definition and significance of plasticity; Distinction between elastic and plastic deformation; Stress and strain tensors in plasticity; Yield criteria and flow rules; Overview of plasticity theories, including isotropic and kinematic hardening concepts.

Module II

Stress-Strain Relationships: True stress and true strain; Hardening mechanisms and material models; Stress and strain paths in metal forming processes; Application of material models to predict behaviour under complex loading conditions.

Module III

Metal Forming Processes: Fundamentals of metal forming processes; Rolling and forging processes; Extrusion and drawing processes; Sheet metal forming techniques; Residual stresses and spring back phenomena.

Module IV

Advanced Topics: Finite Element Analysis (FEA) applications in metal forming simulations; Plastic instability and necking phenomena; Thermo-mechanical processing effects on plastic deformation; Microstructural evolution during plastic deformation

References:

1. Hill, R., The Mathematical Theory of Plasticity, Oxford University Press, (1998).
2. Lubliner, J., Plasticity Theory, Dover Publications, (2008).

3. Gurson, A.L., Continuum Theory of Ductile Rupture by Void Nucleation and Growth: Part I – Yield Criteria and Flow Rules for Porous Ductile Media, Journal of Engineering Materials and Technology, (1977).
4. Shigley, J.E., and Mischke, C.R., Mechanical Engineering Design, McGraw-Hill, (2001).
5. Marciniak, Z., Duncan, J.L., and Hu, S.J., Mechanics of Sheet Metal Forming, Butterworth-Heinemann, (2002).
6. Ghosh, A., and Mallik, A.K., Manufacturing Science, Wiley, (2003).
7. Dawson, P.R., and Siddall, J.N., Sheet Metal Forming: Processes and Applications, Butterworth-Heinemann, (2012).
8. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann, (2005).
9. Chakrabarty, J., Theory of Plasticity, Butterworth-Heinemann, (1987).
10. Timoshenko, S., and Goodier, J.N., Theory of Elasticity, McGraw-Hill, (1970).

23-205-0717: INTRODUCTION TO STATISTICAL THERMODYNAMICS AND MOLECULAR DYNAMICS

Course Outcomes:

On completion of this course, students will be able to:

1. Understand fundamental concepts of statistical thermodynamics and molecular dynamics. to calculate macroscopic thermodynamic properties from molecular-level information.
2. Apply fundamental concepts of statistical thermodynamics to calculate macroscopic thermodynamic properties from molecular-level information.
3. Analyze the microscopic interactions between molecules using potential energy functions and correlate phase transitions to intermolecular forces.
4. Evaluate molecular simulation methods such as Monte Carlo and Molecular Dynamics for generating numerical solutions and estimating ensemble averages.

Mapping of Course Outcomes with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1			1		1		1	3	3	1
CO2	3	3	3	3	1			1		1		1	3	3	1
CO3	3	3	3	3	1			1		1		1	3	3	1
CO4	3	3	3	3	1			1		1		1	3	3	1

Module I

Fundamentals of Statistical Thermodynamics: Review of thermodynamics laws, Statistical interpretation of thermodynamic quantities and equilibrium, Microstates and macrostates, Statistical ensembles (Microcanonical, Canonical, Grand canonical), Boltzmann distribution law and its applications, Quantum statistics (Bose-Einstein, Fermi-Dirac).

Module II

Molecular Interactions and Phase Transitions: Intermolecular forces and potential functions, Calculation of thermodynamic properties of gases, Lattice models and theory of condensation, Critical phenomena, classification of phase transitions.

Module III

Introduction to Molecular Simulation: Statistical mechanical sampling techniques (Monte Carlo, Molecular Dynamics), Potential energy functions and force fields, Verlet algorithm, periodic boundary conditions, Calculation of equilibrium properties from molecular simulations, Enhanced sampling methods.

Module IV

Advanced Simulation Techniques, Density functional theory calculations, Coarse-grained modelling, Multiscale modelling techniques, Advanced simulation methods for biomechanical modelling, Hands-on simulation projects using software packages

References:

1. McQuarrie, D. A. Statistical Thermodynamics, 2nd Edition, University Science Books, (2000).
2. Allen, M. P. & Tildesley, D. J. Computer simulation of liquids, Oxford University Press, (2017).
3. Frenkel, D & Smit, B. Understanding Molecular Simulation, 2nd Edition, Academic Press, (2001).
4. Tuckerman, M. E. Statistical Mechanics: Theory and Molecular Simulation, Oxford University Press, (2010).
5. Leach, A. R. Molecular Modelling: Principles and Applications, 2nd Edition, Prentice Hall, (2001).