COURSES OF STUDY FOR
B. TECH.
IN
MECHANICAL ENGINEERING

(Effective From – Admission Batch 2023)

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

Hazratbal, Srinagar, J&K – 190006 - India

Vision and Mission of the Department

VISION

To nurture Mechanical Engineers with a passion for professional excellence, who are ready to take on global challenges and serve the society with high human values.

MISSION

M1: To provide facilities and infrastructure for academic excellence in the field of Mechanical Engineering.
M2: To inculcate in the students a passion for understanding professionalism, ethics, safety, and sustainability, and enable them to contribute to the society.
M3: To nurture creativity of the students and encourage them to come up with innovative solutions to real life problems.
M4: To prepare the student for lifelong learning with global perspective.

Brief about the Department:

Established in the year 1963, the Department of Mechanical Engineering offers a unique opportunity in terms providing first-class pedagogy and world class facilities for conducting cutting-edge research. Being one of the oldest departments of NIT Srinagar, the department has evolved into one of the finest in terms of teaching curriculum and methodology supported by a well-organized and adequately funded research program. We have a very well-established B. Tech program complemented by three M. Tech programs in Mechanical System Design, Industrial Tribology & Maintenance Management and Thermal Engineering. The masters' students are admitted on the basis of a valid GATE score, and some additional seats are reserved for meritorious sponsored candidates. The Research Scholars (PhD) are admitted to the department every year on the basis of a rigorous examination conducted by the institute.

Our curriculum is designed to cater to the needs and aspirations of the industry, and our top class faculty ensures that the students acquire the necessary technical and decision making skills to be the leaders in the dynamic world of industry.

Our department is, perhaps, the most versatile in terms of the range of specializations of its faculty members. We have faculty members who specialize in Haptics, MEMS and Drone on one end to High-temperature Tribology, Manufacturing Strategies and Quality Control on the other. The traditional areas of Mechanical Engineering such as Machine Design, Fluid Mechanics and Thermal Sciences are also well-represented. The department has a very strong group working in the area of Friction, Lubrication and Wear, with state-of-the-art research facilities and equipment. Our academic curriculum has improved considerably with the passage of time. Regular Board of Studies meetings are conducted to remove any inadvertent deficiencies. Periodic feedback is taken from the students to improve the quality of the education imparted. Feedback is also taken from the visiting companies during the placement season to orient the curriculum towards the needs of the Industry. Specialized courses are floated to cater to the needs of the PhD scholars, preparing them for subsequent research.

We strive to produce engineering graduates of high quality who are team players, accountable, resourceful and above all, technically competent. I take this opportunity to invite prospective students to our department and benefit from our experienced and wonderful talent pool. Our faculty and staff, I am sure, will deliver with unmatched dedication and professional enthusiasm.

List of Programs offered by the Department:

- Bachelor of Technology (B. Tech.) in Mechanical Engineering
- Master of Technology (M. Tech.) in Industrial Tribology & Maintenance Management (ITMM)
- Master of Technology (M. Tech.) in Mechanical System Design(MSD)
- Master of Technology (M. Tech.) in Thermal Engineering
- Doctor of Philosophy (Ph.D.)

PEOs, POs, and PSOs

Program Educational Objectives (PEOs)

PEO1: To prepare students to get employment and pursue research in Mechanical Engineering and allied fields.

PEO2: To train students to identify and analyze Mechanical Engineering problems using an iterative approach that involves defining, quantifying, testing and review of the identified challenges.

PEO3: To enable students to plan, organize, schedule, execute and communicate effectively as an individual, as a team member, or as a leader in a multidisciplinary environment.

PEO4: To provide the students an academic environment that makes them appreciate excellence in the field of Mechanical Engineering and empowers them to understand the significance of lifelong learning.

Program Outcomes (POs)

i) **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

ii) **Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

iii) **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 the public health and safety, and the cultural, societal, and environmental considerations.

iv) **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 for complex problems.

v) **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

vi) **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.

vii) **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

viii) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

ix) **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

x) **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.

xi) **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.

xii) **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Program Specific Outcome (PSOs)

PSO1: Apply the knowledge of basic sciences, mathematics and Mechanical Engineering to real life problems.

PSO2: Inculcate the advance level skills in academic and research pursuits relevant to Mechanical Engineering and other interdisciplinary streams.

PSO3: Ability to integrate major Mechanical Engineering streams with innovative and entrepreneurial activities ensuring high standards of professional ethics.

Contents

Credit Scheme

Program	Semester-wise credit distribution								Total Credits
	1st	2nd	3rd	4th	5th	6th	7th	8th	
B. Tech	22	20	21	22	21	18	15	15	160
Open Electives	-	-	-	-	3*	3*	-	-	
B. Tech (Honors)	22	20	21	22	24	21	21	23	180#
Open Electives	-	-	-	-	3*	3*	-	-	

*Students have the option of taking Open Electives at 5th and 6th Semester levels.
The minimum credits for Open Electives are 3 + 3 = 6 (2 Theory Courses).

As per senate resolution, students completing 180 credits will be eligible for B. Tech Honors.
The minimum credits required for completing B. Tech is 160.

List of Courses Offered (Theory)

S. No.	Course Title	Course Category	Offered by
01	Mechanics of Materials-I	Professional Core	Mechanical Engineering Department
02	Mechanics of Materials-II		
03	Theory of Machines-I		
04	Theory of Machines-II		
05	Manufacturing Processes-I		
06	Manufacturing Processes-II		
07	Fluid Mechanics-I		
08	Fluid Mechanics-II		
09	Applied Thermodynamics-I		
10	Applied Thermodynamics-II		
11	Machine Design-I		
12	Machine Design-II		
13	Industrial Engineering-I		
14	Industrial Engineering-II		
15	Heat Transfer		
16	Fundamentals of Dynamics		
17	Engineering Thermodynamics		
18	Materials Science & Engineering		
19	Measurement & Instrumentation		
20	Elective I-VII	Professional Electives	
21	Engineering Drawing	Basic Engineering	Civil Engineering Department
22	Engineering Mechanics		
23	Elements of Mechanical Engineering		Mechanical Engineering Department
24	Basic Electrical Engineering		Electrical Engineering Department

25	Computer Programming		Information Technology Department
26	Mathematics-I	Basic Sciences	Mathematics Department
27	Mathematics-II		
28	Applied Mathematics-I		
29	Applied Mathematics-II		
30	Engineering Chemistry		Chemistry Department
31	Environmental Studies		
32	Engineering Physics		Physics Department
33	Basic English and Communication Skills	Humanities, Social Sciences, and Management	H&SS Department
34	Advanced English and Communication Skills		
35	Society and Sensitivity		
36	Engineering Economics		
37	Fundamental Knowledge of Accreditation	Compulsory Audit Course	NBA Institute Cell

List of Courses Offered (Laboratory)

S. No.	Course Title	Course Category	Offered by
01	Mechanics of Materials Lab	Professional Core	Mechanical Engineering Department
02	Machine Drawing & Solid Modeling Lab		
03	Fluid Mechanics Lab		
04	Manufacturing Processes-I Lab		
05	Manufacturing Processes-II Lab		
06	Heat Transfer Lab		
07	Theory of Machines-I Lab		
08	Theory of Machines-II Lab		
09	Thermal Engineering Lab		
10	Research Lab		
11	Industrial Engineering Lab		
12	Simulation Lab		
13	Computer Programming Laboratory		Information Technology Department
14	Workshop Practice		Central Workshop
15	Chemistry Laboratory	Basic Sciences	Chemistry Department
16	Engineering & Applied Physics Laboratory		Physics Department
17	English Language Laboratory	Humanities, Social Sciences, and Management	H&SS Department

List of Courses Offered to Other Departments

S. No.	Course Title (Course Code)	Course Category (Offered in)	Offered to
01	Elements of Mechanical Engineering (MET101)	Professional Core (B. Tech. 1st and 2nd Semester)	Chemical Engineering Department
			Civil Engineering Department
			Computer Engineering Department
			Electrical Engineering Department
			Electronics & Comm. Engineering Department
			Information Technology Department
			Mett. & Mat. Science Engineering Department
02	Introduction to Mechatronics (MET901)	Open Elective (B. Tech. 5th Semester)	Chemical Engineering Department
			Civil Engineering Department
			Computer Engineering Department
			Electrical Engineering Department
			Electronics & Comm. Engineering Department
			Information Technology Department
			Mett. & Mat. Science Engineering Department
03	Introduction to Electric Vehicle (MET902)	Open Elective (B. Tech. 5th Semester)	Chemical Engineering Department
			Civil Engineering Department
			Computer Engineering Department
			Electrical Engineering Department
			Electronics & Comm. Engineering Department
			Information Technology Department
			Mett. & Mat. Science Engineering Department
04	Basic Robot Mechanics (MET903)	Open Elective (B. Tech. 6th Semester)	Chemical Engineering Department
			Civil Engineering Department
			Computer Engineering Department
			Electrical Engineering Department
			Electronics & Comm. Engineering Department
			Information Technology Department
			Mett. & Mat. Science Engineering Department
05	Sustainable Engineering (MET904)	Open Elective (B. Tech. 6th Semester)	Chemical Engineering Department
			Civil Engineering Department
			Computer Engineering Department
			Electrical Engineering Department
			Electronics & Comm. Engineering Department
			Information Technology Department
			Mett. & Mat. Science Engineering Department

Coding Scheme for Courses

The following scheme is the revised B.Tech teaching scheme and curriculum applicable from 2023 admission onwards. It proposes a six-letter alphanumeric code for each course – AAB-CDD. The first three letters denote alphabets, and the next three are numerals. AA signifies the department offering the course, B represents the nature of the course, C indicates the year in which the course is offered, and DD denotes the departmental course code.

Departmental Codes

S. No.	Department	Code
01	Mechanical Engineering	**ME**
02	Civil Engineering	**CV**
03	Chemical Engineering	**CM**
04	Computer Science Engineering	**CS**
05	Electrical Engineering	**EE**
07	Electronics and Communications Engineering	**EC**
08	Information Technology	**IT**
09	Metallurgy and Materials Science Engineering	**MT**
10	Chemistry	**CH**
11	Humanities and Social Sciences	**HS**
12	Mathematics	**MA**
13	Physics	**PH**

Course Codes

S. No.	Course Type	Code
01	Theory	T
02	Lab	L
03	Seminar	S
04	Project/Pre-Project	P

National Institute of Technology Srinagar

1st Semester (Group A)

Civil / Mechanical / Chemical / Mett. & Mat. Science

S. No	Course Code	Course Title	Department Offering	Credits	Contact Hours			
					L	T	P	Total
A11	HST101	Basic English and Communication Skills	Humanities	3	2	1	0	3
A12	MAT101	Mathematics-I	Mathematics	3	2	1	0	3
A13	EET101	Basic Electrical Engineering	Electrical	3	2	1	0	3
A14	ITT101	Computer Programming	Information Technology	3	2	1	0	3
A15	CHT101	Engineering Chemistry	Chemistry	3	2	1	0	3
A16	CVT101	Engineering Drawing	Civil	3	1	0	4	5
A17	CHL101	Chemistry Laboratory	Chemistry	1	0	0	2	2
A18	ITL101	Computer Programming Laboratory	Information Technology	1	0	0	2	2
A19	**NBA101**	**Fundamental Knowledge of Accreditation****	**NBA Institute Cell**	**0**	**2**	**0**	**0**	**2**
				20	**13**	**5**	**8**	**26**

** Compulsory Audit Course

1st Semester (Group B)

Electrical / Electronics & Comm. / Computer Science / Information Technology

S. No	Course Code	Course Title	Department Offering	Credits	Contact Hours			
					L	T	P	Total
B11	HST101	Basic English and Communication Skills	Humanities	3	2	1	0	3
B12	MAT101	Mathematics-I	Mathematics	3	2	1	0	3
B13	MET101	Elements of Mechanical Engineering	Mechanical	3	2	1	0	3
B14	PHT101	Engineering Physics	Physics	3	2	1	0	3
B15	CHT102	Environmental Studies	Chemistry	3	2	1	0	3
B16	CVT102	Engineering Mechanics	Civil	3	2	1	0	3
B17	HSL101	English Language Laboratory	Humanities	1	0	0	2	2
B18	PHL101	Engineering & Applied Physics Laboratory	Physics	1	0	0	2	2
B19	WSL101	Workshop Practice	Workshop	2	0	0	4	4
Total				**22**	**12**	**6**	**8**	**26**

National Institute of Technology Srinagar

2nd Semester (Group A)

Civil/ Mechanical / Chemical / Mett. & Mat. Science

S. No	Course Code	Course Title	Department Offering	Credit	Contact Hours			
					L	T	P	Total
A21	HST102	Advanced English and Communication Skills	Humanities	3	2	1	0	3
A22	MAT102	Mathematics-II	Mathematics	3	2	1	0	3
A23	MET101	Elements of Mechanical Engineering	Mechanical	3	2	1	0	3
A24	PHT101	Engineering Physics	Physics	3	2	1	0	3
A25	CHT102	Environmental Studies	Chemistry	3	2	1	0	3
A26	CVT102	Engineering Mechanics	Civil	3	2	1	0	3
A27	HSL101	English Language Laboratory	Humanities	1	0	0	2	2
A28	PHL101	Engineering & Applied Physics Laboratory	Physics	1	0	0	2	2
A29	WSL101	Workshop Practice	Workshop	2	0	0	4	4
Total				**22**	**12**	**6**	**8**	**26**

2nd Semester (Group B)

Electrical / Electronics & Comm. / Computer Science / Information Technology

S. No	Course Code	Course Title	Department Offering	Credit	Contact Hours			
					L	T	P	Total
B21	HST102	Advanced English and Communication Skills	Humanities	3	2	1	0	3
B22	MAT102	Mathematics-II	Mathematics	3	2	1	0	3
B23	EET101	Basic Electrical Engineering	Electrical	3	2	1	0	3
B24	ITT101	Computer Programming	Information Technology	3	2	1	0	3
B25	CHT101	Engineering Chemistry	Chemistry	3	2	1	0	3
B26	CVT101	Engineering Drawing	Civil	3	1	0	4	5
B27	CHL101	Chemistry Laboratory	Chemistry	1	0	0	2	2
B28	ITL101	Computer Programming Laboratory	Information Technology	1	0	0	2	2
B29	**NBA101**	**Fundamental Knowledge of Accreditation****	**NBA Institute Cell**	**0**	**2**	**0**	**0**	**2**
Total				**20**	**13**	**5**	**8**	**26**

** Compulsory Audit Course

B.Tech 3rd Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MET201	Mechanics of Materials-I	2	1	0	3	3
2	MET202	Fundamentals of Dynamics	2	1	0	3	3
3	MET203	Manufacturing Processes-I	3	0	0	3	3
4	MET204	Engineering Thermodynamics	2	1	0	3	3
5	MET205	Fluid Mechanics-I	2	1	0	3	3
6	HST059	Society and Sensitivity	3	0	0	3	3
7	MEL211	Manufacturing Processes-I Lab	0	0	2	2	1
8	MEL212	Fluid Mechanics Lab	0	0	2	2	1
9	MEL213	Machine Drawing & Solid Modeling Lab	0	0	2	2	1
Total			**14**	**4**	**6**	**24**	**21**

B.Tech 4th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MET251	Mechanics of Materials-II	2	1	0	3	3
2	MET252	Theory of Machines-I	2	1	0	3	3
3	MET253	Manufacturing Processes-II	3	0	0	3	3
4	MET254	Heat Transfer	2	1	0	3	3
5	MET255	Applied Thermodynamics-I	2	1	0	3	3
6	MAT204	Mathematics-III	2	1	0	3	3
7	MEL261	Mechanics of Materials Lab	0	0	2	2	1
8	MEL262	Theory of Machines–I Lab	0	0	2	2	1
9	MEL263	Manufacturing Processes-II Lab	0	0	2	2	1
10	MEL264	Heat Transfer Lab	0	0	2	2	1
Total			**13**	**5**	**8**	**26**	**22**

B.Tech 5th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MET301	Machine Design-I	2	1	0	3	3
2	MET302	Theory of Machines-II	2	1	0	3	3
3	MET303	Material Science and Engineering	3	0	0	3	3
4	MET304	Applied Thermodynamics-II	2	1	0	3	3
5	MET305	Industrial Engineering-I	3	0	0	3	3
6		Open Elective-I*	3	0	0	3	3
7	MEL311	Theory of Machines-II Lab	0	0	2	2	1
8	MEL312	Thermal Engineering Lab	0	0	2	2	1
9	MEL313	Research Lab	0	0	2	2	1
Total			**15**	**3**	**6**	**24**	**21**
For B.Tech (Honors) only							
10		Honors Elective-I	2	1	0	3	3

B.Tech 6th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MET351	Machine Design-II	2	1	0	3	3
2	MET352	Fluid Mechanics-II	2	1	0	3	3
3	MET353	Industrial Engineering-II	3	0	0	3	3
4	MAT214	Mathematics-IV	3	0	0	3	3
5	MET0##	Elective-I	3	0	0	3	3
6		Open Elective-II*	3	0	0	3	3
7	MEL361	Industrial Engineering Lab	0	0	2	2	1
8	MEI371	Industrial Training	0	0	0	0	1
9	MES381	Seminar	0	0	2	2	1
Total			**16**	**2**	**4**	**22**	**21**
For B.Tech (Honors) only							
10		Honors Elective-II	2	1	0	3	3

*Open Elective courses have to be opted from other departments.

B.Tech 7th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MET401	Measurement and Instrumentation	3	0	0	3	3
2	HST052	Engineering Economics	3	0	0	3	3
3	MET0##	Elective-II	3	0	0	3	3
4	MET0##	Elective-III	3	0	0	3	3
5	MET0##	Elective-IV	3	0	0	3	3
6	MEL411	Simulation Lab	0	0	2	2	1
7	MEP421	Pre Project	0	0	4	4	2
Total			**15**	**0**	**6**	**21**	**18**
For B.Tech (Honors) only							
8		Honors Elective-III	3	0	0	3	3
9		Honors Elective-IV	3	0	0	3	3

B.Tech 8th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MEP451	Project	0	0	12	12	6
2	MET0##	Elective-V	3	0	0	3	3
3	MET0##	Elective-VI	3	0	0	3	3
4	MET0##	Elective-VII	3	0	0	3	3
Total			**9**	**0**	**12**	**21**	**15**
For B.Tech (Honors) only							
5		Honors Elective-V	2	0	0	2	2
6		Honors Elective-VI	3	0	0	3	3
7		Honors Elective-VII	3	0	0	3	3

Detailed Curriculum for 1st Year – 1st & 2nd Semester Courses

Subject: Basic English and Communication Skills (Code: HST101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Exhibit correct use of basic English phonetics.	*BTL3
CO2	Employ the vocabulary and grammar components properly in English communication.	BTL3
CO3	Demonstrate effective reading and comprehension skills.	BTL5
CO4	Compose paragraphs and essays using the formal writing strategies.	BTL6

Detailed Syllabus:

UNIT I ***CH - 10**

English phonetics: sounds/phonemes of English (vowels and consonants), phonemic transcription of simple words, syllable structure, word stress.

UNIT II **CH - 11**

Vocabulary and grammar: word formation (prefixes and suffixes) [textbook pages 4-8 and 57-62], synonyms and antonyms [textbook pages 33-35], articles, prepositions [textbook pages 8-15, 112-113, and 127-129], punctuation [textbook pages 19-22].

UNIT III **CH - 10**

Reading: techniques for good comprehension [textbook pages 40-42], skimming and scanning [textbook pages 71-75], local and global comprehension [textbook pages 92-95], reading prescribed comprehension passages [textbook pages 1-4, 29-33, and 40-42].

UNIT IV **CH - 11**

Writing: phrases and clauses[textbook pages16-19], redundancies and clichés [textbook pages 89-92 and 116], paragraph writing [textbook pages23-28and76-84], essay writing[textbook pages98-102].

Text Books:

1. N. P. Sudharshana and C. Savitha, English for Engineers, Cambridge, 2018.

Online Resources:

1. dictionary.cambridge.org/help/phonetics.html [For Unit1, Sounds of English].
2. howjsay.com/ [ForUnit1, Transcription/Pronunciation].
3. myenglishlanguage.com/linguistics-language-guide/english-phonology/syllables-andstress/ [For Unit 1, Syllable and Stress].

***Note:** BTL and CH stand for Bloom's Taxonomy Level and Contact Hours, respectively.

Subject: Mathematics-I (Code: MAT101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Solve linear and nonlinear differential equations by various methods.	BTL3
CO2	Apply ordinary differential equations for solving various problems.	BTL3
CO3	Solve the problems related to rank of matrix, Cayley-Hamilton theorem, solutions of equations by matrix method.	BTL3
CO4	Estimate eigenvalues, eigenvectors, and quadratic forms.	BTL4

Detailed Syllabus:

UNIT I **CH - 12**

Exact differential equations, necessary and sufficient condition for exact differential equations, equations reducible to exact form, linear differential equations of second and higher order with constant and variable coefficients, Cauchy's homogeneous linear equation, Legendre's linear equation, simultaneous differential equations of first and second order, simultaneous differential equations of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, nonlinear differential equation.

UNIT II **CH - 12**

Method of variation of parameters, method of undetermined coefficients, series solution of ordinary differential equations (Frobenius method), applications of ordinary differential equations viz. law of growth and decay, Newton's law of cooling, electric circuits, chemical reaction and solutions.

UNIT III **CH - 10**

Rank of a matrix, equivalent matrices, elementary transformations, normal form, inverse of a matrix, Cayley-Hamilton theorem, applications of Cayley-Hamilton theorem for finding inverse and higher powers of a matrix, solution of simultaneous equations by elementary operations, similar matrices.

UNIT IV **CH - 08**

Special matrices viz., orthogonal matrix, idempotent matrix, unitary matrix. eigenvalues and eigenvectors of a matrix, properties of eigenvalues and eigenvectors, quadratic forms, value class of quadratic form.

Text Books:

1. Jain, R.K and Iyengar, S.R.K., Advanced Engineering Mathematics, 3rd edition, 2008, Narosa Publishing House.
2. Kreyszig, E., Advanced Engineering Mathematics, 9th edition, 2006, John Wiley Sons.

Reference Books:

1. Piaggio, H.T.H. Differential Equations, CBS Publishers.

Subject: Basic Electrical Engineering (Code: EET101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate a comprehensive understanding of DC circuits and their elements through application of KVL/KCL and various network theorems.	BTL3
CO2	Analyze and evaluate AC circuits, calculate Power in AC Circuits, and have a basic understanding of three phase circuits.	BTL4
CO3	Comprehend the working principle and characteristics of transformers and evaluate performance indices of transformers.	BTL4
CO4	Gain insight into the working principles of various DC and AC machines and gain working knowledge of basic measurement instruments.	BTL4

Detailed Syllabus:

UNIT I **CH - 10**

DC circuits: introduction to electric circuits and their elements, energy sources and their types (ideal/practical and dependent/independent sources), Kirchhoff's voltage and current laws, nodal analysis, mesh analysis, Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transfer theorem, star-delta transformation.

UNIT II **CH - 08**

AC circuits: introduction to AC circuits and sinusoidal signals, phasor representation, concept of impedance, instantaneous, active, and reactive power, concept of power factor, introduction to three phase circuits.

UNIT III **CH - 08**

Transformers: introduction to transformers and their working principle, ideal and practical transformers, equivalent circuit, and phasor diagram, losses & efficiency.

UNIT IV **CH - 10**

Machines: introduction to electric machines.

DC machines: construction, principle of operation, EMF and torque equations, characteristics of DC generators and motors.

Induction motors: production of rotating magnetic field, principle of operation of 3-φ I.M., torque-speed characteristics of 3-φ I.M.

UNIT V **CH - 06**

Measuring instruments: basic terminology associated with measurement. measurement of current, voltage, resistance and power, sensors and transducers.

Text Books:

1. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition, 2003, PHI.
2. Edward Hughes, Electrical Technology, 10th edition, 2010, ELBS.

Reference Book:

1. V.N. Mittle, Basic Electrical Engineering, 2000, TMH.

Subject: Computer Programming (Code: ITT101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply programming for problem-solving and use various library functions, data types, characters, keywords, and operators of the 'C' language	BTL3
CO2	Analyze and apply the concept of conditional and iterative statements in C language and use of functions.	BTL4
CO3	Evaluate the data types offered by the C language including complex data types: arrays, structures, pointers, and unions.	BTL5
CO4	Analyze the dynamic behavior of memory and implement the file handling concept in C programming.	BTL4

Detailed Syllabus:

UNIT I **CH - 08**

Introduction to problem-solving: engineering problem-solving methodology, flowcharts and algorithms, need for computer languages, high-level languages, history of C, memory layout of a C program, GCC compiler.

Language of bits: binary representation of data, 1's and 2's complement representation, computer arithmetic, octal and hexadecimal representation.

Fundamentals of C: program structure, C character set, library functions, preprocessors directives, compilation flow of a C program, I/O functions in C, comments, header files, C character set, data types, identifiers and keywords, declarations, operators and expressions, type conversion, precedence and associativity.

UNIT II **CH - 13**

Decision control structure in C: decision-making statements (if, if-else, if-else-if, switch), nesting of decision control structures.

Loop control structure in C: looping statements (while, do-while, for), nested loop, use of jumping statements(break, continue, goto).

Functions: concept of library functions, user-defined functions, passing arguments, function prototypes, calling a function, static functions, recursion.

UNIT III **CH - 13**

Arrays and strings: declaration and initialization, passing arrays to a function, matrices as 2D arrays, multi-dimensional arrays, string handling library functions.

Pointers: declarations, passing pointers to a function, operations on pointers, pointer arithmetic, pointers and arrays, arrays of pointers, and function pointers.

Structures and unions: defining and accessing structure, structure as function arguments, an array of structures, pointers to structures, defining and accessing union.

UNIT IV **CH - 08**

Dynamic memory allocation: introduction to dynamic memory allocation (malloc, calloc, realloc, free).

File handling: file operation such as storing, retrieving, and updating a file.

Text Books:

1. Schaums Outline of Theory and Problems of programming with C: Gottfried
2. Programming with C, Byron Gottfried, 3rd Edition, McGraw Hill.
3. Mastering C by Venugopal, Prasad, Tata McGraw Hill
4. Programming in ANSI C, Balaguruswamy
5. C - How to Program, P. J. Deitel and H. Deitel

Reference Books:

1. Complete reference with C, Tata McGraw Hill
2. Engineering Problem Solving with ANSI C, Delores M. Etter, Prentice Hall
3. C Programming, Ivor Horton, Wrox Press Limited
4. The C programming language: Kerninghan and Ritchie

Subject: Engineering Chemistry (Code: CHT101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the properties and use of polymeric and nanomaterials.	BTL4
CO2	Learn the basic concepts of water treatment.	BTL4
CO3	Gain knowledge about fuels and their applications.	BTL4
CO4	Develop insight into the fundamentals of lubricants and corrosion.	BTL6

Detailed Syllabus:

UNIT I **CH - 12**

Polymers: introduction, classification, types of polymerization, mechanisms of polymerization (free radical, cationic, anionic), coordination polymerization and its mechanism, synthesis and applications of some important engineering polymers (Polyethylene, PVC, Teflon, Terylene, Nylon-6, Nylon-6,6), Conducting polymers; classifications, properties, and applications in engineering field.

Nanomaterials: introduction, classification of nanomaterials based on their size, approaches for nanomaterials synthesis (bottom-up approach: sol-gel synthesis, hydrothermal growth and chemical vapour deposition; top-down approach: ball milling and micro-fabrication), applications of nanotechnology in various fields.

UNIT II **CH - 10**

Water treatment: introduction, impurities in water, hard water, determination of hardness and alkalinity, softening of hard water (lime-soda process, zeolite process and ion exchange process), municipal treatment of water for drinking purposes; removal of suspended, dissolved and biological impurities-sterilization by chlorination (effective and break-point chlorination), numerical problems based on hardness, alkalinity and LS process.

UNIT III **CH - 10**

Fuels: introduction, classification, calorific value (HCV and LCV), determination of calorific value using bomb calorimeter, numerical problems based on Dulong's formula. Biofuels: classification of biofuels; first, second, third and fourth generation biofuels, properties and characteristics of liquid biofuels (bioethanol, biobutanol, and biodiesel).

UNIT IV **CH - 10**

Lubricants: introduction, mechanisms of lubrication, hydrodynamic, boundary and extreme pressure lubrication, classification of lubricants: liquid, semi solid and solid lubricants, lubricating oils: fatty oils, mineral oils, blended oils, and synthetic oils, properties of lubricating oils with special reference to flash point, aniline point, viscosity, and viscosity index.

Corrosion: introduction, types of corrosion: dry and wet corrosion (pitting corrosion, crevice corrosion, and stress corrosion), corrosion prevention and control by proper design and material selection, cathodic protection, anodic protection, protective coatings.

Text Books:

1. Jain P.C., Jain M., Engineering Chemistry, Dhanpat Rai Publishing Company, 17th edition, 2019.
2. Dara S.S., Umare S.S., A Text Book of Engineering Chemistry, S. Chand Publication, 1st edition, 2004.
3. Viaram S., Engineering Chemistry, Wiley Publication, 1st edition, 2017.
4. Rao M.S.R., Singh S., Nanoscience and Nanotechnology: Fundamentals to Frontiers, Wiley Publication, 1st edition, 2014.
5. Roussak O.V., Gesser H.D., Applied Chemistry: For Engineers and Technologist, 2nd edition, 2013.

Reference Books:

1. Gowariker V.R., Viswanathan N.V., Sreedhar J., Polymer Science, New Age International Publisher, 3rd edition, 2019.
2. Agarwal C.V., Murthy C.P., Naidu A., Chemistry of Engineering Materials, B.S. Publication, 9th edition, 2018.
3. Cademartiri L., Ozin G. A., Lehn J. M., Concepts of Nanochemistry, Wiley-VCH Publication, 1st edition, 2009.

Subject: Engineering Drawing (Code: CVT101)	**Year and Semester: 1st Year and 1st/2nd Semester**	**Total Course Credit: 3**

	(Common syllabus for all branches)		L	T	P
			1	0	4
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the concepts of projection of points, lines and solids to develop real world objects	BTL3
CO2	Analyze different sectional views of simple geometrical solids	BTL4
CO3	Perceive the intersection and development of surfaces of simple solids	BTL5
CO4	Imagine and construct orthographic, Isometric, and Perspective views of objects.	BTL6

Detailed Syllabus:

UNIT I **CH - 20**

Introduction to engineering drawing: basic principles of engineering drawing, stationery requirements, drawing instruments, lettering, dimensioning, and layout.
Scales: representation of scales, units of measurement, representative fraction, types of scales.
Types of projections: concept of first angle and third angle projections, concepts of projection of points, lines, and planes.

UNIT II **CH - 20**

Introduction to 3D objects: construction of different views of simple geometrical solids using first angle projection.
Sections: types of sectional planes, true shapes of sections.

UNIT III **CH - 15**

Intersection of surfaces: simple case of intersection of two prisms, two cylinders, and cone and a cylinder.
Development of surfaces: development of surfaces of sections of solids and simple intersecting solids.

UNIT IV **CH - 15**

Isometric views: development of isometric views of simple blocks using orthographic third angle projections.

Text Book:

1. Bhatt N.D. and Panchal V.M., Engineering Drawing, Charotar Publishing House, 50th edition, 2010.

Reference Books:

1. Gopalakrishna K. R., Engineering Drawing (Vol. I&II), Subhas Stores, Bangalore, 2007.
2. Shah M. B., and Rana B. C., Engineering Drawing, Pearson, 2nd edition, 2009.
3. Luzzader, Warren. J. and Duff, J. M., Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2005.
4. Venugopal K. and Prabhu R. V., Engineering Graphics, New Age International (P) Limited, 2008.
5. Natrajan K.V., A Textbook of Engineering Graphics, Dhanalakshmi Publishers, Chennai, 2009.

6. Basant A. and Agarwal C. M., Engineering Drawing, Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
7. Gowri S., and Jeyapoovan T., Engineering Graphics, Vikas Publishing House (P) Limited, 2011.

Subject: Chemistry Laboratory (Code: CHL101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60 Marks	40 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Acquire practical knowledge of determination of various parameters of water.	BTL2
CO2	Experimentally learn about synthesis of polymeric materials.	BTL4
CO3	Gain the knowledge about analysis of fuels and lubricants.	BTL4
CO4	Use instrumental methods for chemical analysis.	BTL5

List of Experiments:

S. No.	**Experiment**	**CH**
01	To determine the total, permanent, and temporary hardness of water by EDTA method.	08
02	To determine alkalinity of given water samples/alkali mixtures by Warder's method.	
03	To estimate percentage of available chlorine (free chlorine) in bleaching powder/water.	
04	Synthesis of Urea Formaldehyde resin.	04
05	Synthesis of Phenol Formaldehyde resin (Demonstration).	
06	Proximate analysis of coal.	10
07	To determine the acid value of given lubricating oil.	
08	To determine the aniline point of given lubricating oil.	
09	Estimation of viscosity of lubricating oil by viscometer.	
10	Estimation of strength of HCl by pH meter (Demonstration).	06
11	To verify Beer–Lambert law for coloured solution and to determine the concentration of a given unknown solution (Demonstration).	

Reference Books:

1. Dara S.S., A Textbook on Experiments and Calculations in Engineering Chemistry, S Chand & Company Publication, 9th edition, 2015
2. Mangla B., Sachdeva R., Sethi B., Engineering Practical Chemistry, Manakin Press, 1st edition, 2018.
3. Rattan S., Theory and Practicals of Engineering Chemistry, S.K. Kataria and Sons publication, 1st edition, 2013.
4. Jaspal D., Malviya A., Engineering Chemistry Practical Book, Alpha science International Ltd., 1st edition, 2015.
5. Thakur A., Practical Engineering Chemistry, Narosa Publication, 1st edition, 2018.

Subject: Computer Programming Lab (Code: ITL101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60 Marks	40 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply programming for problem-solving and use various basic components of C program.	BTL3
CO2	Illustrate the use of functions and various decision and loop control structures.	BTL4
CO3	Explore diverse use cases of arrays and strings.	BTL4
CO4	Evaluate various data structures like structures and unions and implement dynamic memory allocation and file handling.	BTL5

List of Programs/Experiments:

1. Understanding compilation flow using GCC.
2. Programs to understand how integers, characters, and strings are stored and represented in C.
3. Programs to understand the ASCII character encoding.
4. Programs to understand how to use different operators available in C.
5. Programs to understand differences between logical and arithmetic operators.
6. Programs to understand differences between logical and bitwise operators.
7. Programs to evaluate algebraic expressions in C.
8. Programs to obtain a full understanding of signed, unsigned, long, and short numbers in C.
9. Programs to understand exactly how numbers are represented in computers (octal, hexadecimal and binary numbers systems).
10. Programs to understand taking input from user using different input functions.
11. Programs to understand printing of various data types using different output functions.
12. Programs to exercise all flags in printf() and scanf() functions.
13. Programs to understand printing of display patterns of numbers and asterisks.
14. Programs to understand the use of conditional statements like if-else.
15. Programs to understand the use of nested control structures.
16. Programs for implementing the switch statements and its use cases.
17. Implementation of loops using C programs.
18. Programs for solving some mathematical problems using loops.
19. Programs for designing the patterns using loops.
20. Programs to understand modularize of code using functions.
21. Programs to implement function with/without arguments and with/without return types.
22. Programs to understand static data types and static functions.
23. Programs to understand direct and indirect recursions using functions.
24. Programs to generate mathematical series using recursion.
25. Programs to understand how arrays work in C, how to use them, and how they are stored in memory.
26. Programs to understand searching in an array.
27. Programs to understand sorting techniques using arrays.
28. Programs to understand pointers in C.
29. Programs to understand the relationship between array indexing and pointer arithmetic.

30. Programs to use pointer to pass the address of data.
31. Programs to understand the relation between the name of the array and pointers.
32. Programs to analyze the effect of arithmetic operations on the name of the array.
33. Programs to understand creating, accessing, and using structures.
34. Programs to understand use of arrays and structures.
35. Programs to understand pointers to structures and pointers as structures members.
36. Programs to understand creating, accessing, and using unions.
37. Programs to understand dynamic memory allocation especially with respect to1D and 2D arrays.
38. Programs to analyze the effect of dynamic memory allocation on memory management.
39. Programs to understand creating, reading, and writing a file.
40. Programs to understand taking input through arguments to the main() function.

Subject: Fundamental Knowledge of Accreditation (Code: NBA101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 0**		
			L	T	P
			2	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify the need of the outcome-based course and Accreditation.	BTL2
CO2	Interpret the graduate attribute, program outcomes, and Bloom Taxonomy levels.	BTL3
CO3	Develop appropriate test items for all outcome based objectives for both summative and formative evaluation.	BTL6
CO4	Plan an outcome-based curriculum document to meet NBA and Washington Accord requirements.	BTL6

Detailed Syllabus:

UNIT I **CH - 06**

Introduction to Outcome Based Learning (OBL) and Outcome Based Education (OBE) and their importance; Vision and Mission statements of the Institute, Vision and Mission statements of the Department.

UNIT II **CH - 06**

Program Educational Objectives (PEOs), Program Outcomes(POs), Program Specific Outcomes (PSOs), Graduate attributes and introduction of Accreditation (Washington Accord, NBA, etc.,).

UNIT III **CH - 08**

Course Outcomes (COs), Bloom Taxonomy, Taxonomy levels, and Instructional Objectives. Assessment and Evaluation as per OBE, ICT for Assessment and Evaluation, Outcome-based Curriculum Design framework.

UNIT IV **CH - 06**

Mapping of outcome-based curriculum with Program outcomes (POs), Program specific outcomes (PSOs), Outcome-based, learning style & learning approaches, and life long learning.

UNIT V **CH - 04**

CO attainments, PO/PSO attainments; Benefits of accreditation to the students and the Institute.

References and Online Resources:

1. NBA user manuals.
2. https://www.nbaind.org/Downloads/Documents
3. https://onlinecourses.nptel.ac.in/noc23_ge46/preview

Subject: Advanced English and Communication Skills (Code: HST102)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Employ the vocabulary and grammatical elements correctly in English communication.	BTL3
CO2	Analyze the selected texts using the critical reading strategies effectively.	BTL4
CO3	Compose persuasive technical writing for academic and professional purposes.	BTL6
CO4	Exhibit impressive verbal and non-verbal interpersonal communication required for work place environment.	BTL6

Detailed Syllabus:

UNIT I **CH-10**

Vocabulary and Grammar: abbreviations and acronyms [textbook pages 88-89], words from foreign languages and technical fields [textbook pages 108-112 and 130-133], noun-pronoun agreement, subject-verb agreement [textbook pages 35-39 and 114-115], tenses, misplaced modifiers [textbook pages 62-71 and 113-115].

UNIT II **CH-11**

Critical Reading: techniques of effective reading [textbook pages 15-16], intensive and extensive reading [textbookpages96-97], practicing reading comprehension [textbook pages 52-57, 85-88, 106-108, and 116-119], reading on-prescribed passages/texts.

UNIT III **CH-10**

Technical Writing: formal letters [textbook pages 43-48] and email writing, job application and résumé writing [textbook pages 48-51], précis writing [textbook pages 102-105], report writing [textbook pages 120-126].

UNIT IV **CH-11**

Interpersonal Skills: non-verbal communication, listening and its types, debate and group discussion, job interviews.

Text Book:

1. N. P. Sudharshana and C. Savitha, English for Engineers, Cambridge, 2018.

Online Resources:

1. learnenglish.britishcouncil.org/business-english/english-emails[For Unit3, Email Writing]
2. www.skillsyouneed.com/ [ForUnit4]

Subject: Mathematics-II (Code: MAT102)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Determine the nature of series and Fourier Series of various functions.	BTL3
CO2	Solve problems related to partial differential equations by various methods.	BTL3
CO3	Apply partial differential equations for solution of wave equation and heat equation.	BTL3
CO4	Solve problems related to double and triple integrals, Beta, and Gamma functions.	BTL3

Detailed Syllabus:

UNIT I **CH-10**

Sequence and series, Fourier series, Dirichlet's condition for a Fourier series, Fourier series for functions having points of discontinuity, Fourier series for functions having arbitrary period, half range series.

UNIT II **CH-12**

Formation of PDE, Lagrange's linear equations, partial differential equations of first order, standard forms, partial differential equations of second and higher order, homogeneous partial differential linear equations with constant coefficients, non-homogeneous linear partial differential equations, Charpit's method.

UNIT III **CH-08**

Classification of linear partial differential equation of second order, vibration of a stretched flexible string, heat flow equation, wave equation, solution by the methods of separation of variables.

UNIT IV **CH-12**

Beta and Gamma functions (definition and related problems), differentiation under the integral sign (Leibnitz rule), Jacobians, double and triple integrals, change of variables in double integrals.

Text Books:

1. Jain R. K. and Iyenger S. R. K., Advanced Engineering Mathematics, 3rd Edition, 2008, Narosa Publishing House.
2. Kreyszig, E., Advanced Engineering Mathematics, 9th Edition, 2006, John Wiley Sons.

Reference Book:

1. Piaggio, H.T.H., Differential Equations, CBS Publishers.

Subject: Elements of Mechanical Engineering (Code: MET101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify materials and manufacturing processes for industrial applications.	BTL2
CO2	Evaluate the performance of energy conversion and conservation systems.	BTL5
CO3	Apply the concepts of fluid engineering in practical and diverse fields.	BTL3
CO4	Demonstrate the ability to select the proper train drive for particular applications.	BTL3

Detailed Syllabus:

UNIT I **CH-10**

Units and measurements, engineering materials and materials response, basics of manufacturing processes, recent advances in mechanical engineering, role of computer-aided design, simulation and 3D printing.

UNIT II **CH-12**

System and surroundings, thermodynamic processes, first and second law of thermodynamics, concept of entropy, engine cycles and efficiency, basic idea of internal combustion engines, heat transfer through conduction, convection, and radiation, heat exchangers, energy conservation and conversion.

UNIT III **CH-12**

General properties of fluids, fluid statics, pressure measurement, equation of fluid motion, Bernoulli's equation, viscous effects, viscosity, laminar and turbulent flows, introduction to hydraulic machines: turbines, pumps, their types, and applications in energy conversion.

UNIT IV **CH-08**

Gears, types, design criteria, speed, torque and power in gear sets, simple, compound, and reverted gear trains, gear ratios, applications.

Text Books:

1. P.N. Rao, Manufacturing Technology: Metal Cutting and Machine Tools (Vol. 2), 2013, Tata McGraw-Hill Education.
2. H S Shan, Manufacturing Processes, 2nd edition, 2017, Tata McGraw-Hill Education.
3. P. K. Nag, K. Tripathi, C. B. Pawara, Basic Mechanical Engineering.
4. Rattan, S. S., Theory of Machines, 2014, Tata McGraw-Hill Education.

Reference Books:

1. Cengel, Yunus, John Cimbala, and Robert Turner, Fundamentals of Thermal-Fluid Sciences (SI units), 2012, McGraw Hill.
2. Shigley, Joseph. Theory of Machine and Mechanisms, 2014, McGraw Hill.

Subject: Engineering Physics (Code: PHT101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the laws of Electromagnetic waves in different engineering fields.	BTL3
CO2	Analyze the concept of relativity to explore various natural phenomena.	BTL4
CO3	Evaluate the concepts of quantum mechanics to understand the underlying mechanism of engineering problems at microscopic level.	BTL5
CO4	Develop the alternative source of energy for future.	BTL6

Detailed Syllabus:

UNIT I **CH-11**

Introduction to electromagnetism: concept of electromagnetism, Nabla operator and its operations, Maxwell equations, electromagnetic wave in different media and its solution in one dimension, characteristic of electromagnetic waves and spectrum, electrostatic energy density and magnetostatic energy density, Poynting vector, Poynting theorem and conservation of momentum of electromagnetic waves, and numerical problems.

UNIT II **CH-10**

Special theory of relativity: inertial frames of reference, Galilean transformations, postulates of relativity, Lorentz transformations, time dilation, Doppler effect in light and its application in expanding of universe, twin paradox, length contraction, velocity addition rule, relativistic mass, energy, and momentum, equivalence of mass and energy, and numerical problems.

UNIT III **CH-11**

Quantum mechanics: transition from classical to quantum mechanics: black body radiation, photoelectric effect, Compton effect, concept of wave packets, De-broglie waves, Heisenberg uncertainty principle and its applications, linearity and superposition of the wave function, expectation values, operators, Schrodinger's equations: time-dependent and steady state form, quantum confinement concept, 1-D particle in a box: finite and infinite potential well, quantum mechanical tunneling, harmonic oscillator, and numerical problems.

UNIT IV **CH-10**

Nuclear physics: fundamental interaction, meson theory of nuclear forces, nuclear composition and properties, stable nuclei, binding energy, liquid-drop model, nuclear fission and fusion, radioactive decay, half life, alpha decay (qualitative analysis), beta decay (Fermi theory) and gamma decay, nuclear hazards, nuclear reactors, fusion reactors, future energy sources.

Text Books:

1. Griffith D. J., Introduction to Electrodynamics, USA, Prentice-Hall, 1999.

2. Resnick R., Introduction to Special Relativity, Singapore, John Wiley & Sons, 2007.

Reference Book:

1. Beiser A., Mahajan S., Choudhury S. R. Concepts of Modern Physics, 6th edition, 2009, India, McGraw Hill Education.

Subject: Environmental Studies (Code: CHT102)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Learn the role of environment and natural resources towards sustainability.	BTL2
CO2	Illustrate an eco-system with the help of biogeochemical cycles.	BTL4
CO3	Classify the environmental pollutions and their control measures.	BTL2
CO4	Discuss the various social aspects related to the environment by field assignment.	BTL4

Detailed Syllabus:

UNIT I **CH-11**

Environment and natural resources: introduction, scope and importance of environmental studies, types of natural resources, natural resources and associate problems (1) forest resources: deforestation, dams and their effects on forests and tribal people, (2) water resources: surface and ground water, floods, drought, conflicts over water, benefits and problems associated with dams, (3) mineral resources: classification and environmental effects of extracting the mineral resources, (4) food resources: world food problems, effects of modern agriculture, problems with the use of fertilizers-pesticides and (5) energy resources: growing energy needs, renewable and non-renewable energy sources and their applications.

UNIT II **CH-10**

Ecology and eco-systems: introduction, basic concept and definitions, ecology, ecosystems, structure and function of an eco-system, energy flow in the ecosystems (food chain, food web, ecological pyramids), biogeochemical cycles (water cycle, nitrogen cycle, carbon cycle, oxygen cycle, phosphorous cycle, sulphur cycle), ecological succession, introduction, types, characteristic features, structure and function of forest and freshwater ecosystems (lake/river).

UNIT III **CH-11**

Environmental pollution: definition of pollution; pollutants; classification of pollutants; solubility of pollutants (hydrophilic and lipophilic pollutants), definition, causes, effects, and control measures of (1) air pollution (global warming, acid rain, ozone layer depletion) (2) water pollution (COD, BOD, DO) (3) soil pollution (4) marine pollution and (5) nuclear hazards.
Solid-waste management: causes, effects and control measures of urban and industrial wastes.

UNIT IV **CH-10**

Social issues and the environment, field assignment: from unsustainable to sustainable development, urban problems related to energy, water conservation, rain water harvesting, watershed management, environmental ethics: issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, environment protection act, air (prevention and control of pollution)act, water (prevention and control of pollution)act, wildlife protection act, forest conservation act.
Field assignment: assignment on local environment problems.

Text Books:

1. Bharucha E., Textbook of Environmental Studies for Undergraduate Courses, Universities Press, 2nd edition, 2019.
2. Mishra D.D., Fundamental Concepts in Environmental Studies, S. Chand & Company Pvt. Ltd, 4th edition, 2014.
3. Rajgopalan R., Environmental Studies: From Crisis to Cure, Oxford University Press, 3rd edition, 2015.
4. Kaushik A., Kaushik C. P., Perspectives in Environmental Studies, New Age International Pvt. Ltd., 7th edition, 2021.
5. Joseph B.,Environmental Studies, McGraw Hill Education, 3rd edition, 2017.

Reference Books:

1. Chiras D.D., Environmental Science, Jones and Bartlett Publishers, 10th edition, 2014.
2. Nazaroff W.W., Alvarez-Cohen L., Environmental Engineering Science, Wiley India Pvt. Ltd., 1st edition, 2009.
3. Gregory K.J., Environmental Sciences: A Student's Companion, SLE Pound Publication, 1st edition, 2008.

Subject: Engineering Mechanics (Code: CVT102)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Utilize the fundamentals of static equilibrium and stress-strain concepts to solve engineering problems.	BTL3
CO2	Analyze the properties of plane surfaces and the concept of friction in mechanical problems.	BTL4
CO3	Determine the forces in plane trusses and explain the principle of virtual displacement.	BTL5
CO4	Apply the concept of dynamics of rigid bodies and energy principles to solve engineering problems.	BTL3

Detailed Syllabus:

UNIT I **CH-18**

Introduction to engineering mechanics-statics: fundamental concepts and laws of mechanics; equilibrium of bodies: free-body diagrams, statical determinacy; force systems: principle of moments, resultant of forces, couple systems; equilibrium of rigid bodies, support reactions, torque due to a force.
Concept of stress and strain: compatibility and stress-strain relations. stress-strain diagrams, Hooke's law, modulus of elasticity (E), lateral strains, Poisson's ratio (μ), multi-axial stress system, volumetric strain, bulk modulus (K), shear stress concept, modulus of rigidity (G), relation between E, G, and K.

UNIT II **CH-10**

Properties of plane surfaces: centroid and center of gravity, first moment of area, second moment of area.
Friction: general concept of friction, static and dynamic friction.

UNIT III **CH-10**

Plane trusses: forces in members of a truss by method of joints and method of sections.
Virtual work: principle of virtual work, calculation of virtual displacement and virtual work.

UNIT IV **CH-04**

Dynamics of rigid bodies: Newton's laws, D'Alembert's principle, energy principles.

Text Books:

1. Hibbeler, R.C., Mechanics of Materials, 6th SI edition, Prentice Hall.
2. Hibbeler, R.C., Engineering Mechanics: Statics and Dynamics, Prentice Hall, 2012.
3. Singer, F. L., Engineering Mechanics Statics & Dynamics, Prentice Hall.

Reference Books:

1. Beer, P. F. And Johnston (Jr.) E. R., Mechanics of Materials, SI version, Tata McGraw Hill, India, 2001.
2. Beer, Johnston, Clausen and Staab,Vector Mechanics for Engineers, McGraw-Hill Higher Education, 2003.

3. Timoshenko and Young, Engineering Mechanics, Tata McGraw Hill Private Limited, 2000.
4. Shames, I.H. Engineering Mechanics: Dynamics, Pearson Education India, 2002.
5. Popov, E.P., Engineering Mechanics of Solids, Prentice-Hall, 1999.
6. Gere J. M., and Goodno, B. J., Strength of Materials, Cengage Learning.
7. Craig, R.R., Mechanics of Materials, 2nd edition, John Wiley and Sons.

Subject: English Language Lab(Code: HSL101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Class Assessment	End-Term		
	60 Marks	40 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate considerable vocabulary enhancement and correct usage of English grammar.	BTL3
CO2	Exhibit effective listening and speaking skills.	BTL4
CO3	Display impressive reading and writing skills.	BTL5
CO4	Present themselves proficiently in various professional settings verbally and non-verbally.	BTL6

List of Modules/Exercises:

1. **Vocabulary I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: English with Ronnie (cuq.in/GXUO)

2. **Listening I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: Listening Time (cuq.in/IDkX)

3. **Speaking I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: English Speaking Success (cuq.in/P1bN)

4. **Reading I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: Oxford Online English (cuq.in/adxO)

5. **Writing I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: Purdue OWL (owl.purdue.edu/)

6. **Grammar I** **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: English with James (cuq.in/UruK)

7. Interpersonal Skills I **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: Let Them Talk TV (cuq.in/6gvC)

8. Vocabulary II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: English with Katherine (cuq.in/wJEO)

9. Listening II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: Aleena Rais Live (cuq.in/4Q72)

10. Speaking II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises) Complementary Material: Speak English with Vanessa (cuq.in/9Rrz)

11. Reading II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: Learn English with Cambridge (surl.li/ivyjd)

12. Writing II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: The Writing Center: University of North Carolina at Chapel Hill (writingcenter.unc.edu/)

13. Grammar II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: English with Jennifer (cuq.in/uncc)

14. Interpersonal Skills II **CH-02**

a) Selected Laboratory Modules (with Practice Exercises)
b) Complementary Material: Advanced English—For Professionals (cuq.in/7wJ7)

Subject: Engineering & Applied Physics Laboratory (Code: PHL101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Class Assessment	End-Term		
	60 Marks	40 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Experimentally verify the interaction of radiation with matter.	BTL4
CO2	Analyze the physical implications of simple harmonic motion under the influence of gravity.	BTL4
CO3	Evaluate the dynamics of electromagnetic fields.	BTL5
CO4	Design semiconductor-based devices.	BTL6

List of Experiments:

S. No.	**Experiment**	**CH**
01	To determine Planck's constant and work function using photoelectric effect.	06
02	To verify inverse square law of radiation using photoelectric effect.	
03	To determine absorption coefficient of a liquid or solution with the help of Photovoltaic cell.	
04	To determine value of acceleration due to gravity with a bar pendulum.	08
05	To determine value of acceleration due to gravity with a Kater's pendulum.	
06	To determine the Young's modulus of the material of a given beam supported on two knife edges and loaded at the middle point.	
07	To verify Stoke's law and determine the coefficient of viscosity of a highly viscous liquid.	
08	To determine the wavelength of sodium light by Newton's rings method.	08
09	To find angle of prism, angle of minimum deviation, and refractive index of a prism.	
10	To study variation of magnetic field along the axis of circular coil carrying current.	
11	To determine the Hall coefficient for a given semiconductor and study its field dependence.	06
12	To plot the V-I Characteristics of the solar cell and hence determine the fill factor.	
13	To plot the V-I Characteristics of the P-N junction diode.	
14	To study the temperature dependence of resistivity of semiconductor and to determine band gap of experimental material (Ge).	

Reference Books:

1. Arora C. L., Practical Physics, India, S Chand, 2016.
2. Gupta S. L., Kumar V., Practical Physics, India, Pragati Prakashan, 2010.
3. Das R., Robinson C. S., Kumar R. and Sahu P. R., A Textbook of Engineering Physics Practical, India, University Science Press, 2016.

Subject: Workshop Practice (Code: PHL101)	**Year and Semester: 1st Year and 1st/2nd Semester (Common syllabus for all branches)**	**Total Course Credit: 2**		
		L	T	P
		0	0	4
Evaluation Policy	Class Assessment	End-Term		
	60 Marks	40 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify and apply relevant tools and techniques in various machining operations.	BTL2
CO2	Introduce various joints, tools, operations, and techniques in welding and sheet-metal shop.	BTL3
CO3	Recognize and apply basic principles and techniques of forging and foundry shop.	BTL3
CO4	Study and practice basic operations using different types of tools and fixtures in carpentry and fitting shop.	BTL5

List of Jobs:

Machining Trade **CH-08**

Theoretical Instructions: Safety precautions, introduction of machine tools such as lathe, drilling machine, and other related metal cutting tools, parts of lathe and basic metal cutting operations, introduction of various types of cutting tools and their material.

Practical Demonstrations: Demonstration on lathe and basic operations such as drilling, facing, turning, taper turning, step turning, knurling, chamfering, etc., demonstration of basic measuring instruments.

Job No. 1: To perform plain and step turning on a workpiece on a centre lathe as per the given drawing.
Job No. 2: To perform taper turning and knurling on a workpiece on a centre lathe as per the given drawing.
Job No. 3: To perform grooving operation on a workpiece on a centre lathe as per the given drawing.

Sheet Metal and Spray-Painting Trade **CH-08**

Theoretical Instructions: Safety precautions, brief introduction of sheet metal, various tools, joints and operations, soldering, brazing, and shearing, fluxes and their applications, introduction to different machines and pattern development in detail, brief description of paints & varnishes.

Practical Demonstrations: Demonstration of all basic hand tools and equipment, fabrication of simple joints and jobs, preparation and painting of surfaces for varnish and painting, etc.

Job No. 1: To develop a cylindrical part.
Job No. 2: To develop a square elbow as per the given drawing.
Job No. 3: To develop a rectangular tray as per the given drawing.

Fitting and Benchwork Trade **CH-08**

Theoretical Instructions: Safety precautions, introduction to fitting and bench work, demonstration of basic hand tools, holding devices and basic fitting operations such as measuring, marking, filing, sawing, drilling, tapping, buffing, etc.

Practical Demonstrations: Demonstration of all basic hand tools/measuring tools and equipment, demonstration of simple operations such as marking, punching, filing, sawing, scrapping, drilling, etc.

Job No. 1: To fabricate a square plate of mild steel workpiece 50x50x5 mm.
Job No. 2: To fabricate a snap fitting of mild steel workpiece 50x50x5 mm.
Job No. 3: To fabricate a cross/square fitting of mild steel workpiece 50x50x5 mm.

Welding Trade **CH-08**

Theoretical Instructions: Safety precautions, introduction to welding processes like electric arc welding, gas welding, MIG welding, TIG welding, submerged arc welding and resistance spot welding, various fluxes and electrodes used in welding, introduction to AC & DC welding and their applications.

Practical Demonstrations: Demonstration of all basic tools and personal protective equipment, demonstration of different types of joints by using arc welding, gas welding, etc.

Job No.1: To perform a rough welding using Shielded Metal Arc Welding (SMAW) machine.
Job No.2: To make a single-V butt joint of mild steel 80x50x8mm
Job No.3: To make a lap joint of mild steel 85x35x6mm

Foundry and Casting Trade **CH-08**

Theoretical Instructions: Safety precautions, introduction to foundry and casting processes, basic steps in casting processes, types of patterns, brief description of common hand tools used in foundry work, introduction to risers, runners, gates, moulding sand and its composition and properties, common metals and materials used in casting.

Practical Demonstrations: Demonstration and practice for preparation of moulding sand, use of hand tools to prepare the mould by using different types of patterns.

Job No. 1: To prepare a green sand mould by using step pulley block for casting.
Job No. 2: To prepare a green sand mould by using open bearing block for casting.
Job No. 3: To prepare a green sand mould by using self cored pattern for casting.

Smithy and Forging Section **CH-08**

Theoretical Instructions: Safety precautions, introduction to forging tools, materials and their heat treatments, description of all forging operations such as hand forging, upsetting, drawing, and punching, introduction to various forging methods, comparison of hot and cold working.

Practical Demonstrations: Demonstration and practice of different smithy operations like forging, cutting, punching, bending, etc., demonstration and practice of forging an MS rod into a ring and octagonal cross-section.

Job No. 1: To forge an MS-square from an MS-round bar by using different forging hand tools.
Job No. 2: To forge a square headed bolt from an MS-round (60x30mm).
Job No. 3: To forge an MS-octagon from a square MS-bar (80x80 mm).

Carpentry and Pattern Making Trade CH-08

Theoretical Instructions: Safety precautions, introduction to carpentry and joinery, different tools used in carpentry, seasoning of wood and defects of wood, various types of joints, brief description of wood working machines and patternmaking.

Practical Demonstrations: Demonstration and practice of different carpentry operations like planning, sawing, and chiseling, joint making, demonstration of pattern making tools and materials.

Job No. 1: Planning, sawing, and chiseling of a wooden plank as per the given drawing.
Job No. 2: To prepare half-lap cross-joint of specified dimensions.
Job No. 2: To prepare a bridle joint of specified dimensions.

Reference Books:

1. Workshop Technology by W. A. J. Chapman.
2. Workshop Technology by Choudhury H S K.
3. Workshop Practice by Swarn Singh.
4. Workshop Technology by Virender Narula.

Detailed Curriculum for 2nd Year – 3rd Semester Courses

Subject: Mechanics of Materials-I (Code: MET201)	Year and Semester: 2nd Year and 3rd Semester		Total Course Credit: 3		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering mechanics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the concept of stress, strain, and elastic constants to various engineering problems.	*BTL3
CO2	Interpret principal stresses, strains, and apply theories of failures.	BTL3
CO3	Analyze shear force and bending moment diagrams and determine the stresses for beams subjected to different loading conditions.	BTL4
CO4	Solve problems of shafts subjected to twisting moments.	BTL6

Detailed Syllabus:

UNIT I ***CH - 10**

Resistance and deformation: concept of resistance and deformation, determinate and indeterminate problems in tension and compression, concept of continuum, homogeneity and isotropy, types of force on a body, state of stress at a point, equality of cross shear, thermal stresses, pure shear, elastic constants: Young's modulus of elasticity, Poisson's ratio, modulus of rigidity and bulk modulus, relation between elastic constants, stress-strain diagrams for brittle and ductile materials, working stress, strain energy in tension and compression, impact loading, constitutive relations.

UNIT II **CH - 11**

Analysis of stress and strain: plane stress and plane strain, stresses and strains on inclined planes, principal stresses and principal strains, maximum shear stress and shear strain, principal angles, shear stresses and shear strains on principal planes, maximum shear stress and maximum shear strain, Mohr circle for plane stress and plane strain conditions, strain measurement: strain gauge rosettes.

Thin and thick cylinders: cylindrical and spherical shells subjected to internal fluid pressure, wire wound thin cylinders, compound cylinders, shrink fit.

UNIT-III **CH - 11**

Shear force and bending moment: types of supports, types of beams, types of loads, articulated beams, shear force and bending moment diagrams.

Theory of simple bending: assumptions, bending stresses in beams, efficiency of various cross sections, composite beams, flexural shear stress distribution in different cross sections of beams, shear stress distribution across the cross section.

UNIT-IV **CH - 10**

Torsion of circular cross sections: theory of pure torsion, transmission of power in solid and hollow circular shafts, combined bending and torsion.

***Note:** BTL and CH stand for Bloom's Taxonomy Level and Contact Hours, respectively.

Buckling of columns: concept of buckling and stability, differential equations of compression member with different boundary conditions, eccentrically loaded columns, secant formula, column with initial imperfections, Rankine formula.

Text Books:

1. Hibbeler, R. C., Mechanics of Materials, 8th edition, 2011, Pearson Education India.
2. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, 2011.
3. Shames, I. H., Pitarresi, J. M., Introduction to Solid Mechanics, Pearson, 2015.

Reference Books:

1. Popov, E. P., Engineering Mechanics of Solids, PHI, 2009.
2. Beer, F. Jr., Johnston, E. R., DeWolf, J., Mazurek, D., Mechanics of Materials, 7th edition, 2014, McGraw-Hill Education.

Subject: Fundamentals of Dynamics (Code: MET202)	**Year and Semester: 2nd Year and 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering mechanics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the concepts and laws of dynamics to solve complex engineering problems.	BTL3
CO2	Use the concepts of impulse-momentum to develop relations governing particle impacts.	BTL3
CO3	Use Newton's second law to determine trajectory properties of particles under central-force attraction.	BTL3
CO4	Apply the knowledge of dynamics of rigid bodies to systems like ships and airplanes.	BTL3

Detailed Syllabus:

UNIT I **CH - 10**

Kinematics of particles, basic concepts, rectilinear motion, plane curvilinear motion, rectangular coordinates (x-y), normal and tangential coordinates (n-t), polar coordinates (r-θ), space curvilinear motion, relative motion (translating axes), constrained motion of connected particles.

UNIT II **CH - 12**

Kinetics of particles, equations of motion and their solution, impulse, momentum, work and energy, linear impulse and linear momentum, angular impulse and angular momentum, impact, central-force motion, relative motion, kinetics of systems of particles, generalized Newton's second law, work-energy, impulse-momentum, conservation of energy and momentum.

UNIT III **CH - 11**

Dynamics of rigid bodies, rotation, absolute motion, relative velocity, instantaneous center of zero velocity, relative acceleration, motion relative to rotating axes, plane kinetics of rigid bodies, translation, fixed-axis rotation, general plane motion, mass moments of inertia.

UNIT IV **CH - 09**

Work energy relations, virtual work, impulse-momentum equation, and three-dimensional dynamics of rigid bodies, gyroscopic motion, and steady precession.

Text Book:

1. Meriam, J. L., Kraige, L. G., Bolton, J. N., Engineering Mechanics: Volume 2, Dynamics, 9th edition, 2018, John Wiley.

Reference Book:

1. Shames I. H. and Rao, G. K., Engineering Mechanics Statics and Dynamics, 4th edition, 2005, Pearson Education India.

Subject: Manufacturing Processes-I (Code: MET203)	**Year and Semester: 2nd Year and 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Describe the parts and working of machine tools.	BTL2
CO2	Analyze the process behavior for different welding processes.	BTL4
CO3	Estimate the power of rolling and analyze the process behavior of various metal-forming processes.	BTL4
CO4	Explain the casting process and its applications in the manufacturing domain	BTL4

Detailed Syllabus:

UNIT I **CH - 10**

Introduction to manufacturing processes, introduction to machine tools, basic working principle of machining, types of machine tools, basic elements of machine tools, primary and secondary motion in machine tools, lathe machine - operations and machining parameters, drilling machines - types, operation and process parameters.

UNITII **CH - 11**

Welding: introduction to welding, principle of welding, classification of welding, arc initiation, characteristic and power of electric arc, power source characteristics, modes of metal transfer in arc welding, SMAW, GTAW, GMAW, resistance, gas welding, thermit, high energy beam welding, solid state welding processes, welding defects.

UNIT III **CH - 10**

Metal forming: hot and cold working, advantages and limitations of hot and cold working, rolling - power estimation in rolling, rolling mills, forging - types and applications, extrusion - direct, indirect, hydrostatic, sheet metal working - punching and blanking.

UNIT IV **CH - 11**

Casting processes: introduction, industrial applications, casting terminology, mould, types of mould, pattern, types, allowances, preparation of mould, stages in casting process, testing of moulding sand, types of casting processes, solidification time, casting defects.

Text Books:

1. A. Ghosh and A.K. Malik, Manufacturing Science, Affiliated East Press, New-Delhi.
2. Rao, P.N., Manufacturing Technology, Volume 1 and 2, McGraw-Hill Education, New Delhi.

Reference Book:

1. Serope Kalpakjian Steven R. Schmid, Manufacturing Processes for Engineering Materials, 6th edition, Pearson.

Subject: Engineering Thermodynamics (Code: MET204)	**Year and Semester: 2nd Year and 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the basic concepts of thermodynamics to engineering systems and apply various laws of thermodynamics to solve thermal related problems.	BTL3
CO2	Apply various laws of thermodynamics to solve problems involving heat and work transfer.	BTL3
CO3	Apply basic thermodynamic laws to heat engines, refrigerators, and heat pumps.	BTL3
CO4	Determine properties of steam using steam tables and Mollier chart.	BTL3

Detailed Syllabus:

UNIT I **CH - 14**

Introduction and basic concepts of thermodynamics, zeroth law, first law, enthalpy, first law for cyclic processes, applications, second law of thermodynamics, entropy, various statements of the second law and their equivalence, refrigerators and heat pumps, reversible cycles, Carnot cycle, inequality of Clausius, the principle of increase of entropy and its applications, absolute temperature scale.

UNIT II **CH - 12**

Maxwell relations, Gibb's function, Helmholtz function, TdS equations, relationship between specific heats, the Clapeyron equation, thermodynamic relations for ideal gases, process with ideal gases and vapours, ideal gas mixtures, Dalton's law of partial pressures, Amagat's law of additive volumes, J.T. effect.

UNIT III **CH - 16**

Pure substance, generation of steam, use of steam tables and Mollier diagram, various phases of a substance, triple point and critical point, sub-cooled liquid, saturated liquid, vapor pressure, two-phase mixture of liquid and vapor, saturated vapor and superheated vapor states of a pure substance, dryness fraction and its measurement, representation of the properties of a pure substance on P-V, T-S, and h-S diagrams, detailed treatment of properties of steam for industrial and scientific use.

Text Books:

1. Moran, M.J., Shapiro, H.J., Boettner, D.D., Bailey, M.B., Fundamentals of Engineering Thermodynamics, John Wiley, 2018.
2. Cengal, Y., Boles, M., and Kanoglu, M., Thermodynamics: An Engineering Approach, McGraw Hill, 2019.

Reference Books:

1. Wark, K., Thermodynamics, McGraw Hill, 2001.
2. Van-Wylen, G.J., Fundamentals of Classical Thermodynamics, John Wiley, 2001.
3. Nag, P.K., Engineering Thermodynamics, McGraw Hill, 2011

Subject: Fluid Mechanics-I (Code: MET205)	**Year and Semester: 2nd Year and 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the basic laws of hydrostatics to engineering problems involving static fluids and submerged bodies.	BTL3
CO2	Apply the principles of continuity, momentum, and energy conservation to systems involving fluid motion.	BTL3
CO3	Apply the Bernoulli equation to compute pressure and velocity changes in flow systems of different configurations.	BTL3
CO4	Apply the knowledge of fluid dynamics to determine head losses in circular pipes and lift and drag forces in engineering systems.	BTL3

Detailed Syllabus:

UNIT I **CH - 08**

Introduction, fluid mechanics, concept of continuum, fluid properties, Newtonian and non-Newtonian fluids, cavitation, fluid pressure, and its measurement, manometers: differential and U-tube, fluid statics: hydrostatic forces on surfaces, buoyancy and floatation.

UNIT II **CH - 11**

Fluid kinematics: types of flow, tools to study type of fluid flow: streamline, streak line, and path lines, continuity equation for one, two and three-dimensional flows, acceleration of a fluid particle, rotational and irrotational motions of a fluid particle, circulation, and vorticity, velocity potential function, stream function, streamline, equipotential line, flow net.

UNIT III **CH - 11**

Fluid dynamics: forces acting on a fluid in motion, Euler's equation of motion along a streamline, Bernoulli's equation of motion along a streamline, analysis of Bernoulli's equation, Bernoulli equation as energy equation, application of Bernoulli equation: Venturi meter, orifice meter, pitot tube.

UNIT IV **CH - 12**

Flow through pipes: laminar flow through pipes (Hagen Poiseuille flow), momentum correction factor, kinetic energy correction factor, Darcy Weisbach equation, energy losses through pipes, pipes in series and parallel, total energy line and hydraulic gradient line, boundary layer theory: concept, Prandtl contribution, characteristics of boundary layer along a thin flat plate, dimensional analysis: Buckingham pi theorem, various forces in fluid mechanics, dimensionless numbers, modelling, and similitude.

Text Books:

1. Pritchard P.J., Leylegian, J.C., Introduction to Fluid Mechanics, 8th edition, 2011, John Wiley and Sons, Inc.
2. Munson, Young, and Okiishi's, Fundamental of Fluid Mechanics, 8th edition, 2018, Wiley.

Reference Books:

1. Shames, I.H., Mechanics of Fluids, 4th edition, 2003, McGraw Hill.
2. White, F.M., Fluid Mechanics, 2001, McGraw Hill.
3. John. M. Cimbala Yunus A. Cengel, Fluid Mechanics: Fundamentals and applications, 4th edition, 2019, McGraw Hill.

Subject: Society and Sensitivity (Code: Code: HST059)	**Year and Semester: 2nd Year and 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Develop an in-depth understanding of sensitive issues as to various human identities.	BTL3
CO2	Dissect relationship and negotiation between individual and society.	BTL4
CO3	Assess and criticize cultural dynamics of human existence and experience.	BTL5
CO4	Discuss and theorize political and spiritual dimensions of everyday citizen life.	BTL6

Detailed Syllabus:

UNIT I **CH - 10**

Identity and sensitivity: social identity: caste, race, religion, and gender, gender awareness and sensitization, class, language, ethnicity, nation, ideological versus humanistic.

UNIT II **CH - 10**

Individual versus society: psychological and social, scientific versus moral, sovereign and interpersonal self, personal and professional relationships.

UNIT III **CH - 10**

Cultural - difference, tolerance, acceptance: cultural roots and modernity, cultural diversity and intercultural engagement, cultural art and education, global perspectives and values.

UNIT IV **CH - 12**

Polity and spirituality: constitutional democracy, rights, and duties, marginalization and positive discrimination for inclusion, civil liberties, Egalitarianism, justice, universal compassion, world peace, innovation, sustainability.

Text Books:

1. Ruthellen Josselson and Michele Harway (editors), Navigating Multiple Identities: Race, Gender, Culture, Nationality, and Roles, 2012.
2. J. Krishnamurti, The Individual and Society, 2012.

Reference Book:

1. Matt Matravers and Lukas Meyer (editors), Democracy, Equality, and Justice, 2015.

Subject: Manufacturing Processes-I Lab (Code: MEL211)	**Year and Semester: 2nd Year and 3rd Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the working and use of various components of conventional machine tools.	BTL2
CO2	Apply knowledge of metal cutting to perform various machining operations.	BTL3
CO3	Explain the basics and working of welding processes.	BTL2
CO4	Apply knowledge of welding to perform various welding operations	BTL3

List of experiments:

S. No.	**Experiment**	**CH**
01	To study the construction details and working principle of the Lathe Machine.	06
02	To perform different turning operations on a Lathe Machine.	04
03	To perform drilling operation on a given workpiece using a Drilling Machine.	04
04	To study positions, joint configurations, and safety precautions in welding.	06
05	To study and perform SMAW in Butt/Lap joint configurations.	04
06	To study and perform GMAW in Butt/Lap joint configurations.	04

Subject: Fluid Mechanics Lab (Code: MEL212)	**Year and Semester: 2nd Year and 3rd Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply basic laws and equations used for static and dynamic fluids.	BTL3
CO2	Evaluate the fluid flow and its applications in industries.	BTL5
CO3	Evaluate the Bernoulli's equation experimentally.	BTL5
CO4	Analyze fluid and its behavior under various conditions of internal and external flows.	BTL4

List of experiments:

S. No.	**Experiment**	**CH**
01	To determine the coefficient of discharge of a venturimeter.	04
02	To determine the coefficient of discharge of an orificemeter.	04
03	To verify the Bernoulli equation.	06
04	To verify Stoke's law and to study the variation of the drag coefficient with Reynolds number for a sphere.	06
05	To study different types of flow regimes with the help of Reynold's apparatus.	04
06	To study the losses due to friction in pipes.	04

Subject: Machine Drawing and Solid Modeling Lab (Code: MEL213)	**Year and Semester: 2nd Year and 3rd Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Engineering Drawing

Course Outcomes: At the end of the course, the student should be able to:

CO1	Sketch machine elements including keys, couplings, cotters, rivets, bolted and welded joints, using the conventions for engineering components and materials.	BTL3
CO2	Apply geometric modelling techniques in design and analysis.	BTL3
CO3	Construct an assembly drawing using part drawings of machine components.	BTL6
CO4	Create part drawing of machine components using machine assembly.	BTL6

Detailed Syllabus:

UNIT I **CH - 04**

Introduction to machine element drawing, review of dimensioning, types of sectioning and use, need and significance of version control in drawings, introduction to generation of drawings as a design process for machine assembly, modelling of existing machine assemblies based on practical usage and applications.

UNIT II **CH - 09**

Introduction to important machine elements such as bearings (rolling contact/sliding contact), representation of springs and related components, detailing of components involving shafts, bearing, pulleys, gears, belts, brackets for assembly, generation of assembly drawings using standard modeling software including sectioning and bill of materials, evolving details of components from assembly considerations.

UNIT III **CH - 05**

Modelling of parts and subsequently develop the assembly of different mini project based physical prototypes.

UNIT IV **CH - 10**

Development of three-dimensional models and fabrication/assembly drawings from engineering sketches and orthographic drawings and utilization of three-dimensional models in design work, additional advanced topics including stress/deflection calculations using beam theory mathematical models, design new models based on new product based ideas, 3D modelling, wire frame and animation of the product based design.

Softwares:

1. Solid Works
2. AutoCAD

Detailed Curriculum for 2nd Year – 4th Semester Courses

Subject: Mechanics of Materials-II (Code: MET251)	Year and Semester: 2nd Year and 4th Semester		Total Course Credit: 3		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Mechanics, Mechanics of Materials-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Determine the slope and deflection of beams.	BTL3
CO2	Calculate the stresses in unsymmetrical bending/curved beams and analyze the effect of forces on springs.	BTL4
CO3	Apply various elastic failure theories to engineering problems..	BTL3
CO4	Analyze and calculate stresses in rotating rings, discs, and cylinders.	BTL4

Detailed Syllabus:

UNIT I **CH - 16**

Deflection of beams: slope and deflection of beams, double integration method, Macaulay's method, strain energy due to normal and shear stresses, the total elastic strain of dilation and distortion, the energy elastic theorems, theorems on virtual work, Castigliano's theorem, complementary energy theorems, strain energy due to axial bending and torsional loads, stresses due to suddenly applied loads, use of energy theorems to determine deflection of beams and twists of shafts, Maxwell's theorem of reciprocal deflections and its corollaries, unit and dummy force methods of determining slope and deflection, continuous beams-Clayperon three moment equation.

UNIT II **CH - 14**

Unsymmetrical bending: stresses due to unsymmetrical bending, combined bending and axial loads, shear centre for symmetrical and unsymmetrical sections.

Bending of curved bars: introduction, stresses in curved bars having rectangular, circular, triangular, and trapezoidal section, stresses in crane hooks.

Springs: axial load and torque on helical springs, stresses and deformations, compound springs, leaf springs.

UNIT-III **CH - 12**

Theories of elastic failure: concept of factor of safety, maximum principal stress theory, maximum principal strain theory, maximum shear stress theory, strain energy theory, and distortion energy theory.

Stresses due to rotation: rotating ring, rotating thin disc, rotating thin solid and hollow disc, disc of uniform strength, rotating long solids and hollow cylinders.

Text Books:

1. Hibbeler, R. C., Mechanics of Materials, 6th Edition, East Rutherford, NJ: Pearson Prentice Hall, 2004.
2. Srinath L. S., Advanced Mechanics of Solids, TMH Publishing Company Limited, 1992.

Reference Books:

1. Boresi A. P., Schmidt R. J., Sidebottom O. M., Advanced Mechanics of Materials, 5th Edition, John Wiley & Sons, 1993.
2. Cook, R. D., Young, W. C., Advanced Mechanics of Materials, Collier Macmillan Publishers, 1985.
3. Ugural A. C., S. K. Fenster, Advanced Mechanics of Materials and Applied Elasticity, Prentice Hall; 5th Edition, 2011.

Subject: Theory of Machines-I (Code: MET252)	**Year and Semester: 2nd Year and 4th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fundamentals of Dynamics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate a comprehensive understanding of the fundamental concepts of machines and develop proficiency in analyzing and synthesizing mechanisms.	BTL3
CO2	Apply design principles to cam-follower mechanisms and analyze gears and gear trains.	BTL3
CO3	Analyze and design machine components involving friction; such as screw jacks, bearings, clutches, and brakes.	BTL4
CO4	Acquire a comprehensive knowledge of machine dynamics, understand flywheels, evaluate governor's principles, and understand gyroscopes and their impact on vehicle stabilization.	BTL4

Detailed Syllabus:

UNIT I **CH - 11**

Definition and types of machines, basic concepts: links, kinematic pairs, kinematic chain, degrees of freedom, displacement, velocity, and acceleration analysis, instantaneous centres of rotation, coriolis acceleration, inversions of mechanisms, four-bar linkages and their applications, slider-crank mechanism, mechanisms with lower pair, elements of synthesis of mechanism.

UNIT II **CH - 10**

Turning moment diagrams, fluctuations of energy, flywheel, governors, watt governor, Porter governor, Proell governor, Hartnell governor, controlling force, sensitivity, stability, hunting, isochronism, effort and power of a governor, gyroscope, gyroscopic couple, gyroscopic effects on an aeroplane and ships, gyroscopic stabilization, stability analysis of a two-wheeler and four-wheeler vehicle.

UNIT III **CH - 09**

Cams, classification and terminology, displacement diagrams, derivatives of follower motion, pressure angle and undercutting, motion of the follower, and layout of the cam profiles.
Types and laws of friction, screw jack, pivot and collar bearings, friction clutches, brakes.

UNIT IV **CH - 12**

Gear terminology and nomenclature, types of gears, fundamental law of gearing, tooth profiles, path and arc of contact, contact ratio, interference and undercutting, interchangeable gears, helical, bevel and spiral gears, gear trains, classification, simple, compound, reverted, and epicyclic gear trains, analysis of epicyclic gear trains, sun and planet gears, automobile differential.

Textbooks:

1. Uicker Jr, John J., Gordon R. Pennock, and Joseph E. Shigley, Theory of machines and mechanisms. Cambridge University Press, 2023.
2. Wilson, Charles E., and J. Peter Sadler. Kinematics and dynamics of machinery. Pearson Education India, 2003.

Reference Books:

1. Ambekar, Ashok G. Mechanism and machine theory, PHI Learning Pvt. Ltd., 2007.
2. Ghosh A. and Mallick A. K. Theory of Mechanisms and Machines, East-West Private Limited, New Delhi, 1988.

Subject: Manufacturing Process-II (Code: MET253)	**Year and Semester: 2nd Year and 4th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Process-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Estimate the machining time and tool life using the knowledge of machine tools and tool behavior.	BTL4
CO2	Apply the mechanics of metal cutting to determine the shear angle and cutting forces in machining	BTL3
CO3	Explain the basics of CNC machines, nontraditional, and abrasive machining processes.	BTL2
CO4	Design the gauges for hole and shaft assembly using the knowledge of limits, fits, and tolerances in manufacturing.	BTL6

Detailed Syllabus:

UNIT I **CH - 09**

Milling machine: types, working principle, milling parameters, operations, up and down milling, indexing methods in milling, machining time estimation in lathe, milling and drilling operations, reaming and broaching process.

UNIT II **CH - 12**

Introduction to machining, tool geometry, orthogonal cutting, oblique cutting, types of chips, mechanics of chip formation, chip breakers, mechanics of metal cutting: Merchant's circle diagram, determination of shear angle, cutting, and thrust forces, thermal aspects of machining.
Mechanisms of tool wear, types of tool wear, tool life, variables affecting tool life, tool materials, desirable properties of cutting tools, determination of tool life, machinability.

UNIT III **CH - 11**

CNC Machines: introduction, advantages, application, basics of CNC Programming.
Nontraditional machining: introduction, need, applications, and classifications.
Abrasive machining process: introduction, grinding: characteristics of a grinding wheel, specification of grinding wheels, loading, glazing, mechanics of grinding process, grinding operations, wheel wear.

UNIT IV **CH - 10**

Metrology: introduction to metrology, accuracy and precision, limits, fits, and tolerances, need of providing tolerance, unilateral and bilateral system, hole basis system, shaft basis system, Taylor's principles of gauge design, sine bars.

Text Books:

1. A. Ghosh and A.K. Malik, Manufacturing Science, Affiliated East Press, New-Delhi.
2. Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi.

Reference Books:

1. Campbell, J.S., Principles of Manufacturing Materials and Processes, McGraw-Hill, New-York,
2. N.V. Raghavendra and L. Krishnamurthy, Engineering Metrology and Measurements, 1st edition, Oxford University Press.
3. Lindberg, R.A., Processes and Materials of Manufacturing, Allyn and Bacon, Boston.

Subject: Heat Transfer (Code: MET254)	**Year and Semester: 2nd Year and 4th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Thermodynamics, Fluid Mechanics-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the basic laws of heat transfer, identify heat transfer in engineering systems, and analyze steady state heat conduction problems in simple geometries.	BTL2
CO2	Solve problems involving transient heat conduction in simple geometries and understand the fundamentals of convective heat transfer.	BTL3
CO3	Evaluate heat transfer coefficients for forced and natural convection.	BTL5
CO4	Analyze heat exchanger performance and evaluate the radiation heat exchange between black and gray surfaces.	BTL4

Detailed Syllabus:

UNIT I **CH - 10**

Introduction, physical origins and rate equations, combined conduction-convection-radiation problems, importance of heat transfer, conduction rate equation, thermal conductivity, general heat conduction equation, boundary and initial conditions, one dimensional steady heat conduction, plane wall, thermal resistance, composite wall, contact resistance, alternate conduction analysis, one dimensional steady heat conduction in cylinders and spheres, critical radius of insulation.

UNIT II **CH - 10**

One dimensional steady state heat conduction with heat generation in plane walls, cylinders and spheres, heat transfer from extended surfaces, fins with constant area, fin performance, unsteady heat conduction, lumped capacity analysis, criteria for lumped capacity analysis, transient heat conduction in a semi-infinite solid, Biot and Fourier numbers.

UNIT III **CH - 12**

Convection boundary layers, velocity and thermal boundary layer, local and average heat transfer convection coefficients, derivation of differential convection equations, solutions of convection equations for a flat plate, Nusselt and Prandtl numbers, relation between fluid friction and heat transfer, turbulent boundary layer heat transfer, flow across cylinders and spheres, internal forced convection, mean velocity, mean temperature, empirical relations for pipe and tube flows, free convection heat transfer on a vertical flat plate, Grashof and Raleigh numbers, empirical relations for free convection, combined free and forced convection.

UNIT IV **CH - 10**

Thermal radiation, black and gray surfaces, radiation laws, radiation shape factor, relation between shape factors, radiation heat exchange between black bodies, radiation heat exchange between non-black bodies, radiation shields, heat exchangers, overall heat transfer coefficient, fouling, types of heat exchangers, log mean temperature difference, effectiveness-NTU method, compact heat exchangers.

Text Books:

1. Incropera, F.P., Dewitt, D.P., Bergman, T.L., Lavine, A.S., Principles of Heat and Mass Transfer, Wiley, 2017.
2. Holman, J.P., Heat Transfer, McGraw Hill, 2011.

Reference Books:

1. Bejan, A., Heat Transfer, John Wiley, 1993.
2. Cengal, Y.A., Ghajar, A.J., Heat Transfer, McGraw Hill, 2020.

Subject: Applied Thermodynamics-I (Code: MET255)	**Year and Semester: 2nd Year and 4th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Thermodynamics, Fluid Mechanics-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify and describe the various components of steam power plants and their operation.	BTL2
CO2	Apply knowledge to find A/F ratio and related combustion characteristics.	BTL3
CO3	Analyze air-standard cycles.	BTL4
CO4	Analyze the working of IC Engines..	BTL4

Detailed Syllabus:

UNIT I **CH - 14**

Carnot vapor power cycle, ideal Rankine cycle, reheat cycle, regenerative cycle, feed water heaters, binary vapor cycle, combined cycles, cogeneration, air standard cycles, Carnot, Otto, Diesel and dual cycles, work output and efficiency, mean effective pressure, deviation of actual cycles from ideal cycles.
Introduction to IC engines, two stroke engine, four stroke engine, SI engine, CI engine, detonation and knocking.

UNIT II **CH - 13**

Combustion analysis, heating values, air requirement, air/fuel ratio, standard heat of reaction and effect of temperature on standard heat of reaction, heat of formation, adiabatic flame temperature, Orsat apparatus and other modern emission measurement techniques, fuels, calorific value.
Steam generators: classifications, working of fire-tube and water-tube boilers, boiler mountings and accessories, draught and its calculations, boiler efficiency, equivalent evaporation, boiler trial and heat balance.
Condensers: classification, condenser performance parameters.

UNIT III **CH - 15**

Flow through nozzle, variation of velocity, area, and specific volume, throat area, nozzle efficiency, effect of friction on nozzle, super saturated flow, Mach number.
Classification of steam turbines, impulse and reaction turbines, staging, stage and overall efficiency, reheat factor, bleeding, velocity diagram of simple and compound multistage impulse and reaction turbines and related calculations work done efficiencies of reaction, impulse reaction turbines, state point locus, comparison with steam engines, losses in steam turbines, governing of turbines, compounding of steam turbines.

Text Books:

1. Eastop, T. D., Applied Thermodynamics for Engineering Technologist, 1990, Pearson Education.

2. Nag, P.K., Applied Thermodynamics, 2014, TMH.
3. Ganeshan, V., Internal Combustion Engine, 2018, TMH.

Reference Books:

1. Helsdon, R. M., Hiller, N., Walker, G. E., Introduction to Applied Thermodynamics, 1965, Elsevier.
2. Cengal, Y., Boles, M., and Kanoglu, M., Thermodynamics: An Engineering Approach, 2019, McGraw Hill.

Subject: Mathematics-III (Code: MAT204)	**Year and Semester: 2nd Year and 4th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the concepts of statistics to various engineering problems.	BTL3
CO2	Apply the concepts of probability to various engineering problems.	BTL3
CO3	Determine the numerical solution of algebraic and transcendental equations.	BTL3
CO4	Apply numerical techniques for solving differential equations.	BTL3

Detailed Syllabus:

UNIT I **CH - 09**

Introduction to basic statistics, moments, correlation, regression, methods of least square, curve fitting (polynomials, exponentials).

UNIT II **CH - 12**

Basic definitions of probability, conditional probability with standard results, Baye's theorem with examples, random variables (discrete and continuous), laws of expectations theory, discrete distributions(binomial distribution, Poisson distribution, geometric distribution), continuous distributions(normal distribution, beta distribution, gamma distribution), introduction to sampling theory.

UNIT III **CH - 11**

Numerical solutions of linear and non-linear algebraic equations(bisection method, Newton Raphson method); interpolation.

UNIT IV **CH - 10**

Integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

Text Books:

1. Spiegel, M. R., Schiller, J. and Srinivasan, R. A., (2010), Probability & Statistics, 3rd Edition Tata McGraw Hill.
2. Sastry, S. S., Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.

Reference Book:

1. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, 11th Edition Sultan Chand & Sons Publications, 2012.

Subject: Mechanics of Materials Lab (Code: MEL261)	**Year and Semester: 2nd Year and 4th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Determine the elastic modulus, tensile and compressive strength of a material by conducting simple tension and compression test and find various critical point locations on the stress-strain diagram.	BTL3
CO2	Determine the modulus of rigidity of a shaft by conducting torsion test.	BTL3
CO3	Determine the hardness of materials by conducting hardness test.	BTL3
CO4	Determine spring stiffness and modulus of rigidity of spring material by conducting compression test.	BTL3

List of Experiments:

S. No.	**Experiment**	**CH**
01	To study the stress-strain characteristics of mild steel by conducting tension test on UTM and determining the modulus of elasticity, yield strength, ultimate strength, and fracture strength of mild steel.	08
02	To find the compressive strength of mild steel by conducting the compression test.	04
03	To determine the modulus of rigidity by conducting torsion test on solid shaft made up of mild steel.	04
04	To measure the hardness (in term of Brinell's and Vickers's hardness number) of mild steel by conducting hardness test.	06
05	To find the modulus of rigidity of the material of a spring and stiffness of spring by conducting compression test.	06

Subject: Theory of Machines-I Lab (Code: MEL262)	**Year and Semester: 2nd Year and 4th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the underlying concepts, methods, and applications of different mechanisms.	BTL2
CO2	Demonstrate proficiency in using laboratory equipment and tools.	BTL3
CO3	Develop a solution-oriented approach incorporating knowledge of mechanisms and machines.	BTL6
CO4	Prepare technical reports and documents detailing the experimental methodology.	BTL3

List of Experiments:

S. No.	**Experiment**	**CH**
01	Determination and verification of the total transmission ratio of given worm and wheel apparatus.	04
02	To calculate the drop time for various weights and compare with experimental measurements on a given flywheel.	04
03	To measure the mass moment of inertia of a flywheel and compare with the theoretical values.	04
04	To perform various experiments on the rolling disc on an inclined plane apparatus.	04
05	To determine the controlling force curves of various governors.	04
06	To determine the rate of precession of a gyroscope for a given rate of spin.	04
07	To experimentally verify the laws of gyroscopic effect and determine the gyroscopic torque.	04

Subject: Manufacturing Processes-II Lab (Code: MEL263)	**Year and Semester: 2nd Year and 4th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Describe the geometry of a single-point cutting tool and compare the theoretical and experimental machining time.	BTL2
CO2	Investigate the effect of machining process parameters on surface roughness.	BTL4
CO3	Explain the working and use of various components of CNC machines	BTL2
CO4	Apply the knowledge of CNC Programming to create CNC programs for machining operations.	BTL3

List of Experiments:

S. No.	**Experiment**	**CH**
01	To study the geometry of a single-point cutting tool.	04
02	To investigate the effect of machining process parameters on the surface roughness of machined components.	06
03	To compare the theoretical and experimental machining time in the turning operation.	04
04	To study the fundamentals of a CNC machine.	04
05	To Study the different codes used in CNC programming.	04
06	To create a program for producing a given profile using a CNC milling/turning machine.	06

Subject: Heat Transfer Lab (Code: MEL264)	**Year and Semester: 2nd Year and 4th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the steps to design and conduct experiments for measuring specific physical variables.	BTL2
CO2	Determine the thermal conductivity of a metal and a liquid.	BTL3
CO3	Examine the heat transfer phenomenon in different thermal systems.	BTL4
CO4	Evaluate heat transfer phenomenon in parallel and counterflow arrangements.	BTL5

List of Experiments:

S. No.	**Experiment**	**CH**
01	To determine the thermal conductivity of a metal bar.	02
02	To determine the thermal conductivity of a liquid.	02
03	To study the heat transfer through the insulating medium.	02
04	To study heat conduction in a composite wall.	04
05	To study heat transfer from a pin fin.	02
06	To study heat transfer in natural convection.	05
07	To study heat transfer in forced convection.	05
08	To study the heat transfer phenomena in a heat exchanger with parallel/counter flow arrangements.	04
09	To determine Stefan Boltzmann constant.	02

Detailed Curriculum for 3rd Year – 5th Semester Courses

Subject: Machine Design-I (Code: MET301)	**Year and Semester: 3rd Year and 5th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Mechanics, Theory of Machines-I, Mechanics of Materials-I, Manufacturing Processes

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate knowledge on basic machine elements used in machine design.	BTL3
CO2	Determine the stress and strain on machine components and identify and quantify failure modes for machine parts.	BTL3
CO3	Design machine elements to withstand the loads and deformations for a given application, while considering additional specifications.	BTL6
CO4	Investigate a design problem successfully, taking decisions when there is not a unique answer.	BTL4

Detailed Syllabus:

UNIT I **CH - 15**

Design requirements, selection of materials and manufacturing considerations in design. Riveted joints: introduction, types of riveted joints, failures of riveted joints, strength of riveted joint, efficiency of riveted joint, design of longitudinal butt joint and circumferential lap joint for a boiler. Bolts, nuts and screws: introduction, advantages and disadvantages, definitions, forms of screw threads, common types of screw fastenings, locking devices, designation of screw threads, stresses in screwed fastening due to static loading.

Welded connections: introduction, advantages and disadvantages of welded joints, welding processes, fusion welding, thermit welding, gas welding, electric arc welding, forge welding, types of welding joints, lap joint, butt joint, strength of transverse fillet welded joints, strength of parallel fillet welded joints, special cases of fillet welded joints, axially loaded unsymmetrical welded sections.

UNIT II **CH - 13**

Stress concentration: theoretical or form stress concentration factor, stress concentration factor due to holes and notches, methods of reducing stress concentration.

Cyclic loading and endurance limit: completely reversed or cyclic stresses, fatigue and endurance limit, effect of loading on endurance limit, effect of surface finish, size and miscellaneous factors on endurance limit.

Combined steady and variable stress: Gerber method for combination of stresses, Goodman method for combination of stresses, Soderberg method for combination of stresses.

UNIT III **CH - 14**

Cotter and couplings: types of cotter joints, socket and spigot cotter joint, design of socket and spigot cotter joint, design of sleeve and cotter joint, types of shaft couplings, design of sleeve and muff coupling, design of flange coupling.

Power screws: types of screw threads used for power screws, torque required to raise load on square threaded screws, torque required to lower load by square threaded screws, efficiency of square threaded

screws, maximum efficiency of a square threaded screw, over-hauling and self-locking screws, and design of screw jack.
Shafts: types of shafts, design of shafts, shafts subjected to twisting moment only, shafts subjected to bending moment only, shafts subjected to combined twisting moment and bending moment.

Text Books:

1. Ullman D.G., The Mechanical Design process, 3rd edition, 2009, McGraw Hill.
2. Mott, R.L, Machine Elements in Mechanical Design, 4th edition, 2005, Prentice Hall, Singapore.
3. Shigley, J.E., Mischke, C. Brown T., Standard Hand book of Machine Design, McGraw Hill.

Reference Book:

1. Shigley, J.E., Hand Book of Machine Design, McGraw Hill, 2004

Subject: Theory of Machines-II (Code: MET302)	**Year and Semester: 3rd Year and 5th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Mechanics, Fundamentals of Dynamics, Theory of Machines-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Develop the mathematical models of vibrating systems, determine their DOF, and determine the free and forced vibration response of such systems.	BTL6
CO2	Determine the response of linear time-invariant systems to arbitrary forcing conditions using the convolution integral and the Laplace Transform method.	BTL3
CO3	Formulate the equations of motion of multiple degree of freedom systems, express it as an eigenvalue problem and determine the free and force vibration response.	BTL6
CO4	Formulate the equations of motion of a continuous system, determine its natural frequencies and mode shapes, and obtain the free vibration response to given initial conditions.	BTL6

Detailed Syllabus:

UNIT I **CH - 10**

Harmonic motion, vibration terminology, complex methods of representing harmonic motion, Fourier series and harmonic analysis, free and forced vibrations, degrees of freedom, mathematical modeling of vibrating systems, differential equations of motion, solution of the differential equation of motion, torsional vibrations, various types of damping, dry friction or coulomb damping, structural damping, viscous damping, logarithmic decrement, energy dissipated by damping, equivalent viscous damping, introduction to energy methods.

UNIT II **CH - 11**

Forced harmonic vibrations, rotating unbalance, support motion, vibration isolation and control, vibration measuring instruments, vibration pickups, vibrometers and accelerometers, vibrations under general forcing conditions, impulse excitation, arbitrary excitation, convolution integral, use of Laplace transforms, pulse excitation and rise time, shock response spectrum, shock isolation.

UNIT III **CH - 10**

Two degree-of-freedom systems, normal mode analysis, coordinate coupling and principal coordinates, forced harmonic vibration, vibration absorbers and vibration dampers, generalized coordinates, natural frequencies and mode shapes, modal analysis, multi degree-of-freedom systems.

UNIT IV **CH - 11**

Continuous systems, longitudinal vibration of a bar, equation of motion and solution, orthogonality of normal functions, lateral vibration of beams, equation of motion, initial conditions, boundary conditions, effect of axial force, effects of rotary inertia and shear deformation, whirling of shafts, critical speeds, balancing of rotating shafts, single-plane balancing, two-plane balancing.

Text Book:

1. Grover, G. K., Mechanical Vibrations, 7th edition, 1996, Nem Chand and Bros, New Delhi, India.

Reference Books:

1. Thomson, W. T., Theory of Vibrations with applications, 5th edition, 2004, Pearson Education.
2. Rao, S. S., Mechanical Vibrations, 6th edition, Pearson Education.

Subject: Materials Science and Engineering (Code: MET303)	**Year and Semester: 3rd Year and 5th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the underlying concepts of engineering material chemistry and crystallography.	BTL2
CO2	Determine crystallographic directions and explain imperfections in solids, and processing of engineering materials.	BTL3
CO3	Examine the mechanisms of strengthening and the phase diagrams.	BTL4
CO4	Examine the need of heat treatment processes and analyze the effect of cooling media on microstructure.	BTL4

Detailed Syllabus:

UNIT I **CH - 09**

Introduction to material science and engineering, importance of materials, classification of engineering materials, modern and advanced materials, atomic structure and bonding, fundamentals of electron arrangements and modern periodic table, primary bonds and secondary bonds. crystallography, concept of unit cells and lattice arrangements, crystal structure, crystal systems, Bravias lattices, co-ordination number, atomic packing factor.

UNIT II **CH - 12**

Miller indices of direction and planes, single crystals, polycrystalline materials, amorphous material, X-ray diffraction and determination of crystal structures, imperfections in solids, point defects, line defects and volume defects, dislocations.

Ceramics: structure, types, properties and applications of ceramics, processing of ceramics. Composite materials: nanomaterials and their potential applications.

Plastics: types of plastics/polymers, polymer structure, thermoplastic and thermosetting polymers, processing of polymers.

UNIT III **CH - 10**

Deformation and strengthening mechanisms, strain hardening, grain refinement, mechanical alloying, solid solution strengthening, precipitation hardening, diffusion in solids, phase diagrams, solubility limit, phases, lever rule, Gibbs phase rule, Iron-Carbon equilibrium diagram, mechanical properties and testing, non-destructive testing.

UNIT IV **CH - 11**

Heat treatment: introduction to heat treatment, different types of heat treatment processes, annealing, normalizing, quenching, tempering, case hardening, time temperature transformation diagram, recovery, recrystallization, ductile to brittle transition, micro-structure of various metals and alloys, micro structure of steel treated with different cooling media.

Text Books:

1. Donald Askeland, The Science and Engineering of Materials, 7th edition, Cengage Learning.
2. Callister Jr., W. D., Rethwisch, D. G., Materials Science and Engineering: An Introduction, 8th edition, John Wiley and Sons.

Reference Books:

1. Raghvan, V., Materials Science and Engineering, 5th edition, 2005, Prentice Hall India Learning Private Limited.
2. Ghosh, A., and Malik, A. K., Manufacturing Science, 2nd edition, 2010, Pearson India.

Subject: Applied Thermodynamics-II (Code: MET304)	**Year and Semester: 3rd Year and 5th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Thermodynamics, Fluid Mechanics-I, Applied Thermodynamics-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand fundamental concepts of compressible fluid flow.	BTL2
CO2	Evaluate and analyze the working of gas turbines, jet engines, and air compressors.	BTL5
CO3	Apply concepts of psychrometry to air conditioning systems.	BTL3
CO4	Analyze the working of refrigeration systems.	BTL4

Detailed Syllabus:

UNIT I **CH - 09**

Introduction to compressible flow, stagnation and static states, use of tables for determining various properties, Mach. No., flow through various cross section passages like nozzles and diffusers, Fanno flow, Rayleigh flow, shock: normal and oblique.

UNIT II **CH - 11**

Gas turbines: Brayton cycle, modification of Brayton cycle and applications, stage efficiency, polytropic efficiency, combined cycles, cogeneration, air compressors.
Jet propulsion: introduction to the principles of jet propulsion, turbojet and turboprop engines and their processes, principle of rocket propulsion.

UNIT III **CH - 12**

Refrigeration: introduction to refrigeration, COP, thermal principles for refrigeration, reversed Carnot cycle, vapor compression cycle, modification of vapor compression cycle and its applications, vapor absorption system, electrolux refrigerator, survey of refrigerants, designation of refrigerants, selection of refrigerants, thermodynamic requirements.

UNIT IV **CH - 10**

Air-conditioning: psychometric process and properties, psychrometer, psychromeric chart, basic air conditioning processes, mixing process, cooling and dehumidifying coils, bypass factor, sensible heat factor, application of air conditioning.

Text Books:

1. Yahya, SM, Fundamental of compressible flow, McGraw Hill, New Delhi,
2. Eastop, T. D., Applied Thermodynamics for Engineering Technologist, Pearson Education, 1990.
3. Arora, C. P., Refrigeration and Air-conditioning, McGraw Hill, New Delhi.

Reference Books:

1. P. K. Nag, Basic and Applied Thermodynamics, McGraw Hill India.
2. Moran, M. J. and Shapiro, H. N., Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 1999.
3. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J, Fundamentals of Thermodynamics, 6th edition, 2003, John Wiley and Sons.

Subject: Industrial Engineering-I (Code: MET305)	**Year and Semester: 3rd Year and 5th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Examine the concept and applications of industrial engineering with a focus on productivity, work design, and work study.	BTL4
CO2	Analyze and apply the method study techniques in relation to a particular job environment.	BTL4
CO3	Analyze and evaluate various engineering work measurement techniques designed to establish the time for a qualified worker to carry out a specific job at a defined level of performance.	BTL4
CO4	Demonstrate the ability to apply the techniques of Material Management (MM) and inventory control for effective designing and systematic implementation of various MM methods and inventory systems in manufacturing set-ups.	BTL3

Detailed Syllabus:

UNIT I **CH - 12**

Introduction and significance of industrial engineering and its techniques, functions of industrial productivity and significance in industries, productivity measurements, factors affecting productivity, basic work content and excess work content.
Introduction to work study and its basic procedures, definitions and concept of work study with examples. Ergonomics**:** scope and objectives, application of human factors in engineering work place design.

UNIT II **CH - 16**

Introduction to method study and the selection of jobs, record, examine and develop, objectives and basic procedure of method study, recording techniques (process charts (PC),and diagrams),outline PC, flow process charts, two hand process charts, SIMO chart, flow diagram, string diagram, cycle graph, chronocycle graph, travel chart, define, install and maintain, the principles of motion economy. Work measurement and its applications, time study, work sampling, rating and their methods, breaking the jobs into elements, types of elements, allowances and their calculations, calculation of standard time, examples of time study, PMT systems, synthetic data, various applications and examples.

UNIT III **CH - 14**

Materials management and inventory control, integrated materials management and their components, functions and objectives of material management, introduction and concepts of inventory management, purchase model with instantaneous replenishment and without shortage, manufacturing model without shortages, purchase model with shortages, manufacturing model with shortages, probabilistic inventory concepts with lead time, selective inventory management-ABC, FSN, VED analyses.

Text Book:

1. Barnes, R.L., Motion and Time Study, Design and Measurement of Work, 7th edition, John Wiley and Sons, New York.

Reference Books:

1. International Labor Office, Geneva, Introduction to Work Study, 4th edition, Geneva.
2. Currie R.M, Work study, ELBS and Pitman, London.
3. Mundel, M.E., Motion and Time Study, 5th edition, Prentice Hall, Englewood Cliff, New York.

Subject: Theory of Machines-II Lab (Code: MEL311)	**Year and Semester: 3rd Year and 5th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Develop proficiency in setting up and conducting vibration experiments using various types of equipment and sensors.	BTL6
CO2	Understand and apply various vibration testing techniques, including modal analysis, frequency response testing, and operational deflection shape analysis.	BTL2
CO3	Develop the ability to identify key parameters such as natural frequencies, damping ratios, and mode shapes from experimental data.	BTL6
CO4	Develop the ability to effectively communicate experimental procedures, results, and analysis through technical reports and presentations.	BTL6

List of Experiments:

S. No.	**Experiment**	**CH**
01	Determine the time period of a simple pendulum. Verify that the time period is independent of the mass of the bob.	04
02	Determine the radius of gyration of a given bar by using a Bifilar suspension.	04
03	Study the undamped free vibration of an equivalent spring-mass system.	04
04	Study the forced vibration of an equivalent spring-mass system.	04
05	Study the torsional vibration of a single rotor shaft system.	04
06	Determine the frequency response function of an equivalent spring-mass-dashpot system.	04
07	Determine the critical speed of rotating shafts.	04

Subject: Thermal Engineering Lab (Code: MEL312)	**Year and Semester: 3rd Year and 5th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand working principles of compressors.	BTL2
CO2	Understand refrigeration and air conditioning systems.	BTL2
CO3	Evaluate the performance and emission testing of SI Engines.	BTL5
CO4	Investigate the performance and emission testing of CI Engines.	BTL4

List of Experiments:

S. No.	**Experiment**	**CH**
01	Study of a refrigeration system.	02
02	Study of an air conditioning system.	02
03	Study of a steam turbine.	02
04	Study of a gas turbine and jet engine.	02
05	Study of different internal combustion engine models.	02
06	Experimental study of a cooling tower.	04
07	Experimental study of characteristic performance curves and emission of a spark ignition engine using gasoline as fuel.	04
08	Experimental study of characteristic performance curves and emission of a compression ignition engine using diesel as fuel.	04
09	Experimental study of characteristic performance curves of a single cylinder reciprocating compressor.	04
10	To study the constructional details of a hermetically sealed reciprocating compressor.	02

Subject: Research Lab (Code: MEL313)	**Year and Semester: 3rd Year and 5th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze surface morphology of different materials using techniques like XRD and FESEM.	BTL4
CO2	Determine viscosity of different fluids using a rheometer.	BTL3
CO3	Investigate the machining performance of CNC machines.	BTL4
CO4	Design and develop a component using a 3D printing machine.	BTL6

List of Experiments:

S. No.	**Experiment**	**CH**
01	Structural determination of powdered crystalline materials by X-Ray diffractometer (XRD).	04
02	Surface morphology of the materials by Field Emission Scanning Electron Microscope (FESEM).	04
03	Determination of viscosity of nanofluids using rheometer.	04
04	Determination of bulk composition using Wavelength Dispersive X-Ray Fluorescence (WDXRF).	04
05	Machining performance of 5-axis CNC machine.	06
06	Produce a given component using 3D printing.	06

Detailed Curriculum for 3rd Year – 6th Semester Courses

Subject: Machine Design-II (Code: MET351)	**Year and Semester: 3rd Year and 6th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Mechanics, Theory of Machines-I, Machine Design-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the stress and strain of mechanical components.	BTL4
CO2	Design different types of friction elements.	BTL6
CO3	Design different types of gears.	BTL6
CO4	Design different types of bearings.	BTL6

Detailed Syllabus:

UNIT I **CH - 13**

Design of friction elements, various types of brakes, design and analysis of various types of brakes, design and analysis of different types of clutches, design of couplings and keys for shafts, etc., design and analysis of flat and V-belts.

UNIT II **CH - 13**

Introduction to gear design, design and analysis of spur gears, equation for σ_b and σ_c for spur gears, design and analysis of helical gears, design and analysis of bevel gears, design and analysis of worm gears.

UNIT III **CH - 16**

Introduction to bearings, types of bearings, types of sliding contact bearings, design and analysis of hydrodynamic bearings, Petroff's equation, McKee's investigation,variation of viscosity with pressure and temperature, viscosity index, Reynolds equation for three dimensional case, Sommerfeld number. Rolling element bearings: types of rolling contact bearings, equations for L_{10} life, static loading and dynamic loading, determination of load based on radial and thrust load for ball bearings, Design and analysis of rolling contact bearings.

Text Books:

1. Mot, R.L., Machine Elements in Mechanical Design, Maxwell Macmillan Intl. Edition New York, USA, 1992.
2. Shigley, J.E., Machine Engineering Design, McGraw Hill, Higher Education, 2004.

Reference Book:

1. Shigley, J.E., Mischke, C. Brown T., Standard Hand book of Machine Design, McGraw Hill.

Subject: Fluid Mechanics-II (Code: MET352)	**Year and Semester: 3rd Year and 6th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fluid Mechanics-I, Applied Thermodynamics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Examine the working of reciprocating compressors and their performance.	BTL4
CO2	Analyze the operation of centrifugal air compressors and axial flow compressors.	BTL4
CO3	Evaluate the working and construction features of hydraulic turbines.	BTL5
CO4	Analyze the working and construction features of pumps.	BTL4

Detailed Syllabus:

UNIT I **CH - 09**

Review of basic principles of thermodynamics, fluid mechanics, and heat transfer.
Introduction to compressors, work input with and without clearance volume and its significance, volumetric efficiency, isothermal efficiency, free air delivery, multistage compression.

UNIT II **CH - 12**

Centrifugal compressors: principle of operation, T-s diagram, energy equation, velocity diagrams, types of blades, influence of blade angle on the performance of the centrifugal compressor, analysis of flow, performance characteristics.
Axial flow compressors: construction, principle of operation, T-s diagram, energy equation, velocity diagrams, analysis of flow, work done factor, stage efficiency, degree of reaction, performance characteristics.

UNIT III **CH - 10**

Principle of impingements of jets, Euler equation, classification of hydraulic turbines, constructional details, analysis, efficiencies and design parameters of impulse (Pelton Turbine) and reaction Turbines (Francis, Kaplan, and Propeller turbine), draft tube, cavitation, governing of hydraulic turbines.

UNIT IV **CH - 11**

Advantages of centrifugal pumps over reciprocating pumps, construction and working of a centrifugal pump, classification of centrifugal pumps, different heads of centrifugal pumps, different efficiencies of a centrifugal pump, analysis of a centrifugal pump, minimum starting speed of a centrifugal pump, maximum suction lift and net positive suction head, pumps in series and in parallel.

Text Books:

1. Ganesan V., Gas Turbines, 3rd edition, 2010, Tata McGraw Hill.
2. Subramanya K., Hydraulic Machines, 1st edition, 2017, Tata McGraw Hill.

Reference Book:

1. Saravanamuttoo H.I.H., Rogers G.F.C., Cohen H., Straznicky P.V., Nix A. C., Gas Turbine Theory, 7th edition, 2020, Pearson.

Subject: Industrial Engineering-II (Code: MET353)	**Year and Semester: 3rd Year and 6th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Industrial Engineering-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Build critical thinking and objective analysis of real-life decision problems which could be analyzed under the ambit of operations research.	BTL6
CO2	Apply the knowledge of industrial engineering techniques to solve linear programming problems.	BTL3
CO3	Estimate the project life cycle and perform project planning activities.	BTL4
CO4	Demonstrate the ability to use the methods of statistical quality control and process control for effective designing of Industrial Quality Monitoring Systems.	BTL3

Detailed Syllabus:

UNIT I **CH - 15**

Overview of Operations Research (OR), OR methodology and techniques, introduction to linear programming (LP), application of LP techniques in production management, graphical method, the simplex method, transportation models and their variants, assignment problems, Big-M and two-phase methods, theory of duality..

UNIT II **CH - 13**

Project planning and scheduling, project life cycle, CPM and PERT, project crashing and recourse allocation problems, decision theory, steps in decision making, decision making under uncertainty and under risk, marginal analysis, decision trees.

UNIT III **CH - 14**

Inspection and quality control**:** Concept and definition of quality, concept of Statistical Process Control (SPC), process variation, sampling inspection, concepts and types of control charts, acceptance sampling, application of control charts and sampling plans.

Text Book:

1. Taha, H.A., Operation Research- an Introduction, 6th edition, Prentice Hall of India, New Delhi.
2. PK Gupta and D.S Hira, Operations Research, 7th edition, 2021, S Chand publishers.

Reference Books:

1. Joseph Ecker, Michael K., Introduction to Operations Research, John Wiley and Sons, 1998.
2. Hillier and Lieberman, Introduction to Operations Research, McGraw Hill, Singapore, 2001.

3. Gupta M.P., Khanna R. B., Quantitative Techniques for Decision Making, Prentice Hall of India, New Delhi, 2008.

Subject: Mathematics-IV (Code: MAT214)	**Year and Semester: 3rd Year and 6th Semester**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the complex functions for continuity, differentiability, and analyticity.	BTL4
CO2	Solve the problems related to complex Integration.	BTL3
CO3	Evaluate Laplace transform and Inverse Laplace transform of various functions.	BTL5
CO4	Apply the Laplace transform method for solving ordinary differential equations.	BTL3

Detailed Syllabus:

UNIT I **CH - 10**

Function of a Complex variable, limits, continuity and differentiability, analytic functions, Cauchy-Riemann equations, Harmonic functions, construction of analytic functions.

UNIT II **CH - 10**

Cauchy's integral theorem and integral formula, Taylor and Laurent series, zeros and poles of analytic functions, residue theorem.

UNIT III **CH - 12**

Laplace transform, Laplace transform of some elementary functions, properties of Laplace transform, differentiation and integration of Laplace transform, Dirac-delta function and its Laplace transform.

UNIT IV **CH - 10**

Heaviside's expansion theorem, inverse Laplace transform, initial and final value theorems, convolution theorem, use of Laplace transforms in the solution of heat, wave and Laplace's equations.

Text Books:

1. Complex Variables and Applications, W. Brown and R. V. Churchill, 8th edition, 2009, McGraw Hill International Edition.
2. Schaum's Outlines Laplace Transforms, Murray R. Spiegel, Tata McGraw Hill, 2009.

Reference Books:

1. R. K. Jain and S. R. K. Iyenger, Advanced Engineering Mathematics, 3rd edition, 2008, Narosa Publishing House.

Subject: Industrial Engineering Lab (Code: MEL361)	**Year and Semester: 3rd Year and 6th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate human factors/ergonomic principles (HF/E) that influence the design, performance and safety of work systems.	BTL3
CO2	Apply HF/E guidelines and use standard HF/E in the design of work systems.	BTL3
CO3	Model work systems using standard techniques, such as flow diagrams, process charts, operation charts, activity charts, block diagrams, and process maps, for purposes of work system documentation, analysis, and design.	BTL4
CO4	Determine the time required to do a job using standard data, occurrence sampling, time study, and predetermined time systems.	BTL3

List of Experiments:

S. No.	**Experiment**	**CH**
01	Ergonomic design study (present/proposed/new) of a product, equipment or work environment (human-machine interface) – This involves about four to five laboratory classes/sessions.	04
02	To assemble a product (electrical holder, etc.), record the cycle time and draw learning curve of the operator performing the assembly.	04
03	To draw outline process chart and two hand flow process charts for the assembly performed in experiment no. 2, and analyze the present method and also suggest improved method(s).	04
04	To study and draw flow process charts (some suitable assembly operation).	04
05	To study and draw multi activity chart of a suitable method and propose better method(s) (man and machine).	04
06	To study suitable movements/travel of man, material or equipment, and draw string diagram, travel chart, and flow diagrams.	04
07	To calculate the standard time of a suitable job, using predetermined time standard techniques.	04

Detailed Curriculum for 4th Year – 7th Semester Courses

Subject: Measurement and Instrumentation (Code: MET401)	**Year and Semester: 4th Year and 7th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Describe various static and dynamic characteristics of instruments and explain their effects on instrument behaviour.	BTL2
CO2	Explain some of the typical methods employed to measure motion, temperature, force, pressure and flow.	BTL2
CO3	Compare advantages and limitations of various measuring systems and comment on their suitability for a particular application.	BTL4
CO4	Examine and illustrate the principles of sensors and transducers used for a particular measurement instrument.	BTL4

Detailed Syllabus:

UNIT I **CH - 10**

Definitions, significance, fundamental methods, generalized measurement system, functional elements, types of input quantities, standards, calibration, uncertainty, errors, classification of instruments, input-output configuration, interfering and modifying inputs, methods of correction, generalized performance characteristics, static characteristics, static calibration, dynamic characteristics, zero and first order instruments, time constant, second-order instruments, transient response characteristics.

UNIT II **CH - 10**

Relative and absolute motion devices, relative displacement, resistive potentiometers, bridge circuit, LVDT, variable inductance and variable capacitance pick-ups, piezoelectric transducers, fibre optic displacement transducer, resistance strain gauge, relative velocity-translational and rotational, mechanical revolution counters and timers, stroboscopic method, moving coil and moving magnet pickups, DC and AC tachometers, eddy current drag-cup tachometer, acceleration measurement.

UNIT III **CH - 11**

Hydraulic and pneumatic load cells, flapper nozzle principle, force transducers with elastic members, proving ring transducer, cantilever beam transducer, electromagnetic balance, dynamometers – absorption, driving, and transmission type, reaction forces in shaft bearings, prony brake, eddy current brake dynamometer, instruments for high, mid and low pressure measurement, dead weight and null type, elastic element gages, differential pressure cell, high pressure measurement, low pressure measurement - Pirani gauge and McLeod pressure gauge.

UNIT IV **CH - 11**

Orifice meters, Venturi meter, pitot tube, flow nozzle, variable area meters, rotameter, design and accuracy, positive displacement flow meter, turbine flow meter, electromagnetic flow meter, ultrasonic flow meters, temperature sensing techniques, liquid-in-glass and bimetallic thermometers, pressure thermometers,

electrical resistance thermometers, thermistors, thermocouples, thermopiles, radiation pyrometers, optical pyrometer.

Text Book:

1. Beckwith, B., Mechanical Measurements, 6th edition, 2008, Pearson Education Int.

Reference Books:

1. Nakra B.C., Instrumentation, Measurements, and Analysis, 2nd edition, 2008, Tata McGraw-Hill, New Delhi.
2. Doeblin, E. O., Measurement systems, 5th edition, 2004, McGraw Hill, New Delhi.

Subject: Engineering Economics (Code: HST052)	**Year and Semester: 4th Year and 7th Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the fundamental understanding of the economic concepts and constraints that determine our behavior as rational consumers.	BTL2
CO2	Assess the impact of costs that the firms/industries/entities face while production.	BTL5
CO3	Evaluate and identify the operation of different forms of markets and their competitive strategies.	BTL5
CO4	Examine the importance of the key macroeconomic concepts and their impacts on entities.	BTL4

Detailed Syllabus:

UNIT I **CH - 11**

Basics of economics and consumer behavior: economics- meaning, divisions, and importance (engineering context), utility- concepts and types, demand- concept and laws, elasticity of demand-types, measurement, and importance, consumer equilibrium and consumer surplus.

UNIT II **CH - 11**

Theory of firms: production-concept, production function, laws of returns to factors (laws of variable proportions), and laws of returns to scale, cost-concepts, types, producer equilibrium, and producer surplus.

UNIT III **CH - 11**

Markets: equilibrium – concept, markets- features, types, and introduction to price and output determination (short-run and long-run) - perfect competition, monopoly, monopolistic competition, duopoly, and oligopoly.

UNIT IV **CH - 09**

The fundamentals of engineering economics: description and role of engineering economics, interest rate-types and rate of return, cash flows- concepts and estimation, benefit-cost analysis.

Text Books:

1. Ahuja, H. L., Advanced Economic Theory: Microeconomic analysis, 21st edition, 2016, S. Chand.
2. Keat, P. G., College, D., Erfle, S., Banerjee, S., and Young, P. K. Y., Managerial Economics, 7th edition, 2018, Pearson.
3. Koontz, H., Weihrich, H., and Cannice, M. V., Essentials of Management, 11th edition, 2020, McGraw Hill, New Delhi.

Reference Books:

1. Koutsoyiannis, A., Modern Microeconomics, 2nd edition (Intl.), 2013, Palgrave – Macmillan.
2. Blank, L., and Tarquin, A. J., Engineering Economy, 8th edition, 2018, McGraw-Hill.
3. Pindyck, R. S., Rubinfeld, D. L., and Banerjee, S., Microeconomics 9th edition, 2022, Pearson Education.
4. Salvatore, D., Schaum's Outline of Microeconomics, 4th edition, 2011, McGraw-Hill.

Subject: Simulation Lab (Code: MEL411)	**Year and Semester: 4th Year and 7th Semester**	**Total Course Credit: 1**		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment	End-Term		
	60	40		

Pre-requisites: Theory of Machines I & II, Mechanics of Materials I & II, Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1	Model and simulate dynamic mechanical systems.	BTL6
CO2	Conduct kinematic and dynamic analysis of simple mechanisms and vibration analysis of mechanical/structural systems.	BTL6
CO3	Analyze structural problems using ANSYS/ABAQUS.	BTL4
CO4	Solve 1D and 2D steady and transient heat conduction problems numerically.	BTL3

List of Simulations:

S. No.	**Simulation/Numerical Analysis**	**CH**
01	Modeling and simulation of dynamic systems using MATLAB/Simulink – Inverted Pendulum and Mass-Spring-Damper System.	04
02	Kinematic and dynamic analysis of simple mechanisms like 2R, 4 bar, and 5 bar mechanisms.	04
03	Free and forced vibration analysis of lumped-mass systems and distributed-mass systems.	04
04	Optimization of mechanical structures – Design of a truss for minimum weight subjected to given strength constraints.	04
05	Analysis of 2D and 3D structural problems using ANSYS/ABAQUS	06
06	Steady and transient heat conduction analysis – Numerical solutions for 1D and 2D systems.	06

List of elective courses

S. No.	Course Code	Course Title	L	T	P	Total Contact Hours	Credits
1	MET001	Additive Manufacturing	3	0	0	3	3
2	MET002	Advanced Casting Processes	3	0	0	3	3
3	MET003	Advanced Fluid Mechanics	3	0	0	3	3
4	MET004	Advanced Machining Processes	3	0	0	3	3
5	MET005	Advanced Manufacturing Technology	3	0	0	3	3
6	MET006	Advanced Solid Mechanics	3	0	0	3	3
7	MET007	Advanced Thermodynamics	3	0	0	3	3
8	MET008	Applied Design Thinking for Innovation and IPR	3	0	0	2	2
9	MET009	Artificial Intelligence in Engineering	3	0	0	3	3
10	MET010	Automation in Production	3	0	0	3	3
11	MET011	Automobile Technology	3	0	0	3	3
12	MET012	Basic Fracture Mechanics	3	0	0	3	3
13	MET013	Computer Integrated Manufacturing	3	0	0	3	3
14	MET014	Condition Monitoring	3	0	0	3	3
15	MET015	Conduction Heat Transfer	3	0	0	3	3
16	MET016	Continuum Mechanics	3	0	0	3	3
17	MET017	Control Systems	3	0	0	3	3
18	MET018	Cryogenics	3	0	0	3	3
19	MET019	Design for Production Tooling	3	0	0	3	3
20	MET020	Design of Energy Systems	3	0	0	2	2
21	MET021	Design of Experiments	3	0	0	3	3
22	MET022	Design of Refrigeration and Air Conditioning Systems	3	0	0	3	3
23	MET023	Entrepreneurship Development and Risk Management	3	0	0	3	3
24	MET024	Experimental Stress Analysis	3	0	0	3	3

25	MET025	Fundamentals of Acoustics	3	0	0	3	3
26	MET026	Fundamentals of Tribology	2	0	0	2	2
27	MET027	Heating, Ventilation, and Air Conditioning	3	0	0	3	3
28	MET028	Industry 5.0	2	0	0	2	2
29	MET029	Internal Combustion Engines	3	0	0	3	3
30	MET030	Introduction to Computational Fluid Dynamics	3	0	0	3	3
31	MET031	Introduction to Electric Vehicle	3	0	0	3	3
32	MET032	Introduction to Finite Element Method	3	0	0	3	3
33	MET033	Introduction to MEMS	3	0	0	3	3
34	MET034	Introduction to Microfluidics	3	0	0	3	3
35	MET035	MATLAB Programming	2	0	0	2	2
36	MET036	Mechanics of Composite Materials	3	0	0	3	3
37	MET037	Noise Monitoring and Control	3	0	0	3	3
38	MET038	Operations Management	3	0	0	3	3
39	MET039	Power Plant Engineering	3	0	0	3	3
40	MET040	Product Development and Value Engineering	3	0	0	3	3
41	MET041	Renewable and Alternate Energy Systems	3	0	0	3	3
42	MET042	Solar Thermal Engineering	3	0	0	3	3
43	MET043	Theory of Elasticity	3	0	0	3	3
44	MET044	Theory of Plates and Shells	3	0	0	3	3
45	MET045	Total Quality Management	3	0	0	3	3
46	MET046	Welding and Allied Processes	3	0	0	3	3

Detailed Curriculum for Elective Courses

Subject: Additive Manufacturing (Code: MET001)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-I, Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Compare Additive Manufacturing (AM) technology with conventional manufacturing techniques.	BTL4
CO2	Understand the basics of additive manufacturing and working principles of different AM processes.	BTL2
CO3	Analyze various AM processes to understand their relative merits and demerits.	BTL4
CO4	Apply the knowledge of AM processes to select the appropriate process for industrial applications.	BTL3

Detailed Syllabus:

UNIT I **CH - 09**

Introduction to Additive Manufacturing (AM), AM evolution, AM vs traditional manufacturing, advantages and limitations of AM over conventional manufacturing, nomenclature of AM machines, prototyping, tooling and manufacturing, classification of AM processes, common AM processes, generalized AM process chain and steps in AM, types of materials for AM.

UNIT II **CH - 12**

Introduction to VAT photo polymerization processes, materials for AM processes utilizing VAT photo polymerization, Stereo-lithography (SL), photo polymerization process, process modeling, variants and classification of VAT photo polymerization process, advantages and drawbacks of VAT photo polymerization processes.

Introduction to Powder Bed Fusion (PBF) technique, materials, powder fusion mechanism, process parameters and modeling, powder handling, powder fusion techniques, PBF process variants, advantages and drawbacks of PBF.

UNIT III **CH - 11**

Introduction to extrusion-based processes, basic principles of extrusion-based processes, Fused Deposition Modeling (FDM), materials, bio-extrusion, contour crafting, non-planar systems, rep-rap FDM systems, process benefits and drawbacks.

Introduction to Material Jetting (MJ) and Binder Jetting (BJ) processes, materials, process description to MJ and BJ, variants of MJ and BJ, comparison between MJ and BJ, benefits and drawbacks.

UNIT IV **CH - 10**

Introduction to sheet lamination AM processes, variants of sheet lamination, Laminated Objected Manufacturing (LOM), Ultrasonic additive manufacturing (UAM), benefits and drawbacks of UAM.

Introduction to Direct Energy Deposition (DED) processes, process description, classification of DED techniques, benefits and drawbacks of DED.

Text Books:

1. Manu Srivastava, Sandeep Rathee, Sachin Maheshwari, TK Kundra**,** AdditiveManufacturing: Fundamentals and Advancements, 1st edition, 2019, Boca Raton: CRC Press, Taylor & Francis group.
2. Ian Gibson, David W Rosen, Brent Stucker., Additive Manufacturing Technologies: 3DPrinting, Rapid Prototyping, and Direct Digital Manufacturing, 2nd edition, 2015, Springer.

Reference Books:

1. Sandeep Rathee, Manu Srivastava, Sachin Maheshwari, TK Kundra, Arshad Noor Siddiquee, Friction Based Additive Manufacturing Technologies: Principles for Building in Solid State, Benefits, Limitations, and Applications, 1st Edition, 2018, Boca Raton: CRC Press, Taylor & Francis group.
2. Chua Chee Kai, Leong Kah Fai, 3D Printing and Additive Manufacturing: Principles & Applications, 4th edition, 2015, World Scientific.
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
4. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

Subject: Advanced Casting Processes (Code: MET002)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-I, Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand and explain the various advanced casting processes with their specific applications.	BTL2
CO2	Apply the fundamentals of evaporative pattern casting and other allied process in advanced casting processes.	BTL3
CO3	Identify casting defects through analysis of mechanization, casting design, and pollution control methods.	BTL2
CO4	Develop proficiency in casting inspection techniques and testing procedures including destructive and non-destructive testing methods.	BTL6

Detailed Syllabus:

UNIT I **CH - 12**

Casting processes: classification, metal mould casting processes, advanced casting processes, investment casting, rheocasting, mould and core making materials and their characteristics, technology of selected casting processes: clay bonded, synthetic resin bonded, inorganic material bonded mould and core making, sand additives, mould coating, continuous casting process, centrifugal casting process.

UNIT II **CH - 13**

Evaporative Pattern Casting (EPC) process and allied processes: EPC, processing steps, requirements and variables in EPC, hybrid EPC (vacuum assisted evaporative pattern casting process), Vacuum Sealed Molding Process (VSMP) and its process parameter, investment casting process, ceramic shell investment casting process, wax: its types and wax pattern preparations, process parameters and steps in shell molding.

UNIT III **CH - 09**

Casting defects: various casting defects, diagnosis and rectification, mechanization and automation in foundries, use of robots, casting design, near net shape casting, pollution control, energy, and waste management in foundries.

UNIT IV **CH - 08**

Casting inspection processes: destructive testing, non-destructive testing, liquid dye penetrant inspection, magnetic particle inspection, ultrasonic testing, radiographic inspection.

Text Books:

1. Heine, R. W. Loper, C. Philip, and C. R. Rosenthal, Principle of Metal Casting, McGraw Hill.
2. P. L. Jain, Principle of Metal Casting, Tata McGraw Hill.

3. P. N. Rao, Manufacturing Technology, Tata McGraw Hill.
4. R. S. Parmar, Welding Engineering and Technology, Khanna publishers.

Reference Books:

1. D. Seferian, Metallurgy of Welding Technology, Chapman & Hall
2. R. Little, Welding and Welding Technology, Tata McGraw Hill.

Subject: Advanced Fluid Mechanics (Code: MET003)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fluid Mechanics-I, Fluid Mechanics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply methods and techniques in viscous flows theory and be in a position to interpret viscous flow phenomena.	BTL3
CO2	Analyze Navier-Stokes equations (conservation laws for mass, momentum, and energy) for simple fluids.	BTL4
CO3	Solve for velocity and pressure fields in a viscous flow subjected to steady and transient conditions and formulate boundary layer approximations.	BTL3
CO4	Identify, formulate, and solve real world flow problems by applying knowledge of fluid mechanics and mathematics.	BTL6

Detailed Syllabus:

UNIT I **CH - 10**

Introduction, concept of a fluid, concept of viscosity, concept of continuum, properties of a fluid, historical outline, flow analysis techniques, Eulerian and Lagrangian flow descriptions, classification of fluid flows, velocity and acceleration field, material derivative, control volume and differential element approach, Reynolds transport theorem, conservation of mass, linear momentum equation, energy equation, fluid element kinematics, linear motion and deformation, angular motion and deformation.

UNIT II **CH - 12**

Vectors and tensors, representation of second order tensor, addition, subtraction, and multiplication of tensors, transpose of a tensor, symmetric and unsymmetric tensor, unit tensor, dyadic product, divergence, curl, gradient of a vector and tensor, significance of gradient of velocity vector, deformation, rotation, divergence theorem, constitutive equations for fluids, stress tensor for a simple flow, Stoke's principle, Navier-Stokes equation.

UNIT III **CH - 12**

Exact solutions of the Navier-Stokes equations, flow through a straight stationary channel, Couette flow, Hagen-Poiseulle flow, flow between two concentric rotating cylinders, axially moving concentric cylinders, unsteady parallel flow (Stoke's first problem), flow near an oscillating flat plate (Stoke's second problem), start-up of Couette flow, transient axisymmetric Poiseulle flow, flow of two immiscible fluids in a channel, fully developed flow of a power law fluid, superposition of Poiseuille and Couette flows.

UNIT IV **CH - 08**

Laminar boundary layers, boundary-layer equations, flow over a flat plate, Blasius flow, momentum-integral equation for the boundary layer, approximate methods for boundary layer equations, Karman-Pohlhausen method for flow over a flat plate.

Text Books:

1. White, F.M., Viscous Fluid Flow, McGraw Hill, 2013.
2. Schlicting, H., Boundary Layer Theory, McGraw Hill, 1979.

Reference Books:

1. Muralidhar, K., Biswas, B., Advanced Engineering Fluid Mechanics, Narosa Publishing, 2015.
2. Graebel, W.P., Advanced Fluid Mechanics, Academic Press, 2009.
3. Aris, R., Vectors, Tensors and Basic Equations of Fluid Mechanics, Dover Publications, 1962.
4. Munson, B.R., Young, D.F., Okiishi, T.H., Fundamentals of Fluid Mechanics, Wiley, 2017.

Subject: Advanced Machining Processes (Code: MET004)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-I, Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze and assess the importance of CNC Machines.	BTL4
CO2	Explain the basics of non-traditional and advanced machining processes.	BTL2
CO3	Identify the need of non-traditional and micro machining processes and explain the effect of input parameters on material removal.	BTL2
CO4	Compare the non-traditional machining processes based on type of energy source.	BTL4

Detailed Syllabus:

UNIT I **CH - 08**

Computer Numeric Control (CNC) machines, open loop and closed loop CNC machines, classification, of CNC machines, CNC programming, G-codes and M-codes, absolute and incremental coordinate system, adaptive control.

UNIT II **CH - 12**

Introduction to machining processes, limitations of traditional machining processes, introduction, need, and applications of non-traditional machining processes, classification of non-traditional machining processes, mechanical machining, introduction, working, process parameters and applications of abrasive jet machining, water jet machining, abrasive water jet machining, ultrasonic machining, effect of input parameters on material removal.

UNIT III **CH - 11**

Thermal machining processes, process mechanism, working, parameters, and applications of electric discharge machining, laser beam machining, electron beam machining, ion beam machining, plasma arc machining, effect of input parameters on material removal.

UNIT IV **CH - 11**

Electrochemical and chemical machining, material removal mechanism, advantages, limitations and applications of electrochemical machining, chemical machining, electrochemical grinding, deburring. Micro machining: Introduction, need, application and classification.

Text Books:

1. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall Press, United States, 2007.
2. A. Ghosh and A.K. Mallik, Manufacturing Science, 2nd edition, East-West Press, New-Delhi

Reference Books:

1. Campbell, J.S., Principles of Manufacturing Materials and Processes, McGraw-Hill, New-York,
2. N.V. Raghavendra and L. Krishnamurthy, Engineering Metrology and Measurements, 1st edition, Oxford University Press.
3. Lindberg, R.A., Processes and Materials of Manufacturing, Allyn and Bacon, Boston.

Subject: Advanced Manufacturing Technology (Code: MET005)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-I, Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify the use of advanced manufacturing processes in industries and explain the micromachining process.	BTL2
CO2	Identify the need for super finishing processes and understand the superfinishing process.	BTL2
CO3	Explain the process of non-conventional forming.	BTL2
CO4	Apply knowledge to select appropriate surface processing technique to get the desired surface properties.	BTL3

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to advanced manufacturing processes, advantages of advanced manufacturing processes, advances in machining: high-speed machining, hard turning, micromachining: introduction and need of micromachining, diamond micro-grinding/turning, abrasive micromachining, ultrasonic micromachining, electric-discharge micro-machining, laser micro-machining, electrochemical micro-machining.

UNIT II **CH - 09**

Superfinishing processes: introduction to finishing processes, need and application of superfinishing processes, abrasive flow finishing, magnetic abrasive flow finishing, magneto rheological abrasive flow finishing.

UNIT III **CH - 11**

Advances in forming: introduction and application of non-conventional forming, the need of non-conventional forming, electro magnetic forming, hydroforming, explosive forming, advantages of non-conventional forming.

UNIT IV **CH - 11**

Surface processing: introduction and need of surface processing, surface properties, cladding, chemical vapor deposition, physical vapor deposition, shot peening, and surface modification by severe plastic deformation, strategies for improving surface properties.

Text Books:

1. Ghosh and A.K. Malik, Manufacturing Science, Affiliated East Press, New-Delhi.
2. Degarmo, E.P., Black, J.T. and Kohser, R.A, Materials and Processes in Manufacturing, 2006, Prentice Hall of India.

Reference Books:

1. Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi.
2. Serop K. Steven, Manufacturing Processes for Engineering Materials, 2004, Prentice Hall of India.

Subject: Advanced Solid Mechanics (Code: MET006)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the concept of tensors.	BTL2
CO2	Examine advanced concepts of stress and strain in structural problems.	BTL4
CO3	Implement the concept of different elastic functions to solve complex problems.	BTL3
CO4	Investigate the influence of various geometric and loading parameters in plane stress and plane strain problems.	BTL4

Detailed Syllabus:

UNIT I **CH - 10**

Mathematical preliminaries: introduction to tensor algebra, symmetric and skew-symmetric tensor, summation convention, eigenvalue and eigenvector of a tensor, spectral theorem, polar decomposition theorem, product of tensor, principal invariants of tensor, coordinate transformation of tensor.
Tensor calculus: gradient, divergence, curl, and differentiation of scalar function of a tensor.

UNIT II **CH - 11**

Analysis of stress and strain: definition and notation of stress, Cauchy stress tensor, equations of equilibrium, principal stresses and stress invariants, stress deviator tensor, octahedral stress components, general deformations, small deformation theory, strain transformation, principal strains, spherical and deviatoric strains, strain-displacement relations, strain compatibility, stress and strain in curvilinear, cylindrical, and spherical coordinates, fundamental equations of plasticity.

UNIT III **CH - 11**

Problem formulation and solution strategies: field equations, boundary conditions, stress and displacement formulation, Beltrami-Michell compatibility equations, Lame-Navier's equations, principle of superposition, uniqueness theorem, Saint-Venant's principle, brief descriptions about general solution strategies - direct, inverse, semi-inverse, analytical, approximate, and numerical methods.

UNIT IV **CH - 10**

Two-dimensional problems: plane stress and plane strain problems, generalized plane stress, anti-plane strain, airy stress function, polar coordinate formulation and solutions, cartesian coordinate solutions using polynomials, and Fourier series method.

Text Books:

1. Martin H. Sadd, Elasticity, Theory, Applications, and Numerics.
2. Stephen Timoshenko and , J. N. Goodier, Theory of Elasticity.

3. Otto T. Bruhns, Advanced Mechanics of Solids, Springer publications.

Reference Books:

1. A.J.M Spencer, Continuum Mechanics, Dover Publications, INC
2. H. Ford and J. M. Alexander, Advanced Mechanics of Materials.
3. W. S. Slaughter, The Linearized Theory of Elasticity, Springer Science + Business Media, LLC.

Subject: Advanced Thermodynamics (Code: MET007)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Thermodynamics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate an in-depth knowledge in the application of the laws of thermodynamics.	BTL3
CO2	Apply concepts of entropy generation and exergy to practical applications/systems.	BTL3
CO3	Possess a coherent knowledge about the evaluation of the thermodynamic properties.	BTL5
CO4	Identify, formulate, and solve a wide range of real world problems involving energy transfer.	BTL6

Detailed Syllabus:

UNIT I **CH - 09**

Scope and methods of thermodynamics, review of thermodynamics, mathematical background, macroscopic and microscopic approaches in thermodynamics, energy and first law of thermodynamics, first law for closed and open systems, broadening understanding of energy transfer by work and heat, structured presentation of first law of thermodynamics.

UNIT II **CH - 10**

Second law of thermodynamics, traditional formulation of second law of thermodynamics, logical relation between alternative statements of the second law, mathematical formulation of second law of thermodynamics, entropy maximum and energy minimum principle, Caratheodory formulation of second law.

UNIT III **CH - 11**

Entropy generation, concept of exergy of system, exergy balance of closed and open systems, second law efficiency (of heat engines, heat pumps, refrigerators, work producing and consuming devices, heat exchangers), thermo economics, exergy account of a vapour power plant (case study), thermodynamics of a biological system.

UNIT IV **CH - 12**

Thermodynamic properties of pure fluid, ideal gas properties, state relationships for real gases and liquids, two-constant and multiconstant equation of state, Virial equations, Vander waals equation of state, Redlich-Kwong equation of state, compressibility charts, generalized equation of state, Maxwell's relations, generalized relations, evaluation of thermodynamic properties, p-v-t relations for gas mixtures, multicomponent systems, chemical potential (fugacity).

Text Books:

1. Bejan, A., Advanced Thermodynamics, John Wiley and Sons, 2006.

2. Moran, M.J., Shapiro, H.N., Boettner, D.D., Bailey, M.B., Principles of Engineering Thermodynamics, Wiley India, 2017.

Reference Books:

1. Kestin, J., A Course in Thermodynamics, McGraw Hill, 1979.
2. Wark, K., Advanced Thermodynamics, McGraw Hill, 1995.

Subject: Applied Design Thinking for Innovation and IPR (Code: MET008)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the need and significance of adopting a design thinking mind-set.	BTL4
CO2	Assess the approach of human centered design for entrepreneurial objectives.	BTL5
CO3	Adapt various design thinking models in creating innovations.	BTL6
CO4	Structure the capability of concept development and commercialization of ideas.	BTL6

Detailed Syllabus:

UNIT I **CH - 09**

Introduction to design thinking: definitions and meaning, design thinking as an art and science, why and how of design thinking?, stages of design thinking, entrepreneurship design thinking.

UNIT II **CH - 12**

Introduction to human centered design: human desirability, technical feasibility, business viability, innovation as a solution, designing for growth, visualization, journey mapping, value chain analysis, mind mapping.

UNIT III **CH - 09**

Design thinking process: inspiration, ideation and implementation, Stanford model of design thinking, empathize, define, ideate, prototype and test, double-diamond model of design thinking.

UNIT IV **CH - 12**

Concept development and commercialization**:** concept development, IPR, basics and process of technology/concept transfer, technology acceptance, challenges faced during adoption, commercialization of technology/concept.

Text Books:

1. Mootee, I., Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, 2013, John Wiley & Sons
2. Cross, N., Design thinking: Understanding How Designers Think and Work. Berg, 2011, Oxford.

Reference Books:

1. Brown, T., and Katz, B., Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation (Vol. 20091), 2019, New York, NY: Harper Business.

2. Liedtka, J., and Ogilvie, T., Designing for Growth: A Design Thinking Tool Kit for Managers, 2011, Columbia University Press.

Subject: Artificial Intelligence in Engineering (Code: MET009)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate the fundamentals of artificial intelligence and machine learning.	BTL3
CO2	Apply feature extraction and selection techniques, as well as machine learning algorithms, to address regression and classification problems.	BTL3
CO3	Devise and develop machine learning models through various stages.	BTL6
CO4	Explain concepts of reinforcement learning and deep learning, and simulate machine learning models for mechanical engineering problems.	BTL6

Detailed Syllabus:

UNIT I **CH - 16**

History of AI, comparison of AI with data science, need of AI in mechanical engineering, introduction to machine learning, basics: reasoning, problem solving, knowledge representation, planning, learning, perception, motion, and manipulation.

Steps in ML modeling, data collection, data pre-processing, model selection, model training (training, testing, K-fold cross validation), model evaluation (understanding and interpretation of confusion matrix, accuracy, precision, recall, true positive, false positive etc.), hyper parameter tuning, predictions. characteristics of reinforced learning; algorithms: value based, policy based, model based; positive Vs negative reinforced learning; models: Markov decision process, Q learning, characteristics of deep learning, artificial neural network, convolution neural network, application of reinforced and deep learning in mechanical engineering, human machine interaction, predictive maintenance and health management, fault detection, dynamic system order reduction, image based part classification, process optimization, material inspection, tuning of control algorithms.

UNIT II **CH - 14**

Approaches to AI: cybernetics and brain simulation, symbolic, sub-symbolic, statistical, approaches to ML: supervised learning, unsupervised learning, reinforcement learning, feature extraction: statistical features, principal component analysis, feature selection: ranking, decision tree - entropy reduction and information gain, exhaustive, best first, greedy forward and backward, applications of feature extraction and selection algorithms in mechanical engineering.

UNIT III **CH - 12**

Classification: decision tree, random forest, naive Bayes, support vector machine, regression: logistic regression, support vector regression, K-means, K-nearest neighbor (KNN), applications of classification and regression algorithms in mechanical engineering, predictions, problem identification: classification, clustering, regression, ranking.

Text Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, Artificial Intelligence – Building Intelligent Systems, PHI learning Pvt. Ltd., 2015.
4. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd edition, Pearson, 2003.

Reference Books

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI, Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress, 2018.
5. Elaine Rich, Kevin Knight and Nair, Artificial Intelligence, Tata McGraw Hill.

Subject: Automation In Production (Code: MET010)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Illustrate and assess the basic concepts of automation and line balancing in automated systems.	BTL4
CO2	Identify and analyze functions and functioning of CNC machines.	BTL2
CO3	Interpret the importance of group technology, material handling, and adaptive control in automated systems.	BTL3
CO4	Develop the usage of automated guided vehicle in automation in production.	BTL6

Detailed Syllabus:

UNIT I **CH - 14**

Introduction: automation, types, reasons for automation, types of production, functions in manufacturing, automation strategies, costs in manufacturing, flow lines: automated flow lines, transfer mechanisms, automation for machining operations, line balancing: basic concepts, general procedure, rank positional weight method, computer aided line balancing (CALB), manual and flexible assembly line, automated assembly systems-types, part feeding device.

UNIT II **CH - 15**

Numerical Control (NC): Components of NC system, NC procedure, NC coordinate system, motion control, applications. Computer control in NC: problems with conventional NC, Computer numeric control (CNC) machines, open loop and closed loop CNC machines, classification, advantages and applications of CNC machines, introduction to CNC programming, G-codes and M-codes, absolute and incremental coordinate system.

UNIT III **CH - 13**

Group technology cell formation: part classification and coding, rank order clustering method for machine component assignment. Computer Aided Process Planning (CAPP) - retrieval and generative type process planning system, adaptive control, material handling equipment, Automated Guided Vehicles (AGVs), Analysis of AGVs.

Text Books:

1. M. P. Groover, Automation, Production System and CIM, PHI.
2. Groover and Zimmers, CAD/CAM, PHI.

Reference Books:

1. Radhakrishnan and Subramanyan, CAD/CAM/CIM, Wiley Eastern.
2. I. Zeid, CAD/CAM Theory and Practice, Tata McGraw Hill.

Subject: Automobile Technology (Code: MET011)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-I, Applied Thermodynamics-II, Machine Design-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the automobile structure, comfort, and safety systems.	BTL4
CO2	Evaluate knowledge on IC engine, electric, and hybrid vehicles.	BTL5
CO3	Understand the manual and automatic transmission systems and control system.	BTL2
CO4	Analyze various electrical and electronics system for vehicle management.	BTL4

Detailed Syllabus:

UNIT I **CH - 08**

Types of automobiles, designing of vehicle construction and different layouts, chassis, frame, and body. ergonomics and safety, basic electric systems in automotives.

UNIT II **CH - 16**

Clutch-types and construction, gear boxes-manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel–torque converter, propeller shaft, slip joints, universal joints.

Steering geometry and types, types of front axle, suspension systems, pneumatic and hydraulic braking systems, antilock braking system and traction control.

UNIT III **CH - 18**

Electronically controlled gasoline injection system for SI engines, diesel injection system, electronic ignition system, turbo chargers, catalytic converter, use of natural gas, liquefied petroleum gas, bio-diesel and hydrogen in automobiles- engine modifications required, performance, combustion and emission characteristics of SI and CI engines with these alternative fuels.

Fundamentals of electric and hybrid vehicles - layout and operation regenerative braking - electric charging and batteries - performance of electric and hybrid vehicles – introduction to drone technology.

Text Books:

1. Newton, K., Steeds, W., and Garrett, T. K., The Motor Vehicle, Butterworth, 1989.
2. Joseph Heitner, Automotive Mechanics, 2nd edition, 1999, East-West Press.
3. Heinz Heisler, Advanced Engine technology, SAE international publications USA, 1998.
4. Kirpal Singh, Automotive Engineering, Vol. I & II, 1997, Standard Publishers, New Delhi.
5. Ganesan .V, Internal Combustion Engines, 3rd edition, 2007, Tata McGraw Hill.

Reference Books:

1. James D. Halderman, Automotive Heating and Air Conditioning, 8th edition, 2018, Pearson Education Inc.
2. Mark Gonter, Ulrich W. Seiffert, Integrated Automotive Safety Handbook, SAE International, 2013.
3. Tom Denton, Automobile Electrical & Electronic Systems, 5th edition, 2018, Taylor and Francis.
4. Chris Mi, M. Abul Masrur, Electric Vehicles, 2nd edition, 2017, John Wiley.
5. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, CRC Press, 2004

Subject: Basic Fracture Mechanics(Code: MET012)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-II, Materials Science and Engineering

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze crack effects in an engineering structure and interpret the state of stress and strain that may arise in the vicinity of the crack front in different materials.	BTL4
CO2	Evaluate fracture toughness for structures with cracks using LEFM techniques.	BTL5
CO3	Determine the fracture toughness for structures using EPFM techniques.	BTL3
CO4	Investigate the crack growth in materials subjected to fatigue loads.	BTL4

Detailed Syllabus:

UNIT I **CH - 12**

Mechanisms of fracture and crack growth, cleavage fracture, ductile fracture, fatigue cracking, summary of basic problems and concepts in fracture, a crack in a structure, theoretical strength of a material, Inglis's solution, crack tip stresses, the Griffith criterion, modified Griffith's theory.

UNIT II **CH - 14**

The elastic crack-tip stress field, stress intensity factor, the effect of finite size, some special cases, elliptic cracks the energy principles, the concept of energy release rate, the criterion for crack growth, the crack resistance, the concept of J-integral, crack opening displacement criterion, KIC and GIC test methods.

UNIT III **CH - 16**

Crack-tip plastic zone, Irwin's plastic zone correction, the Dugdale approach, plane stress versus plane strain, plastic constraint factor, the thickness effect, application of Von Mises and Tresca yield criteria to obtain plasticity effected regions, fatigue failure, S-N curve, crack initiation and propagation, effect of overload, crack closure, environmental assisted cracking, service failure analysis.

Text Book:

1. Anderson T.L., Fracture Mechanics Fundamentals and applications, CRC, Taylor & Francis, 2005.

Reference Books:

1. Janssen, M. J., Zuidema, J., Wanhill R.J. H., Fracture Mechanics, Spon Press, 2004.
2. Prashant Kumar, Elements of Fracture Mechanics, McGraw Hill Education, 2017.

Subject: Computer Integrated Manufacturing (Code: MET013)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	51 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Illustrate and assess the basic concepts of automation and line balancing in automated systems.	BTL4
CO2	Experiment Computer-Aided Process Planning (CAPP) in CAD/CAM integration, focusing on variant and generative approaches.	BTL4
CO3	Assess knowledge of shop floor control and Flexible Manufacturing Systems (FMS), including phases, components, workstation design, and computer control systems.	BTL5
CO4	Articulate the importance of manufacturing enterprise wheel, CIM software in automated systems.	BTL3

Detailed Syllabus:

UNIT I **CH - 10**

Introduction: the meaning and origin of CIM, the changing manufacturing and management scenario, external communication, islands of automation and software, dedicated and open systems, manufacturing automation protocol, product related activities of a company, marketing engineering, production planning, plant operations, physical distribution, business, and financial management.

UNIT II **CH - 10**

Computer Aided Process Planning (CAPP): role of process planning in CAD/CAM integration, approaches to computer aided process planning - variant approach and generative approaches, CAPP and CMPP process planning systems.

UNIT III **CH - 11**

Shop floor control and FMS: shop floor control-phases, factory data collection system, automatic identification methods- bar code technology, automated data collection system, FMS-components of FMS, types, FMS workstation, material handling and storage systems, FMS layout, computer control systems-application and benefits.

UNIT IV **CH - 11**

CIM implementation: CIM and company strategy, system modelling tools-IDEF models, activity cycle diagram, CIM open system architecture (CIMOSA), manufacturing enterprise wheel, CIM architecture, product data management, CIM implementation software.

Text Books:

1. M. P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education.
2. Y. Koren, Computer Integrated Manufacturing System, McGraw-Hill.

Reference Books:

1. P. Radhakrishnan, S. Subramanyan and V. Raju, CAD/CAM/CIM, New Age International.
2. Paul G. Ranky, Computer Integrated Manufacturing, Prentice Hall International.

Subject: Condition Monitoring (Code: MET014)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Classify various types of failures and their effects on system performance.	BTL2
CO2	Examine the main principle of each Non-destructive Examination (NDE) method.	BTL4
CO3	Demonstrate the use of a specific non-destructive examination method in real life situations.	BTL3
CO4	Differentiate between different NDE methods and choose the right one for a specific application.	BTL4

Detailed Syllabus:

UNIT I **CH - 15**

Machinery failures, system and component failure, failure classification, failure types, failure investigations, case study, human factors, causes of failure, introduction to condition-based maintenance (CBM), condition monitoring and integrity of industrial systems, CoM and Diagnostic Engineering management, economic justification and benefits, tribological aspects.

UNIT II **CH - 14**

NDE methods: acoustic cross correlation, acoustic emission, coating thickness measurement, dye penetrant examination, eddy current testing, ferrography, Spectrometric Oil Analysis Programme (SOAP), wear debris analysis.

UNIT III **CH - 13**

Magnetic plugs and magnetic particle examination, noise monitoring, thermography, ultrasonic examination, vibration monitoring, misalignment and eccentricity detection, bearing defects, diagnostic method selection.

Text Books:

1. Amiya R Mohanty, Machinery condition monitoring - Principles and practices, 2015, CRC Press.
2. R. A. Collacott, Mechanical Fault Diagnosis and condition monitoring, 1977, Chapman & Hall.

Reference Books:

1. B. K. N. Rao, A. Davies (eds.), Handbook of Condition Monitoring - Techniques and Methodology, 1998, Springer.
2. Knud G Boving (ed.), Non-Destructive Examination Methods for Condition Monitoring - NDE Handbook, 1989, Butterworths.

Subject: Conduction Heat Transfer (Code: MET015)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify and solve one dimensional steady state heat conduction problems.	BTL3
CO2	Identify and solve two dimensional steady state and transient heat conduction problems.	BTL3
CO3	Identify and solve heat conduction problems involving phase change.	BTL3
CO4	Identify, formulate, and solve real world problems related to heat conduction.	BTL6

Detailed Syllabus:

UNIT I **CH - 14**

Introduction, Fourier's law of heat conduction, thermal conductivity, differential formulation of heat conduction in rectangular, cylindrical and spherical coordinates, general boundary conditions and initial condition, non-dimensional analysis of the heat conduction equation, heat conduction for anisotropic medium, one-dimensional steady state heat conduction, extended surfaces, constant area fins, variable area fins, moving fins, Bessel differential equations and Bessel functions.

UNIT II **CH - 16**

Two-dimensional steady state heat conduction, separation of variable method, homogeneous differential equations and boundary conditions, Sturm-Liouville boundary valve problems, non-homogeneous differential equations, non-homogeneous boundary conditions, method of superposition, solution to problems in Cartesian and cylindrical coordinates, unsteady heat conduction, lumped heat capacity system, non homogeneous equations and boundary conditions, transient conduction in plates, transient conduction in cylinders, transient conduction in spheres, Duhamel's superposition integral, conduction in semi-infinite regions.

UNIT III **CH - 12**

Heat conduction involving phase change, moving interface boundary condition, non-linearity of the interface energy equation, simplified model (quasi-steady approximation), exact solutions, Stefan's solution, solidification of semi-infinite region, melting of semi-infinite region.

Text Books:

1. Jiji, L. M., Heat Conduction, Springer, 2009.
2. Kakac, S., Yener, Y., Naveira-Cotta, C.P., Heat Conduction, CRC Press, 2018.

Reference Books:

1. Ozisik, M.N., Hahn, D.W., Heat Conduction, John Wiley, 2012.

2. Muralidhar, K., Banerjee, J., Conduction and Radiation, Naraosa Publishing House, 2010.
3. Poulikakos, D., Conduction Heat Transfer, Prentice Hall, 1993.

Subject: Continuum Mechanics (Code: MET016)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Interpret linear vector spaces relevant to continuum mechanics and be able to perform vector and tensor manipulations in Cartesian and curvilinear coordinate systems.	BTL3
CO2	Determine motion, deformation, and forces in a continuum.	BTL3
CO3	Develop constitutive models for fluids and viscoelastic solids.	BTL5
CO4	Solve simple boundary value problems for fluids and solids.	BTL3

Detailed Syllabus:

UNIT I **CH - 11**

Introduction: structure of matter, statistical mechanics, continuum assumption, continuum mechanics and its objectives, comparison of continuum and statistical mechanics, need for tensor analysis, continuum nature of real numbers, three-dimensional Euclidean space and continuum body, limitations of continuum mechanics.

Tensor algebra: vectors spaces, index notation, tensors and tensor operations, second order tensors: skew-symmetric, orthogonal and symmetric tensors, invariants of second order tensors, eigenvalue problem, positive definiteness and polar decomposition theorem, isotropic functions, and higher-order tensors, vector and tensor operations in polar coordinates.

Tensor calculus: directional derivative, Frechet derivative, gradient, divergence, curl, and integral theorems.

UNIT II **CH - 12**

Kinematics: the continuum, inertial reference frames, the reference configuration and current configuration of a deformed solid, the displacement and velocity field, examples of deformations and motions, Eulerian and Lagrangian descriptions of motion, the deformation gradient tensor, deformation of line, volume and area elements, strain tensors – Lagrange strain and Eulerian strain, Cauchy-Green strain, infinitesimal strains, compatibility, polar decomposition of the deformation gradient, rotation tensor, left and right stretch tensors, principal stretches and strains, time derivatives of motion: the velocity gradient, stretch rate, spin and vorticity, spatial description of acceleration, Reynolds transport relation, circulation-vorticity relations

Kinetics: external loading – surface tractions, body forces, internal forces – Cauchy stress tensor, principal stresses, stress invariants, stresses near a surface,. Piola-Kirchhoff stresses (nominal and material stress).

UNIT III **CH - 10**

Field equations and conservation laws: mass conservation, linear and angular momentum, static equilibrium, work done by stresses, the principle of virtual work, the first and second laws of thermodynamics for continua, conservation laws for a control volume, transformation of field quantities under changes of reference frame.

Constitutive models: thermodynamics – the dissipation inequality, frame indifference.

UNIT IV **CH - 09**

Mechanics of elastic and compressible, viscous fluids: summary of field equations, constitutive models for fluids, solutions to simple problems.

Mechanics of elastic solids: field equations, constitutive models for hyperelastic materials, solutions to simple boundary value problems for hyperelastic materials, linearized field equations, and examples of linear elastic solutions.

Text Books:

1. Gurtin, M. E., An Introduction to Continuum Mechanics, Academic Press, N.Y. 1981.
2. J. N. Reddy, An Introduction to Continuum Mechanics with Applications, Cambridge University Press 2008.

Reference Books:

1. Gonzalez, Oscar, and Andrew M. Stuart, A first course in continuum mechanics, Cambridge University Press, 2008.
2. Fung, Y. C., A first course in continuum mechanics, Englewood Cliffs, NJ, Prentice-Hall, Inc., 1977.
3. Jog, C. S., Continuum mechanics: Foundations and applications of mechanics, Volume I, 3rd edition, 2015, Cambridge University Press.
4. Chadwick, P., Continuum mechanics: Concise theory and problems, 1999, Dover Publications, Inc., New York.

Subject: Control Systems (Code: MET017)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mathematics-IV, Theory of Machines-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the knowledge of poles and zeroes of the transfer functions to determine the time response and performance characteristics and design PID controllers using empirical tuning rules.	BTL3
CO2	Analyze the stability of linear control systems using the Routh-Hurwitz criterion and classify systems as asymptotically and BIBO stable or unstable.	BTL4
CO3	Determine the effect of loop gain variations on the location of closed-loop scales, sketch the root locus and use it to evaluate parameter values to meet the transient response specification of closed loop systems.	BTL3
CO4	Evaluate the frequency response and plot asymptotic approximations to the frequency response function of a system. Sketch a Nyquist diagram and use the Nyquist criterion to determine the stability of a system.	BTL5

Detailed Syllabus:

UNIT I **CH - 10**

Introduction to control systems, examples of control systems, closed-loop control versus open-loop control, Laplace transforms, transfer functions and block diagrams, mathematical modeling of control systems, differential equation or time-domain models of Linear Time-Invariant (LTI), transfer function or s-domain models, poles and zeros of the transfer function, convolution integral and impulse-response function, mathematical modeling of mechanical systems and electrical systems.

UNIT II **CH - 10**

Transient and steady-state response analyses, transient response analysis of first-order systems, second-order systems, and higher-order systems, performance characteristics of control systems, transient response specifications, rise time, peak time, maximum overshoot, settling time, steady-state errors in unity-feedback control systems, basic control actions, effects of proportional, derivative and integral control actions on system performance, PD, PI, and PID controllers.

UNIT III **CH - 11**

Stability of Linear Time-Invariant (LTI) systems, asymptotic stability, bounded input bounded output (BIBO) stability, Routh's stability criterion, control systems analysis and design by the root-locus method, some developmental concepts, rules of construction, plotting root loci with Matlab, root-locus approach to control-systems design.

UNIT IV **CH - 11**

Control systems analysis and design by the frequency-response method, obtaining steady-state outputs to sinusoidal inputs, Bode diagrams, log-magnitude-versus-phase plots, integral and derivative factors, first-order factors, quadratic factors, polar plots, Nyquist stability criterion, experimental determination of transfer functions, control systems design by frequency-response approach.

Text Book:

1. K. Ogata, Modern Control Systems, 5th edition, 2010, Prentice-Hall of India.

Reference Book:

1. Norman S. Nise, Control Systems Engineering, 4th edition, 2004, John Wiley and Sons.

Subject: Cryogenics (Code: MET018)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-I, Applied Thermodynamics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the basic working of refrigeration systems.	BTL2
CO2	Understand the working of refrigeration systems based on solids as working media.	BTL2
CO3	Understand the principle for gas liquefaction.	BTL2
CO4	Understand the application of adsorption in cryogenics.	BTL2

Detailed Syllabus:

UNIT I **CH - 12**

Cryogenic refrigeration system: ideal isothermal and reversible isobaric source refrigeration cycles, Joule Thomson system, cascade or pre-cooled Joule-Thomson refrigeration systems, expansion engine and cold gas refrigeration systems, Philips refrigerators, Importance of regenerator effectiveness for the Philips refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, COP, FOM, regenerators, pulse tube refrigerators, various types of pulse tube refrigerator.

UNIT II **CH - 07**

Refrigerators using solids as working media: magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization.

UNIT III **CH - 11**

Gas liquefaction systems: introduction, thermodynamically ideal systems, Joule-Thomson effect, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure, cascade, Claude, Kapitza, Heyland systems using expanders, comparison of liquefaction systems, liquefaction systems for Neon, Hydrogen, and Helium.

UNIT IV **CH - 12**

Adsorbents: various adsorbents, salient features – properties, determination of mass of absorbents for the adsorption of gases

Adsorption processes: physical principles of adsorption, BET equation for single and multiple layer, use of sorption process in cryogenics static and dynamic arrangement for the sorption processes, adsorption columns, PSA and VSA adsorption systems, isotherms.

Text Books:

1. Barron, Cryogenic Systems, McGraw Hill Book Co.
2. A. Arkherov, Theory and design of cryogenic systems.

Reference Books:

1. Timmerchand and Flynn, Cryogenic process engineering.
2. Mikulin, Theory and design of cryogenic systems, MIR Publication, 2002.

Subject: Design for Production Tooling (Code: MET019)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the design and application of form tools, including single-point cutting tools and broaches, for various machining operations.	BTL2
CO2	Gain proficiency in forging techniques, including design considerations, die design and equipment selection for both drop and press forging processes.	BTL3
CO3	Develop skills in press tool design for sheet metal operations, covering principles of metal cutting, die design, and methods for reducing cutting forces.	BTL6
CO4	Acquire knowledge of jig and fixture design principles, including locating, clamping, and positioning techniques, for drilling and milling operations.	BTL6

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to form tools, types of form tools, design of single-point cutting tools, method of determining the profile of circular and flat formtool by analytical and graphical method, broaching, cutting process in broaching, geometric elements of broach tool, design of internal and external surface broach, calculation of number of teeth for broach tool, analysis of rigidity, cutting force, power for broaching.

UNIT II **CH - 09**

Forging: forging allowances and equipment, forging operations, design of a forging, forging design factors, die design for drop and press forging, die design for machine forging, determination of stock size, selection of forging equipment, die inserts, tools for flash trimming and hole piercing.

UNIT III **CH - 12**

Press tool design: sheet metal working operations, sheet metal working equipment, principle of metal cutting in sheet metal working, types of dies, clearance, cutting forces, methods of reducing cutting forces, minimum diameter of piercing, punch design, punch support, die block design, blanking die design and piercing die design, design of drawing die (deep drawability, draw die radius, punch radius, draw clearance, drawing speed), design of drawing die (calculation of blank size, number of draws, drawing pressure, blank holding pressure), progressive and compound die design.

UNIT IV **CH - 10**

Jigs and fixture, locating and clamping, principle of location, design principle for location purposes, design principle for clamping purposes, design principle for positioning purposes, design principles common to jigs and fixtures, drilling jigs, types of drilling jigs, design of drilling jig, milling fixture, classification of milling fixture, design of milling fixture.

Text Books:

1. P. N. Rao, Manufacturing Technology, Tata McGraw Hill.
2. A Bhattacharyya, Metal Cutting - Theory and Practice, Central Book Agency, Kolkata.

Reference Books:

1. Cyril Donaldson, Lecain and Goold, Tool Design, Tata McGraw Hill Publications.
2. ASTME, Fundamentals of Tool Design, Prentice Hall.

Subject: Design of Energy Systems (Code: MET020)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Thermodynamics, Fluid Mechanics-I, Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1	Prepare a schematics of thermal system design.	BTL3
CO2	Identify the characteristic components of the thermal systems and their effects on overall system performance.	BTL2
CO3	Simulate a thermal system and solve for a workable solution.	BTL6
CO4	Identify, formulate, and solve a wide range of real world thermal related problems.	BTL6

Detailed Syllabus:

UNIT I **CH - 09**

Introduction, design versus analysis, synthesis versus design, optimal and nearly optimal designs, life cycle design, thermal design aspects, concept, creation and assessment, thermal system (basic characteristics, analysis), some typical examples, formulation of the design problem, steps in design process, material selection.

UNIT II **CH - 12**

Modelling of thermal systems, types of models, mathematical modeling, general procedure (transient/steady state, spatial dimensions, lumped mass approximation, simplification of boundary conditions, negligible effects, idealizations, material properties, conservation laws, simplification of governing equations), final model and validation, physical modeling and dimensional analysis, curve-fitting, numerical modeling and simulation, solution procedures, methods for numerical simulation.

UNIT III **CH - 12**

Formulation of problem for optimization, optimized design, objective function, constraints, operating conditions versus hardware, optimization methods (calculus methods, search methods, etc.), optimization of thermal systems, considerations of second law of thermodynamics, economic analysis, estimation of total capital cost, principles of economic evaluation, thermo-economic analysis and evaluation.

UNIT IV **CH - 09**

Applications with thermodynamics, heat and fluid flow, cogeneration system exergy analysis, thermal insulation, fins, electronic packages, refrigeration, power generation, energy storage by sensible heating.

Text Book:

1. Bejan, A., Tsatsaronius, G., Moran, M., Thermal Design and Optimization, John Wiley, 2013.

Reference Book:

1. Stoecker, W.F., Design of Thermal Systems, McGraw Hill, 2017.

Subject: Design of Experiments (Code: MET021)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain basic statistical concepts and strategies for designing experiments.	BTL2
CO2	Design the experiments based on the number of factors and replicates.	BTL4
CO3	Analyze the results of a designed experiment and conduct the appropriate statistical data analysis.	BTL4
CO4	Model regression equations for data prediction and obtain the optimal parameter combination.	BTL5

Detailed Syllabus:

UNIT I **CH - 08**

Determining central tendency using various methods: mean, median and mode, sampling and sampling distribution, standard deviation, variance, basic statistical concepts, and hypothesis testing.

UNIT II **CH - 11**

Strategy of experimentation, basic principles, and guidelines for designing experiments, simple comparative experiments: randomized designs, experiments with a single factor: the analysis of variance, analysis of the fixed effects model, randomized complete block designs, Latin square design.

UNIT III **CH - 11**

Factorial design: basic definitions and principles, the two-factor factorial designs, statistical analysis of the fixed effects model, the factorial design: the 2^2 design, the 2^3 design, two levels of fractional factorial design: introduction, the one-half fraction of the design, the 3^2 design.

UNIT IV **CH - 12**

The Taguchi design: orthogonal array, signal-to-noise ratio, analysis of variance, examples of L_8 and there L_9 Taguchi design, computer-based data analysis, fitting regression models: introduction; linear regression models; estimation of the parameters in linear regression models, computer-based data analysis.

Text Book:

1. Montgomery Douglas C., Design and Analysis of Experiments, 5th edition, 2008, John Wiley and Sons, New York.

Reference Books:

1. Richard L. Levin and David S. Ruben, Statistics for Management, Hall of India Pvt. Ltd., New Delhi.
2. Angela M. Dean and Daniel Voss, Design and Analysis of Experiments, 2000, Springer, NY.

3. Jiju Antony, Design of Experiments for Engineers and Scientists. 1st edition, 2003, Butterworth-Heinemann.
4. Hines and Montgomery, Probability and Statistics for Engineers, 1990, John Wiley and Sons, NY.

Subject: Design of Refrigeration and Air Conditioning Systems (Code: MET022)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Design and size components of refrigeration and air conditioning systems based on accurate cooling load calculations.	BTL6
CO2	Design air-conditioning systems using cooling load calculations.	BTL6
CO3	Collaborate effectively in interdisciplinary field like complex HVAC&R design challenges and communicate solutions through presentations and reports.	BTL6
CO4	Apply relevant codes, standards, and regulations governing the design, installation, and operation of refrigeration and air conditioning systems.	BTL3

Detailed Syllabus:

UNIT I **CH - 11**

Basic concepts of refrigeration and air conditioning, historical development and importance of HVAC systems, thermodynamic principles and cycles (Carnot cycle, vapor compression cycle), properties of moist air and psychrometric charts, humidity, dew point, relative humidity, and specific humidity, types of air conditioning systems (window AC, split AC, central AC), air distribution systems and duct design, ventilation and filtration considerations.

UNIT II **CH - 11**

Refrigerant properties and selection criteria, vapor compression refrigeration cycle, multistage and cascade refrigeration systems, components of refrigeration systems: compressors: types, working principles, and efficiency, condensers: air-cooled, water-cooled, evaporative condensers, evaporators: types, coil design, and frost formation, expansion devices: expansion valve, capillary tube, and other types, pressure-enthalpy diagrams for refrigerants

UNIT III **CH - 09**

Factors affecting cooling load, sensible and latent heat loads, methods for calculating cooling load (CLTD/CLF method, transfer function method), matching components to the cooling load, selection and sizing of components, system layout and piping design.

UNIT IV **CH - 11**

Energy-efficient technologies and strategies, variable-speed drives and energy recovery systems, control systems and automation, refrigerant management and environmental considerations: environmental regulations and refrigerant phase-outs, refrigerant leakage and safety measures, design projects and case studies: practical design projects involving load calculations, component selection, and system design, case studies of real-world HVAC design challenges.

Text Books:

1. C.P. Arora, Refrigeration and air conditioning Tata McGraw-Hill.
2. Jordan and Priester, Refrigeration and air conditioning, Prentice Hall Inc.
3. William, Refrigeration and air conditioning, Delmar Publishers.

Reference Books:

1. ASHRAE Hand Book (Fundamentals) by ASHRAE
2. Stoecker, Elementary Refrigeration and air conditioning McGraw Hill
3. Jones Arnold, Air Conditioning Engineering, Taylor & Francis group.
4. A Sarao, Refrigeration and Air Conditioning, Satya Prakashan.
5. RS Khurmi, Refrigeration and Air Conditioning: S Chand.

Subject: Entrepreneurship Development and risk Management (Code: MET023)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the knowledge of entrepreneurship and small business to promote startups.	BTL3
CO2	Organize and manage a small business by understanding financial planning, control, and strategic marketing planning.	BTL6
CO3	Validate new product or service development and business plan creation.	BTL5
CO4	Determine the basics of risk management, new product or service development, and business plan creation.	BTL6

Detailed Syllabus:

UNIT I **CH - 12**

Introduction to entrepreneurship: meaning, role of entrepreneur, entrepreneur process: different approaches, motivation for becoming an entrepreneur, importance of entrepreneurship: innovations, qualities of successful entrepreneur, functions of an entrepreneur, types of entrepreneur, contribution of entrepreneurs, entrepreneur carrier: different stages, entrepreneur development programmers.

UNIT II **CH - 16**

Characteristics of entrepreneurship, women entrepreneurship: opportunities, promotion hurdles and prospects of women entrepreneurs, social entrepreneurial initiative: solving social problems, technical and financial feasibility study and analysis of projects under self employment scheme including small entrepreneur, business plan - components of a business plan, strategic plan vs business plan, how to develop a good business plan?, role of entrepreneurial institutions in entrepreneurship development, various schemes and incentive, role of ministry of MSME, registration process of MSME, emerging technologies and business opportunities in India, 3 minute pitching.

UNIT III **CH - 14**

Risk management: risk factor, sensitivity analysis, vulnerability analysis, external risk, internal risk, environmental risk, financial planning, forecasting inputs and outputs, components of the financial plan, bootstrapping, venture and growth capital, managing a micro enterprise, human resource development for enterprise growth; delegation, motivation and leadership in microenterprises.

Text Books:

1. Byrd Megginson, Small Business Management An Entrepreneur's Guidebook 7th edition, McGraw-Hill.
2. Timmons, Jerry A., and Spinelli, Stephen, New Venture Creation: Entrepreneurship for the 21st Century, 8th edition, 2009, Boston, MA: Irwin McGraw-Hill.

Reference Books:

1. Donald F. Kuratko, Entrepreneurship: Theory, Process, Practice Business & Economics, 2008, Cengage, Learning.
2. Carree, M.A., and A.R. Thurik, Impact of Economic Growth, Hand Book of Entrepreneurship Research, New York, Springer.

Subject: Experimental Stress Analysis (Code: MET024)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply basic experimental stress analysis and examine applications of photo-elasticity in stress analysis.	BTL3
CO2	Apply Moire method for measuring strains and calibration procedure for different photo-elastic methods.	BTL3
CO3	Develop and apply different types of coatings for the determination of stresses in engineering components.	BTL6
CO4	Apply digital image processing techniques for strain and stress measurements.	BTL3

Detailed Syllabus:

UNIT I **CH - 09**

Importance of experimental methods, photo-elasticity, permanent and temporary birefringence, types of polariscopes, optics of plane and circular polariscope, stress optic law and secondary principal stresses; scattered light photoelasticity, scattered light technique to solve general three dimensional problem.

UNIT II **CH - 11**

Moire method of strain analysis: Moire phenomenon and formation of Moire fringes; geometric and displacement approach for in-plane problems, photoelastic methods: calibration methods and determination of stress trajectories, basic elements of three dimensional photoelasticity, stress freezing and slicing the model and interpretation of the resulting fringe patterns, fringe sharpening and fringe multiplication techniques.

UNIT III **CH - 11**

Birefringent coatings: surface stress determinations using birefringent coatings, reinforcing, thickness and other effects of photoelastic coatings, separation of principal stresses, birefringent coating materials and applications, brittle coatings, coating stresses, brittle coating failure theories, crack patterns due to direct and relaxation loading, refrigeration technique, calibration methods and scope of application of brittle coating method.

UNIT IV **CH - 11**

Digital image processing: fringe multiplication, fringe thinning and fringe clustering through data acquisition by DIP methods; phase shifting, polarization stepping and Fourier transform techniques phase unwrapping and optical enhanced tiling, use of colour image processing techniques for data acquisition in digital photo-elasticity.

Text Books:

1. Daily, J.W. and Riley, W.F., Experimental Stress Analysis, McGraw Hill.
2. James W. Dally and William F. Riley, Experimental Stress Analysis, College House Enterprises

Reference Books:

1. Frocht, M.M., Photoelasticity (Vol. I and II), John Wiley.
2. James F. Doyle, Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems, John Wiley.

Subject: Fundamentals of Acoustics (Code: MET025)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Theory of Machines-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Determine the mathematical models of various wave motions, and determine the general solution of the wave equation.	BTL3
CO2	Develop and analyze the mathematical models of various inhomogeneous wave motions, and determine their general solution.	BTL4
CO3	Analyze and quantify the radiation and reception of acoustic waves from various sources and determine their directivity.	BTL4
CO4	Analyze and quantify the reflection and transmission of acoustic waves from one medium to another and determine their acoustic impedance.	BTL4

Detailed Syllabus:

UNIT I **CH - 14**

Fundamentals of vibrations: introduction, the simple oscillator, complex exponential method of solution, transient response of an oscillator, power relations, equivalent electrical circuits for oscillators, the Fourier transform.

Transverse motion: vibrations of extended systems, transverse waves on a string, the one dimensional wave equation, general solution of the wave equation, the wave nature of the general solution, initial values and boundary conditions, reflection at a boundary, forced vibration of an infinite string, forced vibration of a string of finite length, normal modes of the fixed string, acoustic measurements.

UNIT II **CH - 14**

The two-dimensional wave equation: vibrations of a plane surface, the wave equation for a stretched membrane, free vibrations of a rectangular membrane, free vibrations of a circular membrane, normal modes of membranes, the diaphragm of a condenser microphone, vibration of thin plates.

The acoustic wave equation and simple solutions: the equation of state, the equation of continuity, the Euler's equation, the linear wave equation, speed of sound in fluids, harmonic plane waves, energy density, acoustic intensity, specific acoustic impedance, spherical waves, the inhomogeneous wave equation, the point source.

UNIT III **CH - 14**

Radiation and reception of acoustic waves: radiation from a pulsating sphere, acoustic reciprocity and the simple source, the continuous line source, radiation from a plane circular piston, radiation impedance, fundamental properties of transducers (directional factor, beam pattern, beam width, source level, directivity).

Reflection and transmission of acoustic waves: transmission from one fluid to another: normal incidence, and oblique incidence, normal specific acoustic impedance, reflection from the surface of a solid: normal incidence, oblique incidence.

Text Book:

1. L. E. Kinsler, Austin R. Frey, A. B. Coppens, J. V., Sanders, Fundamentals of Acoustics, 4th edition, John Wiley and Sons.

Reference Book:

1. Philip M. Morse, K. U. Ingard, Theoretical Acoustics, Princeton University Press.

Subject: Fundamentals of Tribology (Code: MET026)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 2**		
			L	T	P
			2	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Discuss the basic principle of surface roughness.	BTL2
CO2	Interpret adhesion theories and the effect of adhesion on friction and wear.	BTL3
CO3	Analyze the nature and behavior of wear and the type of lubricant used for a specific type of wear.	BTL4
CO4	Investigate the methods to reduce friction for engineering surfaces.	BTL4

Detailed Syllabus:

UNIT I **CH - 06**

Introduction to tribology, energy saving through tribology engineering, Surfaces and interaction between surface, production of engineering surface, surface roughness, RMS value, average value and ten point average of surface roughness, development of engineering surface and measurement of surface roughness.

UNIT II **CH - 07**

Tribology in industry, loss of energy due to friction and wear in industry, tribo-elements and a systems concept in tribology, introduction to friction, static and dynamic friction analysis, Da Vinci concept of friction, Amonton's laws of friction, Coulomb's laws of friction, Bowden and Tabor concept of friction.

UNIT III **CH - 08**

Wear and types of wear, adhesive wear, two body abrasive wear, three body abrasive wear, abrasive wear and its mathematical model, corrosive wear model, erosive wear model, cavitation wear, scuffing wear, delamination wear, pitting wear, wear coefficient and wear measurement, wear measurement through pin-on- disc machine, pin- on-ring, profilometer, wear coefficient of various materials.

UNIT IV **CH - 07**

Lubricants, types of lubricants, physical adsorption, chemisorption, self lubrication properties of materials, solid lubrication, lubrication in space, food industry, etc., high temperature lubrication, hydrodynamic lubrication, various components of Reynolds equation, Somerfield number and its use in hydrodynamic lubrication, materials for tribological applications.

Text Books:

1. Czichos, H., A system approach to science and Technology of Friction, Lubrication and Wear, Volume I, Tribology series, Elsevier Publications, 1978.
2. Glaeser, J, Materials for Tribology, Tribology series Vol. 20, Elsevier Publications, 1992.

Reference Book:

1. Peterson M. B.,Winner W.O, Wear control Handbook, sponsored by The Research Committee on Lubrication, 1980.

Subject: Heating, Ventilation, and Air Conditioning (Code: MET027)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-I, Applied Thermodynamics-II, Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the basic knowledge of heating, ventilation, air conditioning, and refrigeration controls, including wiring configurations and technical components for optimum system performance.	BTL3
CO2	Diagnose and service residential air conditioning systems based on load calculations, equipment selection, and balanced air duct flow.	BTL5
CO3	Analyze the operational procedures and principles used in servicing gas and electric heating systems, including safety inspections and system performance.	BTL4
CO4	Develop the basic knowledge of troubleshooting and testing air conditioning components, systems, and accessories, including the sequence of operations.	BTL6

Detailed Syllabus:

UNIT I **CH - 05**

Introduction to HVAC: fundamentals and scope of HVAC, modes of heat transfer, standards, refrigeration cycle, components of AC, refrigerants and types, classification of air-conditioning systems: window air conditioning systems, split air conditioning systems, central air conditioning systems, package air conditioning systems.

UNIT II **CH - 08**

Air cooled system of air conditioning, chilled water system of air conditioning, air water system of air conditioning, direct refrigerant system of air conditioning, study of psychometric properties of air (SH, RH, DPT, DBT, WBT, enthalpy), load calculation - orientation of building, to read latitude of location of building, calculation of U factor for wall, glass, roof, and partition, calculation of equivalent temperature, difference for wall, glass, roof, and partition.

UNIT III **CH - 09**

Heat load calculation using ASHRAE standards, calculation of sensible heat factor, ADP and dehumidified CFM, chilled water system, definition of STHE, study about chilled water systems, types and application of chillers, open loop& closed loop system, chilled water pipe sizing, types of valves and its connection, valve authority primary and secondary pump system, hydraulic calculation for pump selection, expansion tank sizing, air separator, pump cavitations, pump curves, NPSH calculation for pumps.

UNIT IV **CH - 10**

Advanced psychrometric analysis, determination of mix air temperature, calculation of air flow, ESHF, Ton of refrigeration, design of CAV and VAV systems, components of chilled water system, heat gain calculation, manual calculation, hour analysis program, cooling and heating load calculation using hourly analysis program, (HAP) duct designing calculation of duct sizes by mc-quay duct sizer equipment and air terminal, air terminal selection, cold storage selection, selection of materials of ducts, primary and

secondary pump selections, duct material selection, selection of cooling tower, selection of chillers, AHU and FCU classification and selection, package unit selection, DX unit selection, section DWG, pipe designing refrigerant pipe sizing, chilled water pipe sizing, calculation of chilled water pipe sizes by mc-quay pipe sizer software.

UNIT V **CH - 10**

Estimation of project: understanding the tendering requirements, BOQ (bill of quantities), pump head calculation, static pressure calculation, selection of motor hp, selection fan/blower rpm, ventilation and fresh air ventilation, infiltration load calculations, restaurant and residence kitchen ventilation system design, parking area ventilation and designing, toilet ventilation (industrial and residential), evaporative losses calculation in cooling towers, ESP calculation stairwell pressurization system designing.

Text Books:

1. James E. Brumbou and K. Audel, HVAC Fundamentals Volume-l, 4th edition.
2. Robert Mcdowall, Fundamentals of HVAC Systems, Academic Press, 2007.

References Books:

1. James Kittle, Home Heating and Air Conditioning systems, McGraw Hill.
2. Samuel C. Sugarman, HVAC Fundamentals, Fairmont Press, 2005.
3. ISHRAE, R&AC Hand Book.

Subject: Industry 5.0 (Code: MET028)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 2**		
			L	T	P
			2	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the evolution of industry 1.0 to 5.0	BTL4
CO2	Evaluate technological integration in industry 5.0	BTL5
CO3	Critically assess the sustainability and ethical implications in industry 5.0	BTL5
CO4	Design future-ready industry 5.0 solutions	BTL6

Detailed Syllabus:

UNIT I **CH - 07**

Industry 1.0 to 5.0 evolved from mechanization to human-centric collaboration, emphasizing customization and sustainability, key principles include human-robot collaboration, AI, ML, advanced robotics, IoT, personalization, and social responsibility.

UNIT II **CH - 12**

Industry 5.0 leverages AI and ML for AI-driven manufacturing, predictive maintenance, and quality control, alongside robotics and automation with cobots, AGVs, and advanced HMI design, IoT and cyber-physical systems utilize smart sensors.

IoT platforms, digital twins, and big data analytics for real-time decision-making and enhanced manufacturing processes, responsive and distributed supply chain system, human-centric and value-oriented approaches.

UNIT III **CH - 09**

Industry 5.0 emphasizes sustainability with green manufacturing, circular economy principles, and ethical AI use, supported by Indian policies like Make in India, workforce development focuses on necessary skills and training, while future trends include emerging technologies and enhanced human-machine collaboration, leading towards Industry 6.0.

Text Book:

1. Richa Maheshwari, Industry 5.0: A Human-Centric Solution.

Reference Books:

1. UthayanElangovan, Industry 5.0 - The Future of the Industrial Economy, 1st edition, Taylor & Francis.

2. Alessandro Massaro, Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances, Wiley-IEEE Press, 2021.

Subject: Internal Combustion Engines (Code: MET029)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze air-fuel cycles and internal combustion engine design characteristics.	BTL4
CO2	Recognize operating characteristics of SI and CI engines and determine the engine performance.	BTL3
CO3	Examine the essential systems of IC engines and latest trends and developments in IC engines.	BTL4
CO4	Evaluate the effect of engine emissions on environment and human health and methods of reducing it.	BTL5

Detailed Syllabus:

UNIT I **CH - 08**

Basic nomenclature, engine classification, working principle of two stroke and four stroke engines, analysis of air-standard cycles, fuel-air cycles and actual cycles, thermodynamics of actual working fluids, air capacity of four stroke engines, ideal air capacity, volumetric efficiency, ideal induction process, actual induction process, effect of operating conditions on volumetric efficiency, effect of design on volumetric efficiency, estimating air capacity, valve and port timing diagram.

UNIT II **CH - 11**

Classification of fuels, solid, liquid, and gaseous fuels, fuel properties and fuel rating, alternative fuels, mixture requirements, characteristics of SI and CI engine fuels, combustion and detonation, chemistry of combustion, normal combustion in SI engines, pre-ignition and auto-ignition comparison, detonation in SI engines, combustion in CI engines, detonation in CI engines, methods of reducing detonation, preliminary detonation, preliminary facts about fuel and dopes, Octane and Cetane numbers, effect of design on detonation, mixture requirements, steady running, transient mixture requirements, mixture requirements for fuel injection engines, mixture requirements for SI engines, use of combustion charts for burned mixture, appropriate treatment of fuel air mixtures.

UNIT III **CH - 11**

Types of carburettors, mixture requirements, single point and multipoint injection system in SI engine, rate of fuel injection in CI engine, fuel injection pumps and nozzle, current injection systems in IC engines, ignition system: battery ignition, magneto ignition, and electronic ignition, factors affecting spark advance, spark advance mechanism, current ignition systems, engine friction and lubrication: components of engine friction, friction mean effective pressure, blowby losses, effect of engine variables on friction, side thrust on piston, lubrication principle, types of lubrication, properties of lubricant, heat transfer and cooling system: engine temperature distribution, heat transfer consideration, gas temperature variation, effects of operating variables on heat transfer.

UNIT IV **CH - 12**

Measurement of indicated power, brake power, fuel consumption, air flow rate, speed, spark timing, performance characteristics, heat balance sheet, numericals on engine design, determination of main

dimensions, comparative numerical on two stroke engines and four stroke engines, numericals on heat transfer in IC engines, engine design: selection of type, engine speed and principles of similitude. numericals on alternative fuels, numericals on diesel fuel injection system, numericals on engine specification and verification, numericals on two stroke engines, general design of petrol and diesel engine. Sources of air pollution, pollutants from IC engines and their effect on human health, methods of emission control, effect of alternative fuels, current scenario on the pollution front, pollutant formation, measurement of exhaust emissions, NDIR, FID, CLA, measurement of exhaust smoke, gas chromatography, effect of operating variables on SI and CI engine pollutant, pollution norms.

Text Books:

1. Heywood, John B. Internal Combustion Engine Fundamentals, McGraw-Hill
2. V. Ganeshan, I. C. Engines: Tata McGraw Hill, 4/e

Reference Books:

1. W. W. Pulkrabek, Engineering Fundamentals of I. C. Engines
2. M. L. Mathurand R.P. Sharma: A course in I. C. Engines
3. S. S. Thipse, Internal Combustion Engine, Jaico Books
4. Richard Stone, Introduction to Internal Combustion Engines, material.

Subject: Introduction to Computational Fluid Dynamics (Code: MET030)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fluid-Mechanics-I, Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the differential equations for flow phenomena and numerical methods for their solution.	BTL2
CO2	Critically analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.	BTL4
CO3	Solve computational problems related to fluid dynamics and heat transfer for both internal and external flows.	BTL3
CO4	Analyze the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.	BTL4

Detailed Syllabus:

UNIT I **CH - 09**

Introduction: history and philosophy of Computational Fluid Dynamics (CFD), CFD as a design and research tool, applications of CFD in engineering, programming fundamentals, MATLAB programming, numerical methods.

Governing equations of fluid dynamics: models of the flow, the substantial derivative, physical meaning of the divergence of velocity, the continuity equation, the momentum equation, the energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, physical boundary conditions, forms of the governing equations suited for CFD, conservation form of the equations, shock fitting and shock capturing, time marching and space marching.

UNIT II **CH - 11**

Mathematical behavior of partial differential equations: classification of quasi-linear partial differential equations, methods of determining the classification, general behavior of hyperbolic, parabolic and elliptic equations.

Basic aspects of discretization: introduction to finite differences, finite difference equations using Taylor series expansion and polynomials, explicit and implicit approaches, uniform and unequally spaced grid points.

Grids with appropriate transformation: general transformation of the equations, metrics and Jacobians, the transformed governing equations of the CFD, boundary fitted coordinate systems, algebraic and elliptic grid generation techniques, adaptive grids.

UNIT III **CH - 12**

Parabolic partial differential equations: finite difference formulations, explicit methods - FTCS, Richardson and Dufort-Frankel methods, implicit methods - Lasonen, Crank-Nicolson and beta formulation methods, approximate factorization, fractional step methods, consistency analysis, linearization.

Stability analysis: discrete perturbation stability analysis, Von Neumann stability analysis, error analysis, modified equations, artificial dissipation and dispersion.

Elliptic equations: finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.
Hyperbolic equations: explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, TVD formulations, entropy condition, first-order and second-order TVD schemes.

UNIT IV **CH - 10**

Scalar representation of Navier-Stokes equations: equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTBCS implicit algorithms, applications.
Grid generation: algebraic grid generation, elliptic grid generation, hyperbolic grid generation, parabolic grid generation.
Finite volume method for unstructured grids: advantages, cell centered and nodal point approaches, solution of generic equation with tetrahedral elements, 2-D heat conduction with triangular elements.

Text Books:

1. Anderson, J. D. (Jr), Computational Fluid Dynamics, McGraw-Hill Book Company, 1995.
2. Hoffman, K. A., and Chiang, S. T., Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.

Reference Books:

1. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.
2. Anderson, D. A., Tannehill, J. C., and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill Book Company, 2002.

Subject: Introduction to Electric Vehicle(Code: MET031)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Articulate the configuration of Electrical Vehicles (EV's).	BTL3
CO2	Recognize the EV control systems and vehicle dynamics.	BTL2
CO3	Demonstrate of EV battery chargers, electric vehicle supply equipment, and battery thermal management system.	BTL3
CO4	Evaluate the feasibility and challenges of EV into existing automobile industry.	BTL5

Detailed Syllabus:

UNIT I **CH - 09**

History and benefits of Electric Vehicles (EVs), fundamentals of EVs, social, environmental, and economic impacts of electric and hybrid vehicles, tractive effort, vehicular dynamics, drive cycle and vehicle control unit, impact of modern drive-trains on energy supplies.

UNIT II **CH - 11**

Power train configurations and components, traction motor characteristics, tractive effort, drive cycles, rear-wheel drive powertrains, front-wheel drive (FWD) powertrains, vehicle control unit, vehicle modelling methodology, range modelling of battery electric vehicle, auxiliary system in electric vehicle, powertrain component sizing, auxiliary control functions (anti-roll, start stop etc.)

UNIT III **CH - 10**

Importance of control system in electrical vehicle, study of control architecture in electric vehicle, systems models and their classifications, principles used in modelling of systems, fundamental studies of modelling of vehicle dynamics and control, integrated vehicle dynamics.

UNIT IV **CH - 12**

Introduction to energy storage requirements in electric vehicles, battery-based energy storage and its analysis, battery charging modes, types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges, battery performance characteristics, rechargeable battery vehicles, battery thermal management system (BTMS), types of BTMS, comparison between different BTMS, opportunity and advancement.

Text Books:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.

2. M. Ehsani, Y. Gao, S. Gay and Ali Emadi Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design CRC Press 2005.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Reference Books:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals CRC Press 2003.
2. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives Chris Mi, M. Abul Masrur, David Wenzhong Gao Wiley Publication 2011.
3. Iqbal Husain, Electric and Hybrid Vehicles – Design Fundamentals, 2nd edition, CRC Press, 2011.

Subject: Introduction to Finite Element Method (Code: MET032)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Engineering Mechanics, Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the concepts of variational principles, weighted residual methods, and weak formulations for solving differential equations.	BTL3
CO2	Develop finite element models for one dimensional problems and analyze the structures subjected to axial loads, twisting moments, and thermal loading conditions.	BTL4
CO3	Apply the concepts of geometric transformations for analyzing two dimensional engineering problems.	BTL3
CO4	Apply the finite element method for analysing simple trusses and plane elastic problems.	BTL3

Detailed Syllabus:

UNIT I **CH - 08**

Introduction to finite element method, weak formulations, variational principles, approximation functions, weighted residual methods, virtual work principle, natural and essential boundary conditions.

UNIT II **CH - 11**

One dimensional problems, discretization of domain, elemental equations, connectivity of elements, interpolation functions and their properties, linear, quadratic and higher order shape functions, local and global stiffness matrix, solution of equations, applications to solid mechanics, heat transfer and fluid mechanics problems.

UNIT III **CH - 12**

Two dimensional problems, single variable problems, linear and higher order triangular elements, area coordinates, rectangular elements, higher order rectangular elements, natural coordinates, serendipity elements, numerical integration, coordinate transformations, evaluation of element matrices, boundary integrals, assembly of element equations and application of boundary conditions.

UNIT IV **CH - 11**

Plane truss element, local and global coordinate systems, stress and strain calculations, plane elastic problems, governing equations for plane stress and plane strain, weak formulations, finite element models for plane elastic problems, evaluation of boundary integrals.

Text Books:

1. Reddy J. N., An Introduction to Finite Element Methods, McGraw Hill Education (India).
2. Fish J. and Belytschko T., A First Course in Finite Elements, John Wiley and Sons.

Reference Books:

1. Liu G. R. and Quek S.S., The Finite Element Method; A Practical Course, Butterworth Heinmann.
2. Rao S. S., The Finite Element Method in Engineering, Elsevier Publications.

Subject: Introduction to MEMS (Code: MET033)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate a sound background in the area of microfabrication.	BTL3
CO2	Examine the current microfabrication techniques and synthesize a process for a given application.	BTL4
CO3	Analyze common design and fabrication processes of MEMS through studies of classical and concurrent cases.	BTL4
CO4	Evaluate and conceptualize several intersecting points in study of MEMS devices, such as design, fabrication, performance, robustness and cost, among others, involved in successfully developing integrated MEMS devices.	BTL5

Detailed Syllabus:

UNIT I **CH - 16**

Definition of MEMS, scaling and miniaturization concepts, Silicon as a MEMS material, mechanical properties of Silicon, fabrication technologies, introduction to micro-fabrication, Silicon based MEMS processes, surface micromachining, sacrificial etching process, bulk micromachining and Silicon anisotropic etching, bulk versus surface micromachining, mechanical components in MEMS.

UNIT II **CH - 12**

Review of essential electrical and mechanical concepts, conductivity of semiconductors, review of solid mechanics for design of mechanical components, crystal planes and orientation, mechanical properties of Silicon and the related thin films.

UNIT III **CH - 14**

Review of electrostatics and electrodynamics, electrostatic sensing and actuation, analysis of comb drives, dynamics of comb drives, electrostatic sensing and actuation, piezoelectric sensing and actuation, piezoresitive sensing, thermal sensing and actuation, scaling laws, instrumentation for MEMS testing and characterization.

Text Book:

1. Chang Liu, Foundations of MEMS, 2nd edition, 2012, Pearson.

Reference Books:

1. Senturia, S.D., Microsystem Design, Kluwer Academic Publisher, 2000.
2. Nadim M, An Introduction to Microelectromechanical Systems Engineering, Artech House, 1999.

Subject: Introduction to Microfluidics (Code: MET034)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fluid-Mechanics-I, Fluid-Mechanics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the fundamental principles and applications of microfluidics across various disciplines.	BTL2
CO2	Analyze fluid mechanics at microscales and apply scaling laws to predict flow behavior.	BTL4
CO3	Design microfluidic devices by considering channel geometry and surface modifications and utilizing appropriate fabrication techniques.	BTL6
CO4	Assess the role of microfluidics in biological, chemical, and biomedical engineering applications, demonstrating an understanding of their practical implementations and potential impacts.	BTL5

Detailed Syllabus:

UNIT I **CH - 10**

Introduction to the field, defining microfluidics, its scope, and its significance in various industries such as biomedical engineering, pharmaceuticals, and analytical chemistry.
Understanding the historical evolution of microfluidics, key milestones, and breakthroughs leading to its current state.
Exploring diverse applications of microfluidics, including but not limited to biological analysis, chemical synthesis, drug delivery, and environmental monitoring.

UNIT II **CH - 11**

Understanding how fluid behavior changes at microscales, including the influence of viscosity, inertia, and surface tension, and how these factors differ from macroscale fluid mechanics.
Exploring the predominance of laminar flow in microchannels, its advantages, limitations, and conditions leading to turbulent flow.
Investigating how surface tension affects fluid behavior at small scales, including phenomena like capillary action and droplet formation.

UNIT III **CH - 11**

Learning the key principles behind designing microfluidic devices, including considerations such as channel geometry, flow rates, mixing efficiency, and minimizing sample and reagent consumption.
Exploring various microfabrication techniques essential for manufacturing microfluidic devices, such as photolithography, soft lithography (PDMS-based techniques), and micromachining methods.
Understanding the impact of channel geometry on fluid flow characteristics and exploring surface modification techniques to control fluid behavior, reduce fouling, and enhance device performance.

UNIT IV **CH - 10**

Exploring the role of microfluidics in biological analysis, including cell manipulation, cell sorting, DNA/RNA analysis, single-cell analysis, and organ-on-a-chip technologies.

Examining the use of microfluidics in biomedical engineering, including the development of lab-on-a-chip devices for point-of-care diagnostics, implantable drug delivery systems, and personalized medicine approaches.

Text Books:

1. A. H. Barber and S. Luan, Microfluidics and Nanofluidics: Theory and Selected Applications.
2. S. T. Wereley and C. D. Meinhart, Microfluidics for Biological Applications.

Reference Books:

1. X. Huang and C. Liu, Microfluidics and Bio-MEMS: Devices and Applications.
2. J. C. Neu and C. S. Qian, Microfluidics: Theory and Applications.
3. J. A. Rogers, R. G. Nuzzo, and G. M. Whitesides, Soft Lithography.
4. C. A. Mirkin and G. M. Whitesides, Microfluidic Devices in Nanotechnology: Applications.

Subject: MATLAB Programming (Code: MET035)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 2**		
			L	T	P
			2	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mathematics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply different features of MATLAB as a programming tool for solving different engineering problems.	BTL3
CO2	Develop programming skills and technique to analyze mathematical problems.	BTL4
CO3	Apply MATLAB graphic feature and its applications for solving mathematical problems.	BTL3
CO4	Use MATLAB as a simulation tool.	BTL6

Detailed Syllabus:

UNIT I **CH - 04**

Introduction to MATLAB: The MATLAB Environment, MATLAB basics – Variables, Numbers, Operators, Expressions, Input and output, Vectors, Matrices, and Arrays.

UNIT II **CH - 07**

MATLAB Functions: Built-in Functions and User defined Functions.
Graphics with MATLAB: Files and File Management – Import/Export, Basic 2D, 3D plots, Graphic handling.

UNIT III **CH - 10**

Conditional Statements, Loops, MATLAB Programs – Programming and Debugging, Applications of MATLAB Programming.

UNIT IV **CH - 07**

Mathematical Computing with MATLAB, Algebraic equations, Basic Symbolic Calculus and Differential equations, Numerical Techniques and Transforms.

Text Books:

1. Brian R. Hunt, Ronald L. Lipsman, and Jonathan M. Rosenberg, A Guide to MATLAB -for Beginners and Experienced Users, 2nd edition, Cambridge University Press, 2006.
2. Stephen J. Chapman, Essentials of MATLAB Programming, 2nd edition, Cengage Learning, 2009.

References Books:

1. David McMahon, MATLAB Demystified, The McGraw-Hill Companies, 2007.
2. Holly Moore, MATLAB for Engineers, 3rd edition, Pearson Education, Inc., 2012.
3. David M. Smith, Engineering computation with MATLAB, 2nd edition, Pearson Education, Inc.,

Subject: Mechanics of Composite Materials (Code: MET036)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate the knowledge of the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.	BTL3
CO2	Examine the failure strength of a laminated composite plate.	BTL4
CO3	Apply the concepts of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.	BTL3
CO4	Design, optimize, simulate, and test advanced composite components and structures.	BTL6

Detailed Syllabus:

UNIT I **CH - 12**

Definition and classification of composite materials: polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon composites, reinforcements and matrix materials. Manufacturing techniques for composites: Fiber Reinforced Plastic (FRP) processing: layup and curing fabricating process, open and closed mould process, hand layup techniques, structural laminate bag molding, production procedures for bag molding, filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.

Fabrication process for Metal Matrix Composites (MMC's): powder metallurgy technique, liquid metallurgy technique, and secondary processing, special fabrication techniques.

UNIT II **CH - 10**

Density and mechanical properties of composites, prediction of elastic constants, micromechanical approach, Halpin-Tsai equations, transverse stresses.

Thermal properties: expression for thermal expansion coefficients of composites, expression for thermal conductivity of composites, hygral and thermal stresses.

Mechanics of load transfer from matrix to fiber: fiber elastic-matrix elastic, fiber elastic matrix plastic. Load transfer in particulate composites, numerical problems.

UNIT III **CH - 09**

Elastic constants of an isotropic material, elastic constants of a lamina, relationship between engineering constants and reduced stiffnesses and compliances, variation of lamina properties with orientation, analysis of laminated composites, stresses and strains in laminate composites, inter-laminar stresses and edge effects, numerical problems.

UNIT IV **CH - 11**

Tensile and compressive strength of unidirectional fiber composites, fracture modes in composites: single and multiple fracture, debonding, fiber pullout and delamination fracture, strength of an orthotropic lamina:

maximum stress theory, maximum strain criterion, Tsai-Hill criterion, quadratic interaction criterion, comparison of failure theories.
Fatigue of composites: SN curves, fatigue crack propagation tests, damage mechanics of fatigue, thermal fatigue, creep behavior of composites.
Symmetric laminates, cross-ply laminates, angle ply laminates, antisymmetric laminates, balanced laminate, failure criterion for a laminate, design of a laminated composite, numerical problems.

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd edition, 2005.
2. Krishan K. Chawla, Composite Material Science and Engineering, Springer, 3rd edition, 2012.
3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.

Reference Books:

1. Madhijit Mukhopadhay, Mechanics of Composite Materials and Structures, Universities Press, 2004.
2. Michael W. Hyer, Stress analysis of Fiber Reinforced Composite Materials, McGraw Hill International, 2009.
3. P. C. Mallikand Marcel Decker, Fibre Reinforced Composites, 1993.
4. P. C. Mallik and Marcel Decker, Hand Book of Composites, 1993.

Subject: Noise Monitoring and Control (Code: MET037)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Describe the various parameters related to noise measurement.	BTL2
CO2	Examine some of the typical noise control principles and the equipment used to implement them.	BTL4
CO3	Distinguish between various noise sources and apply the right noise control procedure to mitigate the effects of noise.	BTL4
CO4	Design an active noise control scheme for real-world applications.	BTL6

Detailed Syllabus:

UNIT I **CH - 14**

Introduction to sound and noise, effects of noise, physics of sound, sound intensity, frequency of sound, relationship of sound pressure, sound power and sound intensity, microphones, sound fields, frequency weighting, sound level meters; frequency response, weighting, calibration, sampling procedure, determination of equivalent sound level, noise dosimeters, frequency analyzers, related vibration measurements.

UNITII **CH - 12**

Sound control principle: isolation, absorption, vibration isolation, vibration damping, material selection, equipment specifications, noise control regulations, types of fans, noise source, modifications, isolators, mufflers, location, balancing, and maintenance.

UNIT III **CH - 16**

Basic mechanism of gear noise generation, principal sources of various excitation and response harmonic sets, types of bearings and sources of noise, noise control; selection of bearings to reduce noise.

Introduction to active noise control, passive and active control approaches, noise control in enclosed spaces, sound propagation in ducts, active control, digital system and controller output requirements.

Text Books:

1. Lewis H. Bell, Chris Bell, L. H. Bell, Industrial Noise Control: Fundamentals and Applications, 2nd edition,CRC Press
2. Stan Skaistis, Noise Control of Hydraulic Machinery, Marcel Dekker.
3. Colin Hansen, Noise Control: From Concept to Application, CRC Press

Reference Books:

1. Nicholas P. Cheremisinoff, Noise Control in Industry: A practical guide, William Andrew Publishing.
2. Scott D. Snyder, Active Noise Control Primer, Springer
3. David A. Bies, Colin H. Hansen, Engineering Noise Control: Theory and Practice.

Subject: Operations Management (Code: MET038)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Industrial Engineering-I, Industrial Engineering-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze operations strategies for competitive advantage.	BTL4
CO2	Evaluate forecasting models and demand patterns.	BTL5
CO3	Critically assess aggregate planning and scheduling systems.	BTL5
CO4	Design world-class manufacturing systems.	BTL6

Detailed Syllabus:

UNIT I **CH - 16**

Introduction to operations management (OM), historical perspective and growth, operations strategies for competitive advantage. Forecasting (FC), nature and use of FC, sources of data, demand pattern, FC models. designing products, services and processes, new product design, product development, product life cycle, product development process, product reliability, process technology life cycle, flexible manufacturing systems.

UNIT II **CH - 16**

Scheduling Systems and Aggregate Planning for Products and Services Operations planning and scheduling systems, the aggregate planning process, strategies for developing aggregate planning, master schedule and rough cut capacity planning, implementing aggregate plans and master schedules, material requirement planning (MRP).

UNIT III **CH - 10**

Managing for World class Competition Japanese contribution for World Class Manufacturing (WCM), JIT manufacturing, basic concepts of TQM, ISO, Poka Yoke and Kaizen. Business process re-engineering, lean manufacturing, concepts of supply chain management.

Text Book:

1. Panneerselvam R, Production and Operations Management, 2nd edition, New Delhi, 2005.

Reference Books:

1. Roberta S. Russell, Taylor B.W, Operations Management, Pearson Prentice Hall, 4th edition, 2001.
2. Everett, E.A., Ronald J.E, Production and Operations Management, Prentice Hall of India, 5th edition, New Delhi, 2001

3. Evans J.R., Collier D.A., Operations Management, An Integrated Goods and Services Approach, Cengage Learning India, New Delhi, 2007.

Subject: Power Plant Engineering (Code: MET039)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Applied Thermodynamics-I, Applied Thermodynamics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the layout, construction, and working of the components of coal based thermal power plants.	BTL2
CO2	Analyze the layout, construction, and working of the components of diesel and gas power plants.	BTL4
CO3	Explain the layout, construction, and working of the components of nuclear power plants and renewable energy power plants.	BTL2
CO4	Evaluate the problems associated with pollution by power plants and its control, while extending their knowledge to power plant economics.	BTL5

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to different power plants, load duration curves, location of power plants, power plant economics and Indian energy scenario.
Coal based thermal power plant: layout of modern coal power plant, site selection criteria, Rankine cycle and its improvisations, supercritical, high pressure boilers, FBC boilers, steam combined cycle power plant: binary cycles and cogeneration systems, subsystems of thermal power plants – draught system, fuel and ash handling, feed water treatment, and so on.

UNIT II **CH - 12**

Essential components of diesel power plant, hydro-power plants, gas turbine power plant and nuclear power plant, different systems like fuel supply system, engine cooling system, engine lubrication system, exhaust system, engine starting and stopping system. optimum pressure ratio for maximum thermal efficiency, work ratio, air rate, effect of operating variables on the thermal efficiency and work, cooling of gas turbine blade, combined steam and gas turbine plant, basics of nuclear engineering, layout and subsystems of nuclear power plants, working of nuclear reactors: boiling water reactor (BWR), pressurized water reactor (PWR).

UNIT III **CH - 08**

Hydro electric power plants – classification, typical layout and associated components including turbines. principle, construction and working of wind, tidal, solar photovoltaic (SPV), solar thermal, geothermal and fuel cell power systems.

UNIT IV **CH - 11**

Importance of energy storage, battery technologies (e.g., Lithium-ion, flow batteries), thermal energy storage. power-to-X technologies (power-to-gas, power-to-liquid), general principles of energy management and energy management planning, application of Pareto's model for energy management, obtaining management support, establishing energy database, conducting energy audit, identifying,

evaluating, and implementing feasible energy conservation opportunities, energy audit report, monitoring, evaluating, and following up energy saving measures/projects.

Text Books:

1. P.K. Nag, Power Plant Engineering, Tata McGraw Hill Co., Delhi
2. Rajput R.K., A text book of power plant engineering, Laxmi Publication, New Delhi, 2007.
3. Arora and Domkundwar, Power Plant Engineering, Dhanpat Rai & Co. Delhi.

Reference Books:

1. Nagpal, Power Plant Engineering, Khanna Publishers, Delhi.
2. M.M. El-Wakil, Power Plant Technology, McGraw-Hill Education
3. F.T. Morse, Power Plant Engineering, East-West Press Pvt. Ltd.

Subject: Product Development and Value Engineering (Code: MET040)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the basics of design requirement in product development.	BTL4
CO2	Build a solution oriented approach by an in depth knowledge of product development and value analysis.	BTL6
CO3	Examine the underlying concepts, methods, and application of product development and value engineering	BTL4
CO4	Validate the value engineering concepts in real world case studies.	BTL5

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to design and development of products, design for stiffness and rigidity, design for production, designing with plastics, rubber, ceramics, glass and wood, characteristics of successful product development - duration and cost of product development, the challenges of product development.

UNIT II **CH - 10**

Introduction to product planning, process, identification of opportunities, evaluation and prioritization of projects, allocation of resources and time planning, completion of pre-project planning, reflection of all the results and the process.

UNIT III **CH - 11**

Introduction to value engineering, definition, value engineering recommendations, programs, advantages, evaluation of function, determining function, classifying function, evaluation of costs, evaluation of worth, determining worth, evaluation of value.

UNIT IV **CH - 10**

Value engineering job plan: introduction, orientation, information phase, function phase, creation phase, evaluation phase, investigation phase, implementation phase, speculation phase, analysis phase, value engineering case studies.

Text Books:

1. Karl T. Ulrich, Steven D. Eppinger, Anita Goyal, Product Design and Development, 2009, Tata McGraw Hill, New Delhi.
2. Arthur E. Mudge, Value Engineering: A Systematic Approach, McGraw Hill.

Reference Books:

1. Kevin Otto and Kristini Wood, Product development, 2004, Pearson Education,
2. S. S. Iyer, Value Engineering - A how to Manual, 2009, New age International Publishers.

Subject: Renewable and Alternate Energy Systems (Code: MET041)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Fluid Mechanics-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the difference between renewable and non-renewable energy resources.	BTL2
CO2	Understand the conversion of energy from one form to another.	BTL2
CO3	Evaluate the importance of solar radiation and its utilization.	BTL5
CO4	Develop different energy conversion systems.	BTL6

Detailed Syllabus:

UNIT I **CH - 06**

Introduction to energy, relevance of energy in the development of country, conventional, non-conventional, and renewable sources of energy, status of conventional sources of energy and their conservation, exploring renewable sources of energy.

UNIT II **CH - 13**

Extraterrestrial solar radiation, components of radiation, geometry of earth and sun, geometry of collector and the solar beam, effects of earth's atmosphere, measurements of solar radiation, type of water heaters, selective surfaces, space heating, space cooling, water desalination, solar ponds, solar concentrators, thermos- electric power system, problems.

Introduction to the silicon PN junction, photon absorption solar radiation input, photovoltaic circuit properties and loads, limits to cell efficiency, solar cell construction, other types of photoelectric and thermo-electric generation.

UNIT III **CH - 12**

Principle of hydro power conversion, impulse turbine, reaction turbines, wind turbine types, linear momentum and basic theory, dynamic matching, characteristics of the wind, power extraction by a turbine, electricity generation, mechanical power, problems.

Introduction to bio fuels, classification, bio-mass production for energy farming, direct combustion for heat, pyrolysis (destructive distillation), alcoholic fermentation, anaerobic digestion for bio-gas, agrochemical fuel extractions.

UNIT IV **CH - 11**

Introduction to wave motion, wave energy and power, wave patterns, devices, the causes of tides, enhancement of tides flow power, tidal range, power, world tidal power sites.

Principles of Ocean Thermal Energy Conversion (OTEC), Claude cycle, Andersan cycle.

Introduction to geothermal energy, dry rock and hot aquifer analysis, harnessing geothermal resources

Text Book:

1. S. P. Sukhatme, Solar Energy, Tata McGraw Hill, New Delhi.

Reference Books:

1. John W. Twidell and Anthony D. Weir, Renewable Energy Resources, EFN, Spon. Ltd., London.
2. Bent Sorensen, Renewable energy, Academic press.
3. G D Rai, Non-conventional Energy Sources, Khanna Publishers, Delhi

Subject: Solar Thermal Energy (Code: MET042)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Apply the basic concepts of renewable energy, specifically solar energy.	BTL3
CO2	Apply the basic concepts and applications of solar thermal energy.	BTL3
CO3	Examine the solar distillation technologies.	BTL4
CO4	Formulate scheme for using contemporary methods, utilizing solar energy.	BTL6

Detailed Syllabus:

UNIT I **CH - 12**

Solar radiation: characteristics, earth-sun relations, estimation on horizontal and tilted surfaces, radiation characteristics of opaque and transparent material.

Flat plate and evacuated tube collectors and applications: description, theory, heat capacity effects, time constant, measurement of thermal performance, air heaters.

UNIT II **CH - 12**

Heat storage: sensible and latent heat storage, solid media storage, dual media storage, chemical energy system, and performance calculations.

Flow systems: natural and forced flow systems, water heating systems for domestic, industrial, and space heating requirements, and solar distillation.

UNIT III **CH - 08**

Solar distillation: introduction, working principle, thermal efficiency, external heat transfer, internal heat transfer, overall heat transfer, solar still, and their types, other designs of solar still.

UNIT IV **CH - 10**

Solar air conditioning systems and AWG technologies: introduction to air conditioning systems, solar desiccant cooling, introduction to AWGs, solid desiccant materials, liquid desiccant materials, composite desiccant materials, performance evaluation parameters, and cost analysis.

Text Books:

1. Duffie and Beckman, Solar Thermal Engineering Process
2. J. S. Hsieh, Solar Energy.
3. P. J. Lu, Solar Thermal Engineering

Reference Books:

1. H. P. Garg, Advanced Solar Energy Technology.
2. S. P. Sukhatme Solar Energy
3. G. N. Tiwari, Solar Energy

Subject: Theory of Elasticity(Code: MET043)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain the fundamental concepts of stress & strain followed by an analytical expression relating the stress and strain in 3-D systems.	BTL2
CO2	Implement the compatibility equations and boundary conditions to solve the problems of T.O.E in practice.	BTL3
CO3	Analyze the structural members subjected to pure bending using the fundamental concept of stress, strain, and elastic behaviors of materials.	BTL4
CO4	Apply analytical techniques to predict the effects of stress concentration in simple solids and structural components.	BTL5

Detailed Syllabus:

UNIT I **CH - 13**

Introduction: elasticity, stress components of stress and strain, Hooke's law, equations in polar coordinates, plane stress and plane strain, strain at a point, Mohr's circle for strain rosette, differential equation of equilibrium, boundary conditions, compatibility equations, overview of Airy's stress functions.

UNIT II **CH - 13**

Two dimensional problems in rectangular coordinates: solution by polynomials, St. Venant's principles, determination of displacement, bending of beams, solution by Fourier series, two dimensional problems in polar coordinates: equations in polar coordinates, equation about 1-axis, and pure bending in curved bars.

UNIT III **CH - 16**

Determination of strains and displacement, effect of circular hole on stress distribution in plate concentrated and vertical loading of a straight boundary, circular disc, general solution and its applications, analysis of stress and strain in three dimensions: stress at a point, principal stress, stress ellipsoid and stress director surface, homogenous deformation, strain at a point, principle strain rotation.

Text Book:

1. Timoshanko, S. P. and Goodier, J. N., Theory of Elasticity, Mc-Graw Hill Book Company, New York., USA, 1970.

Reference Book:

1. Love, A.E. H., The Mathematical Theory of Elasticity, Dover Publications, New York, USA, 1944.

Subject: Theory of Plates and Shells(Code: MET044)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Mechanics of Materials-I, Mechanics of Materials-II

Course Outcomes: At the end of the course, the student should be able to:

CO1	Use analytical methods for the solution of plates.	BTL3
CO2	Use analytical methods for the solution of shells.	BTL3
CO3	Investigate numerical techniques and tools for the complex problems in plates.	BTL4
CO4	Investigate numerical techniques and tools for the complex problems in shells.	BTL4

Detailed Syllabus:

UNIT I **CH - 09**

Introduction: space curves, surfaces, shell co-ordinates, strain displacement relations, assumptions in shell theory, displacement field approximations, stress resultants, equation of equilibrium using principle of virtual work, boundary conditions.

UNIT II **CH - 11**

Static analysis of plates: governing equation for a rectangular plate, Navier solution for simply-supported rectangular plate under various loadings, Levy solution for rectangular plate with other boundary conditions.

UNIT III **CH - 10**

Circular plates: analysis under axi-symmetric loading, governing differential equation in polar co-ordinates, approximate methods of analysis - Rayleigh-Ritz approach for simple cases in rectangular plates.

UNIT IV **CH - 12**

Static analysis of shells: membrane theory of shells- cylindrical, conical and spherical shells, shells of revolution with bending resistance - cylindrical and conical shells, application to pipes and pressure vessels, thermal stresses in plates and shell.

Text Books:

1. Timoshenko S. and Krieger W., Theory of Plates and Shells, McGraw Hill.
2. Ugural Ansel C., Stresses in Plates and Shells, McGraw Hill.

Reference Books:

1. KrausH., Thin Elastic Shells, John Wiley and Sons.
2. Chandrashekhara K., Theory of Plates, Universities Press.
3. Ramaswamy G.S., Design and Construction of Concrete Shells.

Subject: Total Quality Management (Code: MET045)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Demonstrate comprehension of the quality environment within an organization.	BTL3
CO2	Examine the principles and practices of the Total Quality Management (TQM) approach for manufacturing and service organizations.	BTL4
CO3	Compare various quality terms and concepts, including Tolerance and Variability, the PDCA cycle, Crosby's 10 points, and Deming's 14 points.	BTL4
CO4	Apply the knowledge of BIS/ISO standards to practical case studies.	BTL3

Detailed Syllabus:

UNIT I **CH - 16**

Evolution of quality - historical perspective, basic concepts of quality, vision, mission and objectives of an organization, corporate structure in an organization and role of quality, quality planning, quality by design, quality costs and cost of failure, waste control, how quality benefits business, quality and competitiveness in business, zero defects and continuous improvement, role of leadership and commitment in quality deployment, team building, motivation and rewards, total employee empowerment, quality functions - measurement, inspection, testing, calibration, and assurance.

UNIT II **CH - 10**

Design control and conformity, tolerance and variability, PDCA cycle, Juran trilogy, Crosby's 10 points and Deming's 14 points customers requirements, customer-supplier and chain links, establishing customer focus-customer, satisfaction, measurement, and customer retention.

UNIT III **CH - 16**

Product liability, total quality concepts and CWQC, difference in Western and Japanese approach of TQM, basic philosophy and fundamental models of TQM, total quality and ethics, internal politics and TQM, quality culture, education and training, implementing TQM- an integrated system approach, total preventive maintenance, self-assessment, international/national quality awards: Malcolm Baldridge award, Deming prize, European award, Rajeev Gandhi award, CII-Exim award, Jamna Lal Bajaj award, golden peacock award.

Text Books:

1. N. V. R. Naidu, G. Rajendra, Total Quality Management, New Age international,1st edition, 2006.
2. R. S. Naagarazan, Total Quality Management, New Age international, 3rd edition, 2015.
3. B. L. Hanson and P. M. Ghare, Quality Control and Application, Prentice Hall of India, 2004.

Reference Books:

1. V. S. Bagad, Total Quality Management, Technical Publications, 1st edition, 2008.
2. S. Rajaram, Total Quality Management, Dreamtech Press, 1st edition, 2008.

Subject: Welding and Allied Processes (Code: MET046)	**Year and Semester: Y Year and S Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Manufacturing Processes-I

Course Outcomes: At the end of the course, the student should be able to:

CO1	Identify the use of welding processes in manufacturing industries.	BTL2
CO2	Apply knowledge to select appropriate welding process based on the application.	BTL3
CO3	Explain welding of plastics and underwater welding.	BTL2
CO4	Analyze the process of thermal spraying and thermal cutting.	BTL4

Detailed Syllabus:

UNIT I **CH - 08**

Welding principle, application of welding in industries, weldability of materials, arc welding consumables, shielding gases and association mixtures. weld bead geometry and shape factors. weld dilution, weld joint configurations, liquation cracking, hot cracking, automation in welding.

UNIT II **CH - 12**

Fusion welding processes: classification of fusion welding processes, submerged arc welding, electroslag welding, plasma arc welding, etc.

Solid state welding: introduction, advantages of solid state welding over fusion welding processes, explosive welding, ultrasonic welding, friction welding, friction stir welding, welding zones in friction stir welding.

UNIT III **CH - 12**

Welding of plastic: introduction, classification of plastic welding, hot plate welding, hot gas welding, ultrasonic welding, friction welding, applications of plastic welding.

Underwater welding: need and application of underwater welding, dry underwater welding, wet underwater welding, advantages and limitations of dry and wet underwater welding.

UNIT IV **CH - 10**

Thermal spraying: introduction, thermal spray processes, application of thermal spraying.

Thermal cutting of metals: introduction, methods, and applications, oxy-fuel gas cutting, cutting torch, oxygen-lance cutting, plasma arc cutting.

Text Books:

1. A. Ghosh and A.K. Malik, Manufacturing Science, Affiliated East Press, New-Delhi.
2. John A. Schey, Introduction to Manufacturing Processes, McGraw Hill, New-York.

Reference Books:

1. Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi.
2. Lindberg, R.A., Processes and Materials of Manufacturing, Allyn and Bacon, Boston.
3. Khan N. Z, Siddiquee A. N. and Khan Z. A., Friction stir welding of dissimilar Aluminium alloys, CRC Press, Boca Raton, 2017.

Detailed Curriculum for Open Elective Courses

Subject: Introduction to Mechatronics (Code: MET901)	**Year and Semester: 3rd Year and 5th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the basic electrical, semiconductor, and digital logic concepts relevant to mechatronic systems.
CO2	Explain the working of sensors and actuators and their role in measurement and control.
CO3	Develop Microcontroller-based applications involving signal conditioning and hardware interfacing.
CO4	Implement basic feedback control and integrate components into simple mechatronic systems.

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to Mechatronics: definition, interdisciplinary nature, basic elements (sensors, actuators, controllers, mechanical components), common applications; Basic circuit elements: resistors, capacitors, inductors; Semiconductor electronics: diodes (Zener and optoelectronic), transistors (BJT and MOSFET), voltage regulators; Digital logic fundamentals: combinational logic (basic gates, adders, multiplexers), sequential logic (flip-flops, latches, counters, shift registers), brief overview of logic families (TTL, CMOS).

UNIT II **CH - 10**

Sensors: position and speed measurement, vibration and acceleration measurement, stress and strain measurement, force and pressure measurement, semiconductor sensors and microelectromechanical devices; Actuators: overview of actuator types - electrical, hydraulic, pneumatic (their principles and characteristics); Electrical actuators: DC Motors (brushed, brushless, PWM control), stepper motors, servo motors, motor drivers (H-bridge), relays, and solenoids.

UNIT III **CH – 12**

Signal conditioning: analog vs. digital signals, amplification, basic filtering (RC filters), ADC/DAC concepts; Analog signal processing: operational amplifiers (Op-Amps) and their basic configurations for signal conditioning; Arduino architecture and programming: digital and analog I/O, PWM, serial communication; Polling vs. interrupts, use of timers, libraries, and serial monitors; Direct register manipulation and bit masking; Interfacing sensors and actuators with Arduino.

UNIT IV **CH - 09**

Control fundamentals: open-loop vs. closed-loop control, block diagrams, time and frequency response; Basic control actions: proportional, integral, derivative, and their combinations; Arduino-based implementation of feedback control: speed and position control of DC motors, sensor-based control of LEDs; Emphasis on real-world mechatronic system integration through hands-on projects and case studies.

Text Book:

1. David G. Alciatore, Introduction to Mechatronics and Measurement Systems, 5th Edition, McGraw Hill, 2019

Reference Books:

1. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 7th Edition, Pearson, 2023
2. G. Onwubolu, Mechatronics - Principles and Applications, 1st Edition, Elsevier (Butterworth-Heinemann), 2005.

Subject: Introduction to Electric Vehicle(Code: MET902)	**Year and Semester: 3rd Year and 5th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Articulate the configuration of Electrical Vehicles (EV's).
CO2	Recognize the EV control systems and vehicle dynamics.
CO3	Demonstrate of EV battery chargers, electric vehicle supply equipment, and battery thermal management system.
CO4	Evaluate the feasibility and challenges of EV into existing automobile industry.

Detailed Syllabus:

UNIT I **CH - 09**

History and benefits of Electric Vehicles (EVs), fundamentals of EVs, social, environmental, and economic impacts of electric and hybrid vehicles, tractive effort, vehicular dynamics, drive cycle and vehicle control unit, impact of modern drive-trains on energy supplies.

UNIT II **CH - 11**

Power train configurations and components, traction motor characteristics, tractive effort, drive cycles, rear-wheel drive powertrains, front-wheel drive (FWD) powertrains, vehicle control unit, vehicle modelling methodology, range modelling of battery electric vehicle, auxiliary system in electric vehicle, powertrain component sizing, auxiliary control functions (anti-roll, start stop etc.)

UNIT III **CH - 10**

Importance of control system in electrical vehicle, study of control architecture in electric vehicle, systems models and their classifications, principles used in modelling of systems, fundamental studies of modelling of vehicle dynamics and control, integrated vehicle dynamics.

UNIT IV **CH - 12**

Introduction to energy storage requirements in electric vehicles, battery-based energy storage and its analysis, battery charging modes, types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges, battery performance characteristics, rechargeable battery vehicles, battery thermal management system (BTMS), types of BTMS, comparison between different BTMS, opportunity and advancement.

Text Books:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
2. M. Ehsani, Y. Gao, S. Gay and Ali Emadi Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design CRC Press 2005.

3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Reference Books:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals CRC Press 2003.
2. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives Chris Mi, M. Abul Masrur, David Wenzhong Gao Wiley Publication 2011.
3. Iqbal Husain, Electric and Hybrid Vehicles – Design Fundamentals, 2nd edition, CRC Press, 2011.

Subject: Basic Robot Mechanics (Code: MET903)	**Year and Semester: 3rd Year and 6th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand robotic structure and kinematics using coordinate transformations and DH representation.
CO2	Analyze manipulator velocities using Jacobians and identify singularities.
CO3	Model simple robotic systems dynamically using the Lagrangian method.
CO4	Apply basic trajectory planning in joint and Cartesian spaces.

Detailed Syllabus:

UNIT I **CH – 15**

Introduction to robotics: definition, applications, and classification of robots; robot anatomy—links, joints, degrees of freedom, end-effectors; coordinate frames and transformation matrices; rotation matrices, Euler angles, and homogeneous transformations; Denavit–Hartenberg representation; forward and inverse kinematics of typical planar manipulators; workspace analysis and singularities.

UNIT II **CH – 13**

Differential motion of manipulators; velocity relationships and Jacobian matrix—geometric and analytical formulations; Jacobian for standard manipulator structures; interpretation of Jacobian in joint and operational space; kinematic singularities and their implications; Jacobian transpose; basic understanding of dexterity and manipulability.

UNIT III **CH – 14**

Dynamic modeling of manipulators; physical interpretation of mass, inertia, and acceleration in robotic arms; Lagrangian formulation for simple manipulators; notable properties of dynamic models; conceptual overview of forward and inverse dynamics; Basic trajectory planning in joint and Cartesian space.

Text Book:

1. S. B. Niku, Introduction to Robotics: Analysis, Control, Applications, 3rd Edition, John Wiley, 2024.

Reference Books:

1. J. J. Craig, Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson, 2004
2. K. M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning, And Control, Cambridge English, 2017

Subject: Sustainable Engineering (Code: MET904)	**Year and Semester: 3rd Year and 6th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain sustainable development and different environmental agreements and protocols
CO2	Discuss real time activities causing environmental issues and different methods to use renewable energy resources
CO3	Differentiate between carbon emissions for regular and sustainable cities and explain different practices to move industries towards sustainability
CO4	Discuss different renewable energy resources and explain methods to implement green technology

Detailed Syllabus:

UNIT I **CH – 08**

Foundations of Sustainable Engineering: Sustainable development, conceptual frameworks: triple bottom line model, egg of sustainability model, Atkisson's pyramid model, prism model, tenets of sustainable development and engineering, sustainability risks.

Environmental Ethics and Governance: Environmental ethics and education, international environmental agreements and protocols, implementation of India's environmental statutes – The Water Act, The Air Act, The Environment Act.

UNIT II **CH – 09**

Community-Scale Environmental Problems: Solid waste management, consequences of solid waste for natural assets, zero waste philosophy and reduce-reuse-recycle principle, energy recovery from waste: thermo-chemical conversion, biochemical conversion.

Planetary Environmental Challenges: Resource deterioration: degradation of aquatic resources, soil deterioration, atmospheric pollution, climatic change and global heating, stratospheric ozone depletion, carbon footprint, emissions trading.

UNIT III **CH – 05**

Sustainability Implementation Tools: Environmental Management System (EMS), ISO14000 framework, Life Cycle Assessment (LCA): core elements, benefits, limitations, case example. Environmental Impact Assessment (EIA), environmental auditing, biomimicry, case analyses.

UNIT IV **CH – 10**

Eco-Conscious Habitats: Green building principles, eco-friendly construction materials, building sustainability certification and ratings: Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED) rating, energy-conserving structures, sustainable urban areas, eco-friendly transit, sustainable pavement systems, sustainability engineering exemplars: Green building, sustainable metropolis, sustainable transit network.

Sustainable Industrial and Urban Development: Eco-sensitive urbanization, sustainable industrial practices, sustainable material choice, pollution abatement, industrial ecosystems, industrial mutualism, alleviating impoverishment.

UNIT V **CH – 10**

Alternative Energy Sources: Traditional and alternative energy forms, solar power, fuel cells, wind power, micro-hydropower installations, biogas systems, biofuels, marine energy, geothermal power, energy preservation.

Eco-Technology and Sustainable Enterprise: Environmentally responsible business, eco-technology, clean energy, sustainable construction, low-impact transportation, environmentally benign chemistry, energy-efficient computing.

Text Book:

1. R. L. Rag and Lekshmi Dinachandran Remesh. Introduction to Sustainable Engineering. 2nd Edition, PHI Learning Pvt. Ltd., 2016.

Reference Books:

1. D. T. Allen and D. R. Shonnard. Sustainability Engineering: Concepts, Design and Case Studies, 1st Edition, Prentice Hall, 2011.
2. A.S. Bradley, A. O. Adebayo, P.Maria. Engineering applications in sustainable design and development, 1st Edition, Cengage learning, 2016.