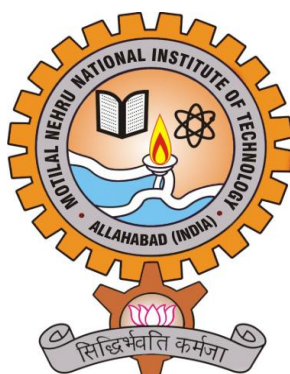


**MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY
ALLAHABAD**



**B. Tech. in
MECHANICAL ENGINEERING
SCHEME OF INSTRUCTION AND SYLLABI
For B. Tech. Program
(Effective from 2026-2027)**

DEPARTMENT OF MECHANICAL ENGINEERING

Vision and Mission of the Institute

Motilal Nehru National Institute of Technology Allahabad

VISION

To attain a distinct identity for the Institute through innovation, knowledge creation and dissemination for the benefit of the society.

MISSION

- To nurture an eco-system for continuous enhancement of value-based teaching and learning process in the emerging areas of technology.
- To train quality human and knowledge resources in the service of society.
- To develop sustainable products and technologies.

Vision and Mission of the Department

VISION

To be a centre of excellence in Mechanical Engineering education and research for the benefit of society and humanity.

MISSION

- To educate and develop competent human resources for contemporary industry, academia and research.
- To promote interdisciplinary research and innovation skills in the graduates.
- To enhance the efforts to develop sustainable products, processes and technologies by developing competent engineers for the benefit of the society.

The Department of Mechanical Engineering is one of the oldest departments of the institute and was established in the year 1961. We are the largest community of energetic, and dynamic faculty, staff and students in the institute. The department is having 44 highly qualified and experienced faculty members. The department is broadly divided into three academic streams in which students receive education with a wide choice of specializations, electives and research areas. These three academic streams are: Design Engineering, Production and Industrial Engineering and Thermal Engineering.

The department offers eight semester (i.e. 4 year) Bachelor of Technology (B. Tech.) programme in Mechanical Engineering. Every year 220 students are admitted through JEE (mains) and 15% of this intake is through Direct Admission to Students Abroad (DASA) scheme. Some students are also through ICCR and MEA (Govt. of India) Schemes.

The department has temporarily discontinued Computer Aided Design and Manufacturing, Product Design and Development specializations in M.Tech. Additionally, *the department has planned to start new M.Tech program, namely Robotics and Automation, Advanced Automotive Engineering, and Industrial Management and Engineering, in the 2027-2028 academic session, for which BOG approval is pending. Design Engineering, Thermal Engineering and Production Engineering are continuing as the specialization for the M.Tech in the department. Every year 125 students are admitted through GATE in the above M. Tech. programmes.

The department also offers Doctor of Philosophy (Ph.D.) programme in various areas of Mechanical Engineering as well as Production and Industrial Engineering. The strength of the department lies in its Ph.D. programme with more than 100 PhDs already been awarded till March, 2026. About 80 research scholars are presently pursuing their PhDs. Every year the department admits Ph.D. students equal to half of the number of faculty holding Ph.D. degree. The department is also a QIP centre for PhD and M. Tech programmes.

Today, the world of Mechanical Engineering is being transformed under the influence of advanced computational tools, improved simulation and analysis, and entirely different manufacturing protocols. This has opened up new avenues for research in the department.

List of Programmes offered by the Department:

Program	Title of the Program
B. Tech.	Mechanical Engineering
M. Tech.	Design Engineering
	Thermal Engineering
	Production Engineering
	*Robotics and Automation
	*Advanced Automotive Engineering
	*Industrial Management and Engineering
Ph.D.	Mechanical Engineering

B. Tech. – Mechanical Engineering**Program Educational Objective**

PEO-1	To transform our students into employable technologists through education and training to contribute in the frontiers of Mechanical Engineering.
PEO-2	To groom the graduates for achieving team work capability and leadership qualities.
PEO-3	To impart multidisciplinary competence in the graduates for exploring ventures in Government, Public, Private, R and D and entrepreneurial sectors.
PEO-4	To imbibe ethical and human values in the graduates for the benefit of the society.

Program Articulation Matrix

PEO Mission Statement	PEO1	PEO2	PEO3	PEO4
To educate and develop competent human resources for contemporary industry, academia and research.	3	3	2	3
To promote interdisciplinary research and innovation skills in the graduates.	2	3	2	2
To enhance the efforts to develop sustainable products, processes and technologies by developing competent engineers for the benefit of the society.	2	2	3	2

1-Slight; 2-Moderate; 3-Substantial

**B. Tech. – Mechanical Engineering
Program Outcomes**

PO-01	Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Mechanical Engineering specialization to the solution of complex Engineering problems related to Mechanical Engineering.
PO-02	Problem Analysis: Identify, formulate, research literature and analyze complex Mechanical Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO-03	Design/ Development of Solutions: Design solutions for complex Mechanical Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
PO-04	Conduct investigations: Conduct investigations of complex Mechanical Engineering problems using research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.
PO-05	Modern Tool Usage: To apply appropriate techniques, resources and engineering and IT tools for modeling of different Mechanical Engineering problems with an understanding of the limitations.
PO-06	The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO-07	Environment and Sustainability: Understand the impact of professional Engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
PO-08	Ethics: Apply ethical principles and commit to professional ethics responsibilities and norms of Engineering practice.
PO-09	Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams as well as in multi disciplinary settings.
PO-10	Communication: Communicate effectively on complex Mechanical Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
PO-11	Project Management and Finance: Demonstrate knowledge and understanding of Mechanical Engineering and management principles and apply these to one's own work, as a member and leader of a team, to manage projects and in multidisciplinary environments.
PO-12	Life-long Learning: Recognize the need for the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO-01	Graduates will be able to apply fundamental knowledge of sciences and engineering to identify, comprehend, formulate, design and analyse real life problems in Mechanical Engineering and allied multidisciplinary fields.
PSO-02	Graduates will be able to apply the acquired computational, experimental and soft skills to solve Mechanical Engineering problems, interact and work coherently in a team environment, develop life-long learning, scientific skills and distinctive managerial traits.

SCHEME OF INSTRUCTION

B. Tech. Mechanical Engineering (PROPOSED) – Course Curriculum Structure

S. No.	Code	Course	Credit	L-T-P	Contact Hours
Semester-I					
1	CY11XXX	Engineering Chemistry	3	2-0-2	4
2	MA11XXX	Mathematics-I	4	3-1-0	4
3	HS11XXX	Professional Communication	3	2-0-2	4
4	ME11XXX	Engineering Materials	4	3-0-2	5
5	ME11XXX	Design Thinking and Product Visualization	3	2-0-2	4
6	ME11XXX	Engineering Graphics	2	1-0-2	3
7	ID11XXX	Environment and Climate Change	2	2-0-0	2
8	EA11XX- EA11XX	Extra Academic Activity-A*	2	0-0-4	4
		Total	23		30
Semester-II					
1	PH12XXX	Engineering Physics	4	2-1-2	5
2	MA12XXX	Mathematics-II	4	3-1-0	4
3	CS12XXX	Introduction to Artificial Intelligence and Machine Learning	3	2-0-2	4
4	CEE12XXX	Basic Electrical and Electronics Engineering	3	2-0-2	4
5	AM12XXX	Engineering Mechanics	3	2-0-2	4
6	ME12XXX	Workshop and Product Realization	2	1-0-2	3
7	ME12XXX	Engineering Thermodynamics	3	3-0-0	3
8	EA12XXX	Professional Ethics and Social Values	2	0-0-4	4
		Total	24		31
Semester-III					
1	ME13XXX	Computer based Mathematical Techniques	4	3-0-2	5
2	AM13XXX	Fluid Mechanics and Hydraulic Machines	4	3-0-2	5
3	ME13XXX	Heat and Mass Transfer	4	3-0-2	5
4	HS13XXX	Management Concepts and Applications	3	3-0-0	3
5	ME13XXX	Computer Aided Design	4	3-0-2	5
6	AM13XXX	Mechanics of Materials	4	3-1-0	4
7	EAA-B	Extra Academic Activity-B	2	0-0-4	4
		Total	25		31
Semester-IV					
1	ME14XXX	Energy Conversion Technologies	4	3-0-2	5
2	ME14XXX	Instrumentation and Process Control	4	3-0-2	5
3	ME14XXX	Manufacturing Science and Technology-I	4	3-0-2	5
4	ME14XXX	Design of Machine Elements - I	4	3-1-0	4
5	AM14XXX	Mechanism of Machines	3	3-0-0	3

Department of Mechanical Engineering

6	ME14XXX	Industrial Engineering and Production Management	3	3-0-0	3
7	ME14XXX- ME14XXX	Core Elective Course - 1	3	3-0-0	3
8	EAA-C	Extra Academic Activity-C	2	0-0-4	4
9	MN	Minor Course [@]	4 [@]	3-1-0	4 [@]
		Total	27[@]		32[@]
Semester-V					
1	ME15XXX	Design of Machine Elements-II	4	3-0-2	5
2	ME15XXX	Manufacturing Science and Technology - II	4	3-0-2	5
3	ME15XXX	Robotics	4	3-0-2	5
4	ME15XXX	Refrigeration and Air-Conditioning	4	3-0-2	5
5	ME15XXX	Project	2	0-0-4	4
6	ME15XXX- ME15XXX	Core Elective Course-2	3	3-0-0	3
7	ME15XXX- ME15XXX	Core Elective Course - 3	3	3-0-0	3
8	MN	Minor Course [@]	4 [@]	3-1-0	4 [@]
9	HN	Honours Course [#]	4 [#]	4-0-0	4 [#]
10	RS	Research Course ^{\$}	4 ^{\$}	4-0-0	4 ^{\$}
		Total	24^{@#\$}		30^{@#\$}
Semester-VI					
1	ME16XXX	Finite Element Analysis	4	3-0-2	5
2	ME16XXX	Automobile Engineering	3	3-0-0	3
3	HS16XXX	Soft Skill and Personality Development	3	3-0-0	3
4	ME16XXX	Metrology and Quality Engineering	3	3-0-0	3
5	ME16XXX	Mechatronics	4	3-0-2	5
6	ME16XXX- ME16XXX	Core Elective Course - 4	3	3-0-0	3
7	ME16XXX- ME16XXX	Core Elective Course - 5	3	3-0-0	3
8	ME16XXX	Project and Project based Colloquium	2	0-0-4	4
9	MN	Minor Course [@]	4 [@]	3-1-0	4 [@]
10	HN	Honours Course [#]	4 [#]	4-0-0	4 [#]
11	RS	Research Course ^{\$}	4 ^{\$}	4-0-0	4 ^{\$}
		Total	25^{@#\$}		29^{@#\$}
Semester-VII					
1	ME17XXX	AI in Mechanical Engineering	4	3-0-2	5
2	ME17XXX	Machine Tools and CAM	4	3-0-2	5
3	ME17XX- ME17XX	Core Elective - 6	3	3-0-0	3
4	ME17XX-	Open Elective Course	3	3-0-0	3

	ME17XX				
5	HS17XXX	Project Management Business Economics	3	3-0-0	3
6	ME17XXX/ ME17XX	Vocational Training*/STTP*	2	0-0-4	4
7	ME17XXX	Major Project	2	0-0-4	4
8	MN	Minor Course [@]	4 [@]	3-1-0	4 [@]
9	HN	Honours Course [#]	4 [#]	4-0-0	4 [#]
10	RS	Research Project ^{\$}	4 ^{\$}	4-0-0	4 ^{\$}
		Total	21^{@#\$}		27^{@#\$}

Semester-VIII					
1	ME18XXX/ ME18XXX	Major Project/Internship	8	0-0-16	16
		Total	08		16

1*: A student can opt for Vocational training / STTP (short-term training program) of minimum three weeks during the summer vacation after IV and/or VI semester and its two credits will be considered in the VII semester after the submission of successful completion certificate from the Industry, report and successful presentation.

@: A student can opt for one or two Minor courses in IV, V, VI and VII semesters as per the Minor courses offered by the other departments. Total credits in these semesters will be based on the credits of the Minor course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Minor in ()

#: 1. A student can opt for one or more Honours courses in V, VI and VII semesters as per the Honours courses offered by the department. Total credits in these semesters will be based on the credits of the Honours course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Honours

2. A student, opting for Honours registration, is required to complete a total of 16 credits of the Honours courses offered by the department of Mechanical Engineering. Honours courses will be from any of the M.Tech. programme of Department of Mechanical Engineering.

\$: 1. A student can opt for one or more research courses in V, VI and VII semesters as per the Research courses offered by the department. Total credits in these semesters will be based on the credits of the Research course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Research. In VII semester the research course will be a research project which may continue in VIII semester as Major Project.

2. A student, opting for Research registration, is required to complete a total of 16 credits of the Research courses offered by the department. Research courses will be from any one of the M.Tech. programme of Department of Mechanical Engineering.

List of Electives and Minors: B. Tech. (Mechanical Engineering)

IV Semester: Core Elective Courses - 1

S. No.	Code	Name
1.	ME14XXX	Design and Analysis of Experiments
2.	ME14XXX	Modelling and Simulation in Engineering
3.	ME14XXX	Noise and Vibration
4.	ME14XXX	Operations Research
5.	ME14XXX	Solar Energy Systems
6.	ME14XXX	Compressible Flow
7.	ME14XXX	Industrial Safety and Reliability Engineering

V Semester: Core Elective Courses – 2 and 3

S. No	Code	Course Name
Core Elective Courses – 2		
1.	ME15XXX	Energy Management
2.	ME15XXX	Optimization Methods in Engineering
3.	ME15XXX	Hybrid Electric and Fuel Cell Vehicles
4.	ME15XXX	Product Lifecycle Management
5.	ME15XXX	Supply Chain Management
6.	ME15XXX	Production and Operations Management
7.	ME15XXX	Tool Engineering
8.	ME15XXX	Experimental Stress Analysis
Core Elective Courses – 3		
9.	ME15XXX	Alternative Fuels Technology
10.	ME15XXX	Carbon Capture and Hydrogen Technology
11.	ME15XXX	Industry 4.0 and IOT
12.	ME15XXX	Condition Monitoring and Diagnostics
13.	ME15XXX	Ergonomics
14.	ME15XXX	Design for Manufacturing and Assembly
15.	ME15XXX	Industrial Tribology

VI Semester: Core Elective Courses – 4 and 5

S. No	Code	Course Name
Core Elective Courses – 4		
1.	ME16XXX	Turbulence Modelling
2.	ME16XXX	Sustainable Materials and Green Buildings
3.	ME16XXX	Alternative Refrigerant Technologies
4.	ME16XXX	Solar Architecture
5.	ME16XXX	Conventional Micromachining
6.	ME16XXX	Additive Manufacturing
7.	ME16XXX	Micro-electro-mechanical systems (MEMS)

8.	ME16XXX	Mechanical System Design
9.	ME16XXX	Advance Mechanics of solids
10.	ME16XXX	Supply Chain Management
Core Elective Courses – 5		
11.	ME16XXX	Gas Turbine and Jet Propulsion
12.	ME16XXX	Non-conventional Energy Resources
13.	ME16XXX	Unconventional Micro-Nano Machining
14.	ME16XXX	Laser Processing of Materials
15.	ME16XXX	Automotive Safety
16.	ME16XXX	Control Engineering
17.	ME16XXX	Surface Treatments and Characterization
18.	ME16XXX	Composite Materials
19.	ME16XXX	Computational Fluid Dynamics

VII Semester: Core Elective Courses – 6

S. No	Code	Course Name
1.	ME17XXX	Cryogenics
2.	ME17XXX	Two Phase Flow and Heat Transfer
3.	ME17XXX	Energy Economics
4.	ME17XXX	Computer Integrated Manufacturing
5.	ME17XXX	Industrial Automation
6.	ME17XXX	Surface and Interface Engineering
7.	ME17XXX	Advanced Machining Processes
8.	ME17XXX	High Temperature Materials
9.	ME17XXX	Design against Fatigue and Fracture
10.	ME17XXX	Smart materials
11.	ME17XXX	Vehicles Dynamics
12.	ME17XXX	Electric Vehicles
13.	ME17XXX	Mechatronics system design
14.	ME17XXX	Nuclear Engineering and Technology
15.	ME17XXX	Total Quality Management

VII Semester: Open Elective Course

S. No	Code	Name
1.	ME17XXX	Energy Management
2.	ME17XXX	Non-Conventional Energy Sources
3.	ME17XXX	Advance Automotive Technology
4.	ME17XXX	Quality Engineering
5.	ME17XXX	Total Quality Management
6.	ME17XXX	Product Design and Development
7.	ME17XXX	Electrical Vehicles Technology

Semester-I

Course Code: CY11XXX	Engineering Chemistry	Credits: 2-0-2:3
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Prerequisites: Knowledge of basic Chemistry

Course Outcome

S.N.	Outcomes
CO1	Achieve the understanding of different fundamental chemical concepts of the chemical kinetics, fuel, lubricant and polymer.
CO2	Ability to interpret experimental data related to rate of reactions, fuel, lubricants and electrochemical cells.
CO3	Develop the capability to apply the knowledge for the industrial applications.

Course Articulation Matrix:

Unit	Content	No. Hrs
1.	Chemical Kinetics: Rate of a chemical reaction, factors affecting the rate of reactions: concentration, temperature, pressure and catalyst; elementary and complex reactions, order and molecularity of reactions, rate law, rate constant and its units.	04
2.	Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF, Case study for electrorefining process.	03
3.	Fuels: Classification, calorific values, analysis of solid fuels, liquid fuels and its properties, refining, cracking and reforming of petroleum, knocking and octane and cetane rating, anti-knocking agents, biofuels.	03
4.	Corrosion: Theories of corrosion, type of corrosion, its prevention and control, Case study on corrosion control in industry.	04
5.	Lubricants: Definition, functions, mechanisms and classifications of lubricants, properties and testing of lubricants.	03
6.	Polymers, plastics, rubber and Adhesives: Polymers, composites, thermoplastic and thermosetting plastics, rubber, biodegradable polymers, adhesives.	03

Practical: List of Experiments

1. Determination of flash point of oils by Abel's apparatus.
2. Determination of flash point of lubricating oil by Pensky Martin's 'closed' tester.
3. To study the viscosity of the given sample of lubricating oil with a Redwood viscometer and to study the viscosity at various temperatures.
4. To find out the aniline point of the given sample of fuel.
5. Determination of Steam Emulsification Number (SEN) of a given lubricating oil.
6. To carry out the % of moisture content only of a given sample of coal as a part of proximate analysis.
7. Determination of viscosity average molecular weight of a polymer sample by Viscometer.
8. Kinetic study of hydrolysis of ethyl acetate by volumetric titration method.

9. Preparation of biodiesel & it's flash point determination.

Text Books:

1. Engineering Chemistry, Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
2. Engineering Chemistry, Shashi Chawla, Dhanpat Rai Publishing Co., New Delhi.

Reference Books:

1. Engineering Chemistry- A Textbook, Harish Kumar Chopra, Anupama Parmar, Narora, New Delhi.
2. Elements of Physical Chemistry, Peter Atkins, Julio D. Paula, Oxford, UK.
3. Polymer Science, V R Gowariker, N V Viswanathan, Jayadev Sreedhar, New Age International Private Limited, New Delhi.
4. Inorganic Chemistry: Principles of Structure and Reactivity, By James E. Huheey, Ellen A. Keither, Richard L. Keiter, Okhil K. Medhi Pearson.
5. Manufacturing Science, Amitabha Ghosh, Ashok Kumar Mallik, Affiliated East- West Press Pvt. Ltd, New Delhi.
6. Advanced Polymer Chemistry – A Problem Solving Guide, Manas Chandra, Marcel Dekker Inc, New Work.
7. Online resources.

Course Code: ME11XXX	Engineering Materials	Credits: 3-0-2:4
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Prerequisites: Basic knowledge of Physics

Course Outcome

S.N.	Outcomes
CO1	Students will be able to understand the metal structure, crystallization, Deformation mechanisms, and failure mechanisms.
CO2	Students will be able to understand and select the appropriate heat treatment method to improve one or more properties of materials.
CO3	Students will be able to select the materials for various engineering parts/components.
CO4	Students will be able to evaluate and test materials.

Course Articulation Matrix:

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

Unit	Content	No. Hrs
1.	Introduction and classification of materials; Metal Structure and Crystallization- Atomic bonding, crystal structure and grain morphology.	05
2.	Defects in metals. Plastic deformation mechanisms of metals: dislocation slip, deformation twinning, martensitic transformation. Strengthening mechanism of metals. Failure mechanisms: fracture, fatigue and creep.	05
3.	Constitution of Alloys and Phase Diagrams- Iron-Iron Carbide Equilibrium Diagram, Various Heat treatments and Surface treatments of Steel to improve one or more properties of steels, TTT and CCT diagrams	10
4.	Alloy steels: Purpose of alloying, Effects of alloying elements upon Ferrite and Carbide, Influence of alloying elements on the Iron- Iron carbon Diagram, in Tempering; Ni, Cr, Ni-Cr, Mn, Mo, W, V, Si, Stainless, Martensitic Stainless, Ferritic Stainless, Austenitic Stainless Steels; Tool Steels; Cast Iron; Nonferrous Metals and Alloys; ceramics; polymers; and composites. Composite fabrication: metal matrix, polymer matrix and ceramic matrix composites. Introduction to advanced materials: shape memory alloys, piezoelectric materials, biomaterials, superalloys, high entropy alloys, nanomaterials, Powder metallurgy, Coating techniques.	10
5.	Mechanical characterization: tensile test, hardness test, impact test, fracture/fatigue/creep test; X-ray diffraction (XRD) technique:	05
6.	<u>List of Practical</u> Specimen preparation, polishing, etching; microstructure and grain size studies; studies of UTM, Hardness and Impact test machines; Tensile/compression, hardness, impact tests, etc.	16

Text Books:

- | | | |
|---|---|--------------------------------------|
| 1. Introduction to Physical Metallurgy | Sidney Avner | McGraw Hill Education |
| 2. Materials Science and Engineering: An Introduction | William D. Callister Jr.,
David G. Rethwisch | Wiley |
| 3. Materials Science and Engineering: A First Course | Raghavan V | Prentice Hall India Learning Private |
| 4. Thermal Analysis of Materials | Speyer, R.F. | Marcel Decker |
| 5. Mechanical Metallurgy | G. Dieter | McGraw Hill Education |

References:

- | | | |
|---|---------------|-------------------|
| 1 Surface Engineering | ASM Hand Book | ASM International |
| 2 Surface Engineering for corrosion and wear resistance | J. R. Davis | ASM International |
| 3 Materials characterization | ASM Hand Book | ASM International |

Course Code: ME11XXX	Design Thinking and Product Visualization	Credits: 2-0-2:3
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Pre-requisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand innovation processes, design thinking principles, and product development methodologies.
CO2	Students will be able to identify customer needs, generate, compare and select engineering concepts using systematic design approaches.
CO3	Students will be able to develop product architecture and intellectual property concepts.
CO4	Students will be able to apply visualization, material selection, and prototyping techniques for the development of engineering products.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction - Design and innovation, Who designs and develops products, Practical and Industrial examples.	4
2.	Generic Product Development Process, Concept Development	4
3.	Case Studies: Identifying Customer Needs, Concept Generation,	6
4.	Product Architecture, Industrial Design, Intellectual Property Rights	4
5.	Materials in Product Design, Materials selection, Material Processing methods, Prototyping	6

Laboratory Exercises		
Exp no	Name of Experiment	No of Hrs

1.	3D Digital Prototyping using CAD Software	6
2.	Microcontroller Basics and Circuit Design	2
3.	Mini-project	16

Text Books:

1. Product Design and Development, **Ulrich K. T, Steven D Eppinger S. D.**, McGraw Hill
2. Engineering Design, **George E. Dieter**, McGraw Hill

References:

1. Gerard Volland, Engineering by Design, Pearson,
2. Human Factors in Engineering Design- Mark S. Sanders & Ernst J. Mc Cornick, McGraw-Hill Publishers.
3. https://ocw.mit.edu/courses/esd-051j-engineering-innovation-and-designfall2012/video_galleries/lecture-notes-and-videos/

Course Code: ME11XX	Engineering Graphics	Credits: 1-0-2:2
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Pre-requisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	Understand the importance of engineering drawing in real life.
CO2	Understand orthographic projection and apply it by hand practice and using computer aided drafting software.
CO3	Apply the knowledge of orthographic projection in assembly drawing.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to engineering drawing and its importance in real life design and manufacturing. Drawing instruments and their use, types of lines, lettering, dimensioning, scales etc. Scales/Representative Fraction (R.F.).	2L+2P
2.	Introduction to projection. Orthographic projection of points, projection of lines, projection of planes, orthographic projection of 3-dimensional objects.	4L+8P
3.	Introduction to computer aided drafting software and hands on practice of orthographic projection of 3-dimensional objects. Sectional views of solid objects and hands on practice of sectional views of solid objects using computer aided drafting software.	3L+6P
4.	Isometric Drawing and Orthographic Projection: Isometric scale, isometric drawing of lines, plane figures, simple and compound solids; conventions of isometric drawing; conversion between isometric drawings and orthographic views; visualization and interpretation of engineering objects. Assembly drawing of nut-bolt, cotter/knuckle joint etc. using computer aided drafting software.	3L+2P

Text Books:

3. Engineering Drawing: With an Introduction to AutoCAD, Jolhe D. A., Tata McGraw Hill Education, 2019.

References:

1. Engineering Drawing, Basant Agrawal, C. M. Agrawal, Tata McGraw Hill Education, 2019 .
2. Elementary Engineering Drawing, Bhatt N.D., Charotar Publishing House Pvt. Ltd, 2012.
3. Machine Drawing, Bhatt, N. D. and Panchal V. M., Charotar Publishing House Pvt. Ltd 2011.
4. Machine Drawing includes AutoCAD, Ajeet Singh, McGraw Hill Education, 2008.

Semester-II

Course Code: AM12XXX	Engineering Mechanics	Credits: 2-0-2:3
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Prerequisites: Basic knowledge of Physics and Mathematics

Course Outcomes:

CO1	Draw free body diagrams for engineering problems and develop understanding about equilibrium of forces
CO2	Calculate the resultant of a distributed force system and different geometric properties for structural members
CO3	Compute internal forces in beams under various loading
CO4	Apply laws of friction to analyze the effect of friction on various bodies in contact
CO5	Analyse kinematics and kinetic behaviour of rigid bodies in motion

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: Idealizations in Mechanics, Forces, Moments, Free body diagram and Force systems, Equilibrium of forces and moments, Varignon's Theorem, Parallel shifting and Transmissibility of forces.	06
2	Geometric Properties: Center of Gravity, Center of Mass, and Centroid, Moments of inertia -Area and Mass Moment of Inertia, Product of inertia, Principal axes and Principal moments of inertia.	06
3	Beams: Introduction, Shear force and Bending Moment Diagrams.	03
4	Friction: Introduction, Laws of Coulomb friction, Angle of friction, Angle of Repose, Sliding Friction, Rolling Resistance, Rope and Belt Friction, Screw Friction, Wedge Friction.	06
5	Virtual Work, Kinematics and Kinetics: Principle of Virtual work, Potential Energy and Equilibrium, Stability, Kinematics and Kinetics of Rigid Bodies- Types of motions in plane, Rotation of rigid bodies, D'Alemberts Principle, Force, Mass and Acceleration, Work and Energy, Impulse and Momentum.	07

Text Books:

1. Beer F.P. and Johnston E.R., Mechanics for Engineers-Volume I -Statics, Volume-II - Dynamics, McGraw Hill, New York.
2. Merriam J.L and Kraige L.G., Engineering Mechanics, Volume 1-Statics, Volume-II - Dynamics, John Wiley & Sons, New York.
3. Shames L.H., Engineering Mechanics, Prentice Hall, New Delhi.
4. R. C. Hibbler, Engineering Mechanics, Vol I and II, Pearson Press, 2002.

List of experiments:

1. Friction between inclined plane and sliding box
2. Friction between inclined plane and roller
3. Mass moment of inertia of flywheel
4. Equilibrium of parallel forces
5. Belt and pulley friction
6. Screw jack
7. Polygon law of forces

Course Code: ME12XXXX	Workshop and Product Realization	Credits: 1-0-2;2
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Prerequisites: Engineering Materials

Course Outcomes:

CO1	Students will be able to understand the importance of manufacturing which comprises materials, processes and systems.
CO2	Students will be able to understand the metal casting, metal working process and able to perform casting of metals, forging and sheet metal operations through practical classes.
CO3	Students will be able to understand the machining operations, permanent joining processes. They will be able to perform machining operations on Lathe machine and joining through arc and gas welding processes.
CO4	Students will be able to learn and perform operations related to carpentry, fitting, plastic molding, and Computer Numerical Control (CNC) machines.

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

Unit	Details	No. Hrs
1	Concept of Manufacturing- Manufacturing definition; Role of materials, processes and systems in manufacturing; Classification and brief introduction of engineering materials such as metals and alloys, Classification and brief introduction of manufacturing processes	4
2	Sand Casting Process of Metals- Elements of Green Sand Mould; Pattern design and making, Method of Preparation of Green Sand Mould; Casting Defects	2
3	Metalworking Processes- Classification of Metalworking Processes-brief introduction of bulk and sheet metal processes, Hot Vs Cold Working; Hot and Cold Rolling; Types of Rolling Mills, Forging, Extrusion, Drawing	3
4	Machining Processes: Classification of machining processes and machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine	2
5	Fabrication Processes and Basics of 3D printing- Classification of Welding Operations, Types of Joints and Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering. Fundamentals of additive manufacturing; 3D printing processes; materials used in 3D printing; CAD-to-print workflow; advantages, limitations,	3

	and engineering applications.	
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Text Books:

1. M. P. Grover, Fundamental of Modern Manufacturing: Materials, Processes and Systems, John Wiley, (2009).
2. Serope Kalpakjian and Steven R. Schmid, Manufacturing Engineering and Technology, Seventh Edition, Pearson, (2018).
3. Workshop Technology (Vol. I & II) by B. S. Raghuvansi (Manufacturing Processes)
4. Workshop Technology by R. S. Khurmi and J. K. Gupta (Manufacturing Processes)

List of Practical

1. **Safety in Workshop (Demonstration)**
Safety precautions and utilization of hand tools and machines of different shops with safe working habits. Introduction to measuring equipments and gauges of different shops.
2. **Carpentry**
Study of wood works, types of hand tools and machine. Making of one job involving wood work joint
3. **Fitting**
Study of different fits and hand tools. Making of one job involving fitting to size, male- female fitting with drilling and tapping
4. **Welding**
Study of electric arc welding and gas welding, tools, types of weld joints and safety precaution during welding. Making of one joint using electric and gas welding. Students will be introduced to brazing and soldering (demonstration)
5. **Sheet Metal Work**
Study of different hand tools, machine and sheet metal joints. Making of one utility job in sheet metal
6. **Foundry**
Principles of molding, methods, core and core boxes, preparation of sand mould of given pattern and casting (demonstration)
7. **Black Smithy**
Introduction to hot working and Study of forging hand tools, furnace and machine. Making a job on hot upset forging.
8. **Machining**
Study of lathe machine, cutting tools and turning related operations. Making of one job on lathe machine including facing, step and taper turning, threading operations.
9. **Plastic Processing**

Introduction to plastics and different plastic molding techniques. Study of injection molding process with demonstration.

10. Computer Numerical Control (CNC) and 3D printing

Introduction to automation and CNC, Assembly of models of CNC, CNC wood router, engraving and exposure to part programming. Preparation of part program for simple profiles. Making a job on CNC (Demonstration). 3D model visualization, preparation of CAD models for printing, demonstration of 3D printing processes, familiarization with printing materials, and examination of printed parts and their applications.

11. Mini Project

Team activity – Fabrication of prototype model based on above practical.

Course Code: ME12XXX	Engineering Thermodynamics	Credits: 3-0-0:3
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Prerequisites: Basic knowledge of Physics and Chemistry

Course Outcomes:

CO1	To understand the concept of thermodynamic system and its properties, work, power, heat and first law of thermodynamics.
CO2	To understand the concept of thermodynamic temperature scale, refrigerator, heat pump and feasibility of any process based on second law of thermodynamics.
CO3	To apply combined first and second law to evaluate entropy, Irreversibility and exergy.
CO4	To perform thermodynamic analysis of refrigeration, Gas and vapour power cycle.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to thermodynamics: System, surroundings, boundaries, classification of systems. Unit and dimensions, conversion factors. Properties of systems, equilibrium, processes, heat and work interaction. The work interaction. Thermodynamic definition of work, characteristics of the work interaction. Evaluation of work. Adiabatic systems and processes.	6
2	Zeroth law: Diathermic boundary, Zeroth law, Isothermal states. Empirical temperature. Principles of thermometry. Scales of temperature. Gas thermometer. The ideal gas. Ideal gas temperature scale.	4
3	The first law: Basic form energy of a system, The heat interaction, Sign convention. First law for open systems, Steady-flow energy equation and its applications. Properties of gases. Properties of steam. Introduction to steam tables. Other equations of state.	8
4	The second law: Kelvin-Planck and Clausius statements. Equivalence of statements. Carnot theorem. Thermodynamic temperature. Kelvin scale. Carnot engine, refrigerator and heat pump. Definition of entropy. Combined first and second law, Evaluation of entropy. Principle of increase of entropy.	8
5	Availability: Introduction to availability and irreversibility, dead state and maximum useful work. Availability analysis for closed and open systems, exergy balance, second-law efficiency, and applications of exergy analysis in thermal engineering systems.	7
6	Introduction to thermodynamic cycles: Classifications of cycles. Gas power	7

	cycles- Otto, Diesel, Brayton. Vapour power cycle- Rankine cycle, vapour-compression refrigeration cycle.	
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Text Books:

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|---|--------------------------------|-----------------|-------------|
| 1 | Engineering Thermodynamics | P.K. Nag | McGraw Hill |
| 2 | Thermodynamics: An engineering | Cengel & Boles, | McGraw Hill |

References:

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|---|--|--|---------|
| 1 | Fundamentals of Engineering Thermodynamics | Moran M. J. & Shapiro H. N | Wiley |
| 2 | Fundamentals of Thermodynamics | Sonntag R.E., Borgnakke C. & Van Wylen C. J. | Wiley |
| 3 | Engineering Thermodynamics | Rogers G.F.C. & Mayhew Y.R | Longman |

Semester III

Course Code: ME13XXX	Computer based Mathematical Techniques	Credits: 3-0-2:4
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Prerequisites: Mathematics-I and Mathematics-II

Course Outcomes:

CO1	Understand the fundamentals of modeling and simulation of engineering systems.
CO2	Develop mathematical models of mechanical systems.
CO3	Apply numerical methods for solving engineering problems.
CO4	Analyze dynamic behavior of engineering systems through simulation.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to Modeling and Simulation: Concepts of modeling and simulation; Types of models: Physical, Mathematical, Analog and Numerical; Continuous and discrete systems; Steps in model development; Applications in mechanical engineering.	06
2	Mathematical Modeling of Mechanical Systems: System elements and parameters; Modeling of translational mechanical systems; Modeling of rotational mechanical systems; Thermal and fluid system modeling basics; Differential equation representation of engineering systems	07
3	Numerical Methods for Simulation: Sources of numerical errors; Solution of algebraic equations; Euler method; Runge-Kutta method; Numerical solution of ordinary differential equations	06
4	Dynamic System Simulation: System response and behavior; Continuous-time simulation; Linear and nonlinear systems; Introduction to stochastic simulation; Monte Carlo simulation concepts	06
5	Simulation Tools and Applications: Programming fundamentals of MATLAB/SciLab/ Python; Introduction to Simulink; Block diagram modeling and simulation; Result visualization and interpretation	05
6	Engineering Applications and Model Validation: Simulation of vibration systems; Thermal system simulation; Manufacturing system simulation concepts; Verification and validation of models; Case studies in mechanical engineering.	06

Text Books:

- | | | | | |
|---|---|--------------------|---------------------|------|
| 1 | Simulation Modelling and Analysis | Averill M. Law | Mc Graw Hill | 2024 |
| 2 | System Dynamics: Modeling, Analysis, Simulation, Design | Ernest O. Doebelin | Marcel Dekker, Inc. | 1998 |

References:

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|---|---|-----------------------------------|--|------|
| 1 | System Dynamics | Katsuhiko Ogata | Pearson College Div | 2003 |
| 2 | Applied Numerical Methods with MATLAB for Engineers and Scientists | Steven C. Chapra | McGraw-Hill | 2022 |
| 3 | Modelling and Simulation of Dynamic Systems | Robert L. Woods, Kent L. Lawrence | Pearson College Div | 1997 |
| 4 | Introductory Methods for Numerical Analysis | S.S. Sastry | Prentice Hall India Learning Private Limited | 2012 |
| 5 | Simulation of Dynamic Systems with MATLAB and Simulink | Harold Klee, Randal Allen | CRC Press | 2017 |
| 6 | Mathematical Modeling and Simulation: Introduction for Scientists and Engineers | Kai Velten | Wiley-VCH | 2008 |

Modeling and Simulation in Engineering Lab

Unit	Details	No. Hrs
1	Introduction to MATLAB/ Scilab/Python Environment: Basic commands, script files, functions, and plotting of engineering data.	2
2	Modeling of a Spring–Mass–Damper System: Development of mathematical model and simulation of system response.	2
3	Simulation of Free and Forced Vibrations: Analysis of displacement, velocity, and acceleration responses.	2
4	Numerical Solution of Ordinary Differential Equations: Implementation of Euler and Runge–Kutta methods for engineering problems.	2
5	Modeling and Simulation of Rotational Mechanical Systems: Simulation of torsional vibration systems using MATLAB/Simulink.	2
6	Thermal System Modeling: Simulation of heating and cooling processes using first-order thermal models.	2
7	Fluid Tank Level System Simulation: Modeling and simulation of liquid level dynamics in interconnected tanks.	2
8	Simulation of Control Systems: Analysis of first-order and second-order systems; study of step and impulse responses.	2
9	Monte Carlo Simulation for Engineering Applications: Estimation of uncertainty and reliability using random number generation.	2
10	Mini Project: Modeling and Simulation of a Mechanical Engineering System Examples: Vehicle suspension system, robotic arm, manufacturing process, heat exchanger, or conveyor system. Model development, simulation, validation, and report preparation.	2

Course Code: AM13XXX	Fluid Mechanics and Hydraulic Machines	Credits: 3-0-2:4
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Pre-requisites: Basic knowledge of Physics and Engineering Mechanics

Course Outcomes:

S.N.	Outcomes
CO1	To give fundamental knowledge of fluid, its properties, hydrostatic laws and application of mass, momentum and energy equation in fluid flow.
CO2	To develop understanding about Dimensional Analysis, different types of flows and losses in a flow systems.
CO3	To learn the importance of flow measurements and its applications in Industries.
CO4	To develop basic knowledge of hydraulic machines and its applications.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Fluid Mechanics- Statics and Kinematics: Physical properties of fluids, Rheology of fluids, Hydrostatic pressure on plane and curved surfaces, centre of pressure, Kinematics of Fluid flow: Types of fluid flows, Description of motion, continuity equation, stream function and velocity potential, applications of potential flow.	8
2.	Dynamics of Fluid Flow and Dimensional Analysis: Euler's Equation of motion, Bernoulli's equation and its applications, Pitot tube, Orifice, Venturi, nozzle and bend meter. Reynolds transport theorem, Momentum equation (Navier-Stokes equation). Dimensional Analysis and similarity, Buckingham's Pi theorem, Important dimensionless numbers and their physical significance.	8
3.	Laminar and Turbulent Flows: Equation of motion for laminar flow through pipes, Stokes law, isotropic and homogenous turbulence, scale and intensity of turbulence, eddy viscosity, Prandtl's mixing length theory, velocity distribution in turbulent flow over smooth and rough surfaces, minor losses,	7

	pipe in series and parallel.	
4.	Boundary Layer: Displacement, momentum and energy thickness, boundary layer over a flat plate, Prandtl boundary layer equation, laminar and turbulent boundary layer, application of momentum equation, separation and its control, drag and lift, drag on a sphere, 2D cylinder and aerofoil, Magnus effect.	7
5.	Introduction to Hydraulic Machines: Hydraulic Turbines: Introduction to hydroelectric power station and its components, Classification of turbines, Heads and efficiencies, Pelton wheel, Francis and Kaplan turbines, specific speed and unit quantities, Characteristic curves. Pumps: Centrifugal Pumps, specific speed, priming, Characteristic curves, Reciprocating pumps, Comparison between Centrifugal and Reciprocating pumps. Cavitation in pumps and turbines.	10

Text Books:

- | | | | |
|---|---------------------------------|-------------------------------|---------------------|
| 1 | Fluid Mechanics | F. M. White | McGraw- Hill, India |
| 2 | Introduction to Fluid Mechanics | Fox, R.W., and McDonald, A.T. | Wiley India |

References:

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|----|--|---|--|
| 1. | Fluid Mechanics | Kundu P.K., and Cohen, I.M. | Academic Press, Elsevier, UK |
| 2 | Mechanics of Fluids | Shames, I.H. | McGraw Hill, International Students Edition. |
| 3 | Introduction of Fluid Mechanics & Fluid Machines | Som, S.K., Biswas G and Chakraborty, S. | TMH, New Delhi. |

Fluid Mechanics and Hydraulic Machines Lab

Unit	Content
1	Experiment 1: To verify the momentum equation using the experimental set-up on diffusion of submerged air jet.
2	Experiment 2: To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness.
3	Experiment 3: To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.

4	Experiment 4: To study the variation of friction factor 'f' for turbulent flow in commercial pipes.
5	Experiment 5: To calibrate an orifice meter, venture meter, and bend meter and study the variation of the co-efficient of discharge with the Reynolds number.
6	Experiment 6: To study the impact of jets in a flat plate.
7	Experiment 7: To study performance of a Pelton wheel/ Francis turbine/ Kaplan Turbine.
8	Experiment 8: To study performance of two Centrifugal pumps connected in series and parallel.
9	Experiment 9: To study performance of a Reciprocating pump.

Text Books:

1. Singh, S. Experiments in Fluid Mechanics, PHI Learning, New Delhi.
2. Prakash, M. N. S., Experiments in Hydraulics and Hydraulic Machines: Theory and Procedures, PHI Learning, New Delhi.
3. Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.

References

1. "Instrumentation, Measurements & Experiments Fluids", E. Rathakrishnan, CRC Press, NY, 2007.
2. "Low-Speed Wind Tunnel Testing", A. Pope and J.J. Harper, John Wiley & Sons Inc., NY, 1966.
3. "Experimental Methods for Engineers", J.P. Holman, McGraw-Hill Inc., NY, 2001.
4. "Design & Analysis of Experiments", D.C. Montgomery, Wiley, 7th ed., 2009.

Course Code: ME13XXX	Heat and Mass Transfer	Credits: 3-0-2:4
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Prerequisites: Engineering Thermodynamics

Course Outcomes:

CO1	Understand the basic modes of heat and mass transfer.
CO2	Apply principles of heat and mass transfer to predict transfer coefficients
CO3	Analyze working of various heat transfer equipment
CO4	Design heat and mass transfer equipment.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to Heat Transfer: Modes of Heat transfer; Conduction, convection and radiation; Effect of temperature on thermal conductivity of materials; Introduction to combined heat transfer mechanism. Conduction-One-dimensional general differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems; Initial and boundary conditions. Steady State one-dimensional Heat Conduction-Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation; Thermal resistance concept; Analogy between heat and electricity flow; Thermal contact resistance; Critical thickness of insulation. Two dimensional steady state heat conduction-solution by Numerical Relaxation method.	8
2	Fins: Heat transfer from extended surfaces, Fins of uniform cross-sectional area; Errors of measurement of temperature in thermometer wells. Transient Conduction: Transient heat conduction; Lumped heat capacity method; Time constant; Unsteady state heat conduction in one dimension only, Heisler charts.	6
3	Convective heat transfer fundamentals: Newton's law of cooling, Types of convective heat transfer, Laminar and Turbulent flows, Hydrodynamic boundary layer, Thermal boundary layer, Non-dimensional numbers, Buckingham Pi Theorem. Forced Convection: Flow over a flat plate; Approximate integral boundary layer analysis; Analogy between momentum and heat transfer in turbulent flow over a flat surface; Mixed boundary layer; Flow across a single cylinder and a	8

	sphere; Flow inside ducts; Empirical heat transfer relations; Relation between fluid friction and heat transfer; Liquid metal heat transfer. Natural Convection: Physical mechanism of natural convection; Buoyant force; Empirical heat transfer relations for natural convection over vertical planes and cylinders, horizontal plates and cylinders, and sphere; Combined free and forced convection.	
4	Condensation and Boiling: Fundamentals of boiling and condensation heat transfer, pool and flow boiling mechanisms, boiling curve and critical heat flux. Filmwise and dropwise condensation, heat transfer correlations, condensation on vertical and horizontal surfaces, and industrial applications in thermal systems and heat exchangers.	5
5	Heat Exchanger: Types of heat exchangers; Fouling factors; Overall heat transfer coefficient; Logarithmic mean temperature difference (LMTD) method; Effectiveness-NTU method; Compact heat exchangers.	5
6	Thermal Radiation: Basic radiation concepts; Radiation properties of surfaces; Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; Gray body; Shape factor; Black-body radiation; Radiation exchange between diffuse non black bodies in an enclosure; Radiation shields; Radiation combined with conduction and convection.	6
7	Introduction to Mass Transfer: Introduction; Fick's law of diffusion; Steady state equimolar counter diffusion; Steady state diffusion through a stagnant gas film.	2

Text Books:

- 1 Fundamentals of Heat & Mass transfer Incropera F.P., Dewitt.D.P. John Wiley & Sons (Pvt). Ltd.
- 2 Heat and Mass Transfer (In SI units) A practical approach Yunus A. Cengel TMH Education pvt. Ltd.
- 3 Heat and Mass Transfer PK Nag McGraw-Hill Education - Europe

References:

- 1 Principles of Heat Transfer Frank Kreith McGraw-Hill Book co.
- 2 Fundamentals of Momentum, Heat and Mass Transfer James R.Welty John Wiley & Sons (Pvt). Ltd.
- 3 Heat Transfer J.P. Holman McGraw-Hill International edition
- 4 Heat Transfer: A Basic Approach [Ozisik](#), N. McGraw-Hill Inc., US

Unit	Details	No. Hrs
1	Study of the heat transfer in pin fin apparatus.	3
2	Study of the heat transfer in natural convection apparatus.	3
3	Study of the heat transfer in the forced convection apparatus.	3
4	Study of the Stefan Boltzmann apparatus and estimation of Stefan Boltzmann constant.	3
5	To estimate the thermal conductivity of metal bar.	3
6	Study of heat transfer through Heat pipe.	3
7	Study of emissivity measurement apparatus.	3
8	To estimate the thermal conductivity of insulating powder	3
9	Study of heat transfer in lagged pipe apparatus.	3
10	To estimate effectiveness in double pipe heat exchanger.	3

References:

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|---|---|--|--|
| 1 | Principles of Heat Transfer
Fundamentals of Heat & Mass transfer | Frank Kreith
Incropera F.P., Dewitt.
D. P. | McGraw-Hill Book co.
John Wiley & Sons (Pvt).
Ltd. |
| 2 | Heat and Mass Transfer (In SI units) A practical approach | Yunus A. Cengel | TMH Education pvt. Ltd. |
| 3 | Fundamentals of Momentum, Heat and Mass Transfer | James R. Welty | John Wiley & Sons (Pvt). Ltd. |
| 4 | Heat Transfer | J. P. Holman | McGraw-Hill International edition |

Course Code: ME13XXX	Computer Aided Design	Credits: 3-0-2:4
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Pre-requisites: Design Thinking and Product visualization and basic knowledge of computer

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to model the objects geometrically with parametric curves.
CO2	Students will be able to apply geometrical transformations and projection methods to an available geometric model.
CO3	Students will be able to design surface and solid models of the objects.
CO4	Students will be able to analyse the applications of solid modelling in different fields.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: Historical Development, Vectors, Coordinate Systems, Intrinsic and Extrinsic properties, Explicit and Implicit Equations, Parametric Equations, Parametric Space.	2
2.	Design of Curves: Parametric Representation, Hermite curve, Reparametrization, Composite curve, Bezier Curve, Composite Bezier curve, B-Spline Curve, Rational curves, NURBS.	8
3.	Geometric Transformations: Translation, Rotation, Shear, Scaling and Reflection, Homogeneous Transformations, Orthographic Projections, Isometric Projection, Perspective Projection.	6
4.	Design of Surfaces: Parametric Representation, Bezier Surface, B-Spline Surface, Surfaces of Revolutions, surfacing operations.	7
5.	Design of Solids: Topology, Constructive Solid Geometry, Boundary Representation, Sweep Representation, Rendering and Visualization.	7
6.	Data exchange formats, Downstream Applications of CAD.	6

Experiment	Details	No. Hrs.
	Using available CAD software, attempt:	

1	To understand the interface, input and output options of the CAD software and create a 2D drawing of a given object.	2
2	To create surface models of a given object using lofted/swept/revolved surfaces and perform surface editing by extrude/fill/trim/extend/knit operations	6
3	To create solid models of a given object.	6
4	To create assembly models of different objects.	6
	Using MATLAB [®] software, attempt:	
5	To execute the following basic functions: matrix operations, control statements, mathematical operations, 2D and 3D graphical plots, keyboard and mouse inputs, file handling.	2
6	To draw a Bezier curve of n^{th} degree using (a) Matrix and (b) Blending function approach based on the user inputs. Also demonstrate the effect of different control points on the shape of the curve generated.	2
7	To draw B-Spline curve of a given order for the given control points. Also demonstrate the effect of different curve parameters on the shape of the curve generated.	2
8	To demonstrate the applications of different Geometric Transformations (translation, rotation, scaling and reflection) on a rectangle of size $l \times w$ and different Projections (orthographic, axonometric, oblique and perspective) on a rectangular box of size $l \times w \times h$.	2

Text Books:

1. Mathematical Elements of Computer Graphics, D F Rogers and J A Adams, McGraw Hill Education, 2002.
2. Geometric Modeling, M E Mortenson, McGraw Hill Education, 2013.
3. CAD/CAM: Theory and Practice, Ibrahim Zeid, McGraw Hill Education, 2009.
4. Computer Graphics: Principles and Practice, Foley, van Dam, Feiner, and Hughes, Pearson Education India, 2019.

References:

1. Curves and Surfaces for Computer Aided Geometric Design: A Practical Guide, G. Farin, Academic Press, 2001.
2. Bezier and B-spline Techniques, H. Prautzsch, W. Boehm, M. Paluszny, Springer-Verlag, 2013.
3. Computer-Aided Engineering Design, A Saxena and B Sahay, Springer, 2005.
4. Computer Aided Design and Manufacturing, <https://nptel.ac.in/courses/112102101>
5. Computer Aided Engineering Design, <https://nptel.ac.in/courses/112104031>

Course Code: ME13XXX	Mechanics of Materials	Credits: 3-1-0:4
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Pre-requisites: Basic Knowledge of Mathematics and Physics

Course Outcomes:

S.N.	Outcomes
CO1	Understand the concept of internal forces and moments, stress, strain and deformations in members subjected to axial, bending and torsional loads.
CO2	Understand the concepts of stress and strain at a point, and principal stress and strain to solve the problems of engineering systems.
CO3	Apply the concepts to calculate stress, strain, and displacements in mechanical structures and components containing the fundamental elements such as beams, shaft, shells and springs.
CO4	Analyse the mechanical engineering structures and components for safer mechanical design by considering appropriate failure criteria and the design requirements.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Analysis of Stress and Strain: Uniaxial Stress and Strain, Generalized Hooke's Law, Stress-Strain Curves, Elastic Constants, Strain Energy, Statically Indeterminate Problems, Thermal Effects, Impact Loading.	6
2.	Bi-axial Stress and Strain: Stress at a Point, Stress Transformation, Analysis of Strain, Strain-Displacement Relations, Strain Transformation, Strain Measurements, Principal Stresses and Strain	8
3.	Bending and Shear Stresses: Introduction to Shear Force and Bending Moment Diagrams, Pure Bending, Normal Stress and Shear Stresses in beams, Composite Beams.	6
4.	Torsion of Shaft, Springs, and Pressure Vessels: Torsion of Circular Shaft, Power Transmitted by a Shaft, Compound Shaft, Combined Loadings, Thin-	8

	Walled Shells, and Closed Coil Helical Springs	
5.	Deflections of Beams: Equation of Elastic Curve, Methods for Determining Deflections: Double Integration, Macaulay's Method, Moment-Area Method, Castigliano's Theorem	6
6	Columns and Theories of Failure: Euler's Theory for Long Columns, Rankine-Gordon Formula, Eccentrically Loaded Columns, Theories of failure	6

Text Books

1. Mechanics of Materials, Gere and Timoshenko, CBS Publications.
2. Mechanics of Materials, E. P. Popov, Prentics Hall Publications.

Reference Books

1. Elements of Strength of Materials, S.P. Timoshenko and D.H. Young, East-West Press Pvt. Ltd. Publications.
2. Introduction to Mechanics of Solids, Crandall, Dahl and Lardener, Tata Mcgraw Hill Publications.
3. Mechanics of Materials, Pytel and Kiusalaas, Cengage Learning Publications.
4. Strength of Materials, G. H. Ryder, Macmillan India Limited.
5. Strength of Materials, Pytel and Singer, Harpercollins College division publications.
6. Mechanics of Materials, Riley, Struges and Morris, John Wiley & Sons.
7. Mechanics of materials, Hibbeler, R.C., 2005, Pearson Education.

Semester IV

Course Code : ME14XXX	Energy Conversion Technologies	Credits: 3 -0 -2:4
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Pre-requisites: Engineering Thermodynamics, Heat and Mass Transfer

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand the concept of Energy Conversion Technologies and systems.
CO2	Students will be able to Identify the components related to steam power plants and internal combustion engines along with their working principle
CO3	Students will be able to do the thermal analysis of the Energy Conversion Technologies along with the analysis of the effects of different performance parameter
CO4	Students will be able to do critical analysis and of the systems and suggests methods to enhance the performance of the Energy Conversion systems

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Review of Carnot and Rankine cycle, Effect of operating conditions on thermal efficiency of Rankine cycle, Principle methods of increasing thermal efficiency, Deviation of actual cycle from theoretical cycle, Efficiencies, Requirement of ideal working fluid, Binary vapour cycle, Regenerative feed heating cycles, Reheating and regenerative cycles.	08
2.	Classification of nozzles and diffusers. Steady flow energy equation through nozzles, momentum equation. Nozzle and diffuser efficiencies. Principles of working of steam turbines, classification comparison, and velocity diagram for impulse and reaction turbines, losses in steam turbines, state point locus and	07

	reheat factor.	
3.	Function of boilers, Classification of boilers, modern boilers, heat absorption in water tube boilers, circulation in down comer-riser circuits and their sizing, steam drum and internal, mountings and accessories, Function of condenser, condensing system, surface and jet condensers, mass of circulating water, condenser and vacuum efficiency, Cooling tower: construction details and analysis.	05
4.	Engine Geometry, Performance Parameters, Air standard Cycle and their Analysis, Fuel-air Cycle and their Analysis, Actual cycle and their analysis, Inlet and exhaust processes in the four-stroke cycle, Valve timing diagram, Volumetric efficiency, Scavenging in two-stroke cycle engines and supercharging and Turbo charging. SI Engine combustion and CI Engine combustion.	08
5.	Classification, Ideal Cycles and their analysis, Design Point Performance Calculations, Comparative Performance of Practical Cycles, Combined Cycle and Cogeneration Schemes, closed cycle gas turbines	06

Text Books:

5. Power Plant Engineering	PK. Nag	McGraw Hill	2007
6. Internal Combustion Engine	John B. Heywood,	McGraw Hill	1988

References:

5. Power Plant Technology	M.M. El-Wakil,	McGarw Hill	1988
6. Internal Combustion Engine	V. Ganeshan	McGraw Hill	1994

Exp. No.	Details	No. Hrs
1.	Study and performance of complete steam power plant	2
2.	Study and performance of Nestler Boiler (To find the equivalent evaporation, Boiler efficiency and prepare the heat balance)	2
3.	Study and performance of Steam Turbine	2
4.	Study and performance of surface condenser	2
5.	To find the dryness fraction of wet steam using separation throttling calorimeter	2
6.	Study of 600 Rovers Gas Turbine and to draw the air fuel, lubrication and power cycles	2

7.	Study of 2-Stroke and 4-stroke C.I. and S.I. Engine with valve timing diagram	2
8.	Disassembly of single cylinder Diesel Engine and Assembly of single cylinder Diesel Engine.	2
9.	Performance characteristic of multi-cylinder C.I. Engine. (Willan's line method)	2
10.	Performance characteristic of single cylinder diesel engine	2
11.	Study and performance characteristics of MPFI Engine and Morse test	2

Text Books:

- | | | | |
|-------------------------------|------------------|-------------|------|
| 1. Power Plant Engineering | PK. Nag | McGraw Hill | 2007 |
| 2. Internal Combustion Engine | John B. Heywood, | McGraw Hill | 1988 |

References:

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|-------------------------------|----------------|-------------|------|
| 1. Power Plant Technology | M.M. El-Wakil, | McGarw Hill | 1988 |
| 2. Internal Combustion Engine | V. Ganeshan | McGraw Hill | 1994 |

Course Code : ME14XXX	Instrumentation and Process Control	Credits: 3 -0 -2:4
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Pre-requisites: Physics, Basic Electrical and Electronics Engineering

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basic calibration, possible errors and measures to minimize them based on their characteristics.
CO2	Apply knowledge on sensors and their suitability in the application of measuring different physical quantities and their ranges.
CO3	Apply working principles in the measurement of field quantities.
CO4	Analyze the process control systems based on the requirement.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Instruments and measurement system: Functions of instruments and measurement system, Elements of generalized measurement system, Classification of instruments, Analog and digital modes of operation, error in measurements, Statistical analysis of experimental data	8
2.	Characteristics of instruments and measurement systems: Static characteristics of measuring instruments, calibration and standards, Dynamic characteristics of measuring instruments.	5
3.	Transducers: Introduction to sensors and transducers, Mechanical input transducers, Electrical transducers like Resistive, Capacitive and Inductive transducers, Measurement of various physical quantities like pressure, temperature, force, liquid level, flow, speed and humidity, Instrument selection criteria and installation procedures	8
4.	Signal Conditioning and Data Acquisition System: Introduction, Signal Conditioning, Multiplexing, Accuracy of Digital Meter, Aperture Time for Sample and Hold Mechanism, image processing, signal analysis and FFT	4
5.	Indicating instruments, display devices and recorders: Essentials of indicating instruments, Principles of indicating instruments and their applications like wattmeter, watt-hour meter, dynamometer type power factor	5

	meter, Recorders, X-Y Plotter.	
6.	Process Control: Introduction, Proportional Control, Integral Control, Derivative Control, Proportional-cum-integral Control (PI Control), Proportional-cum-integral-cum-derivative (PID) Control, Integral Windup, Electronic Controller, Pneumatic Controller, Selection of Control Technique, Three-element Control (Concept of Feed Forward), Analysis and Modelling of Process Control Systems for Pressure, Temperature, Flow, Level etc.	5

Text Books:

1. Fundamentals of Industrial Instrumentation and Process Control, William C Dunn, McGraw Hill Education, 2014.

References:

1. Measurement systems – Application and Design, E.O. Doebelin, McGraw Hill Education, 2004.
2. Instrumentation, Measurement and Analysis, Nakra, Chaudhary, McGraw Hill Education, 2016.
3. Mechanical Measurements and Instrumentation, R.K. Rajput, S. K. Kataria & Sons, 2005.
4. Process Control Instrumentation Technology, C. D. Johnson, Pearson, 2015.
5. A course in Electronic and Electrical Measurements, J. B. Gupta, S. K. Kataria and Sons, 2014.
6. Principles of Measurement Systems, John P. Bentley, Pearson India Ltd, 2002.
7. Transducers and instrumentation, D. V. S. Moorthy, Prentice Hall of India Pvt. Ltd., 2004.

Instrumentation and Process Control lab

Unit	Details	No. Hrs
1	Study the displacement and current characteristics in Linear variable differential transformers (LVDT).	02
	Find the relationship between displacement and change in signal generated due to Capacitive type transducer (Proximity Tutor).	
2	To draw the calibration graph for the Bimetallic transducer using a thermometer as standard and determine the time constant for the transducer.	02
3	Find the relationship between displacement and change in signal generated due to strain gauge.	02
	To calibrate the given force measuring elastic transducer for compression and tensile loads.	
4	To plot the calibration graph between the temperature and RTD readings.	02
	To study the variation of light intensity with distance from source with a luxmeter.	
5	Calibration of Bourdon pressure gauge for (i) above atmospheric pressure,	02

	and (ii) below atmospheric pressure conditions	
6	To make the study and use of micrometer and depth gauge	02
	To measure the angle of a given taper specimen with the help of a clinometers first and then calculate the accurate value using sine bar.	
7	To determine the diameter of a specimen and the error in given specimen with the help of passameter and slip gauges.	02
8	To measure the screw parameters i.e. external diameter, pitch, flank angle using Tool Makers Microscope.	02
	To determine the outside and core diameter of a given specimen with the help of Floating carriage micrometer	
9	To study the three mode (PID) control of level, flow, pressure and temperature	4

Text Books

- 1 Fundamentals Of Industrial Instrumentation and Process Control William C Dunn Tata McGraw-Hill, New Delhi

References:

- 1 Measurement systems – Application and Design E.O. Doebelin Tata McGraw-Hill, New Delhi.
- 2 A course in Electronic and Electrical Measurements J. B. Gupta S. K. Kataria and Sons, New Delhi.
- 3 Process control instrumentation technology C. D. Johnson John Wiley & Sons, New York.
- 4 Mechanical Measurements and Instrumentation R.K. Rajput S. K. Kataria & Sons, New Delhi.
- 5 Principles of Measurement Systems, John P. Bentley, Pearson India Ltd.
- 6 Instrumentation, Measurement and Analysis, Nakra, Chaudhary, Tata McGraw-Hill, New Delhi.
- 7 Transducers and instrumentation. D. V. S. Moorthy, Prentice Hall of India Pvt. Ltd.

Course Code: ME14XXX	Manufacturing Science and Technology-I	Credits: 3 -0 -2:4
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Pre-requisites: Workshop and Product Realization, Fluid Mechanics, Heat transfer, Engineering Mechanics, Engineering Materials

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of metal casting and apply principles of fluid mechanics and heat transfer in analysis of metal casting processes
CO2	Understand the basic principles and analyse the bulk metal forming processes such as Flat Rolling, Disc Forging, Wire Drawing and Billet Extrusion using flow curve equation and slab method
CO3	Understand the basic principles of the sheet metal operations and calculations of Punch and Die dimensions and forces
CO4	Understand the principles of Thermo-fabrication processing such as Powder processing, Polymer processing, Layer processing and Coating Processing

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	Hrs
1.	Metal Casting: Classification of casting processes; Sand Mould Casting -Elements of green sand mould; Mould Materials and Pattern Design for Moulding; Metal Melting and Gating Design for Pouring; Casting Solidification and Riser Design for Feeding; <i>Precision Sand Mould Casting Processes</i> -Shell and Vacuum moulding; Investment and Evaporative casting; Metal Mould Casting -Principles and Applications of Continuous casting, Die casting, and Centrifugal casting; Casting defects and Inspections	9L
2.	Bulk Metal Forming: Classification of bulk metal forming processes; Yielding and Flowing; Temperature and Friction; Dies and Lubrications; Technology and Analysis (load estimation) of FLAT ROLLING, DISC FORGING, WIRE DRAWING and BILLET EXTRUSION using Flow Equation and Slab Method;	12L

3.	Sheet Metal Operations: SHEARING-Clearance and shearing mechanism; Calculation of punch and die dimensions and Shearing forces in Blanking and Punching; BENDING-Allowances and Spring back, Calculation of developed length and bending force; DRAWING- Clearance and drawing mechanism; Calculation of blank size and drawing forces; Redrawing and Reverse drawing; Progressive, Compound and Combination dies; Principles of Spinning and Stretching; Impulse forming and Hydroforming; Defects in sheet metal working processes; Formability of sheet metals and characterization techniques	6L
4.	Thermo-fabrication Processing: <i>Powder Processing:</i> Production and Mixing of powders, Compaction and Sintering of powders, Cold and hot isostatic pressing; <i>Polymer Processing</i> -Extrusion, Calendaring and Thermoforming; Injection, Compression, Transfer and Blow Molding; <i>Layer Processing:</i> Stereo Lithography and Solid Ground Curing, Selective Laser Sintering and Three Dimensional Printing, Fused Deposition Modelling and Laminated Object Manufacturing; <i>Coating Processing</i> -Physical Vapour Deposition and Chemical Vapour Deposition, Electro-Chemical Deposition	6L
5	Experiments: 1. Design and Preparation of a wooden pattern for the given dimensions of a casting of V- block made of Steel 2. Study of Sieve Shaker and to find Grain Fineness Number for a given sample of foundry sand 3. Study of Permeability Tester and to find Permeability Number for a given sample of foundry sand. 4. Study of Strength Tester and to find green compression and shear strength of a given sample of green sand 5. Study of Moisture and Clay Content Tester and to find the moisture content and clay content in a given sample of green sand 6. Study of Shatter Index Tester and to find shatter index of a given sample of green sand 7. Study of Hydro Forming Process and making a cup shaped part using Sheet Hydro Forming Setup 8. Study and working Demonstration of Power Press and Power Hammer 9. Study and working Demonstration of Injection Moulding Machine 10. Study and working Demonstration of 3D printer	2X10=20P

Text Books:

1. Groover's Principles of Modern Manufacturing: Materials, Processes and Systems
2. Manufacturing Science by Ghosh and Mallik

References:

3. Manufacturing Processes for Engineering Materials by Kalpakjian and Schmid

Course Code: ME14XXX	Design of Machine Elements- I	Credits: 3-1-0:4
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Prerequisites: Engineering Material, Engineering Mechanics

Course Outcomes:

CO1	Students will be able to understand and apply the standards and design data book during a design problem.
CO2	Students will be able to identify the materials and its properties to design a machine component for a particular application
CO3	Students will be able to identify the critical sections of the components and understand its importance during design of a machine component.
CO4	Students will be able to evaluate and apply the concepts of factor of safety and theory of failures for design and creation of a particular machine component under static and cyclic loading conditions.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	General Introduction: Standards in Design and Selection of Preferred Size, BIS and international system of material designation, Materials for design (such as Cast Iron, Steels and Alloys, Non-ferrous metals, Plastics and Rubbers) and selection methods: Selection strategy, selection procedure, case studies, The statistical significance of material properties, Strength and cold work, Temperature effects.	7
2	Design against Static and variable Load: Static strength, Stress concentration, Failure theories for ductile and brittle materials, Selection of failure criteria, Introduction to fracture mechanics, Factor of Safety and selection criteria, Notch Sensitivity Factor, Design criteria for variable loads, Endurance Limit and fatigue strength, Design for Finite and Infinite Life.	10
3	Shafts and keys: Design of Shafts against Static and Fluctuating Load, Design for Strength and Rigidity, Critical speeds for shafts, Design of Square and Flat Keys and Splines.	6
4	Power Screws and Joints: Form of Threads, Square Threads, Trapezoidal Threads, Stresses in Screw, Design of Screw Jack, Screwed Joints, Welded Joint and Eccentric Loading of above Joints, Design for Fatigue Loading.	9

5	Mechanical Springs: Materials for spring, Design against static and fatigue loading of helical compression and extension springs, <i>Multi Leaf Springs and Spiral Springs (self study)</i>	9
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Text Books:

- 1 Mechanical Engineering Design (in SI Units) Joseph E. Shigley and Charles R. Mischke TATA McGraw Hill

References:

- 1 Machine Design: An Integrated Approach R. L. Norton Pearson Prentice Hall
- 2 Machine Component Design Juvinall R. C. and Marshek, K. M., John Wiley,
- 3 Design of Machine Element V. B. Bhandari TATA McGraw Hill
- 4 Design Data sheets Instructor
- 5 <https://nptel.ac.in/courses/112105124>

Course Code : AM14XXX	Mechanism of Machines	Credits: 3 -0-0:3
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Pre-requisites: Engineering Mechanics

Course Outcomes:

S.N.	Outcomes
CO1	To get the knowledge of mechanisms and to analyse the position, velocity and acceleration of mechanisms.
CO2	To analyse the motion of different cams and followers, gear and gear trains for motion and power transmission applications.
CO3	To analyse the effects of the static and dynamic forces acting on planar mechanisms and analyse fluctuation of energy in machines.
CO4	To analyse balancing of rotating and reciprocating masses in mechanical systems and multi-cylinder engines.
CO5	To study the control of speed and angular motion of mechanisms.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Mechanisms and Kinematics – Introduction to Kinematic Links and Pairs, Classification of Kinematic Pairs, Kinematic Chains and Mechanisms, Constrained Motion, Degrees of Freedom and Mobility Criterion, Inversions of Mechanisms, Four-Bar Chain and Single Slider Crank Chain Mechanisms	3
2.	Velocity and Acceleration Analysis – Velocity and Acceleration of a Link, Relative Velocity Method, Instantaneous Centre Method, Kennedy's Theorem, Coriolis Component of Acceleration.	5
3.	Cam Mechanisms – Classification of Cams and Followers, Nomenclature of Cam Profiles, Types of Follower Motion, Generation of Cam Profiles with Uniform Velocity, Simple Harmonic Motion, Uniform Acceleration and Retardation, Cycloidal Motion of the Follower.	4
4.	Gear and Gear Trains – Types of Gears, Gear Terminology, Law of Gearing, Gear Profiles, Interference and Undercutting, Contact Ratio, Gear Trains: Simple,	8

	Compound, Reverted and Epicyclic Gear Trains.	
5.	Static and Dynamic Force Analysis – Static Force Analysis of Planar Mechanisms, Dynamic Force Analysis including Inertia and Frictional Forces, Turning Moment Diagram for Engines, Fluctuation of Speed.	8
6.	Balancing – Static and Dynamic Balancing of Rotating and reciprocating Masses, Two Plane Balancing, Balancing of Single and Multi-cylinder Engines, Firing Order.	6
7.	Mechanisms for Control – Flywheels, Governors, Gyroscopes	6

Text Books:

7. Theory of Machines and Mechanisms, John J. Uicker, Jr., Gordon R. Pennock, and Joseph E. Shigley, Oxford University Press, 2014.
8. Theory of Machines and Mechanisms, Amitabha Ghosh and Asok Kumar Mallik, East-West Press Private Limited (EWP), 2015.
9. Design of Machinery, Robert L. Norton, McGraw-Hill, 2015.

References:

1. Kinematics and Dynamics of Machines, George H. Martin, McGraw-Hill, 1982.
2. Theory of Machines, Thomas Bevan, CBS Publishers, 1984.
3. Theory of Machines, S. S. Rattan, McGraw Hill, 2014.
4. Kinematics, Dynamics, and Design of Machinery, Kenneth J. Waldron, Gary L. Kinzel, and Sunil K. Agrawal, John Wiley & Sons, 2016.
5. Mechanism and Machine Theory, J S Rao and R V Dukkati, New Age International (P) Limited

Course Code: ME14XXX	Industrial Engineering and Production Management	Credits: 3 -0-0:3
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Pre-requisites: Manufacturing Science and Technology -1, Management Concepts and Applications

Course Outcomes:

S.N.	Outcomes
CO1	Understand and explain the fundamentals of industrial engineering, production systems, productivity, plant location and layout, and basic cost and break-even analysis.
CO2	Students will be able to describe the job evaluation, merit rating and wage-incentive plans.
CO3	Students will be able to implement work study techniques for better productivity and learn to do work measurement and calculate the standard time for doing a job.
CO4	Design and selection of appropriate material handling devices, design and control inventory systems using classical deterministic models.
CO5	Develop and evaluate production planning and control decisions, including forecasting, aggregate planning, MRP, sequencing, scheduling, and lean/JIT practices.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Basics of Industrial Engineering: Production System and Types of Production; Productivity Measurement and Improvements; Plant Location and Layout; Cost accounting and methods of depreciation; Production costs and Break-Even Analysis.	7

2.	Job evaluation and Merit Ranking: Job evaluation, Benefits of Job evaluation, Methods of Job evaluation, Merit Rating, Methods of Merit Rating, Requirements for success of Merit Rating System, Objectives of a Good Wage-Incentive Plan, Basis of a Good Wage-Incentive Plan, Types of Wage-Incentive Plans.	7
3.	Work Study: Method Study, Micro Motion Study, Principles of Motion Economy, Time Study, PMTS, Work Sampling.	7
4.	Material Handling System and Inventory Control: Principles of Material Handling, types, and devices, Inventory types and functions, ABC analysis, Economic Order Quantity, Concept of Inventory Control.	7
5.	Production Planning and Control: Need and Objectives of PPC, PPC Phases and functions, Concepts of MRP- I, MRP-II, and ERP, Lean and JIT manufacturing.	7

Text Books:

1. Industrial Engineering and Production Management, Martand T. Telsang, S. Chand Publishers, 2018.
2. Production, Planning, and Control: A Comprehensive Approach, D R Kiran, 2018.

References:

1. Production and Operations Management, S.N Chary, McGraw-Hill Education, 2019.
2. Modern Production/Operations Management, Elwood S. Buffa and Rakesh K. Sarin, John Wiley and Sons, 1987.
3. Turner, W.C., et. al., 1993, “Introduction to Industrial and System Engineering”, Prentice Hall.
4. Ralph M. Barnes, “Motion and Time Study: Design and Measurement of Work”, Wiley Publishers

Semester V

Course Code: ME15XXX	Design of Machine Elements-II	Credits: 3-0-2:4
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Pre-requisites: Engineering Mechanics, Mechanics of Materials, Mechanism of Machines Instrumentation and process control, and Design of Machine Elements-I

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to identify materials which can be used to make the transmission elements for a particular application.
CO2	Students will be able to apply AGMA design methodology for design of gears.
CO3	Students will be able to understand and analyze the principles of lubrication in design and selection of bearings.
CO4	Students will be able to select and design flexible transmission elements, brakes and clutches.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Spur Gears: Kinematics of gears, Conjugate Action, standard tooth systems for spur gears, Profile shifted gears, Involutometry, gear cutting methods, Modes of gear failure, Spur gear tooth force analysis, Tooth bending stress – AGMA procedure, Bending fatigue strength – AGMA procedure, Buckingham equation for dynamic load on gears, Buckingham contact stress equation, Contact stress – AGMA procedure, Surface fatigue strength – AGMA procedure, Gear materials.	8
2.	Helical Gears: Kinematics, geometry and nomenclature, force analysis, Design of helical gears: bending stress, contact stress, Crossed helical gears Worm Gears: Geometry and nomenclature, Force analysis, Friction analysis	6

	and efficiency, thermal capacity, bending and surface strength, power rating efficiency, worm gear standards and proportions. Bevel Gear and Worm and Worm Gear [Self Study]	
3.	Antifriction bearing: Types of ball bearings, roller bearings, needle bearings, friction life of bearings, reliability considerations, selection of ball bearings, roller bearing, tapered roller bearing, thrust bearing, lubrication and sealing, Mounting of bearings.	6
4.	Lubrication and sliding bearings: Type of lubrication, viscosity, hydrodynamic theory of lubrication, types of bearing, design of bearing using design charts, boundary lubrication, hydrostatic bearing, and hydrodynamic thrust bearings.	7
5.	Flexible Elements: Design of Flat belts and pulleys – Selection of V belts and pulleys – Selection of hoisting wire ropes and pulleys – Design of Transmission chains and Sprockets.	6
6	Clutches and Brakes: Design of plate clutches –axial clutches-cone clutches-internal expanding rim clutches- Electromagnetic clutches. Band and Block brakes, Disc Brake, Electro-mechanical brakes	7

Text Books:

10. Mechanical Engineering Design, Joseph E. Shigley and Charles R. Mischke, Tata McGraw-Hill, New Delhi, 2006.

References:

6. Machine Design An Integrated Approach, R. L. Norton, Pearson Prentice Hall, 2019.
7. Machine Component Design, Juvinall R. C. and Marshek, K. M., John Wiley, 2016.
8. Design of Machine Element, V. B. Bhandari, Tata McGraw-Hill, 2021.
9. Design Data sheets – Will be provided by the course instructors.
10. <https://nptel.ac.in/courses/112106137>

Design of Machine Elements Lab		
Unit	Experiment	Practical
1	Assembly drawing of threaded Joints using AutoCAD/Solid works.	1
2	Assembly drawing of Cotter and Knuckle joint using AutoCAD/Solid works.	1
3	Assembly drawing of Tailstock using AutoCAD/Solid works.	1
4	Assembly drawing of Plummer block using AutoCAD/Solid works.	1
5	Assembly drawing of Blow-off cock using AutoCAD/Solid works.	1
6	Production drawing of any assembly using AutoCAD/Solid works.	1
7	Assembly drawing of Screw Jack using AutoCAD/Solid works	1
8	Design and drawing of a helical spring of a mechanical system using MATLAB and AutoCAD/Solid works.	1
9	Design and drawing of a Cylinder relief valve of a mechanical system using MATLAB and AutoCAD/Solid works.	1

10	Design and drawing of a helical gear of a mechanical system using MATLAB and AutoCAD/Solid works.	1
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Text Books:

- | | | | |
|---|--|--|--------------------------------------|
| 1 | Machine Drawing | Ajit Singh | TATA McGraw Hill |
| 2 | Production Drawing | K L Narayana, P Kannaiah,
K Venkata Reddy | New Age International
Publication |
| 3 | Mechanical Engineering Design
(in SI Units) | Joseph E. Shigley and
Charles R. Mischke | TATA McGraw Hill |

References:

- | | | | |
|---|-----------------|--|--------------------------------------|
| 1 | Machine Drawing | K L Narayana, P Kannaiah, K Venkata
Reddy | New Age International
Publication |
| 2 | Machine Drawing | R K Dhawan | S Chand Publication |
| 3 | Machine Drawing | N D Bhatt and V M Panchal | |

Course Code: ME15XXX	Manufacturing Science and Technology-II	Credits: 3 -0 -2:4
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Pre-requisites: Workshop and Product Realization, Manufacturing Science and Technology-I, Fluid Mechanics, Heat transfer, Engineering Materials

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of orthogonal metal cutting principles and cutting tool technology
CO2	Understand the various metal cutting operations and analyse the basic metal cutting operations such as Turning, Shaping, Drilling, and Milling performance parameters
CO3	Understand the principles of abrasive finishing operations and unconventional machining operations
CO4	Understand the principles and processes of welding, brazing and soldering operations and analyse standard fusion welding operations applying principles of heat transfer

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	Hrs
1.	Metal Cutting Principles and Cutting Tools -Elements and Types of chipping; Orthogonal Cutting models-Shear angle and shear strain; Shear and chip velocity; Merchant's Circle for Cutting Forces; Specific Cutting Energy and Power; Calculation of tool-chip interface temperature and Applications of cutting fluids; Tool Materials and Tool Life	9L
2.	Metal Cutting Operations and Machine Tools: Classifications of Metal Cutting Operations; <i>Single Point Tool Machining</i> -Tool geometry and Tool signature; TURNING: Process geometry, Performance parameters and Cutting forces; Turning related operations; Taper turning and thread cutting calculations; Machinability and Economics of Turning; SHAPING: Process geometry, Performance parameters and Cutting forces; Shaping related operations; <i>Multi Point Tool Machining</i> -DRILLING-Twist drill geometry and	12L

	specification; Process geometry, Performance parameters and Cutting forces; Drilling related operations; MILLING-Milling cutter geometry and specification; Types of milling operations; Process geometry, Performance parameters and Cutting forces in Peripheral Slab Milling; Gear cutting; Broaching and Sawing Operations; <i>Machine Tools</i> : Construction and Kinematics of Rotary Machine Tools-Lathe, Drilling and Milling machines; Reciprocating Machine Tools-Shaper, Planer and Slotter	
3.	Abrasive Finishing Operations: Principles of Grinding and Honing; Lapping and Polishing; Abrasive Flow Finishing and Magnetic Abrasive Finishing; Unconventional Machining Operations -Principles and applications of Electro-Discharge Machining and Beam Machining Processes, Electro-Chemical Machining and Chemical Machining Processes; Ultra-Sonic Machining and Jet Machining Processes	6L
4.	Metal Welding- Types of Joints and Welds; Principles and Processes of <i>Fusion Welding</i> -Arc welding (SMAW and PAW; GMAW and GTAW; SAW and ESW), Resistance welding, Gas welding, Thermit welding and Beam welding; Principles of <i>Solid Welding</i> -Friction welding, Friction stir welding, and Ultrasonic welding; Welding defects; Principles of Brazing, Soldering and Adhesive Joining	6L
5	Experiments: 1. Preparation of Single Point Cutting Tool as per the given tool specification 2. To make a job as per drawing on the Capstan Lathe. Write the process sheet and draw the sketches of the capstan Lathe and various cutting tools attached 3. To make a job as per drawing using Radial Drilling Machine and determination of cutting forces using tool dynamometer 4. To make a rectangular slot as per the given drawing using Vertical Milling Machine and determination of cutting forces using tool dynamometer 5. To cut spur gear on a gear blank using Indexing Mechanism on Horizontal Milling Machine. Write the process sheet and draw the sketches of the Horizontal Milling Machine and Gear cutter 6. Study of constructional details and working of Reciprocating Machine Tools such as Shaper, Planer and Slotter 7. Study of constructional details and working of Cylindrical Grinding Machine and Surface Grinding Machine 8. Study and working demonstration of DIE SINKING-EDM and WEDM machines 9. Study and working demonstration of DIE SINKING-ECM and LBM 10. Study of TIG and MIG welding machines	2X10=20P

Text Books:

1. Groover's Principles of Modern Manufacturing: Materials, Processes and Systems
2. Manufacturing Science by Ghosh and Mallik
3. A Course in Workshop Technology Vol. II (Machine Tools) by B.S. Raghuvanshi

References:

1. Manufacturing Processes for Engineering Materials by Kalpakjian and Schmid

Course Code: ME15XXX	Robotics	Credits: 3-0-2: 4
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Pre-requisites: Basic knowledge on Kinematics

Course Outcomes:

CO1	Students will understand and classify and select a particular robot for specific application.
CO2	Students will be able to design and analyze various actuators for different robot orientations.
CO3	Students will be able identify and classify the commonly used sensors for robots and able to solve the motion analysis problems based on robot kinematics.
CO4	Students will be able to prepare the robot programming for different trajectories and analyse their functionality in real robot. To get familiar with the latest improvements in robotics systems.

Course Articulation Matrix:

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

Units	Details	Nos. of Hrs
1	Introduction: Automation and Robotics, An over view of Robotics – present and future applications – classification by coordinate system and control system.	06
2	Components of the Industrial Robotics: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Types of End effector, Gripper force analysis etc.	06
3	Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Coordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic	08

	Differential Transformation: Introduction, Jacobian Transformation etc.	
4	Actuators - Introduction – Characteristics of actuating systems – Comparison of actuating systems – Hydraulic devices – Pneumatic devices – Electric motors and stepper motors – Microprocessor control of electric motors.	08
5	Sensors – Introduction – Sensor characteristics ,Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, – Position sensors – Velocity sensors – Acceleration sensors – Force and pressure sensors – Torque sensors – Micro-switches – Light and Infrared sensors – Touch and Tactile sensors – Proximity sensors – Range-finders – Vision systems– Remote center compliance device, and Intelligent Sensors etc.	08
6	Introduction, Various Teaching Methods, Typical Programming Examples such as Palletizing, Loading a Machine Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion straight line motion – Robot programming, languages, Introduction to Collaborative robot (COBOT) etc.	06

References

1. FU K S, Gonzalez RC, Lee CSG; Robotics –Control, sensing, TMH Publ.
2. Fundamentals of Robotics by D. K. Pratihar, Narasa Publication House, 2017
3. Saeed B. Niku, Introduction to Robotics, Analysis, Systems, Applications, PHI Publications.
4. S R Dev, Robotics Technology and Flexible Automation, Tata McGraw Hill
5. Ghosal Ashitava; Robotics Fundamental concepts and analysis; Oxford
6. Saha S; Introduction to Robotics; TMH Publications

LAB COMPONENT

Module	Name of Experiment	Duration
1	Introduction To Robotic System, Degrees Of Freedom And Robot Joints	03
2	Study of different components and working of MOTOMAN (HP3) NX100, 6-DOF robot	03
3	Study of Forward and Inverse Kinematics of Robots	03
4	Programming and demonstration of MOTOMAN 6-axis robot using Teach pendent.	03

5	Understanding Virtual Reality SOFTWARE and its features/Offline Robot Programming for Pick and place operation.	03
6	Virtual Reality SOFTWARE based programming for different robot motions	03
7	Programming of MOTOMAN 6-axis robot using offline programming to move the End effector in various trajectories	03
8	Design and Development of a robotic systems (Mini Project-I).	18

Reference Books/Manuals:

- 1 Saha S; Introduction to Robotics; TMH Publications
- 2 FU K S, Gonzalez RC, Lee CSG; Robotics –Control, sensing, TMH Publ
- 3 Instruction and operating manual of Motoman HP3 NX100 6-axis robot by Yaskawa

Course Code: ME15XXXX	Refrigeration and Air-Conditioning	Credits: 3-0-2:4
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Prerequisites: Engineering Thermodynamics and Heat and mass Transfer

Course Outcomes:

CO1	Students will be able to identify basic components of a refrigeration systems
CO2	Students will be able to evaluate the performance of various refrigeration systems.
CO3	Students will be able to perform calculations for various psychrometric processes using the psychrometric charts
CO4	Students will be able to explain the functioning of the air conditioning system under different conditions
CO5	Students will be able to calculate load for air conditioning applications

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	1	2	2	3	1	-	1	-	-	-	-	2	2	1
CO2	3	3	2	3	1	3	3	2	2	2	2	-	3	3
CO3	3	2	2	2	1	2	2	-	-	-	-	-	2	2
CO4	3	2	1	1	1	-	-	-	-	2	-	-	2	1
CO5	3	3	3	3	1	2	2	2	2	-	2	-	2	2

Unit	Details	No. Hrs
1	Refrigeration: Introduction, methods of refrigeration, Applications, Carnot refrigeration cycle, Unit of refrigeration capacity, Coefficient of Performance, Heat Pumps	6
2	Vapour compression system: Analysis of ideal vapour compression cycle, Use of T-s and p-h charts, Effect of pressure changes, subcooling of condensate and superheating of suction vapour on COP, Actual Vapour-Compression cycle, Cascade refrigeration systems	6
3	Vapour Absorption system: Comparison between absorption and compression systems, Water-Lithium Bromide and Ammonia –water absorption systems, Single-effect and double-effect systems, electrolux (three fluid) refrigeration system.	4
4	Air refrigeration cycle: Introduction to air refrigeration cycles and Bell-Coleman cycle, thermodynamic analysis, COP, and performance evaluation. Study of aircraft refrigeration systems including simple, bootstrap, and regenerative systems. Dry air rated temperature (DART).	6
5	Refrigerants: Classification and properties of refrigerants, desirable characteristics, primary and secondary refrigerants. Environmental issues related to refrigerants including ODP and GWP, eco-friendly refrigerants,	4

	refrigerant selection criteria, and applications in refrigeration and air-conditioning systems.	
6	Psychrometry: Properties of moist air, psychrometric processes, psychrometric chart and its applications. Analysis of air-conditioning processes including heating, cooling, humidification, dehumidification, and mixing of air streams, comfort chart.	6
7	Air-conditioning systems: Cooling and heating loads calculations, Apparatus Dew Point and By-pass factor of cooling coils, window, split and central air-conditioning systems.	8

Text Books:

- | | | | |
|---|------------------------------------|----------------|-----------------------|
| 1 | Refrigeration and Air-conditioning | C.P.Arora | Tata McGraw-Hill |
| 2 | Refrigeration and Air-conditioning | Manohar Prasad | New Age International |

References:

- | | | | |
|---|-------------------------------------|--------------------------------|--------------------------------|
| 1 | Refrigeration and air conditioning, | W. F.Stoecker, and J. W. Jones | Mc GrawHill Book Co, New York. |
| 2 | Principles of refrigeration | Roy J Dossat | Prentice Hall |
| 3 | Refrigerant Tables and Charts | Banwait & Laroia | Birla Publications. |

Module	Name of Experiment	Duration
1	Study and Performance analysis of vapour compression refrigeration system	2
2	Study and Performance analysis of Triple fluid vapour absorption system	2
3	Study and Performance analysis of vortex tube refrigerator R434	2
4	Study and Performance analysis of heat pump trainer	2
5	Study and Performance analysis of different types of psychrometers	2
6	Study and Performance analysis of air-conditioning unit.	2
7	Study and performance analysis of Ice-plant.	2
8	Evacuation and charging of a vapour compression refrigeration system	2
9	Analysis of vapour compression cycle using cool pack software	2
10	Analysis of vapour compression cycle using open-source coding platform	2
11	Load calculation of building and energy analysis using E-Quest software package	2

Text Books:

- | | | | | | |
|---|-------------------------------|-----|------|----------------|-----------------------|
| 1 | Refrigeration
conditioning | and | Air- | C.P.Arora | Tata McGraw-Hill |
| 2 | Refrigeration
conditioning | and | Air- | Manohar Prasad | New Age International |

Course Code: ME15XXXX	Project	Credits: 0-0-4:2
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Pre-requisites: Knowledge of various subjects studied.

Course Outcomes:

S.N.	Outcomes
CO1	Able to identify need and define problem.
CO2	Apply the knowledge acquired to solve relevant engineering problems.
CO3	Analyse real world engineering problems.
CO4	Evaluate the ideas obtained through analysis.
CO5	Create a prototype or model for the solution to the problem.
CO6	Present the same to the society.
CO7	Project management and finance learning

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Identify the need, define problem, go through literature, and find if solution to the problem is available and identify the shortcomings of existing solutions or gap.	12
2.	Define objectives and prepare work plan. Devise the methodology if not available for executing the plan.	8
3.	Execute the ideas for the problem undertaken.	4
4.	Design/simulate and evaluate the solution	12
5.	Develop/fabricate.	16
6.	Make it in presentable/usable form to the society. Write a report for the whole project.	12

Semester VI

Course Code: ME15XXX	Finite Element Analysis	Credits: 3 -0 -2:4
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Prerequisites: Engineering Mathematics, Heat transfer, Mechanics of materials

Course Outcomes:

	Outcomes
CO1	Understand FE formulations of 1D Problems such as Axial Elastic Deformation of BARS and Axial Heat Transfer in FINS
CO2	Understand FEA of plane truss structure and plane beam bending problems
CO3	Understand FE formulations of 2D Plane and Axisymmetric thermal and elasticity problems
CO4	Understand FEA of elasticity and thermal practical problems using professional software

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1	Introduction of FEM with historical background and engineering applications; Step by Step procedure for FE Formulations; FEA of 1D Problems: Discretization and Interpolation with Linear and Quadratic element; Assembly procedure; Solution procedure with Imposition of boundary conditions; Rayleigh-Ritz Potential Energy and Galerkin's weighted Residual Approaches of FE formulations for Axial Elastic Deformation of BARS-Stress Analysis and Axial Heat Transfer in FINS	12L
2	FEA of Plane Truss Structure: Local and global coordinate system of truss element, Element stiffness matrix derivation using Rayleigh-Ritz Potential Energy Approach; Stress Calculations; FEA of Plane Beam Bending: Total Potential Energy Functional for Beam Element and Derivation of Finite Element Equations for linear beam element; Post processing for Shear force and Bending moment calculations	9L
3	FEA of 2D and Axisymmetric Problems: Discretization and Interpolation with Isoparametric mapping concept; Derivation of Elemental Equations using Galerkin's Weighted Residual Approach for 2D plane and Axisymmetric thermal problems; Computer aided assembly and solution with imposed boundary condition; Derivation of Elemental Equations using Rayleigh-Ritz Potential Energy Approach for 2D plane stress/strain and axisymmetric elasticity problems; Computer aided assembly and solution with imposed boundary conditions; Types of 3D elements and its application for stress and thermal analysis	15L

4	Practical Class: Professional Software based FEA: 1. Demonstration of FE modelling practice for different types of solids using professional software 2. Demonstration of Pre-processing, solution and post-processing using any commercial FE software 3. FEA of few problems of plane truss structure with different types of loading 4. FEA of few problems of plane beam with different types of loading 5. FEA of a plate as Plane strain/stress problems 6. FEA of a pressure vessel problem 7. FEA of 2D thermal problems of manufacturing 8. FEA of Axisymmetric thermal problems of manufacturing 9. FEA of 2D Plane and axisymmetric problems for thermal stresses 10. FEA of 3D thermal and structural problems	2X10=20P
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Text Books:

1. Introduction to Finite Elements in Engineering by Chandrupatla and Belegundu
2. The Finite Element Method in Engineering by S.S. Rao
3. A First Course in the Finite Element Method by Daryl Logan

Reference Book:

4. An Introduction to Finite Element Method by J.N. Reddy
5. Concepts and Applications of Finite Element Analysis by R.D. Cook, D.S. Malkus, M.E. Plesha, and R.J. Witt
6. The Finite Element Method: Its Basis and Fundamentals (6th Ed) by O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu

Course Code: ME16XXX	Automobile Engineering	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Engineering mechanics, Engineering Materials.

Course Outcomes:

CO1	Students will be able to understand the different types of auto vehicles and transmission system.
CO2	Students will be able to acquire knowledge on the steering system and suspension system.
CO3	Students will be able to acquire knowledge of braking system, wheels and tyre assembly.
CO4	Students will be able to understand the control systems of an automobile and basics of EV's.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to Auto Vehicles: History of automobile, Classification of automobiles, Types of chassis layout and type of drive, Types of chassis- fully forward, Truck or bus chassis, two and three-wheeler chassis layout.	6
2	Power Transmissions: (Manual, Semi-automatic and Fully Automatic) Clutches and its types, Gear Box and its types, Fluid Couplings, Torque converters, Semi-Automatic and Automatic Transmission, Continuous Variable Transmission (CVT), Telescopic joint and Propeller Shaft, Differential and its types, Axles and its types and Traction Control.	10
3	Steering and Suspension System Steering linkages, functions of steering mechanism, steering gear box types, wheel geometry, and power steering systems. Suspension geometry, Dependent and independent suspension systems, coil and leaf spring suspension, Shock Absorbers and Torsion Bar	8
4	Braking System and Wheels and Tyre Assembly: Mechanical Brakes, Hydraulic Brakes, construction and operation of Anti-lock Brake System (ABS), Pneumatic Brakes and Vacuum Brakes and hand brake.	8

	Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.	
5	Automotive Controls and Introduction to EV's: Sensors and Actuators, Electronics Control Unit (ECU), Advanced Driver Assistance System (ADAS), EV architecture and layout, Overview of Battery management systems.	6

Self-Study: Vehicle body styles, Aerodynamic considerations in body profiling, resistance calculation. Road Safety, seat belt, air bags, bumper, anti-lock brake system (ABS), wind shield, suspension sensors, traction control, mirrors, central locking and electric windows, speed control. Lubricating system and cooling systems, Air-conditioning and Lighting system in automobile and exhaust System.

Text Books:

- | | | |
|---|-----------------------------|---|
| 1 | The Motor Vehicle | Newton & Steeds & Butterworth-Heinemann
Garrot |
| 2 | Advanced Vehicle Technology | Heinz Heisler
Butterworth-Heinemann |
| 3 | Automotive Engineering | David A Crolla.
Elsevier collection |

References:

- | | | | |
|---|---------------------------|-----------------|-----------------------------|
| 1 | Tire and Vehicle Dynamics | Hans B Pacejka | Elsevier Ltd |
| 2 | Road Vehicle Dynamics | Rao V Dukkipati | Springer |
| 3 | Ground Vehicle Dynamics | Werner and Karl | Berlin Heidelberg |
| 4 | Theory of Ground Vehicles | Wong H. | McGraw Hill, Second edition |

Course Code : ME16XXX	Metrology and Quality Engineering	Credits: 3 -0 -0:3
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Pre-requisites: Engineering Mathematics, Industrial Engineering and Production Management

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of engineering metrology, quality control and quality management
CO2	Understand the principles of Measurement and Gauging for Dimension, Form, and Finish
CO3	Apply principles of statistics and probability for quality control by variable and attribute control charts
CO4	Apply principles of statistics and probability for quality control by single and double sampling plans and understanding the basic concept of Six Sigma and its variants

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	Hrs
1.	<i>Introduction of Metrology</i> -Definition and Type of Metrology; Accuracy and Precision; Repeatability and Reproducibility; Inspection by Measurement Vs Inspection by Gauging; <i>Introduction of Quality</i> -Definition and Dimensions of Quality; Design Quality and Conformance Quality; Quality Cost and Quality Value; Quality Control Vs Quality Management	3L
2.	Inspection by Measurement and Gauging: <i>Dimensional Measurements</i> using Vernier and Micrometer Instruments, Sine bar and Measuring Gauges; Miscellaneous Taper Measurements; <i>Form Measurements</i> : Concept of geometrical forms as Straightness and Flatness; Squareness and Parallelism; Roundness and Cylindricity and measurement using Auto-Collimator, Optical Flats and Talyrond; <i>Finish Measurements</i> : Roughness conditions (Lays, Flaws, Waviness and Roughness), parameters (R_z , R_m , R_q and R_a) and measurements with Stylus and Optical Instruments; Metrology of Screw Threads and Spur Gears; Tolerances and Analysis in Assembly; System of Limits and Fits; Interchangeability and Selective Assembly; Types of Limit Gauges; Design of Limit Gauges	18L
3.	Quality Control using Control Charts: Relation of Average and Standard Deviation with Normal Curve; <i>Control Charts for Variables</i> -X bar and R chart; X bar and S chart; Process capability, Process spread and Specification limits; <i>Control Charts for Attributes</i> -P chart and NP chart; C chart and U chart; Principles and Applications of Group control charts and CUSUM charts; Principle and	6L

	Applications of Six Sigma quality management	
4.	Quality Control using Sampling Plans: Need and Economics of sampling; Acceptance Sampling and Poisson Probability Distribution; Methods of Sampling; Operating Characteristic (OC) Curve and Quality Indices-AQL, LTPD, and AOQL; 100% Inspection, Acceptance Sampling Analysis using - Single Sampling, Double Sampling, Multiple Sampling and Sequential Sampling Plans.	6L

Text Books:

1. A Textbook of Engineering Metrology by I.C. Gupta
2. Introduction to Statistical Quality Control by D.C. Montgomery

Course Code: ME16XXX	Mechatronics	Credits: 3-0-2: 4
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Pre-requisites: Basic knowledge of Control Systems,

Course Outcomes:

CO1	Students will understand and identify the different components of a mechatronics system.
CO2	Students will be able to draw the equivalent mechatronics model for mechanical systems and study/analyse the mechanical and electro-mechanical systems.
CO3	Students will be able to identify and classify commonly used sensors for electro-mechanical systems.
CO4	Students will be able to prepare the PLC programming by using Ladder diagram for different mechatronics systems and analyse the functionality. To get familiar with the latest Improvements in mechatronics systems.

Course Articulation Matrix:

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

Units	Details	Nos. of Hrs
1	Introductions, Fundamental concept of Mechatronics systems, Past, Present & Future; definitions and concepts. Conventional vs. Mechatronics Systems. Need of Mechatronics in Mechanical Engineering. Classification of Mechatronics etc.	06
2	Components of Mechatronic systems, Modelling of different Mechatronics systems. Mechatronics model and block diagram of different mechanical systems.	08
3	Sensors and transducers with special reference to Mechatronics, modeling of commonly used sensors, their design concepts etc.	08
4	Signals system and actuating devices, Stepper motors, Servo motors, Microprocessor based control of electrical motors, Real time interfacing. Application of Mechatronics in manufacturing and automation.	08
5	Advance Mechatronics systems such as CNC machines, Industrial Robotics, SCADA, PLCs systems, Ladder Diagram Programming of commonly used mechatronics systems.	08

Text Books:

1. Mechatronics by W. Bolton, Pearson Publication McGraw Hill.

References

1. Mechatronics by Dan Neculescu, Pearson Publication
2. Mechatronics by David G. Alciatore and Michael B. Hstand, TMH Edition.
3. Mechatronics by M. D. Singh and Joshi J. G.
4. Mechatronics System Design by Devdas Shetty and Richard A. Kolk.

LAB COMPONENT

Module	Name of Experiment	Duration
1	Study and operation of Mechatronics sensor kit.	03
2	Operation of Hydraulic actuators in different operating conditions.	03
3	Operation of Electro pneumatic system with Programmable Logic Controller (PLC).	03
4	Study and operation of Proportional-Integral-Derivative (PID) controller.	03
5	Control of the DC/Stepper motor at different operating conditions.	03
6	Control of the Vertical take-off and landing (VTOL) system.	03
7	Control of the Rotary Pendulum position.	03
8	Development & programming of Mechatronics systems (Mini Project-I).	18

Reference Books/Manuals:

- 1 Mechatronics by W. Bolton, Pearson Publication McGraw Hill.
- 2 Mechatronics System Design by Devdas Shetty and Richard A. Kolk.
3. Lab Manuals of different mechatronics systems available in Mechatronics Lab

Course Code: ME16XXX	Project and project based colloquium	Credits: 0-0-4: 2
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Pre-requisites: Knowledge of various subjects studied.

Course Outcomes:

S.N.	Outcomes
CO1	Able to select topic of interest and relevant to present scenario.
CO2	Understand the latest development on the topic, identify need and define problem.
CO3	Apply understanding to the problem.
CO4	Analyse the problem and propose solution.
CO5	Project management and finance learning

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	Period
1.	Select project based topic to work upon.	1 st to 2 nd week
	Present the same in front of the committee to finalise the topic.	3 rd to 4 th week
2.	Collect the study materials on the topic selected with latest development and study them. Find the problem to work. Define objectives and present the work plan to the committee and get feedback. After getting feedback from the committee modify the objective and work plan accordingly if any.	5 th to 8 th week
3.	Work on objectives. Present the work progress. Get feedback from the committee.	9 th to 11 ^h week
4.	Work on remaining objectives and complete the work.	12 th to 13 th week
5.	Finally present the completed work and submit first draft of the report.	14 th to 15 th week
6.	Submit the final report.	16 th week

Semester VII

Course Code: ME17XXX	AI in Mechanical Engineering	Credits: 3-0-2:4
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Pre-requisites: Knowledge of probability, calculus and linear algebra

Course Outcomes:

S. No.	Outcomes
CO1	Understand the fundamental concepts of Artificial intelligence and Machine Learning.
CO2	Develop regression and classification models for engineering datasets.
CO3	Implement supervised and unsupervised learning algorithms.
CO4	Apply deep learning methods to mechanical engineering problems.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Artificial intelligence (AI) and Machine Learning (ML), Industrial applications: predictive maintenance, robotics, digital twins. AI ethics and reliability in engineering systems. Types of learning: Supervised learning, Unsupervised learning, Reinforcement learning, Introduction to probability and statistics, Sample and population properties, Engineering datasets and pre-processing. Applications: sensor logs, vibration signals, acoustic emissions, thermal profiles, noise filtering, and signal pre-processing.	4
2.	Covariance and correlation matrix, Linear regression, Model parameterisation and fitting, Coefficient of determination (R^2), Confidence intervals and hypothesis testing, Logistic regression, Softmax regression, Loss functions, Statistical basis of loss functions. Applications: Predicting material fatigue life, estimating heat transfer coefficients, and modelling tool wear progression using regression.	6
3.	Overfitting and underfitting, Bias-variance tradeoff, Regularisation techniques: Ridge Regression, LASSO. Training of ML models, Gradient Descent Algorithm, Stochastic Gradient Descent. Variants: Momentum, AdaGrad, RMSProp, Adam. Cross-validation methods: k-fold cross-validation, Leave-one-out cross-validation. Hyperparameter tuning: Grid search, Randomised search, Bayesian optimisation.	8

	Applications: Regularised regression to predict remaining useful life of bearings from vibration spectra without overfitting sparse sensor data, optimizing manufacturing process parameters (e.g., feed rate, cutting speed).	
4.	Unsupervised learning concepts, Singular Value Decomposition (SVD), Principal Component Analysis (PCA). Clustering algorithms: K-means clustering, Density-based clustering (DBSCAN). Support Vector Machines (SVM). Applications: Reducing CFD data using PCA, clustering acoustic emissions for fault categorization in rotary machinery, and classifying manufacturing defects using SVM.	8
5.	Introduction to Neural Networks, Feed-forward neural networks, Backpropagation, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Physics-Informed Neural Networks (PINNs). Applications: Surface defect detection on assembly lines using CNNs, Remaining Useful Life prediction from time-series vibration data using RNNs, and solving heat equations or solid mechanics problems using PINNs.	10

Laboratory Exercises		
Experiment No.	Name of Experiment	No. Hrs
1.	Python basics and NumPy/Pandas	4
2.	Regression model implementation	2
3.	Classification using logistic regression	2
4.	PCA and clustering	2
5.	SVM implementation	2
6.	CNN-based defect classification	4
7.	PINN implementation for simple PDE	4

Text Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Géron, Aurélien, Third Edition, O'Reilly Media, Inc, 2022.
2. Pattern Recognition and Machine Learning, Bishop, Christopher M., and Nasser M. Nasrabadi, Vol. 4, no. 4. New York: Springer, 2006.
3. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, The MIT Press, 2016.
4. Python Machine Learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow, Sebastian Raschka and Vahid Mirjalili, Packt Publishing, 2019.
5. Introduction to Statistical Learning: With applications in Python, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Jonathan Taylor, Springer Nature, 2023.

References:

1. Introduction to deep learning using R: A step-by-step guide to learning and implementing deep learning models using R, Beysolow II, Taweh, Springer, Berkeley, CA, A press, 2017.
2. Machine Learning for Core Engineering Disciplines, <https://nptel.ac.in/courses/127108778>
3. Inverse Methods in Heat Transfer, <https://nptel.ac.in/courses/112106316>
4. Physics-informed machine learning, George Em Karniadakis, Ioannis G. Kevrekidis, Lu Lu, Paris Perdikaris, Sifan Wang, and Liu Yang. Nature Reviews Physics 3, no. 6 (2021): 422-440

Course Code: ME17XXX	Machine Tools and CAM	Credits: 3-0-2:4
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Pre-requisites: Manufacturing science and Technology- I, Manufacturing science and Technology- II, Robotics and Mechatronics.

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand the structure of Machine Tool Structure and their design
CO2	Students will be able understand the features of CNC machines and tooling of CNC machine tools.
CO3	Students will be able to learn and write manual part programming, automated part programming for CNC turning and CNC machining center. Also Students will be able to understand the automatic part programming through CAD/CAM software.
CO4	Students will be able to write and implement part programming on CNC lathe and CNC milling machines.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Machine Tools- Classification and Components of Machine Tools, machine tool structure; Drives and Transmission, Classification of Speed and Feed Boxes, Design of Guideways, Bed, Column and Spindle.	14
2.	Computer Numeric Control (CNC) technology: Introduction to CNC; Components of CNC systems, NC co-ordinate systems, CNC motion control systems, Actuation system, open loop and close loop CNC.	04
3.	CNC – Concepts CNC, machining centre and DNC; CNC and DNC efficiency; Adaptive Control, Tooling for CNC	05
4.	CNC Part programming methods – Introduction to G and M codes; Manual programming methods, Computer-assisted programming methods; APT (Automatically Programmed Tool) and Part Program generation through CAD/CAM software.	03

5.	CNC Part Programming: Tool motion commands; Tool Length Offset; Cutter radius compensation commands, fixed cycle commands, scaling, rotation, mirror image, Sub routines, Do loop features, Macros programming etc. Case study/ term project	08
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Text Books:

- | | | | |
|--|-------------------|-----------------------|------|
| 1 Machine Tool Design and Numerical Control | N. K. Mehta | McGraw Hill Education | 2017 |
| 2 CAD/CAM/CIM Principles and Applications | P. N. Rao | McGraw Hill Education | 2017 |
| 3 Automation, Production Systems and Computer Integrated Manufacturing | Mikell P. Groover | Prentice Hall India | 2015 |

References:

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|--|--------------------------------|--------------------------|------|
| 1 Principles of Machine Tools | G. C. Sen and A. Bhattacharyya | New Central Book Agency | 2009 |
| 2 Numerical Control and Computer Aided Manufacturing | Kundra, Rao and Tiwari | McGraw-Hill Book Company | 1987 |
| 3 Computer Control of Manufacturing Systems | Yoram Koren | McGraw-Hill Book Company | 2017 |
| 4 CNC Machining Technology - Vol. 1, 2 & 3 | G. T. Smith | Springer-Verlag | 1993 |

Machine Tools and CAM Lab

Unit	Details	No. Hrs
1	Study of structures and components of machine tools: Lathe, Milling and Drilling Machines	2
2	Study of guide ways, speed and Feed mechanisms of machine tools: Lathe, Milling and Drilling Machines	2
3	Study of HMT CNC TRAINMASTER Lathe and Mach3 controller/ Denford ORAC CNC Lathe and Mach3 controller and study of CNC tooling for Lathe	2
4	Part programming using GM codes for lathe machine (2 programs) and verification on HMT T70/ Denford ORAC CNC Lathe through Mach3 controller Program1: Facing, Step Turning, Taper turning, Profile Turning, boring Program2: Threading, use of canned (fixed) cycles in lathe operations	4
5	Study of PMT CNC PND-320 turning centre and features of Fanuc O-T controller	2
6	Study of various types of Automatic Tool changers (Fitted in PND-320, Denford ORAC lathe and Denford TRIAC Milling)	2
7	Study of HMT CNC TRAINMASTER Vertical Machining Centre and Mach3 controller/ Denford TRAIC CNC milling machine and Mach3 controller and study of CNC tooling for machining center	2

- | | | |
|---|--|---|
| 8 | Part programming using GM codes for Drilling/ Milling (2 programs) and verification on software and HMT VMC200/ Denford Traic CNC milling machine through Mach3 controller
Program1: Drilling, slot milling, pocket milling
Program2: Profile milling (with tool radius compensation), use of canned (fixed) cycles in milling/drilling operations | 4 |
| 9 | Automatic generation of G-M code from CAD/CAM software and a case study | 2 |

References:

- | | | |
|---|--|-------------------------|
| 1 | Operating and instruction manual of HMT T70 train master lathe | HMT |
| 2 | Operating and instruction manual of HMT train master vertical machining centre (VMC200) | HMT |
| 3 | Operating and instruction manual of PMT PND 320 CNC turning centre and Fanuc-OT programming manual | PMT Automatics,
Pune |
| 4 | Mach3 programming manual for CNC Lathe and milling machine | Artsoft |

Course Code: ME17XXX/ME17XXX	Vocational Training/STTP	Credits: 0-0-6:3
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Prerequisites: Knowledge of the subjects studied

Course Outcomes:

S.N.	Outcomes
CO1	Able to get exposure of practical aspect of engineering.
CO2	Able to relate the knowledge acquired to the real life application.
CO3	Learn to apply the knowledge to actual engineering problem.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Course Code: ME17XXX	Major Project	Credits: 0-0-2:02
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Pre-requisites: Knowledge of the subjects studied

Course Outcomes:

S.N.	Outcomes
CO1	Identify the practical needs of the society and formulate the problems.
CO2	Apply the knowledge of the subject on the problems.
CO3	Analyze problems undertaken and provide solution for the same.
CO4	Project management and finance learning

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Semester VIII

Course Code: ME18XXX/ME18XXX	Major Project/ Internship	Credits: 0-0-16:08
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Pre-requisites: Knowledge of the subjects studied

Course Outcomes:

S.N.	Outcomes
CO1	Student will be able to apply the knowledge of the subjects studied to solve and analyze the real world problems.
CO2	Apply the knowledge of the subjects studied to fabricate or model the solutions for the real world problems.
CO3	Student will be able to interact and work coherently in a team environment, and manage projects in multidisciplinary environments.
CO4	Student will be able to make presentation and write report effectively.
CO5	Project management and finance learning

Course Articulation Matrix (CO-PO-PSO Mapping):

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

List of Electives and Minors: B. Tech. (Mechanical Engineering)

IV Semester: Core Elective Courses - 1

Course Code: ME14XXX	Design and Analysis of Experiments	Credits: 3-0-0-3
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Pre-requisites: Design Thinking and Product Visualization

Course Outcomes

CO1	Understand the principles of experimental design
CO2	Apply ANOVA techniques to engineering data
CO3	Design and analyze engineering experiments and evaluate interaction effects using factorial designs
CO4	Optimize engineering processes using Taguchi and RSM; Use statistical software for DOE applications

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1	Fundamentals of Experimental Design: Introduction to Design of Experiments (DOE); Importance of DOE in mechanical engineering; Basic principles: Randomization, Replication, Blocking; Experimental errors and precision; Planning and conducting experiments; Engineering applications of DOE	6
2	Analysis of Variance (ANOVA): Introduction to ANOVA; One-way ANOVA; Two-way ANOVA; F-test and hypothesis testing; ANOVA table construction and interpretation; Applications in machining and manufacturing experiments	6
3	Single Factor Experimental Designs: Completely Randomized Design (CRD); Randomized Block Design (RBD); Latin Square Design (LSD); Assumptions, merits, and limitations; Comparison of designs; Industrial case studies.	6
4	Factorial Experiments and Taguchi Method: Introduction to factorial experiments; (2^2) and (2^3) factorial designs; Main and interaction effects; Confounding and fractional factorial designs; Introduction to Genichi Taguchi methods; Orthogonal arrays; Signal-to-noise ratio	6

5	Regression and Response Surface Methodology: Linear and multiple regression models; Correlation analysis; Response Surface Methodology (RSM); First-order and second-order models; Central Composite Design; Optimization of machining/process parameters	5
6	DOE Applications and Software Tools: DOE applications in: Manufacturing, Thermal engineering, Quality control, Product design; Introduction to software: MATLAB, Minitab, R; Experimental data analysis using software; Mini-project/case study	6

Text Books:

1. Design and Analysis of Experiments, Douglas C. Montgomery, John Wiley & Sons, 2016.
2. Engineering Statistics, Douglas C. Montgomery, George C. Runger, Norma F. Hubele, John Wiley & Sons, 2011.
3. Design and Analysis of Experiments, Angela M. Dean, Daniel Voss, Danel Draguljić, Springer International Publishing AG, 2017.
4. Taguchi Techniques for Quality Engineering, P. J. Ross, McGraw-Hill, 2005.
5. Quality Engineering using Robust Design, Madhav S. Phadke, Prentice Hall, 2008.

References:

1. Experiments: Planning, Analysis, and Optimization, C. F. Jeff Wu, Michael S. Hamada, Wiley, 2009.
2. Introduction to the Design and Analysis of Experiments, Geoffrey M. Clarke, Robert E. Kempson, Wiley, 1996.
3. Product and Process Design for Quality, Economy and Reliability, R. V. Dukkipati and Pradip K. Ray, New Age International, 2005.

Course Code: ME14XXX	Modelling and Simulation in Engineering	Credits: 3-0-0:3
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Pre-requisites: Mathematics I and II, Computer based Mathematical Techniques

Course Outcomes:

S.N.	Outcomes
CO1	To understand the basics of modelling and simulation.
CO2	To understand the concepts and methodologies of modelling.
CO3	To understand the system models and dynamic response of systems.
CO4	To understand the system transfer functions and frequency response.
CO5	To understand the state-space formulation, optimization and implementing the model using software.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: Concept of System and Environment, Stochastic activities, Continuous and Discrete systems, System Modelling, Ways to study a system, Simulation models, Principles of Modelling, Advantages and Disadvantages of Simulation.	4
2.	System simulation: Techniques of simulation, Monte Carlo method, Comparison of Simulation and Analytical methods, Experimental Nature of Simulation, Numerical computation techniques, Progress of a Simulation Study, Feedback systems.	5
3.	System models: Mathematical models, Mechanical system building blocks, Electrical system building blocks, Fluid system building blocks, Thermal system building blocks, Rotational-translational systems, Linearity.	10
4.	Dynamic responses of systems: Modelling dynamic systems, Terminology, First-order systems, Second-order systems, Performance measures for second-order systems.	4
5.	System transfer functions: The transfer function, First-order systems, Second-order systems, Systems in series, Systems with feedback loops, Effect of pole location on transient response, Compensation.	4

6.	Frequency response and State space formulation: Sinusoidal input, Phasors, Frequency response, Modelling in state space.	4
7.	Simulation of Dynamic Systems: Simulation using SIMULINK, Simulation of simple and compound pendulums, Simulation of planar mechanisms.	5
8.	Optimization: Optimal Problem Formulation, Engineering Optimization Problems, Classification of Optimization Algorithms.	4

Text Books:

1. System Simulation, Geoffrey Gordon, Prentice Hall, 1969.
1. Modern Control Engineering, Katsuhiko Ogata, Pearson (Prentice Hall), 2009.
2. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, John Wiley & Sons, 2012.
3. Simulation Modeling and Analysis, Averill M. Law, McGraw-Hill, 2014.
4. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, William Bolton, Pearson Education Limited, 2018.
5. Simulation of Dynamic Systems with MATLAB and Simulink, Harold Klee, CRC Press, 2018.
6. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons, 2019

References:

1. System Dynamics: Modeling, Analysis, Simulation, Design, Ernest Doebelin, CRC Press, 1998.
2. Dynamic Response of Linear Mechanical Systems: Modeling, Analysis and Simulation, Jorge Angeles, Springer, 2012.
3. Mathematical Modeling and Simulation: Introduction for Scientists and Engineers, Kai Velten, Wiley, 2024.
4. Online Course on NPTEL <https://nptel.ac.in/courses/112107214>.
5. https://youtu.be/5GOR0Q5WBOc?si=UtHoWCsvyCzb_mAt.
6. https://youtu.be/SXulwFsKBgg?si=qK_0cRz45lscBit1.

Course Code: ME14XXX	Noise and Vibration	Credits: 3-0-0:3
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Pre-requisites: Basic knowledge of Mathematics, Mechanics of Materials

Course Outcomes:

S.N.	Outcomes
CO1	Understand the concept of noise and vibration in the design of products and systems.
CO2	Understand to formulate the analytical and numerical model for noise and vibration for the system.
CO3	Apply the principles of noise and vibration control in the design of products and systems.
CO4	Analyse and determine the effect of system parameters on noise and vibration.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Random aspects of noise, traffic noise, community noise, automobile noise, jet noise, aircraft noise, Signal Analysis and Fast Fourier Transform (FFT)	4
2.	Sonic bang, acoustic fatigue, industrial noise, noise in piping system.	4
3.	Identification of noise sources and control, Automotive noise control principles, Sound in enclosures, Sound energy absorption, Sound transmission through barriers.	4
4.	Noise control: types and design of exhaust mufflers, sound absorbing materials.	4
5.	Noise measurement and instrumentation, Effect of noise on human beings, auditory/non-auditory effects of noise, Noise standards and limits, Noise standards in India	4
6.	Vibration-Systems with one degree of freedom, Free and forced vibration, torsional vibration. Analysis by Rayleigh's method. Stodola method and	20

	iterative method of Holtzer. Analysis and application of forced vibration in steady state as well as transient state, self-excited vibrations. Free vibrations of systems with several degrees of freedom. Free vibration of elastic bodies, Free longitudinal vibrations of Prismatic bar, orthogonality principle. modal analysis, vibration absorbers, vibration control, case studies, vibration measurement and instrumentation	
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Text Books:

11. Mechanical Vibrations, Singiresu S.Rao, Pearson Education, 2025.
12. Fundamentals of Sound and Vibrations, Frank Fahy and David Thompson, CRC Press, 2015.

References:

1. Noise and Vibration Control, Munjal M L, World Scientific Publishers, 2015.
2. Elements of Vibration Analysis, Leonard Meirovitch, Tata McGrmv- Hill, New York. 1986

Course Code: ME14XXX	Operations Research	Credits: 3-0-0:3
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Pre-requisites: Management Concepts and Applications

COURSE OUTCOME

CO	Outcomes
CO1	Understand the nature, scope and models of Operations Research and distinguish between different types of decision-making environments.
CO2	Formulate real-life decision problems as linear programming models and solve using standard methods such as Simplex and its variants.
CO3	Develop and solve transportation, assignment, sequencing and related models for improving efficiency of industrial and service operations.
CO4	Apply basic game theory techniques to analyse two-person zero-sum games and recommend suitable strategies for decision makers.
CO5	Construct and analyse network models (CPM, PERT and related algorithms) to plan, schedule and control projects.

Course Articulation Matrix

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

Unit	Content	No. Hrs
1	BASICS OF OR – Definition of Operations Research, Characteristics and Scope of Operations Research, Scope of Operations Research in Management, Financial Management, Applications of various OR Techniques, objective of OR, Models in OR.	03
2	LINEAR PROGRAMMING – Introduction, Formulation of Linear Programming Models, The General Linear Programming problem, Canonical and Standard forms of Linear programming Problem, Theory of Simplex Method, Analytical method or Trial and Error Method, The Simplex Method, Artificial Variables Techniques, The Big-M Method, The Two-Phase Method	12
3	TRANSPORTATION MODELS -Introduction of the Model, Definition of the Transportation Model, Matrix Terminology, Formulation and solution of Transportation Models, Variants in Transportation Problems, Additional problems.	10

	ASSIGNMENT MODEL-Definition of the Assignment Model, Mathematical Representation of the Assignment Model, The Hungarian Method for solution of the Assignment Problems, Formulation and solution of the Assignment Models, Variations of the Assignment Problem, The Travelling Salesman Problem. SEQUENCING MODELS - Sequencing problems, Assumptions in Sequencing Problems, Processing n Jobs through two machines, Processing n Jobs through three machines, Processing two Jobs through m Machines, Processing n Jobs through m Machines, Problems related to Sequencing, Minimal Path Problem.	
4	GAME THEORY - Game theory, Formulate two-person zero-sum game, Solve a simple game, Solve mixed strategy games using graphical method and LP, Describe reduction using dominated strategy, Introduce saddle point condition, Additional problems.	06
5	NETWORK ANALYSIS - Network models, Identify the situation in which shortest path algorithm can be used, Identify the situation in which maximal flow algorithm can be used, Draw network diagram, Analyse the network, Identify critical path, CPM, Apply PERT using Optimistic, Most Likely, Pessimistic times of activities, Find the probability of completing the project, Minimal Spanning tree problem, Shortest Route Problem, Maximal flow problem.	06

Text Books:

1. Operations Research: An Introduction, Hamdy A. Taha, Pearson Education, 2022.
2. Operations Research, D S Hira and P K Gupta, S. Chand and Company Limited, 2025.

REFERENCES

1. Introduction to Operations Research, Hillier & Lieberman, McGraw Hill, 2021.
2. Operations Research: Quantitative Techniques for Management, V K Kapoor, S. Chand and Sons, 2014.
3. Operations Research: Theory, Methods, and Applications, S D Sharma, Kedar Nath Ram Nath, 2014.

Course Code: ME14XXX	Solar Energy Systems	Credits: 3-0-0:3
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Pre-requisites: : Engineering Thermodynamics, Heat and Mass Transfer

COURSE OUTCOME

CO	Outcomes
CO1	Understand the basics of solar energy including its production at the Sun, and collection at Earth surface.
CO2	Understand various methods to collect the solar energy and its measurement.
CO3	Apply solar energy to solve various technical problems overcoming their conventional methods for safely realization, betterment of mankind and to protect our planet from effects of climate change such as global warming.
CO4	Analyse the performances of various solar energy applications e.g. Thermal, Photovoltaic and Daylight.

Course Articulation Matrix

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

Unit	Content	No. Hrs
1	Introduction: Energy saving and Protection of Environment, The Sun, The Earth, Solar spectrum. Global warming and it's effect, Importance of Solar Energy. Solar energy systems and It's types: Active and Passive. A brief overview of various applications of solar energy.	04
2	Solar Water Heating: Introduction (need and working principle), Heat and mass transfer mechanism, Types of solar water heating systems, Basic energy balance equations, Efficiency and Performance. Solar Air Heating/Cooling: Introduction (need and working principle), Heat and mass transfer mechanism, Types of solar air heating and cooling systems, Basic energy balance equations, Efficiency and Performance.	04
3	Solar Water Heating: Introduction (need and working principle), Heat and mass transfer mechanism, Types of solar water heating systems, Basic energy balance equations, Efficiency and Performance. Solar Air Heating/Cooling: Introduction (need and working principle), Heat and mass transfer mechanism, Types of solar air heating and cooling systems, Basic energy balance equations, Efficiency and Performance.	06

4	Solar Distillation: Introduction (need and working principle), Heat and mass transfer mechanism, Types of solar distillation systems, Basic energy balance equations, Efficiency and Performance. Solar Passive house: Concept of passive house, Solar architecture, Principles of making a solar passive house. Daylight and its Use.	06
5	Photovoltaics: Introduction, Materials and Doping, Fermi level, p-n junction and its characteristics, Photovoltaic effect, Solar Cell, Module, Array and PV Plant, Solar cell efficiency, Fill factor, Packing factor, Hybrid PV-T applications- a brief study.	06
6	Other applications of solar energy: A brief study of Solar cooking, Solar Aquaculture, Solar Aquaponics, Solar Greenhouse, Solar cooling, Solar Thermal Power Generation plant etc.	04

Text Books:

- | | | | |
|---|------------------------------|-----------------------------|------|
| 1. Solar Energy- Fundamentals, Design, Modeling & Applications | G.N. Tiwari, | Narosa Publications | 2002 |
| 2. Solar Energy | S. P. Sukhatme
J.K. Nayak | McGraw-Hill
Publications | 2017 |
| 3. Solar Photovoltaics: Fundamentals, Technologies and Applications | C. S. Solanki | PHI Publications | 2015 |
| Principles of Solar Energy | Frank Krieth | John Wiley | 1978 |

References:

- | | | | |
|--|---------------------------------------|-----------------------------|------|
| 1. Solar Energy Engineering | S. Kalogirou | Academic Press | 2009 |
| 2. Solar Engineering of Thermal Processes | John A. Duffie,
William A. Beckman | John Wiley,
New York | 2013 |
| 3. Solar Photovoltaic Technology and Systems-A manual for technicians, Trainers and Engineers | C. S. Solanki | PHI Publications | 2013 |
| 4. Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows | D. Bainbridge,
K. Haggard | Chelsea Green
Publishing | 2011 |

Course Code: ME14XXX	Compressible Flow	Credits: 3-0-0:3
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Pre-requisites: Fluid Mechanics, Engineering Thermodynamics

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of Flow Regimes
CO2	Understand the fundamental equations of compressible flows through conservations of mass, momentum and energy
CO3	Apply principles of compressible flows in studying nozzles and diffusers.
CO4	Analyse the role of unsteady shocks in flows with solid boundaries

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Definition of Compressible Flow, Flow Regimes, A Brief Review of Thermodynamics, Aerodynamic Forces on Body.	6
2.	Fundamental conservation equations of mass, momentum and energy, One-Dimensional Flow Equations, Speed of Sound and Mach Number, characteristic and stagnant quantities, Alternative Forms of the Energy Equation, governing equations in quasi one-dimensional flows, area-velocity relations, applications to nozzles and diffusers	12
3.	Normal shock relations, Hugoniot equations, one dimensional flow with heat addition, one dimensional flow with friction.	6
4.	Oblique Shock and Expansion Waves – Introduction, source of oblique shocks, oblique shock relations, supersonic flows over wedges and cones, shock polar, Regular Reflection from a Solid Boundary.	8

5.	Unsteady Wave Motion - Moving Normal Shock Waves, Reflected Shock Wave, Incident and Reflected Expansion Waves.	5
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Text Books:

1. Modern Compressible Flows, John D. Anderson, McGraw Hill, 2003
13. Applied Gas Dynamics, E. Rathakrishnan, Wiley Publications, 2010

References:

1. Fundamentals of Gas Dynamics by Robert D. Zucker and Oscar Biblarz, Wiley, 2019
2. Elements of Gas Dynamics by H.W. Liepmann and A. Roshko, Dover, 1957

Course Code: ME14XXX	Industrial Safety and Reliability Engineering	Credits:3 3-0-0 :3
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Prerequisites: Industrial application and safety Engineering

Course Outcomes:

CO1	Students will be able to understand basic knowledge in failure rate and time between failures.
CO2	Students will be able to formulate the root cause analysis. Explain the different failure distribution and probability plotting techniques.
CO3	Students will be able to analyze and determine the effect of the lifecycle cost and allocation. Express the RBD approach and Fault Tree Analysis.
CO4	Students will be able to predict knowledge on risk assessment techniques. Measure reliability allocations and non-parametric methods.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction, key concepts, terminologies, and safety quantification, safety by design. Hazard identification techniques (e.g., HAZOP, FMEA, etc.). Fault tree and event tree analysis (qualitative and quantitative). Bow-tie and quantitative risk assessment (QRA).	05
2	Safety function deployment, Safety vs reliability – quantification of basic events (repair to failure, repair-failure-repair, and combined processes) Safety vs reliability – quantification of basic events (contd.), Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets) Human error analysis and safety.	07
3	Accident investigation and analysis, Application of virtual reality, OSHAS 18001 and OSHMS. Rules for combining probabilities of events, Definition of Reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables, probability density and distribution functions.	06
4	Hazard rate, derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Bath tub curve. Preventive and corrective maintenance. Modes of failure. Measures of reliability: mean time to failure and mean time between failures.	05

5	Classification of engineering systems: series, parallel and series-parallel systems- Expressions for the reliability of the basic configurations. Reliability evaluation of Non-series-parallel configurations: Decomposition, Path based and cutset based methods, Deduction of the Paths and cut sets from Event tree.	06
6	Approximate system Reliability analysis of Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutset/failure mode approach.	08

Text Books:

- | | | |
|---|---|---|
| 1 | Probabilistic Risk Assessment For Engineering and Scientist | Komamoto and Henley, IEE Press 1995 |
| 2 | Industrial Accident Prevention | Heirich et al. Mc Graw Hill, 1980 |
| 3 | Techniques For safety management –A system Approach | Petersen D, ASSE 1998 |
| 4 | Reliability evaluation of Engineering systems | Roy Billinton and Ronald N Allan, BS Publications |
| 5 | Reliability Engineering | A. Elsayed, Prentice Hall Publications. |

References:

- 1 Reliability Engineering: Theory and Practice Alessandro Birolini, Springer Publications.
- 2 An Introduction to Reliability and Maintainability Engineering Charles Ebeling, TMH Publications.
- 3 Reliability Engineering E. Balaguruswamy, TMH Publications.
- 4 Reliability Engineering Srinath L.S Affiliated East-West Press Pvt Ltd, New Delhi, 1998.
- 5 Reliability and Risk analysis Modarres Maral Dekker Inc. 1993.
- 6 The Reliability of Mechanical system. John Davidson published by the Institution of Mechanical Engineers, London, 1988.
- 7 Introductions to Reliability in Design Smith C.O McGraw Hill, London, 1976.

V Semester: Core Elective Courses – 2 and 3

Course Code: ME15XXX	Energy Management	Credits: 3-0-0-3
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Prerequisites: Engineering Physics, Engineering Thermodynamics

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy conservation opportunities in different sectors of the economy.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	05
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	03
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	05
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	05
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	03

Text Books:

- | | | | |
|---|-----------------------------------|-------------|-------------------------|
| 1 | Energy Systems and Sustainability | Boyle et al | Oxford University Press |
| 2 | Renewable Energy | Boyle et al | Oxford University Press |

References:

- | | | | |
|---|-----------------------------------|-------------------|----------------------------------|
| 1 | Energy efficiency | Eastop and Croft | Longman Scientific and Technical |
| 2 | Bureau of Energy Efficiency (BEE) | Ministry of Power | Government of India |
| 3 | Our Choice | Al Gore | Bloomsbury Publishing |
| 4 | An Inconvenient Truth | Al Gore | Oscar winning documentary |
| 5 | Before the flood | Leonardo DiCaprio | National Geographic documentary |

Course Code: ME15XXX	Optimization Methods in Engineering	Credits: 3-0-0: 3
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Pre-requisites: Mathematics I, Operation Research

Course Outcomes:

S.N.	Outcomes
CO1	To understand the terminology and formulation of optimization problems and solve linear programming problems.
CO2	To formulate and solve constrained single and multi-variable, non-linear optimization problems by hand calculations and software.
CO3	To formulate and solve constrained and specialized multi-variable, non-linear optimization problems by hand calculations and software.
CO4	To formulate and solve multi-variable, non-linear optimization problems using nature inspired optimization methods by hand calculations and software.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction- Terminology, Problem Formulation, Engineering Optimization Problems, Linear Programming- Simplex Method.	4
2.	Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods (Any one), Region Elimination Methods (Any one), Gradient Based Methods (Any one). Problem solving using software.	4
3.	Multivariable Unconstrained Optimization Algorithms: Optimality Criteria, Direct Search Methods (Any one), Gradient Based Methods (Any two), Problem solving using software.	6
4.	Multivariable Constrained Optimization Algorithms: Kuhn Tucker Conditions, Lagrangian Duality Theory, Transformation Methods: Penalty Function Method, Method of Multipliers. Sensitivity Analysis. Problem solving using software.	12
5.	Nature Inspired Optimization Algorithms: Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization.	10

	Advanced Topics: Multi-Objective Optimization, Topology Optimization. Problem solving using software.	
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Text Books:

1. Optimization for Engineering Design, Kalyanmoy Deb, Prentice-Hall India, 2012.
2. Engineering Optimization, Singiresu S. Rao, John Wiley & Sons, 2009.

References:

1. Operations Research, J. K. Sharma, MacMillan India Ltd., 2006.
2. Optimization, Rajesh Kumar Arora, CRC Press Taylor & Francis Group, 2015.
3. Engineering Optimization, A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, John Wiley & Sons, 2006.
4. Introduction to Optimum Design, J. S. Arora, Elsevier, 2016.

Course Code: ME15XXX	Hybrid Electric and Fuel Cell Vehicles	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Energy Conversion Technology

Course Outcomes:

CO1	Students will be able to understand and analyze different types of Fuel cells, its operation, and performance
CO2	Students will be able to quantify fuel cell processing using codes and standards.
CO3	Students will be able to comprehend basic concept of Hybrid and Electric traction.
CO4	Students will be able to understand the need and environmental importance of Hybrid technology and analyze it.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Fuel Cell Technology -Introduction to Electrochemistry, Unit Cells, Fuel cell stacking, Fuel cell Types (Polymer Electrolyte Fuel cell, Alkaline Fuel cell, Phosphoric acid Fuel cell, Molten carbonate fuel cell, and Solid oxide fuel cell), and Timeline of introduction of fuel cell technology in automobiles.	08
2	Fuel Cell Performance -Role of Gibbs free energy and Nernst Potential, Cell Energy balance, Cell efficiency, Performance variables, various mathematical models. Polymer Electrolyte Fuel cell-Cell Components, PEFC system Performance, Alkaline Fuel Cell-Cell component, Performance.	06
3	Introduction to Fuel cell Hybrids: Fuel cell Auxiliary Power Systems, Sample Calculations-Fuel cell Calculations, Fuel Processing Calculations for PEFC, AFC. Fuel cell related codes and Standards	06
4	Hybrid Electric Technology and Electric drive trains -Introduction, History, Environmental importance, Basic concept of Hybrid Traction, Basic concept of electric traction, Introduction of electric components used in electric vehicles. Principles of Hybrid Electric Drive trains, Architectures, Hybrid control Strategies – Parallel Hybrid, Series Hybrid – (Charge Sustaining, Charge Depleting), Low-Voltage Storage System.	08
5	Hybrid Vehicle Technology -Sizing the drive system: Matching the electric machine and the Internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, and supporting subsystems. Energy Management Strategies in hybrid and electric vehicles, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	08

Text Books:

- | | | | |
|---|----------------------------------|---|------------------------|
| 1 | Fuel Cell Technology Handbook | Hoogers, G., Edr. | CRC Press |
| 2 | Fuel Cell Systems Explained | Larminie, J. and Dicks, A. | John Wiley & Sons, Ltd |
| 3 | Vehicular Electric Power Systems | Ali Emadi, Mehrdad Ehsani, John M. Miller | Marcel Dekker, Inc. |

References:

- | | | | |
|---|------------------------------|-------------------------------|---------------------------------------|
| 1 | Fuel Cell Handbook | EG&G Technical Services, Inc. | National Energy Technology Laboratory |
| 2 | Electric and Hybrid Vehicles | Tom Denton | Institute of the Motor Industry |

Course Code: ME15XXX	Product Lifecycle Management	Credits: 3-0-0:3
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Prerequisites: Industrial Engineering and Production Management, Basic knowledge of Design and Manufacturing

Course Outcomes:

CO1	Understand the basics of product life cycle, PLM and PDM, and their role in modern engineering enterprises.
CO2	Describe product development processes and strategies across the life cycle, including new product development and technology forecasting.
CO3	Analyze PLM architectures, product data models, product structures and configuration management in industrial contexts.
CO4	Apply PLM concepts to integrate CAD/CAE/CAM and other enterprise applications, and to support virtual product development and collaboration.
CO5	Evaluate PLM implementation issues, benefits, challenges and metrics through case studies and propose PLM solutions for real industrial scenarios.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to Product Life Cycle and PLM Environment – Product life cycle: stages from concept to retirement; life-cycle views (technical, business, environmental); need for Product Life Cycle Management (PLM) in global competitive markets; definitions and scope of PLM and Product Data Management (PDM); present market constraints, need for collaboration and digitally connected enterprise.	6
2	New Product Development and PLM – Strategies – Basics of product development and product development methodologies; overview of product design and development process; new product development (NPD) phases, gates and decision points; product development planning and management; views of PLM (functional, process, information, lifecycle views); PLM strategies and development.	8
3	PLM / PDM Architectures, Product Data and Configuration Management – PLM/PDM concepts and terminology; components of typical PLM/PDM setup (hardware, software, databases, clients and servers); document management,	8

	versioning and access control; product data models and product structures (BOM, EBOM, MBOM, variant structures); configuration management: baselines, effectivity, change control	
4	Integration of PLM with Engineering and Enterprise Applications – Role of PLM in integrating CAD/CAE/CAM and other engineering tools; associativity between geometry, analysis and manufacturing data; virtual product development tools and digital mock-up; integration of PLM with ERP, MES, CRM and supply chain systems.	8
5	PLM Implementation, Applications and Case Studies – Application of PLM in manufacturing and service industries; typical PLM use cases (change management, portfolio management, regulatory compliance, design reuse, design for X, after-sales support); opportunities and benefits of PLM, overview of PLM and emerging paradigms (Industry 4.0, IoT, Digital Twin, sustainability and life-cycle assessment).	10

Text Books:

1. Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, McGraw Hill, 2020.
2. Product Lifecycle Management: 21st Century Paradigm for Product Realisation, John Stark, Springer London Ltd, 2004.
3. System Lifecycle Management: Engineering Digitalization (Engineering 4.0), Martin Eigner, Springer Vieweg, 2021.

References:

1. Computer- Integrated Design and Manufacturing, David Bedworth, Mark Henderson, Philip Wolfe, McGraw Hill, 2012.
2. The Product Manager's Desk Reference, Steven Haines, McGraw Hill Education, 2014.
3. The Principles of Product Development Flow: Second Generation Lean Product Development, Donald G. Reinertsen, Celeritas Pub, 2009.

Course Code: ME15XXX	Supply Chain Management	Credits: 3-0-0:3
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Pre-requisites: Industrial Engineering, Operation Research

Course Outcome

S. N.	Outcomes
CO1	Understand how each functional component and its processes become one integrated operation to satisfy customer's needs.
CO2	Develop an understanding of how to manage the interaction of business functions across companies in the supply chain.
CO3	Develop an understanding of how to manage the impact of demand on the supply chain and the considerable competitive advantages that can result from managing demand across companies.
CO4	Effectively manage the flow of resources and information among the various partners of the supply chain.
CO5	Develop an understanding of how logistics and supply chain strategies can create value generation and utilise IT applications

Course Articulation Matrix:

CO1	2	3	3	3	3	2	2	2	2	2	3	3	3	2
CO2	1	3	3	3	3	2	3	3	2	2	3	3	3	2
CO3	2	3	3	3	3	3	2	2	2	3	3	3	2	3
CO4	2	3	3	3	3	3	2	2	3	2	3	3	2	3
CO5	1	3	3	2	2	3	2	2	2	2	3	3	3	3

Unit	Content	No. Hrs
1	Basics of Supply Chain: Introduction to Supply Chain Management, Understanding the Supply Chain, Supply Chain Performance: Competitive and Supply Chain Strategies, achieving Strategic Fit and Scope of Strategic Fit	08
2	Design of Supply Chain Drivers: Supply Chain Drivers and Metrics: Drivers of Supply Chain Performance, Framework for structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing and Pricing, Case Study: Seven-Eleven Japan Company, Planning Demand and Supply In a Supply Chain: Demand Forecasting in a Supply Chain, Aggregate Planning in a Supply Chain	08
3	Design of Distribution Network and Network Design: Designing Distribution Networks and Application to E-Business- Role of distribution, factors influencing distribution network design, design options for a distribution network, E-Business and the distribution network, Network	08

	Design in the Supply Chain- Role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions	
4	Role of Information Technology in supply chain, coordination in a supply chain, Bullwhip Effect, Effect on performance due to lack of coordination, obstacles to coordination in a supply chain, Factors influencing logistics and decisions, Benchmarking and performance measurement, Internal Supply Chain Management and its drivers, External Supply Chain Management and its drivers.	10
5	Sustainable Supply Chain Management, Digital Supply Chain Management and Smart Supply Chain Management	04

Text Books:

1. Supply Chain Management: Strategy, Planning & Operations, Sunil Chopra and Peter Meindle, Pearson Prentice Hall Publication, 2019.
2. Supply Chain Management: For Global Competitiveness, B.S Sahay, Laxmi Publications, 2007.

Reference Books:

1. Logistics Management: The Integrated Supply Chain Process, Donald J. Bowersox and David J. Closs, McGraw Hill Education, 2017.
2. World Class Supply Management: The Key to Supply Chain Management, Burt, Dobler and Straling, McGraw- Hill Education, 2002.
3. Supply Chain Management: Theories & Practices, R P Mohanty and S. G Deshmukh, Dreamtech Press, 2005.
4. E-Procurement: From Strategy to Implementation, Dale Neef, Financial Times Prentice Hall, 2001.

Course Code: ME15XXX	Production and Operations Management	Credits: 3-0-0:3
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Pre-requisites: Industrial Engineering, Production Management

Course Outcomes:

S.N.	Outcomes
CO1	Able to understand the concepts of production system, process planning, control of resources and supply chain management using advanced technologies in the context of industrial scenarios.
CO2	Able to run different levels of industrial operations and shop floor management effectively.
CO3	Apply the concepts of modern production technologies and simulations to increase the productivity of the system.
CO4	Identify and analyse the flow of resources and information among the various partners through the knowledge of customer needs.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Production and Process Planning, Aggregate Production Planning- Purpose and Scope, Strategies, Master Scheduling, Bill of Materials and MRP, Forecasting- Time Horizon, Methods, Errors.	07
2.	Capacity Planning, Capacity Strategy, Measuring Capacity, Capacity Decisions, Evaluation Methods, Plant layout- Types of Plant layout, Design of Plant layouts- Product and Process.	07
3.	Production Processes Classification: Flow, Job-Shop, Cellular, Mass. Modern Production Technologies – Group Technology, Process Automation, Advanced Manufacturing Technologies, Smart Manufacturing.	07
4.	Kanban and Pull System, JIT and its benefits, Elements of JIT, Evaluation of JIT production, Bottleneck Scheduling and Theory of Constraints. Simulation Models, Steps in Simulation Modelling, Sample Simulation, Evaluation of Simulation Output.	08

5.	Smart Factory Implementation- Digital transformation roadmap for manufacturing enterprises, Artificial Intelligence (AI) in operations management- Case Studies, Sustainable operations and Green Manufacturing- ESG in Manufacturing, Green Supply chain management- Circular Economy Concepts in Manufacturing, Sustainable Sourcing, Life cycle assessment for product and processes.	07
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Text Books:

1. Production and Operations Management, S.N. Chary, McGraw Hill Education, 2019. 7
2. Production and Operations Management: Concepts, Models, and Behavior, Everett E. Adam, Jr. Ronald, J. Ebert, Pearson Prentice Hall Publication, 1992.
3. Modern Production/Operations Management, Elwood S. Buffa and Rakesh K. Sarin, John Wiley and Sons, 2007.
4. Production and Operations Management, R. Panneerselvam, PHI Learning, 2012.

References:

1. Production and Operations Management: Total Quality and Responsiveness, Hamid Noori and Russell Radford, McGraw-Hill Inc., US, 1994.
2. Operations Management for Competitive Advantage, Richard B. Chase, F. Robert Jacobs, Nicholas J. Aquilano, Irwin Professional Pub, 2005.
3. Production and Operations Management: An Applied Modern Approach, Joseph S. Martinich, John Wiley & Sons, 1996.

Course Code: ME15XXX	Tool Engineering	Credits: 3-0-0:3
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1. **Prerequisites:** Engineering Mechanics, Engineering Materials, Mechanics of Materials

Course Outcomes:

CO1	Students will be able to design jigs and fixtures for the effective use of machining processes on different components
CO2	Students will be able to understand the machine tool structure, guideways, drives and transmissions in machine tools
CO3	Students will be able to select and/or design the cutting tools to manufacture and inspect the geometric features on parts/components.
CO4	Students will be able to understand the design of tools and dies for cutting, forming and drawing operations.

2. **Course Articulation Matrix:**

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

Unit	Details	No. Hrs
1	Jigs and Fixtures: Classification of Jigs and Fixtures, Fundamental Principles of design of Jigs and Fixtures, Location and Clamping in Jigs and fixtures, Simple design for drilling Jigs, Milling fixtures, Indexing Jigs and fixtures, Welding Fixtures, etc.	10
2	Gauges: Classification and Selection of materials for Inspection Tools; Construction, working and design of Limit Gauges, Plug gauges, Snap gauges, and Screw gauges.	04
3	Forming and Cutting Dies: Classification of forming and cutting dies and presses; Construction, working and design of bulk metal deformation dies such as wire drawing dies, Extrusion dies, Forging dies and Rolling dies; Construction, working and design of sheet metal working dies such as Blanking dies, Piercing dies, Bending and Deep drawing dies.	10
4	Cutting Tools: Classification of Cutting Tools; Design of single point tools for Lathes, Shapers and Planers; Design of Inserts, Chip breakers; Design of Multi Point Cutting Tools- Drills, Reamers, Milling cutters, Broaches, Grinding wheels and Taps.	10

Text Books:

1 Tool Design	Donaldson	Tata McGraw Hill
2 Jigs and Fixtures	P. H. Joshi	Tata-McGraw Hill
3 Tool Design	Herman W. Pollack	Prentice-Hall

References:

- | | | | |
|---|--|-----------------------------|---------------------------------|
| 1 | Fundamentals of Tool Design | ASTME | Prentice Hall of India Pvt. Ltd |
| 2 | Principles of Jig and Tool Design | M.H.A. Kempster | English University Press Ltd. |
| 3 | Machine Tool Structures | Koenigsberger
and Tlusty | Kluwer Academic |
| 4 | Geometric Dimensioning and Tolerancing | D. James, and S,
Meadow | Marcel Dekker Inc., |

Course Code: ME15XXX	Experimental Stress Analysis	Credits: 3-0-0:3
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Pre-requisites: Mechanics of Materials, Instrumentation and Process Control, Engineering Materials

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand the different experimental techniques for stress analysis.
CO2	Students will be able to select a suitable method for experimental determination of service stresses for a real-life problem.
CO3	Students will be able to analyze the results obtained from different experimental methods.
CO4	Students will be able to apply the strain gauges/rosettes and measure and analyze strain.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Overview of Experimental Stress Analysis: Stress, Strain and Displacement Fields, Physical Principle of Strain Gauges, Photoelasticity and Moiré, Introduction to Moiré, Brittle Coatings and Holography, Introduction to Shearography, TSA, DIC and Caustics, Fringe Patterns – Richness of Qualitative Information.	10
2.	Transmission Photoelasticity: Introduction to Transmission Photoelasticity, Ordinary and Extraordinary Rays, Light Ellipse, Passage of Light Through a Crystal Plate, Retardation Plates, Stress-optic Law, Plane Polariscope, Circular Polariscope, Determination of Photoelastic Parameters at an Arbitrary Point, Calibration of Photo elastic Materials, Fringe Thinning Methodologies, Fringe Ordering in Photoelasticity	13
3.	Introduction to Three Dimensional Photoelasticity and Digital Photoelasticity: Three dimensional photoelasticity, Stress freezing, Slicing, Application to a complex problem, Integrated photoelasticity, Principle of	7

	optical equivalence. Introduction to digital photoelasticity, Use of colour information for quantitative analysis, Three Fringe Photoelasticity (TFP), Refined TFP (RTFP) to solve slow time variant problems. Paradigm shift in data processing, Processing of intensity data for photoelastic data extraction, Overview of digital photoelasticity, Ten-step method, Understanding phase maps.	
4.	Photoelastic Coatings and Brittle Coatings: Introduction to Photoelastic Coatings, Correction Factors for Photoelastic Coatings, Coating Materials, Selection of Coating Thickness, Industrial Application of Photoelastic Coatings, Calibration of Photoelastic Coatings, Introduction to Brittle Coatings, Analysis of Brittle Coatings	5
5.	Strain Gauges: Strain Sensitivity of a Strain Gauge, Bridge Sensitivity, Rosettes, Strain Gauge Alloys, Carriers and Adhesives, Performance of Strain Gauge System, Temperature Compensation, Two wire and Three-wire Circuits, Strain Gauge Selection, Bonding of a Strain Gauge, Soldering, Accounting for Transverse Sensitivity Effects, Correction Factors for Special Applications, Special Gauges	5

Text Books:

14. Experimental Stress Analysis, J.W. Dally and W.F. Riley, McGraw-Hill, 1991

References:

1. Experimental Solid Mechanics, A Shukla and J.W. Dally, College House Enterprises, LLC, 2017
2. E-Book on Experimental Stress Analysis, K. Ramesh, IIT Madras, 2009. URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm
3. Digital Photoelasticity, K. Ramesh, Advanced Techniques and Applications, Springer, 2000.
4. Springer Handbook of Experimental Solid Mechanics, W.N. Sharpe (Ed.), Springer, 2008.
5. Experimental Stress Analysis, L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Tata Mc Graw Hill, 1984.

Course Code: ME15XXX	Alternative Fuels Technology	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Basics of Internal Combustion Engines

Course Outcomes:

CO1	Students will able to understand about the various alternative fuels available and its properties
CO2	Students will able to determine various properties of bio fuels and their significance in IC engines.
CO3	Student will able to analyze the various gaseous alternative fuels for IC engine applications
CO4	Students will able to explain the concepts of Electric, Hybrid and Fuel Cell Vehicles.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Need for alternate fuel: Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars	8
2	Alcohols as Fuels: Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines.	8
3	Vegetable Oils and Biodiesel as Fuels: Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, preheating Transesterification and emulsification of Vegetable oils - Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines.	6
4	Hydrogen, Biogas, Natural Gas and LPG as Fuels: Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen. Production methods of Biogas, Natural gas and LPG. Properties studies. CO ₂ and H ₂ S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines.	10
5	Electric, Hybrid and Fuel Cell Vehicles: Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles. System	8

	components, Electronic control system – Different configurations of Hybrid vehicles. Power split device. High energy and power density batteries – Basics of Fuel cell vehicles.	
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Text Books:

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|---|---|---|-------------------------------------|
| 1 | Handbook of Alternative Fuel Technologies | Sunggyu Lee James G. Speight Sudarshan K. Loyalka | CRC Press, Taylor and Francis Group |
| 2 | Biodiesel Handbook | Gerhard Knothe, Jon Van Gerpen, Jargon Krah | AOCS Press Champaign |
| 3 | Alternative Fuels: The Future of Hydrogen | Michael F. Hordeski | The Fairmont Press |
| 4 | Hybrid, Electric and Fuel-cell Vehicles | Delmar Cengage Learning | Delmar Cengage Learning |

References:

- | | | | |
|---|---|---|------------------|
| 1 | Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines | Akhilendra Pratap Singh, Dhananjay Kumar, Avinash Kumar Agarwal | Springer |
| 2 | Electric, Hybrid, and Fuel Cell Vehicles | Dr. Amgad Elgowainy | Springer Science |
| 3 | Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.). | | SAE Publication |

Course Code: ME15XXX	Carbon Capture and Hydrogen Technology	Credits: 3-0-0:3
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Pre-requisites: Engineering Thermodynamics, Engineering Chemistry

Course Outcome

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment using hydrogen and carbon capture technologies.
CO2	Use the techniques of energy, emission analysis
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy reduction and opportunities in different sectors of the economy.

Course Articulation Matrix:

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

Unit	Content	No. Hrs
1	An overview of hydrogen technology: Energy vector; hydrogen technology: Applications, Advantages and challenges properties gaseous, liquid and slush hydrogen, isotopes of hydrogen and their uses; ortho-hydrogen and para-hydrogen;	04
2	Production of Hydrogen: Production of Synthesis gas (Steam Reforming, Partial Oxidation, Auto-thermal Reactor); Processing of Synthesis gas (Linde-Bronn Process and l'Air Liquide System), Natural gas decomposition (NGD)	08
3	Different means of storing hydrogen – Overview; compressed gaseous hydrogen storage; metal hydride storage of hydrogen; Cryosorption storage of hydrogen in carbonaceous materials	08
4	Transportation of Hydrogen: Overview of cryogenic liquefaction cycles; maximum inversion temperature; overview of cryogenic liquefaction cycles; Liquefaction of hydrogen, Problems; Ortho-para conversion of hydrogen; Large scale hydrogen production process. Safety issues on hydrogen	08
5	Introduction and Necessity of Carbon capture and storage (CCS): global emissions, climate change, evidence of climate change, Concept of carbon trading, Concept of carbon credit and carbon footprint.	04
6	Introduction to carbon dioxide sequestration: Biological carbon sequestration, Forests and woodlands biological carbon sequestration, Soil biological carbon sequestration, Ocean Biological carbon sequestration, Geological carbon sequestration, Technological Carbon Sequestration, Industrial Carbon Sequestration	08

Text Books:

- 1 Hydrogen Technologies: Production, Transportation, Storage, and Utilization Olayinka I. Ogunsola and Olubunmi M. Ogunsola CRC Press, Boca Raton, 2024
- 2 Carbon Capture Utilization and Storage: Law, Policy and Standardization Perspectives Eduardo G. Pereira, Alberto J. Fossa, and Thomas L. Muinzer Springer Nature Switzerland, Cham, 2025
- 3 Alternative Fuels: The Future of Hydrogen Michael F. Hordeski The Fairmont Press

References:

- 1 Carbon Capture, Storage and Utilization: A Possible Climate Change Solution for Energy Industry Malti Goel, M. Sudhakar, and R. V. Shahi (Eds.), Malti Goel, M. Sudhakar, and R. V. Shahi Published June 25, 2024 by CRC Press
- 2 Cryogenic Systems Randall F. Barron McGraw-Hill Inc., New York, 1967

Course Code: ME15XXXX	Industry 4.0 and IOT	Credits: 3-0-0:3
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Prerequisites: Introduction to Manufacturing, Robotics and Mechatronics

Course Outcomes:

CO1	Understand basic concepts and Business issues of Industry 4.0, Smart Business Transformation.
CO2	Understand the Concepts of Industrial IOT in various sectors, Components of IIOT - Sensors, Interface, Networks, People and Process and role of IOT in manufacturing.
CO3	Understand various system components and architecture of IOT.
CO4	Able to understand sensors, transducers and actuators. Hardwire the sensors with different protocols and Building Automation Controls.
CO5	Learn and understand Opportunities and the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world. Challenges and Benefits in implementing IIOT.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1.	The Various Industrial Revolutions - Digitalization and the Networked Economy - Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0 Comparison of Industry 4.0 Factory and Today's Factory - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation	6
2.	Internet of Things (IoT) and Industrial Internet of Things (IIoT) and Internet of Services. Components of IIOT - Sensors, Interface, Networks, People & Process, IOT Market, Trends and future Real life examples, Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining and Manipulation; Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools.	12
3.	Overview of IOT components, Various Architectures of IOT and IIOT, Advantages and disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT.	6
4.	Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT, Various types of sensors, Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial and Parallel, Ethernet, Building Automation Controls Network (BACnet), Current, M2M.	10
5.	Opportunities and Challenges - Future of Works and Skills for Workers in the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world Application of	6

	IIoT: Smart Metering, e-Health Body Area Networks, City Automation, automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector. Challenges and Benefits in implementing IIOT - Smart Manufacturing - Smart Devices and Products - Smart Logistics - Smart Cities - Predictive Analytics.	
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Text Books:

1. Introduction to IoT. Sudip Misra, Anandarup Mukherjee, Arijit Roy, Cambridge University Press, 2022.
2. Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications. Daniel Minoli, John Wiley & Sons, 2013

References:

1. The Internet of Things: Connecting Objects to the Web, Hakima Chaouchi, Wiley Publications, 2017.
2. Internet of Things Applications: From Research and Innovation to Market Deployment, Ovidiu & Peter, River Publishers, 2014.
3. The Internet of Things: Key Applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi, Wiley Publishers, 2011.
4. Introduction to Industry 4.0 and Industrial Internet of Things, Sudip Misra, IIT Kharagpur.

Course Code: ME15XXX	Condition Monitoring and Diagnostics	Credits: 3-0-0:3
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Pre-requisites: Basic knowledge of science and engineering, Instrumentation and Process control

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of condition monitoring and diagnostics of the systems.
CO2	Understand to select appropriate condition monitoring and diagnostics technique for a given system/plant.
CO3	Apply principles of data acquisition, signal processing, noise filtration on the data acquired from the system.
CO4	Analyse the data and identify the faults in the system.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Principles of Maintenance: Reactive Maintenance, Preventive Maintenance, Predictive Maintenance, Enterprise Resource Planning, Bath Tub Curve, Failure Modes Effects and Criticality Analysis (FMECA)	5
2.	Digital Signal Processing: Classification of Signals, Signal Analysis, Frequency Domain Signal Analysis, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Signal Demodulation, Cepstrum Analysis, Artificial Intelligence, ML, Digital Twin Framework, Case studies.	8
3.	Vibration Monitoring: Principles of Vibration Monitoring, Misalignment	8

	Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Unbalanced Shaft, Looseness, Rub, Bearing Defects, Gear Fault, Faults in Fluid Machines, Case studies.	
4.	Electrical Machinery Faults: Construction of an Electric Motor, Faults in Electric Motor, Fault Detection in Electric Motors, MCSA for Fault Detection in Electrical Motors, Instrumentation for Motor Current Signature Analysis, Fault Detection in Mechanical Systems by MCSA, MCSA for Fault Detection in any Rotating Machine, Fault Detection in Power Supply Transformers, Fault Detection in Switchgear Devices, Case studies.	5
5.	Thermography and Wear Debris Analysis: Thermal Imaging Devices, Use of IR Camera, Industrial Applications of Thermography, Applications of Thermography in Condition Monitoring, Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis, Case studies.	5
6.	Machine Tool Condition Monitoring: Tool Wear, Sensor Fusion in Tool Condition Monitoring, Sensors for Tool Condition Monitoring, A Tool Condition Monitoring System	5

Text Books:

15. Machinery Condition Monitoring: Principles and Practices, Mohanty, A. R, Taylor and Francis, CRC Press, 2015.

References:

11. Mechanical fault diagnosis and condition monitoring, Collacott, R.A. Springer, 1977.
12. Handbook of condition monitoring, Davis, A. Springer, 1998.
13. Machinery malfunction diagnosis and correction, Davis, A. Eisenmann, R. C, Prentice Hall, 1997.
4. Practical Plant Failure Analysis, A Guide to Understanding Machinery Deterioration and Improving Equipment Reliability, Sachs, P. E., Taylor and Francis, CRC Press, 2020.
5. Machinery Fault Diagnosis and Signal Processing: https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_me41

Course Code: ME15XXX	Ergonomics	Credits: 3-0-0:3
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Pre-requisites: Industrial design Engineering Production Management

Course Outcomes:

S.N.	Outcomes
CO1	Apply the physical ergonomics concepts for the product improvement.
CO2	Apply ergonomics concepts for the design of work space and work environments.
CO3	Understand the human information processing and apply these principles for the product interface design.
CO4	Apply human factors in product design for enhanced safety.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to ergonomics and relevance to design, Anthropometric measures and use of anthropometric data.	6
2.	Physiology, Biomechanics, Kinesiology, Work-related musculoskeletal disorders, Case studies.	8
3.	Workspace Design: Postural triangle, design for standing operator, design for sitting operator, design for hand use, design for foot operation, Case studies.	8
4.	Manual material handling, Hand tool design, Human information processing, Case studies.	8
5.	Design of controls and displays, Graphic-user interface, Tactile interface, Human Error, Accidents, and Safety, Human Factors in Systems Design, Case studies.	8

Text Books:

3. Introduction to Human Factors and Ergonomics, Bridger, R. S., CRC Press, 2025.
4. Ergonomics - How to design for ease and efficiency, Kroemer, K., Kroemer, H., and Kroemer-Elbert, K. E., Prentice Hall, 2000.
5. Human-Computer Interaction: A Compact Reference for Practitioners, Dix, A., Finlay, J., Abowd, G. D. and Beale, R., Pearson Education, 2003.
6. Ergonomics and safety in hand tool design, Cacha, C. A., CRC Press, 1999.

References:

7. Production Ergonomics, Cecilia Berlin, Ubiquity Press London, 2017.
8. Ergonomic Workplace Design for health, wellness, and productivity, Alan Hedge, CRC Press, 2017.
9. Ergonomics in the Automotive Design Process, 1st edition, Vivek D. Bhise, CRC Press, 2012.
10. Ergonomics for beginners: Industrial design perspective, <https://nptel.ac.in/courses/107103004>
11. Ergonomics in Automotive Design: <https://nptel.ac.in/courses/107103084>

Course Code: ME15XXX	Design for Manufacturing and Assembly	Credits: 3-0-0:3
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Pre-requisites: Workshop and Product Realization, Manufacturing Science and Technology I and II.

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand the significance of Design for Manufacture and Assembly.
CO2	Students will be able to apply the concept of DFM for casting and machining
CO3	Students will be able to apply the concept of DFM for forming, sheet metal work and assembly
CO4	Students will be able to apply the concept of DFMA for a given product

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: How Does DFMA Work?, Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design?, Typical DFMA Case Studies, Overall Impact of DFMA on Industry. Selection of Materials and Processes: General Requirements for Early Materials and Process, Selection, Selection of Manufacturing Processes, Process Capabilities, Selection of Materials, Primary Process/Material Selection, Systematic Selection of Processes and Materials	6
2.	Design for Manual Assembly: General design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, Effect of Part Symmetry, Thickness, Weight on Handling Time, Effects of Combinations of Factors, estimation of insertion time.	5
3.	Design for Machining: General design rules for machining - Dimensional tolerance and surface roughness — Design for machining — Ease — Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.	4
4.	Design for Sand Casting and Die Casting: Sand Casting Alloys, Basic Characteristics and Mold Preparation, Sand Cores, Melting and Pouring of Metal, Cleaning of Castings, Cost Estimating, Design Rules for Sand Castings. The Die Casting Cycle, Auxiliary Equipment for Automation, Determination of the Optimum Number of Cavities, Determination of Appropriate Machine Size, Die Casting Cycle Time Estimation, Die Cost Estimation, Design Principles.	5

5.	Design for Forging, Extrusion and Sheet Metal Working: Design factors for Forging — Closed die forging design — parting lines of die, drop forging die design — general design recommendations. Design guidelines for extruded sections - Dedicated Dies and Press-working, Press Selection, Turret Press working, Press Brake Operations, Design Rules	6
6	Design for other Misc Processes; Design for Human Factors; Design for X – Reliability, Serviceability, Environment, Disassembly Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.	7

Text Books:

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|---|---|------------------|------------|
| 1 Product Design for Manufacture and Assembly | Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight | CRC Press | 2010 |
| 2 Assembly Automation and Product Design | Geoffrey Boothroyd | Book Enterprises | World 2005 |

References:

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|---|------------------------------------|--------------------------|------|
| 1 Design for Manufacturability Handbook | James Bralla | McGraw-Hill Professional | 1998 |
| 2 Design for Manufacturing and Assembly: Concepts, architectures and implementation | O. Molloy, E. A. Warman, S. Tilley | Chapman & Hall | 1998 |
| 4 Engineering Design – Material and Processing Approach | George E. Deiter | McGraw Hill Intl | 1991 |

Course Code: ME15XXX	Industrial Tribology	Credits: 3-0-0:3
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Pre-requisites: Mechanics of Machines, Engineering Mechanics

Course Outcomes:

S.N.	Outcomes
CO1	To understand the fundamental concepts of tribology, surface characteristics, and surface roughness analysis relevant to engineering applications.
CO2	To study the mechanisms of friction and wear, identify different wear types, and evaluate factors influencing tribological performance of materials.
CO3	To describe and compare different lubrication regimes and evaluate the role and properties of lubricants in tribological systems.
CO4	To apply tribological principles to engineering components, industrial applications, MEMS/NEMS systems, and emerging areas such as green tribology and biomimetics.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: Definition and History of Tribology, Industrial Significance of Tribology, Nature of Surfaces, Physico-Chemical Characteristics of Surface Layers, Analysis of Surface Roughness, Measurement of Surface Roughness, Contact Between Solid Surfaces.	6
2.	Friction, Wear: Role of friction, Laws of friction, Causes of friction; Adhesion. Theory of Dry Friction, Friction measurement, Friction of materials; Wear definition, Types of wear mechanism, Types of particles present in wear debris, Factors affecting wear, Wear of materials.	8
3.	Fluid Film Lubrication: Regimes of fluid film lubrication, Viscous flow and Reynolds equation, Hydrostatic lubrication, Hydrodynamic lubrication, Elastohydrodynamic lubrication, Mixed lubrication, Gas lubrication.	10

4.	Boundary Lubrication and Lubricants: Boundary lubrication, Lubricants and its functions, Types of lubricants, Lubricant Additives; Physical properties of lubricants, Lubricant viscosity, Viscosity-temperature relationship, Viscosity Index, Viscosity-pressure relationship, Viscosity-Shear rate relationship.	6
5.	Tribological Components and Applications: Common tribological components, MEMS/NEMS, Industrial Applications	3
6.	Green Tribology and Biomimetics: Twelve principles of green tribology, Areas of green tribology, Lessons from nature, Industrial significance	2

Text Books:

1. Engineering Tribology, G. W. Stachowiak and A. W. Batchelor, Elsevier Butterworth-Heinemann, 2005.
2. Introduction to Tribology, Bharat Bhushan, John Wiley & Sons, 2013.

References:

1. Fundamentals of Engineering Tribology with Applications, Harish Hirani, Cambridge University Press, 2016.
2. Applied Tribology: Bearing Design and Lubrication, Khonsari and Booser, John Wiley & Sons, 2017.
3. Friction, Wear, Lubrication, Kenneth C. Ludema and Oyelayo O. Ajayi, CRC Press Taylor & Francis Group, 2019.

VI Semester: Core Elective Courses – 4 and 5

Course Code: ME16XXX	Turbulence Modelling	Credits: 3-0-0:3
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Pre-requisites: Fluid Mechanics and Hydraulic Machines, Engineering Mathematics

Course Outcomes:

S.N.	Outcomes
CO1	Understand the fundamental of turbulence
CO2	Apply principles of principles of turbulence and statistical modelling in different flows.
CO3	Analyse the role of different types of turbulence models for a given problem.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. of hours
1	Fundamentals of Turbulence: Laminar vs turbulent flows, Characteristics of turbulence: randomness, diffusion, dissipation, Reynolds number and transition to turbulence, Scales of turbulence: large eddies, inertial subrange, Kolmogorov scales, Energy cascade concept	8
2	Statistical Description of Turbulence: Reynolds decomposition, Time averaging and ensemble averaging, Reynolds-Averaged Navier–Stokes (RANS) equations, Reynolds stresses and closure problem, Turbulent kinetic energy and dissipation	8
3	Turbulence Closure Problem: Nature of closure problem, Zero-, one-, and two-equation models, Eddy viscosity hypothesis, Boussinesq approximation	8
4	Eddy Viscosity Models: Mixing length theory (Prandtl), Algebraic turbulence models, One-equation models (Spalart–Allmaras), Two-equation models: $k-\epsilon$ (standard, RNG, realizable), $k-\omega$, SST $k-\omega$, Near-wall treatment	6

	and wall functions	
5	Reynolds Stress Models (RSM): Transport equations for Reynolds stresses, Pressure–strain correlation, Advantages and limitations of RSM, Applications to complex flows (separation, rotation, curvature)	5
6	Direct Numerical Simulation (DNS): DNS fundamentals, Resolution requirements, Computational cost and limitations, Role of DNS in turbulence research	5

Text Books:

1. Turbulent Flows Fundamentals, Experiments and Modeling by Gautam Biswas and V. Eswaran, CRC Press.
2. A First Course in Turbulence, Hendrik Tennekes, John Leask Lumley, MIT Press.
3. Fundamentals of Turbulence and Its Modeling, Sawan S. Sinha, Springer Nature.

Course Code: ME16XXX	Sustainable Materials and Green Buildings	Credits: 3-0-0:3
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Prerequisites: Basics Knowledge of green technology and sustainability, Basics Knowledge of civil engineering building materials,

Course Outcomes:

CO1	Expose the students to the concepts of sustainability
CO2	Understand the concept of building and conventional engineered building materials
CO3	Understand the concept of conventional engineered building materials
CO4	Make student aware of various green building councils

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to sustainability and green building: Introduction to sustainable materials and the concept of green building, Embodied energy and Operational energy in Building and Life cycle energy, Ecological footprint, Bio- capacity and calculation of planet equivalent.	08
2	Sustainable materials: Role of Material: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission, Sustainability issues for concrete, Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability.	08
3	Energy and resources consumption: Reduction in water consumption in concrete, recycled aggregate, Energy for grinding and crushing of cement, aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity. Clay Bricks, Types of kilns, Comparative energy performance, emission performance and financial performance, Indoor air quality.	08
4	Operational energy consumption: Paints, Adhesive and sealants for use in building, Volatile organic content (VOC) emission issues and indoor air quality for Sustainability and Health hazard. Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm.	08
5	Energy and resources balance: Radiation budget, Surface water balance, Effects of trees and microclimatic modification through greening. Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency.	08
6	Energy codes: ECBC requirement, Concepts of Overall Thermal Transfer Value (OTTV), Green Performance rating, requirements of Leadership in Energy	08

	and Environmental Design (LEED), Green Rating for Integrated Habitat Assessment (GRIHA) and Indian Green Building Council (IGBC).	
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Text Books:

- | | | | |
|----|--|---------------------------------------|--|
| 1 | Sustainability Engineering: Concepts, Design and Case Studies | Allen, D. T. and Shonnard, D. R. | Prentice Hall |
| 2 | Engineering applications in sustainable design and development | Bradley. A.S; Adebayo, A.O., Maria | Cengage learning |
| 3 | Environment Impact Assessment Guidelines | Notification of Government of India | |
| 4 | Basic Concepts in Environmental Management | Mackenthun, K.M. | Lewis Publication London |
| 5. | GRIHA Rating System | New Delhi Bureau of Energy Efficiency | Publications- Rating System
TERI Publications |

Course Code: ME16XXXX	Alternative Refrigerant Technologies	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Heat and Mass Transfer, Refrigeration and Air Conditioning.

Course Outcomes:

CO1	Understand the basics of refrigerants and their characteristics
CO2	Understand the safety protocols associated with refrigerants
CO3	Apply principles of environmental implications of refrigerants
CO4	Analyse the design considerations for alternative refrigerant systems
CO5	Understand the basics modifications required for retrofitting systems with alternative refrigerants.

Course Articulation Matrix (CO-PO-PSO Mapping):

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	1	-	-	-	-	-	-	-	-	-	-	2	2	1
CO2	3	2	2	2	1	3	2	2	2	2	2	-	2	3
CO3	3	3	2	3	1	2	3	-	-	-	-	-	3	2
CO4	3	2	1	1	1	-	-	-	-	2	-	-	2	1
CO5	3	3	3	3	1	2	2	2	2	-	2	-	2	2

Unit	Details	No. Hrs
1.	Review of Alternative Refrigerants: Refrigerants and its classification – Need of alternate refrigerants, Desirable properties- thermodynamic-chemical and transport properties - designation of refrigerants - inorganic, halo carbon refrigerants - secondary refrigerants.	7
2.	Properties of refrigerant blends and Flammability: Properties of mixtures of refrigerants, Ozone depletion potential and global warming potential. Flammability of the alternate refrigerants, methods for identifying the safe zone of operation.	7
3.	Environmental impacts, Safety and risk assessments of refrigerants: Measuring the financial and environmental impact of leakage of refrigerants on the environment. Refrigerant Hazards. Safety and risk assessment of alternative refrigerants.	6
4.	System design for alternative refrigerants: System design using alternative	5

	refrigerants. Performance analysis of alternative refrigerants and comparison with conventional refrigerants.	
5.	Leak Detection of Alternative refrigerants: Leak detection of alternative refrigerants, Maintenance and repair of alternative refrigerant systems, Retrofitting existing systems.	5

Text Books:

1. Refrigeration and Air Conditioning - Arora, R.C - PHI Pvt Ltd - 2010.
2. Refrigeration and Air Conditioning - Arora, C.P - Tata McGraw-Hill - 2000.

References:

1. Cryogenic Process Engineering - Klaus D. Timmerhaus and Thomas M. Flynn - Plenum Press New York, 1989
2. Cryogenic heat transfer - Randall F. Barron - CRC Press – 1999
3. Refrigeration and Air Conditioning - Stoecker N.F and Jones - TMH NewDelhi-2nd edition 1982.

Course Code: ME16XXX	Solar Architecture	Credits: 3-0-0:3
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Prerequisites: Solar Energy Systems

Course Outcomes:

CO1	Understand the basics of solar energy including its production at the Sun, and collection at Earth surface, various methods to collect and measure the solar energy.
CO2	Understand the energy consumption pattern in heating and cooling of various types of buildings and solar architecture.
CO3	Apply principles of solar architecture to reduce energy consumption in buildings and protect our planet from effects of climate change such as global warming.
CO4	Analyse the performances of buildings constructed using principles of solar architecture and their comparison with conventional buildings.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: Thermal comfort and its parameters (Physiological, Physical and Intermediate parameters), Energy consumption patterns in building, Construction materials and design considerations, Problems in modern buildings, Cooling and Heating load in buildings, Role of building in Global warming and energy crisis facing the world and the country. Solar Energy (types, Sun-Earth angles, measurement) and relation with buildings and thermal comfort.	08
2	Buildings and Solar Architecture: Buildings and its types (Ancient Buildings, Modern Buildings, Zero energy building, Green building, Energy efficient building etc.), Climate classification and bio-climatic approach, Vernacular Architecture. Basics of Solar Architecture and its various principles.	08
3	Passive Heating and Cooling Techniques of Building: Introduction, Heat and mass transfer mechanism in buildings, Various passive heating methods, Types of solar air heating systems, Basic energy balance equations, Efficiency and Performance. Sol-air temperature, Heat flux for bare, wetted and Blackened/glazed surface, Thermal gain by direct, indirect and isolated ways. Various passive cooling methods e.g. evaporative cooling, nocturnal radiation cooling, ventilation, and solar chimney. Effect of Passive heating/cooling on energy consumption in buildings.	08
4	Active Heating and Cooling Techniques of Building: Introduction, Integration buildings with photovoltaic panels, desert cooler, Air Conditioner, fan, blower, and Earth-Air heat exchanger etc., Effect of Active heating/cooling on energy consumption in buildings.	08

5	Daylighting: Introduction, Concept of Skylight, Daylight and Shading, Artificial lighting vs Daylight, Psychological effects of daylight, Energy saving by daylighting. Illuminance standards in different buildings.	04
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Text Books:

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|--|---------------------------|--------------------------|------|
| 1. Solar Energy – Fundaments, Design, Modeling & Applications | G.N. Tiwari | Narosa Publications | 2002 |
| 2. Solar Energy | S P Sukhatme, J K Nayak | McgrawHill Publication | 2017 |
| 3. Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows | D. Bainbridge, K. Haggard | Chelsea Green Publishing | 2011 |

References:

- | | | | |
|---|------------------------------------|----------------------|------|
| 1. National Building code of India 2016 (Volume-I and Volume-II) | Bureau of Indian Standards | Govt. of India | 2016 |
| 2. Indian Standard Code of Practice for Interior Illumination | Bureau of Indian Standards | Govt. of India | 1992 |
| 3. Solar Photovoltaics: Fundamentals, Technologies And Applications | C. S. Solanki | PHI Publications | 2015 |
| 4. Solar Engineering of Thermal Processes | John A. Duffie, William A. Beckman | John Wiley, New York | 2013 |
| 5. Principles of Solar Energy | Frank Krieth, John F Kreider | John Wiley New York | 1978 |

Course Code: ME16XXX	Conventional Micromachining	Credits: 3-0-0:3
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Pre-requisites: Engineering Materials, Manufacturing Science and Technology-I and II

Course Outcomes:

S.N.	Outcomes
CO1	Able to understand the fundamental concepts of modern mechanical micromachining technology.
CO2	Apply the concepts of micro turning, micro drilling, micro milling and micro grinding for fabrication and finishing of micro-featured products.
CO3	Utilize and apply the in-process monitoring tool in micromachining to improve the tool life and product quality.
CO4	Identify and analyse the possibilities of mechanical micromachining techniques in the emerging areas.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Subject Details	No. Hrs
1.	Fundamentals of Micromachining- Introduction, Materials in Micromachining, Experimental Observation and Theoretical Prediction of an Atom, Micromachining Mechanics: Size Effect, Minimum Chip Thickness, Specific Cutting Energy, Surface Generation and Burrs, Surface Roughness, Cutting Fluid, Issues and Challenges, Mechanical Micromachining Processes, Ductile Mode Machining of Brittle Materials, Machined Surface Quality with Chip Formation Mode.	7
2.	Micro Turning and Diamond Turning- Basics of Micro Turning, Mechanics of Micro Turning, Size Effect in Micro Turning, Diamond Technology, Ultra-precision Diamond Turning, Material Perspective and Micro-structuring, Surface Quality in Micro Turning.	6
3.	Micro Drilling- Introduction to Micro Drilling, Issues and Challenges, Cutting Mechanics, Tool Selection, Burr Elimination, Hole Quality and Roundness	5

	Error, Process Parameter Selection.	
4.	Micro Milling- Introduction, Elements in Micro Milling, Micro Milling Mechanics of chip Removal, Scientific and Technological Challenges, Surface Quality and Burr Removal, Hybrid Micro Milling Process, Freeform Milling, Process Parameter Selection.	7
5.	Micro Grinding- Introduction, Chip Removal Mechanism, Interaction between Diamond Abrasive and Work material, Implementation Perspective: Truing and Dressing, Tool Topography and Edge Distribution, Profile Grinding.	5
6.	In-Process Monitoring, Product Quality and Industrial Applications- In-Process Monitoring of Cutting Force, Tool Wear and Surface Form, Online Measurement by Machine Vision and Integrate Probe, Surface Integrity and Other Related Measurements, Product Quality, Industrial Applications of Micromachining: Semiconductor, Electronics, Optics, Heat Transfer, Medical, Aerospace and Automotive Industry.	6

Text Books:

- | | | | |
|---|--|---------------------------------|-------------------|
| 1 | Micromachining of Engineering Materials | J.A. McGeough | CRC Press |
| 2 | Micromachining Techniques for Fabrication of Micro and Nano Structures | Mojtaba Kahrizi | InTech |
| 3 | Micro-Cutting Fundamentals and Applications | Kai Cheng, Dehong Huo | Wiley |
| 4 | Nano and Micromachining | J. Paulo Davim, Mark J. Jackson | John Wiley & Sons |

References:

- | | | | |
|---|--|--------------------------------------|----------------------------|
| 1 | Comprehensive Materials Processing | M.S.J. Hashmi | Elsevier |
| 2 | Micromachining with Nanostructured Cutting Tools | Mark J. Jackson | Springer |
| 3 | Advanced Machining and Finishing | Kapil Gupta, Alokesh Pramanik | Elsevier |
| 4 | Control of Cutting Vibration and Machining Instability | C. Steve Suh, Meng-Kun Liu | Wiley |
| 5 | An Introduction to Surface-Micromachining | Robert W. Johnstone, M. Parameswaran | Kluwer Academic Publishers |

Course Code: ME16XXX	Additive Manufacturing	Credits: 3-0-0:3
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Prerequisites: Computer Aided Design, Manufacturing Science and Technology I and II

Course Outcomes:

CO1	Students will be able to apply the basic CAD and Reverse Engineering (RE) concepts for generating solid models of objects using CAD and RE software for AM.
CO2	Students will be able to understand the Additive Manufacturing process chain from CAD to part printing to post processing, and the AM materials and hardware.
CO3	Students will be able to comprehend the various types of Additive Manufacturing processes for printing different materials along with their comparative strengths, limitations and applications.
CO4	Students will be able to familiarize with the basic concepts of Design for Additive Manufacturing (DfAM) including Topology Optimization, Generative Design and Lattice Design in Additive Manufacturing and apply them to execute an application mini project.

Course Articulation Matrix:

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

Unit	Details	Hrs
1	Introduction to AM: Evolution of AM/3DP vs CNC and Injection Moulding; CAD for AM: Geometric transformations, curve, surface and solid modeling, Data exchange formats, Reverse engineering, Modeling with point cloud data, 3D Scanning devices;	06
2	AM process chain: Tessellation of CAD model, file formats, STL file problems, manipulation and repair, part orientation and support generation, slicing algorithms tool path generation, machine setup and post processing; AM materials and hardware;	08
3	AM processes: Liquid polymer based (FDM, SLA), powder based (SLS, MJP, Binder Jetting), molten metal based (DMLS, SLM, EBM, DED, WAAM), solid sheet based (LOM), Bio printing etc.; AM Process selection for targeted applications and case studies including aerospace, medical and commodity products;	12
4	Basics of Design for Additive Manufacturing (DfAM): Topology Optimization, Generative Design and Lattice Design; Rapid Tooling;	10

	Software application of DfAM and 3DP through a product development mini project; Optimization of AM processes for build time, support material, surface finish and part errors.	
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Text Books:

- 1 Additive Manufacturing Technologies - 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing – 2016 Ian Gibson, D W Rosen and Brent Stucker Springer
- 2 Additive Manufacturing: Principles, Technologies and Applications - 2021 C P Paul and A N McGraw Hill Jinoop

References:

- 1 3d Printing and Additive Manufacturing: Principles and Applications - 2016 C K Chua and K F Leong World Scientific Publishing
- 2 Metal Additive Manufacturing - 2021 E Toyserkani, D Sarker, O Olbhadode, F Liravi, P Russo, K Taherkhani Wiley
- 3 Additive Manufacturing. 3D Printing for Prototyping and Manufacturing - 2016 Andreas Gebhardt and Jan-Steffen Heotter Hanser Gardner Publications
- 4 Rapid prototyping and engineering applications: A toolbox for prototype development – 2019 Frank W Liou CRC Press
- 5 Additive Manufacturing, 2020 Amit Bandyopadhyay and Susmita Bose CRC Press
- 6 CAD/CAM: Theory and Practice – 2009 Ibrahim Zeid and R Sivasubramanian McGraw Hill Education
- 7 Engineering Design and Rapid Prototyping– 2010 Ali K Kamrani and Emad Abouel Nasr Springer

Online Resources:

1. <https://www.3dsystems.com/>
2. <https://www.metal-am.com/>
3. <https://www.hubs.com/guides/3d-printing/>
4. <https://www.3dprintingindustry.com/>

5. <https://www.thingiverse.com/>
6. <https://all3dp.com/>
7. <https://www.stratasys.com/>
8. <https://www.engineering.com/home>
9. <https://www.ntopology.com/>
10. <https://www.sculpteo.com/>
11. <https://www.materialise.com/>

Course Code: ME16XXX	Micro-electro-mechanical systems (MEMS)	Credits: 3-0-0:3
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Pre-requisites: Basic Electrical and Electronic Engineering, Engineering Materials, Mechanics of Materials, Manufacturing Science and Technology I and II

Course Outcomes:

S.N.	Outcomes
CO1	Understand the concept of micro-electro-mechanical systems, its working principles and applications.
CO2	Understand to design and simulate the basic micro sensors and actuators in the micro system.
CO3	Apply the principles of the MEMS fabrication and manufacturing processes to develop MEMS products.
CO4	Analyse and determine the effect of system parameters on the characteristics of sensors and actuators.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Overview of Micro Electro Mechanical systems (MEMS): MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Micro-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization	5
2.	Working Principles of Microsystems: Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics, Case studies.	5
3.	Engineering Science for Microsystems Design and Fabrication: Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry, Case studies.	5

4.	Materials for MEMS and Bio MEMS: Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials.	5
5.	Engineering Mechanics and thermo-fluid Engineering for Microsystems Design: Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale, Case studies.	7
6.	Fabrication and manufacturing Processes for Microsystems: Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process, Case studies.	8
7.	Applications and Case studies: Micro-fluidics, Bio-MEMS, Polymer MEMS	5

Text Books:

1. MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering, Hsu, T.R, John Wiley & Sons, Inc. New Jersey, 2020.
2. Foundations of MEMS, Chang Liu, Pearson Education, 2011.

References:

1. Fundamentals of Microfabrication, Madau, M. J., Taylor & Francis, 2002
2. Handbook of MEMS: Introduction and Fundamentals, Gad-el-Hak, M., Taylor & Francis, 2005.
3. MEMS and Microsystems: <https://nptel.ac.in/courses/117105082>
4. Fabrication Techniques for MEMS based sensors: Clinical Perspectives: <https://nptel.ac.in/courses/108108113>
5. Support center for Microsystems Education (SCME) USA: <https://scme-support.org/>

Course Code: ME16XXX	Mechanical System Design	Credits: 3-0-0:3
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Prerequisites: Mechanics of Materials, Design of Machine Elements I and II

Course Outcomes:

CO1	Students will be able to apply knowledge of basic science and engineering fundamentals for design of a more complex and diverse engineering system utilizing a systems approach.
CO2	Students will have ability to communicate within the design group effectively to identify the requirements of a design problem and will be able to formulate and give a tangible solution.
CO3	Students will be able to evaluate the concepts and designs developed during different phases of the design.
CO4	Students will be able to test the design by mathematical tools, prototype testing and verify the results.

Course Articulation Matrix:

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

Units	Title	Lectures
1	Design Process: Types of design work, The role of the designer, creativity, The morphology of the design process; Systems Approach: Fundamentals of Technical System: System, plant, components, equipment, machines, and assemblies; The Application of Systems concepts in Engineering Design, Identification of Engineering functions and engineering characteristics, Conversion of energy, material and signals, Functional relationship, Working interrelationship: physical effects, Product and function decomposition diagram, Engineering Activity Matrix, A case study.	7
2	Problem Definition and Need Identification, Identifying Customer Needs, System interface, importance and types of requirements, Types of Customer requirements, Functional requirements and company requirements; Gathering Information on Existing Products, Establishing the Engineering Characteristics, Quality Function Deployment, Product Design Specification, Team Behaviour and Tools, Gathering Information, Types of Design Information, Sources of Design Information	7
3.	Functional analysis and variants: Creative thinking, Functions, classification of functions, functional variants, relocating functions, subdividing functions, combining or eliminating functions, Study of system equation, Physical effects –Physical effects for generating force and other functions, Physical laws and effects relating physical quantities, Solutions for basic functions; Generating concept variants from sub-solutions, TRIZ, case study: Liquid pressure variator;	7

	Concept evaluation: absolute and relative, Case study.	
4.	Decision Making and Concept Selection: Introduction, Decision Making - Behavioral aspects of decision making, Decision theory, Decision tree; Evaluation processes, Using models in evaluation, Pugh Concept selection process, Weighted Decision Matrix, Analytic Hierarchy Process (AHP)	4
5.	Configuration – Product architecture and Part design, Embodiment/Parametric – Steps in parametric design, Belt and Pulley example and Detail design, Manufacturing considerations in design, guidelines in designing for assembly	5
6	Mathematical Modelling Concepts: Models – Iconic, Analog, symbolic and a proof-of-concept, prototype; Choosing appropriate model, Aids to mathematical modelling – Dimensional analysis, scale model, A Process for Mathematical Model Building, Geometric modelling, Finite Element Method, Case Study	5

Text Book:

1. G.E. Dieter, “Engineering Design: A Materials and Processing Approach” McGraw Hill.
2. Hundal, M. S., “Systematic Mechanical Designing: A Cost and Management Perspective”, New York, ASME Press, 1997.

References:

1. J.R.Dixon, “Design Engineering and design for manufacture” Field Stone Pub.
2. David G.Ullman, “The Mechanical Design Process”, McGraw Hill
3. R.J.Eggert, “Engineering Design”, Pearson/Prentice Hall.
4. Martin S Ray, “Elements of Engineering Design”, Prentice Hall
5. Principles of Design: Nam P Suh, McGraw Hill 1999
6. Total Design: Stuart Pugh, Pearson Education

Course Code : ME16XXX	Advance Mechanics of solids	Credits: 3-0-0:3
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Pre-requisites: Engineering Mechanics, Mechanics of Materials

Course Outcomes:

S.N.	Outcomes
CO1	Analyze three-dimensional stress-strain systems and apply stress transformation techniques.
CO2	Apply failure theories and evaluate stresses in curved beams, torsion members, and columns.
CO3	Use energy methods to determine deflection, twist, and stability of structural members.
CO4	Explain unsymmetrical bending, shear centre, and introduction of photoelasticity.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Stress and Strain in Three Dimensions: Cauchy stress relations, Principal stresses and strains, Hydrostatic and deviatoric stresses, Stress transformation and Mohr's circle, Octahedral shear stress, Strain energy density.	10
2.	Theories of Failure and Beam on Elastic Foundations: Maximum principal stress theory, Maximum shear stress theory, Maximum strain energy theory, Distortion energy theory (von-Mises), Beam on elastic foundation.	7
3.	Curved Beams and Torsion: Bending of curved beams, Crane hooks and chains, Torsion of non-circular sections, Hollow and thin-walled sections, Membrane analogy	10
4.	Columns and Energy Methods: Euler's column theory, initially curved columns, Rankine formula, Strain energy methods, Castigliano's theorem, Deflection and twist calculations.	8
5.	Unsymmetrical Bending and Photoelasticity: Unsymmetrical bending, Shear centre, Introduction to photoelasticity, Polariscopes and stress optic law, Engineering applications of photoelasticity.	5

Text Books:

3. L S Srinath, [*Advanced Mechanics of Solids*](#), Tata McGraw Hill
4. M H Sadd, [*Elasticity: Theory, Applications and Numerics*](#), Elsevier, 2005
5. S P Timoshenko and J N Goodier, [*Theory of Elasticity*](#), Mc Graw Hill
6. S M A Kazimi, [*Solid Mechanics*](#), Tata McGraw Hill

References:

1. Advanced Strength of Materials (NPTEL) by Prof. S.K. Maiti nptel.ac.in/courses/112101095
2. Solid Mechanics (NPTEL) by Dr Ajeet Kumar nptel.ac.in/courses/112102284

Course Code: ME16XXX	Supply Chain Management	Credits: 3-0-0:3
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Pre-requisites: Industrial Engineering, Operation Research

Course Outcome

S. N.	Outcomes
CO1	Understand how each functional component and its processes become one integrated operation to satisfy customer's needs.
CO2	Develop an understanding of how to manage the interaction of business functions across companies in the supply chain.
CO3	Develop an understanding of how to manage the impact of demand on the supply chain and the considerable competitive advantages that can result from managing demand across companies.
CO4	Effectively manage the flow of resources and information among the various partners of the supply chain.
CO5	Develop an understanding of how logistics and supply chain strategies can create value generation and utilise IT applications

Course Articulation Matrix:

CO1	2	3	3	3	3	2	2	2	2	2	3	3	3	2
CO2	1	3	3	3	3	2	3	3	2	2	3	3	3	2
CO3	2	3	3	3	3	3	2	2	2	3	3	3	2	3
CO4	2	3	3	3	3	3	2	2	3	2	3	3	2	3
CO5	1	3	3	2	2	3	2	2	2	2	3	3	3	3

Unit	Content	No. Hrs
1	Basics of Supply Chain: Introduction to Supply Chain Management, Understanding the Supply Chain, Supply Chain Performance: Competitive and Supply Chain Strategies, achieving Strategic Fit and Scope of Strategic Fit	08
2	Design of Supply Chain Drivers: Supply Chain Drivers and Metrics: Drivers of Supply Chain Performance, Framework for structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing and Pricing, Case Study: Seven-Eleven Japan Company, Planning Demand and Supply In a Supply Chain: Demand Forecasting in a Supply Chain, Aggregate Planning in a Supply Chain	08
3	Design of Distribution Network and Network Design: Designing Distribution Networks and Application to E-Business- Role of distribution, factors influencing distribution network design, design options for a distribution network, E-Business and the distribution network, Network	08

	Design in the Supply Chain- Role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions	
4	Role of Information Technology in supply chain, coordination in a supply chain, Bullwhip Effect, Effect on performance due to lack of coordination, obstacles to coordination in a supply chain, Factors influencing logistics and decisions, Benchmarking and performance measurement, Internal Supply Chain Management and its drivers, External Supply Chain Management and its drivers.	10
5	Sustainable Supply Chain Management, Digital Supply Chain Management and Smart Supply Chain Management	04

Text Books:

3. Supply Chain Management: Strategy, Planning & Operations, Sunil Chopra and Peter Meindle, Pearson Prentice Hall Publication, 2019.
4. Supply Chain Management: For Global Competitiveness, B.S Sahay, Laxmi Publications, 2007.

Reference Books:

5. Logistics Management: The Integrated Supply Chain Process, Donald J. Bowersox and David J. Closs, McGraw Hill Education, 2017.
6. World Class Supply Management: The Key to Supply Chain Management, Burt, Dobler and Straling, McGraw- Hill Education, 2002.
7. Supply Chain Management: Theories & Practices, R P Mohanty and S. G Deshmukh, Dreamtech Press, 2005.
8. E-Procurement: From Strategy to Implementation, Dale Neef, Financial Times Prentice Hall, 2001.

Course Code: ME16XXX	Gas Turbine and Jet Propulsion	Credits: 3-0-0:3
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Pre-requisites: Fluid Mechanics and Hydraulic Machines, Engineering Thermodynamics, Heat and Mass Transfer, Compressible Flows

Course Outcomes:

S.N.	Outcomes
CO1	Understand the fundamental of turbulence
CO2	Apply principles of principles of turbulence and statistical modelling in different flows.
CO3	Analyse the role of different types of turbulence models for a given problem.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. of hours
1	Introduction to Air Breathing Propulsion: Evolution of aircraft propulsion systems, Classification of propulsion systems, Air-breathing vs non-air breathing engines, Principle of jet propulsion, Applications of gas turbines, Basic thermodynamic concepts used in propulsion	8
2	Thermodynamics of Gas Turbines: Brayton cycle, Ideal and actual gas turbine cycles, Cycle analysis for turbojet engines, Effect of pressure ratio and turbine inlet temperature, Thermal efficiency and propulsive efficiency	6
3	Aircraft Engine Components: Types of air intakes, Diffuser performance Subsonic and supersonic intakes, Centrifugal compressors, Axial flow compressors, Types of combustion chambers, Fuel-air ratio, Combustion efficiency, Axial flow turbines, Convergent and convergent-divergent nozzles, choked flow, Nozzle efficiency, Thrust generation	12

4	Types of Gas Turbine Engines: Turbojet engines, Turbofan engines, Turboprop engines, Turboshift engines, Ramjet and scramjet engines, Pulse jet engines	6
5	Jet Propulsion Performance: Thrust equation, Momentum theory, Thrust power and propulsion efficiency, Specific thrust, Fuel consumption parameters, Engine performance under varying flight conditions, Altitude effects on engine performance	8

Text Books:

1. Aircraft Propulsion by Saeed Farokhi, Wiley.
2. Elements of Propulsion: Gas Turbines and Rockets by Jack D. Mattingly, AIAA Education Series
3. Jet Propulsion by Nicholas Cumpsty, Cambridge Press.

Course Code: ME16XXX	Non-conventional Energy Resources	Credits: 3-0-0:3
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Pre-requisites: Energy Conversion Technology

Course Outcomes:

CO1	Understand the concept of energy crisis, non-conventional energy resources, availability and their importance.
CO2	Understand various methods to harness non-conventional energy resources.
CO3	Apply the methods for better harness, conversion techniques, and utilization of non-conventional energy resources.
CO4	Analyse various problems, limitations, complexities and performances of power plants based on non-conventional energy resources.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: The energy crisis – causes and options, various conventional and non-conventional forms of energy and their characteristics, availability of non-conventional energy and land area requirements.	4
2	Solar energy: Introduction, Solar radiation, Sun-Earth angles, Measurement of solar radiation at the earth's surface, Types of collectors such as flat-plate and concentrating collectors, solar thermal power generation, solar ponds and energy storage. Principle of Solar photovoltaic, materials, mono-crystalline, polycrystalline and amorphous silicon cells and their production technology, I-V characteristics, parameters of performance, modules, array and PV plant configurations and power generation.	6
3	Biomass energy: Introduction, Incineration, Thermo-chemical and biochemical conversion to solid, liquid and gaseous fuels; Production technologies for bio-ethanol, biogas and producer gas, Urban waste to energy processes.	5
4	Ocean, Wave and Tidal energy: Introduction, Ocean thermal energy conversion (OTEC) – closed and open cycles and their limitations, Wave energy and its conversion processes, Tidal energy – nature of the tides and tidal barrages for power generation.	5
5	Wind energy: Fundamentals, power in the wind, site selection, maximum power coefficient, wind turbine and its types – horizontal axis and vertical axis machines, performance of wind machines, wind energy farms.	5
6	Geothermal energy: Introduction, Geothermal energy resources, Hot aquifers and hot dry rock systems, geothermal electric power plants.	4

7	Other Technologies: Magnetohydrodynamics (MHD) Energy conversion, Fuel Cells, Nuclear Energy, Hydrogen, Methanol, Energy Storage.	4
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Text Books:

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|---|---|---|---|
| 1 | Renewable Energy Sources and Emerging Technologies | D.P. Kothari, K.C. Singal and R. Ranjan | PHI Learning Pvt. Ltd., New Delhi |
| 2 | Solar Energy-Fundamentals, Design, Modeling & Applications' | G.N. Tiwari | Narosa Publishing House, New Delhi, India |

References:

- | | | | |
|---|--|-----------------------------|---|
| 1 | Advanced Renewable Energy Sources | G.N. Tiwari and R.K. Mishra | RSC Publishing, Cambridge, U.K |
| 2 | Biogas Systems: Principles and Applications | K.M Mittal | New Age International Limited Publishers. |
| 3 | Wind Energy Come of Age | Gipe P | John Wiley and sons, New York. |
| 4 | Solar Energy Fundamentals | S. Kalogirou | Academic Press |
| 5 | Solar Photovoltaics: FundamentalsTechnologies and Applications | C.S. Solanki | PHI Learning Pvt. Ltd., New Delhi |
| 6 | Energy Technology (Non Conventional, Renewable And Conventional) | S. Rao, BB Parulekar | Khanna Publishers |

Course Code: ME16XXX	Unconventional Micro-Nano Machining	Credits: 3-0-0:3
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Pre-requisites: Manufacturing Science and Technology-II, Advanced Machining Processes

Course Outcomes:

S.N.	Outcomes
CO1	Explain the need for unconventional machining processes and its classification.
CO2	Able to understand the fundamental concepts of modern unconventional micro-nano machining technology.
CO3	Apply the concepts of unconventional micro-nano machining for fabrication and finishing of micro-featured products.
CO4	Identify and analyse the non-traditional micromachining processes for the application possibilities of in the emerging areas.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Subject Details	No. Hrs
1.	Fundamentals of Micro-nano machining- Introduction, Materials in Micro-nano machining, Experimental Observation and Theoretical Prediction of an Atom, Micromachining Mechanics: conventional and unconventional Micro-nano machining Processes.	6
2.	Principles of Non-traditional Micro-nano Machining Methods- Ultra Sonic Micro Machining, Chemical and Electro Chemical Micro Machining, Electric Discharge Micro Machining, Electron Beam Micro Machining, Laser Beam Micro Machining, Ion Beam Micro Machining.	8
3.	Analysis of Non-traditional Micro-nano Machining Methods- Analysis of Ultra Sonic Micro Machining, Chemical and Electro Chemical Micro Machining, Electric Discharge Micro Machining, Electron Beam Micro Machining, Laser Beam Micro Machining, Ion Beam Micro Machining.	8
4.	Micro and Nano Finishing Processes: Need for Nano finishing, Magnetic abrasive Finishing, Magnetorheological Finish, Elastic, Emission Finishing,	8

	Magnetic Float Polishing, Ion Beam finishing.	
5.	Applications of Nano and Micromachining in Industry:- Applications in optical manufacturing, Semiconductor and electronics related applications; Introduction to lithography, RIE, DRIE.	6

Text Books:

- | | | | |
|---|--|--------------------------------|-------------------|
| 1 | Micromachining of Engineering Materials | J.A. McGeough | CRC Press |
| 2 | Micromachining Techniques for Fabrication of Micro and Nano Structures | Mojtaba Kahrizi | InTech |
| 3 | Nano and Micromachining | J. Paulo Davim, Mark J.Jackson | John Wiley & Sons |

References:

- | | | | |
|---|------------------------------------|-------------------------------|----------|
| 1 | Comprehensive Materials Processing | M.S.J. Hashmi | Elsevier |
| 2 | Advanced Machining and Finishing | Kapil Gupta, Alokesh Pramanik | Elsevier |
| 3 | Micro and Precision Manufacturing | Kapil Gupta | Springer |

Course Code: ME16XXX	Laser Processing of Materials	Credits: 3-0-0:3
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Pre-requisites: Manufacturing Science and Technology-I and II, Advanced Machining Processes

Course Outcomes:

S.N.	Outcomes
CO1	Identify the need and understand various Laser Processing Techniques in industry.
CO2	Apply the basic principles of Laser Processing of Materials for product manufacturing/development.
CO3	Realize the applications of Laser Processing of Materials for product development through material removal, joining, forming and surface engineering.
CO4	Prepare for future roles in meeting these requirements in advanced manufacturing environment through Laser Material Processing

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Subject Details	No. Hrs
1.	Introduction: Concept of laser, basic mechanisms in lasers; Properties of laser; Types of laser gas, liquid and solid state lasers; Pulsed and CW lasers.	2
2.	Laser-Material Interaction: Interaction of laser with metals, ceramics, polymers, composites and other materials; Laser heating fundamentals.	4
3.	Laser Forming: Process principle, analysis and applications of Laser forming processes such as Bending and Deep drawing.	6
4.	Laser Machining: One, two and three dimensional laser machining; Process principle, analysis and applications of laser Drilling, Cutting, Turning, and Milling processes Laser assisted machining (LAM).	6
5.	Laser Welding: Principles, Significance of laser welding variables; Laser welding of various materials including steel, aluminium and its alloys and titanium and its alloys.	6

6.	Laser Surface Engineering: One dimensional thermal heating and cooling of metals; Mechanisms of hardening in steel and cast irons, Laser glazing; Laser alloying; Microstructural considerations in laser rapid heating process. Laser surface texturing.	8
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Text Books:

- | | | | |
|---|---|----------------------------|-----------------|
| 1 | Laser Material Processing | William M. Steen | Springer-Verlag |
| 2 | Principles of Laser Materials Processing, | Elijah Kannatey-Asibu, Jr. | Wiley |

References:

- | | | | |
|---|--|---|--|
| 1 | Laser Machining: Theory and Practice | George Chryssolouris, P. Sheng, Frederick F. Ling (Editors) | Springer-Verlag, New York |
| 2 | Laser Materials Processing | Bass, M. | North Holland Publishing Co., Amsterdam |
| 3 | Industrial Lasers and Their Applications | Luxon, J. T. and Parker, D. E., | Prentice-Hall, Englewood Cliffs, NJ. |
| 4 | Laser Material Processing | Steen W. M., | Springer |
| 5 | Unconventional Machining Processes | M. Adithan | Atlantic Publishers and Distributors Pvt Ltd |

Course Code: ME16XXX	Automotive Safety	Credits: 3-0-0:3
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Pre-requisites: Automobile Engineering

Course Outcomes:

S.N.	Outcomes
CO1	To understand the effect of crash on human body and ways to avoid it.
CO2	To analyze vehicle structural behavior and design energy-absorbing components
CO3	To perform computational crash simulations and interpret structural failure
CO4	To evaluate safety systems against global regulatory standards and functional safety protocols

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Biomechanics and Injury Science: Human Anatomy in Impact, Injury Metrics for head, chest and neck, Crash Test Dummies, Pedestrian Safety	8
2.	Structural Crashworthiness: Energy Absorption Mechanics, Material Selection, Vehicle Architecture, Battery Safety in EVs, Thermal Runaway prevention in EV, Intrusions in EV battery	10
3.	Occupant Restraint Systems: Seatbelt Physics, Airbag Deployment, Seat Design, Interior Safety	10
4.	Active Safety Integration and Standards: Mechanical Actuators for Active Safety, ASIL levels for mechanical systems, Crash Simulation	8
5.	Vehicle-to-Vehicle and Vehicle-to-Infrastructure safety protocols. Global Regulations: Comparative study of Euro NCAP, US NCAP, and Bharat NCAP (Star Rating protocols)	6

Text Books:

1. Nahum, Alan M., and John W. Melvin, eds. Accidental injury: biomechanics and prevention. Springer Science & Business Media, 2012.
2. Peters, George A., and Barbara J. Peters. Automotive vehicle safety. CRC Press, 2002.
3. Design, Modern Vehicle. "An Introduction to Modern Vehicle Design." (2002).
4. Wech, Lothar, and Ulrich W. Seiffert. Automotive Safety Handbook. Vol. 377. SAE International, 2007.
5. HANS-LEO. ROSS. FUNCTIONAL SAFETY FOR ROAD VEHICLES: New Challenges and Solutions

- for E-mobility and... Automated Driving. SPRINGER, 2018.
6. Huang, Matthew. Vehicle crash mechanics. CRC press, 2002.

References:

1. Jones, Norman, and Tomasz Wierzbicki, eds. Structural Crashworthiness and Failure: Proceedings of the Third International Symposium on Structural Crashworthiness held at the University of Liverpool, England, 14-16 April 1993. CRC Press, 2010.

Course Code: ME16XXX	Control Engineering	Credits: 3-0-0:3
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Pre-requisites: Instrumentation and Process Control

Course Outcomes:

S.N.	Outcomes
CO1	Understand the basics of the modelling fundamentals to obtain state-space and transfer function models of linear control systems.
CO2	Determine the time response and frequency response of linear control systems.
CO3	Apply principles of the linear control systems to identify the characteristics of the systems.
CO4	Analyse and design the linear controller based on the desired characteristics of the systems.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to control, open-loop control, feedback control, Mathematical Modelling of physical systems- Transfer function-stability with reference to 's' plane, transient and steady state analysis, steady state errors, Performance Indices, State-space representation, State-space model solution.	8
2.	Time response of first order system, time-constant, Time response of second order systems, Pole locations and Time Response, Transient Response Analysis, Stability analysis using the Routh-Hurwitz test, Relative Stability, Steady state error, PID Controller Design.	10
3.	Root locus analysis: Sketching a root locus, Selection of gain from the root locus, Design of Lead and Lag Compensators using the root locus.	8
4.	Frequency response analysis: Bode plot, Nyquist plot, Stability Analysis: Nyquist theorem, Stability Margins, Closed loop frequency response, Design of Lead and Lag Compensators using Frequency Domain Techniques.	8

5.	Linear discrete time systems: z-transform, mathematical modelling, stability analysis, steady-state error, dynamic performance of discrete time systems.	6
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Text Books:

3. Automatic Control Systems, B C Kuo and F Golnaraghi, McGraw-Hill Education, 2017.
4. Modern Control Engineering, Katsuhiko Ogata, PHI Pvt. Ltd. New Delhi, 2015
5. Discrete-Time Control Systems, K Ogata, Pearson Education, 2015.

References:

4. Control Systems Engineering, I J Nagrath and M Gopal, New Age International, 2024.
5. Modern control systems, Dorf R. C. and Bishop R. H, Prentice Hall.

Course Code: ME16XXX	Surface treatment and characterization	Credits: 3-0-0:3
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Prerequisites: Engineering Materials, Metrology and Quality Engineering,

Course Outcomes:

CO1	Students will be able to know the surface treatment and characterization methods for the newly developed materials and also would be able to conduct the failure analysis of the materials.
CO2	Students will be able to obtain the mechanical and metallurgical properties of the engineering materials
CO3	Students will be able to prepare the specimen for a particular material and characterization technique.
CO4	Students will be able to understand the surfaces, properties, structures and phases of the engineering materials

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Property enhancing and surface processing operations: Surface cleaning methods; Mechanical cleaning, chemical cleaning Surface treatment methods: Surface engineering to change the surface metallurgy, surface engineering to change the surface chemistry, surface engineering to add a surface layer or coating, Process comparisons.	06
2	Mechanical Property characterization: Principles and characterization techniques related to Tensile, compressive, hardness, fatigue and fracture toughness properties.	04
3	Characterization: Optical/Electron Microscopy Techniques: Surface topography, specimen and surface preparation, mounting, elements of phase identification, grain size determination, inclusion analysis, Image analysis, etc. Scanning Electron Microscopy: Theory and principles, construction, controls and operation of scanning electron microscopy, Environmental scanning electron microscopy, High resolution SEM imaging, EDS / EDAX analysis. Transmission Electron Microscopy: Theory and principles, construction and controls.	08
4	XRD: Principle, Crystallography and Rietveld analysis, Quantitative and qualitative analysis, Residual stress analysis, Determination of layer thicknesses, Small Angle X-ray Scattering (SAXS) Scanning Probe Microscopy: STM and AFM- Principle, scanning techniques, image capturing and manipulation, and analysis techniques.	06
5	Thermal Analysis: Principles and applications of thermal analysis; Dynamic Mechanical Analyzer	02

6	Case studies on characterization of Engineering Materials :Metals and Alloys; Polymers; Composites; ceramics; glasses; Superalloys; Piezoelectric materials (PZT); Shape memory alloys (SMA); Micro-electro-mechanical (MEMS) materials; Nano-structured materials; etc.	04
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Text Books:

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|---|---|-------------|-----------------------------|
| 1 | Introduction to Physical Metallurgy | Avner, S.H. | McGraw-Hill Education, 2017 |
| 2 | Surface Engineering for corrosion and wear resistance | J. R. Davis | ASM International |

References:

1. Speyer, R.F., Thermal Analysis of Materials, Marcel Decker, 1994.
2. Surface Engineering, Vol. 5, ASM Hand book, 1994.
3. Materials Characterization, Vol. 10, ASM Hand book, ASM International, 2019.

Course Code: ME16XXX	Composite Materials	Credits: 3-0-0:3
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Pre-requisites: Engineering Materials, Engineering Mechanics, Mechanics of Materials

Course Outcomes:

S.N.	Outcomes
CO1	Understand the fundamentals of composite materials, types of matrices and reinforcements, fibre architectures, properties, advantages, limitations, and engineering applications of composites.
CO2	Evaluate the elastic properties, stress–strain relationships, stiffness, and deformation behaviour of composite lamina and laminates using macro and micro-mechanical approaches.
CO3	Assess the failure and strength of composite laminates using appropriate failure theories and design criteria for safe engineering applications.
CO4	Gain knowledge of fabrication methods for polymer, metal, and ceramic matrix composites and select suitable manufacturing methods for different engineering applications.
CO5	Analyze the mechanical, thermal, and microstructural behaviour of composite materials using standard testing and characterization techniques.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Composites: Definition, Role of different phases, Classification based on matrix and reinforcement, Classification of fibres, Fibre weaving patterns, Classification of matrix, Advances in composites (Natural fibre composites, Smart composites, Nanocomposites). Advantages and limitations of composite over conventional materials, Laminate configurations, Application of composites in various fields.	6
2.	Macro and Micro Mechanical Analysis of Composite Lamina: Volume and mass fractions, Density and void content, Evaluation of elastic properties,	8

	Ultimate Strength of Unidirectional Lamina. Stress-strain relations, Relation between mathematical and engineering constants, Transformation of stress, strain and elastic constants.	
3.	Elastic Behaviour of Composite Laminate: Assumptions, Strain-displacement relations, Force and moment resultants, Laminate stiffness, Determination of lamina or laminate stress and strains, Coupling effects.	6
4.	Failure Theories of Composites: Maximum stress, Maximum strain, Tsai-Hill, Tsai-Wu, Strength ratio, Failure envelopes, Analysis and Design of laminates.	6
5.	Fabrication of Composites: PMC (Hand Layup, Autoclave/Vacuum Bagging, RTM/VARTM, Compression Moulding, Pultrusion, Filament Winding, Injection Moulding, Automated Tape Placement), MMC (Stir Casting Method), CMC (Powder Metallurgy), Advanced fabrication methods.	6
6	Testing and Characterization Techniques: Mechanical testing, Thermal Analysis, Characterization (SEM, TEM, XRD, FTIR, Optical Microscopy, EDS).	8

Text Books

1. Composite Materials by K. K. Chawla, Springer Cham, 2019.
2. Analysis and Performance of Fibre Composites by B. D. Agarwal, L. J. Broutman and K. Chandrashekhara, John Wiley & Sons, 2017.

Reference Books

1. Mechanics of Composite Materials by R. M. Jones, CRC Press, 1998.
2. Mechanics of Composite Materials by A. K. Kaw, CRC Press, 2005.

Course Code: ME16XXX	Computational Fluid Dynamics	Credits: 3-0-0:3
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Pre-requisites: Engineering Mathematics I and II, Fluid Mechanics, Heat and Mass Transfer, Computer Based Mathematical Techniques

Course Outcomes:

S.N.	Outcomes
CO1	To understand various discretization methods for solving PDE problem
CO2	To understand fundamental matrix algebra concepts to solve simultaneous linear equations numerically
CO3	To apply numerical methods to obtain approximate solutions of General Transport equations

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Mathematical Description of the Physical Phenomena-Governing equations— mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations, Behaviour of the scalar transport equation with respect to these equation type.	7
2.	Introduction to finite difference, finite volume and finite element methods, consistency, stability and convergence of FDE; Lax's equivalence theorem, Discretization Methods- Methods, Method for solving discretization equations – iterative methods,	8
3.	Diffusion Equation- 1D-2D steady and transient diffusion, Treatment of source terms non-linearity, Boundary conditions, interface diffusion coefficient, Unsteady diffusion: Explicit, Implicit and Crank-Nicolson scheme, Two-dimensional conduction, Boundedness, accuracy, stability and convergence for diffusion problems. Von-Neumann stability analysis	9
4.	Convection and Diffusion- Steady and transient one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme, Two-dimensional	7

	convection-diffusion, Accuracy of Upwind scheme; false diffusion and dispersion	
5.	Flow Field Calculation- Incompressibility issues and pressure-velocity coupling, Primitive variable versus other methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms.	9

Text Books:

- | | | | |
|----------|---|---------------------------------|------------------|
| 1 | Computational Fluid Dynamics-
The basics with applications | Jr. Anderson | TATA McGraw-Hill |
| 2 | Numerical Heat Transfer and
Fluid Flow | Suhas
Patankar | V. CRC Press |
| 3 | Computational Methods for
Fluid Dynamics | Ferziger J. H.Â
and Peric M. | Springer |

References:

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|----------|---|-----------------------------|------------|
| 1 | An Introduction to
Computational Fluid Dynamics:
The Finite Volume Method | H. Versteeg
Malalasekera | W. Pearson |
|----------|---|-----------------------------|------------|

VII Semester: Core Elective Courses – 6

Course Code: ME17XXX	Cryogenics	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Heat and Mass Transfer, Refrigeration and Air Conditioning.

Course Outcomes:

CO1	Students will understand the fundamentals of the cryogenic systems and will be able to know how to design components of the cryogenic system like heat exchangers, insulation, etc.
CO2	Students will be able to analyse the losses in each component of different cycles.
CO3	Students will be able to identify the appropriate refrigeration cycle for a particular application.
CO4	Students will be able to identify the criteria for the selection of materials for the manufacturing of the components used in cryogenic applications.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: Historical background Current applications. Refrigeration and liquefaction Principles. Joule-Thomson expansion cycles: Simple Linde-Hampson system, Precooled Linde-Hampson system, Cascade system, and Mixed-Refrigerant Cascade Cycles. Isentropic expansion cycles: Simple Gas Expansion Cycle: Simon Helium Liquefier, Kapitza system, Claude system, Collins helium-liquefaction system. Refrigerators for temperatures below 2 K: Magnetic refrigeration systems, Dilution refrigerators. Cold-gas refrigerators: Stirling cycle, Gifford-McMahon cycle and Pulse Tube Refrigerator	08
2	Separation and purification systems: Properties of mixtures, General characteristics of mixtures, Temperature-composition diagrams Principles of gas separation: Simple condensation or evaporation, Principles of rectification, Flash calculations Air-separation systems: Linde single column system, Linde double-column system, Argon-separation systems; Neon-separation system	08
3	Measurement systems: Temperature scales and fixed points, Metallic resistance thermometers, Semiconductor resistance thermometers, Thermocouples	08

	Vacuum measurement: McLeod gauge, Knudsen gauge, Momentum Transfer gauge, Pirani gauge, Ionization Gauge Insulations: Expanded-foam insulations, Gas-filled powders, and fibrous insulations, Vacuum insulation, Evacuated-powder, and fibrous insulations, Opacified-powder insulations, Multilayer insulations, Comparison of insulations, Vapor-shielded vessels	
4	Properties of engineering materials: Mechanical properties: Ultimate and yield strength, Fatigue strength, Impact strength, Hardness, and ductility, Elastic moduli Thermal properties. Thermal conductivity: Specific heats of solids, Specific heat of liquids and gases, Coefficient of thermal expansion. Electric and magnetic properties: Electrical conductivity, Superconductivity Properties of cryogenic fluids: Helium 4 and Helium 3. Critical components of refrigerators: Heat exchangers: Heat-transfer coefficients and friction factors, Effectiveness-NTU approach in heat-exchanger analysis, Effect of heat-exchanger effectiveness on system performance.	08

Text Books:

- | | | | |
|---|-------------------------------|---|--|
| 1 | Cryogenic heat transfer | Barron, Randall F., and Gregory F. Nellis | CRC Press. |
| 2 | Cryogenic systems | Barron, Randall F | Oxford University Press, and Oxford: Clarendon Press |
| 3 | Cryogenic process engineering | Timmerhaus, Klaus D., and Thomas M. Flynn | Springer Science & Business Media |

References:

- | | | | |
|---|---|--|----------|
| 1 | Measurement systems: application and design | Doebelin, Ernest O., and Dhanesh N. Manik | Pearson |
| 2 | Cryogenic mixed refrigerant processes | Venkatarathnam, Gadhiraju, and Klaus D. Timmerhaus | Springer |

Course Code: ME17XXX	Two Phase Flow and Heat Transfer	Credits: 3-0-0:3
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Pre-requisites: Fluid Mechanics, Engineering Thermodynamics, and Heat and Mass Transfer

Course Outcomes:

S.N.	Outcomes
CO1	Explain the fundamental parameters of two-phase flow (void fraction, volumetric flux, slip, drift velocity).
CO2	Apply homogeneous and separated flow models to analyse one-dimensional two-phase flow and evaluate pressure drop.
CO3	Analyse two-phase flow behavior using drift flow models, including evaluation of distribution parameters and effects of gravity and phase interaction.
CO4	Analyse boiling phenomena, including nucleation, bubble dynamics, boiling regimes, critical heat flux, and apply heat transfer correlations for pool and forced convection boiling.
CO5	Evaluate condensation processes using Nusselt theory and boundary layer analysis and apply correlations for condensation in vertical and horizontal configurations.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: Types of flow; volumetric concentration; void fraction; volumetric flux; relative velocity; drift velocity; flow regimes; flow maps; analytical models.	5
2.	Homogeneous Flow: One-dimensional steady homogeneous equilibrium flow;	8

	homogeneous friction factor; turbulent flow friction factor.	
3.	Separated Flow: Slip; Lockhart-Martinelli method for pressure drop calculation; pressure drop for flow with boiling; flow with phase change.	7
4.	Drift Flow Model: General theory; gravity flows with no wall shear; correction to simple theory; Armond or Bankoff flow parameters.	8
5.	Boiling: Regimes of boiling; nucleation; gas nucleation in bulk liquid; growth of bubbles; motion at a heating surface; heat transfer rates in pool boiling; forced convection boiling; heat transfer correlations; maximum heat flux or burnout; metal boiling.	6
6	Condensation: Nusselt theory; boundary layer treatment of laminar film condensation; experimental results for vertical and horizontal tubes; condensation inside a horizontal tube, condensation outside a horizontal tube.	6

Text Books:

- 1** Two-phase Flow and Heat Transfer Butterworth, D. Oxford 1977
and Hewitt, G. F.,
- 2** Boiling Heat Transfer and Two-phase Flow Tong, L. S. and Taylor & Francis 1997
Tang, Y.S.

References:

- 1** One-Dimensional Two-Phase Flow,” Wallis, G. B. McGraw Hill 1969
- 2** Convective Boiling and Condensation Collier, J.G. McGraw Hill 1982
- 3** Handbook of Heat Transfer Fundamentals Rohsenow, W.M., Hartnett, J.P. and Ganic, E.N. (Ed.), McGraw Hill 1998
- 4** Boiling, Condensation, and Gas-Liquid Flow Whalley, P.B. Clarendon Press, Oxford 1987
- 5** Two-phase Flow in Pipelines and Heat Exchangers Chisholm, D., Longman Inc. New York. 1969

Course Code: ME17XXX	Energy Economics	Credits: 3-0-0:3
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Pre-requisites: Basics of Energy and its generation

Course Outcome

S.N.	Outcomes
CO1	Understand the concepts of advanced techno-economics assessment of energy generation, transportation and structure of energy markets and methods used for pricing electricity and other forms of energy.
CO2	Understand the concept of life cycle assessment based on energy and money.
CO3	Apply advanced techno-economics assessment such as cash flows, time value of money and evaluation of investments and projects.
CO4	Analyse and decide about installation of energy generation systems based on techno-economics.

Course Articulation Matrix:

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

Unit	Content	No. Hr
1.	Introduction to Energy Economics Introduction: Importance of Energy, its Demand and Generation, Energy and Multidimensional Interactions, Classification, Energy-money-environment relationship, Sector-wise (Buildings Sector, Industrial Sector, Transportation Sector) Global and Indian Energy Consumption, Energy crisis, Energy Security. Energy Information, Energy Accounting Framework, Energy Balance, Energy Flow Diagram, Reference Energy Systems (RES), Demand Analysis and Forecasting, Energy Demand Management.	06
2	Economics of Energy Supply Economic analysis of energy projects, Economic vs Financial investment analysis, Uncertainty and Risks in projects, Economics of fossil fuel and Renewable energy supply, Economics of Electricity supply.	08
3	Energy Markets and Pricing Basic market model, Cost vs Return of Investment, Basic Energy pricing principles, Short run versus long run marginal cost pricing, Peak, seasonal and off-peak load, Sectoral pricing of electricity, pricing of natural gas and petroleum products, green power markets, Market Failures, Investment issues in Energy Sector, Energy taxes and subsidies, Energy Efficiency Policies: An overview.	08
4	Energy Sector Issues and Effect on Pricing Global energy challenges, Issues facing resource-rich and poor countries, management	08

	issues, Impact of high energy prices e.g. price shocks, Energy security issues, Investment issues: Global and local investment needs, distribution, Foreign direct investments (FDI) etc., Energy Access: current and future outlook, indicators of energy poverty, energy ladder and its use.	
5	Economics of Energy-Environment Interactions Economics of environment protection, Energy-Environment Interactions, Environmental Kuznets curve, Addressing energy related environmental problems, pollution and its control from static and mobile sources, economics of climate change, clean development mechanism, Energy regulations.	08

Text Books:

4. Energy Economics: Concepts, Issues and Governance	S.C. Bhattacharya,	Springer London Ltd. ISBN 978-1447174707	2020
5. Financial Evaluation of Renewable Energy Technologies	T.C. Kandpal & H.P. Garg	Macmillan India ISBN 1-4039-0952-0	2003
6. Energy Policy Analysis and Modeling	M. Munasinghe & P. Meier	Cambridge University Press ISBN 9780511983573	2012

References:

7. Engineering Economics	C. S. Park, G. Kim, & S.Choi	Pearson Prentice Hall, New Jersey ISBN 0-13-187628-7	2007
8. An Introduction to Energy Economics Vol.-I	P. Stevens	The economics of energy Cheltenham	2000
9. Engineering Economy	G. J. Thuesen & W. J. Fabrycky	Prentice Hall of India ISBN 978-0132774420	2002
10. Energy Economics: A Modern Introduction	Ferdinand E. Banks	Kluwer Academic Publishers London	2000
11. Energy Economics	Peter M. Schwarz	Taylor & Francis ISBN 9781041042884	2023

Course Code: ME17XXX	Computer Integrated Manufacturing	Credits: 3-0-0:3
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Pre-requisites: Computer aided Design, Industrial Engineering and Production Management

Course Outcome

S.N.	Outcomes
CO1	Understand and apply the basics of CAD-CAM to link with the present industrial requirement.
CO2	Identify the levels of integration and required devices for industrial automation and up graduation requirements.
CO3	Identify the parameters of capacity planning, manufacturing resource planning and their effects on current market trends.
CO4	Evaluate and apply the concepts of industry 4.0 environment and to develop business strategy on the basis of studied parameters.
CO5	Apply and analyse the required knowledge in developing business competencies, ethics and to develop strategy for dynamic customer's requirement.

Course Articulation Matrix:

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

Unit	Content	No. Hr
1	CIM Concepts: Manufacturing Enterprise: External and Internal Challenges, world-class order-winning criteria, CIM- definition, SME manufacturing wheel, CIM benefits and implementation steps; Manufacturing Systems: Classification, elements or sections of a typical manufacturing organization. Functions and Components of CIM System: Design process, concurrent engineering, Concept of CAD/CAM and CIMS.	10
2	Database and Communication in CIM System: Data Communication technologies, Database Management technologies, Automated data collection in shop floor.	06
3	Planning and Scheduling Functions in CIM System: Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Planning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP).	07

4	Group Technology and Cellular Manufacturing: Concept of Group Technology and its Application, Classification and Coding Techniques; Clustering Techniques and Cellular Manufacturing, Flexible Manufacturing Systems. Computer-Aided Process Planning: Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation.	09
5	Automated Material Handling Systems Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems. Introduction to Advanced Manufacturing Systems Introduction to Lean Manufacturing systems, Agile Manufacturing systems, Quick Response Manufacturing, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems, Agent-Based Manufacturing Systems, Web-based manufacturing, Virtual Manufacturing.	08

Reference Books:

1. James A. Rehg and Henry W. Kraebber, 2005. Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
2. Mikell P. Groover, 2005. Automation, Production Systems and Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
3. Nanua Singh, 1995, Systems Approach to Computer Integrated Design and manufacturing, John Wiley & Sons.

Course Code: ME17XXX	Industrial Automation	Credits: 3-0-0
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Pre-requisites: Industrial Engineering and Production Management, Workshop and Product Realization, Robotics and Mechatronics,

Course Outcomes:

S.N.	Outcomes
CO1	Understand the principles and components of industrial automation systems.
CO2	Analyze the operation of sensors, actuators, and industrial control elements.
CO3	Develop PLC ladder logic programs for automation applications.
CO4	Evaluate modern automation technologies including IoT and Industry 4.0 applications.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Industrial Automation: Evolution of automation; Types of automation: Fixed, programmable, and flexible automation; Objectives and benefits of automation; Elements of automation systems; Industrial control systems; Automation hierarchy; Automation in manufacturing and process industries; Industrial safety standards and practices; Introduction to smart manufacturing	6
2.	Sensors, Transducers, and Actuators: Introduction to sensors and transducers; Types of sensors: Proximity sensors; Temperature sensors; Pressure sensors; Flow sensors; Position and displacement sensors; Signal conditioning systems; Actuators: Electrical actuators; Pneumatic actuators; Hydraulic actuators; Servo motors and stepper motors; Solenoid valves and relays; Industrial applications of sensors and actuators.	10
3.	Programmable Logic Controllers (PLC) and Industrial Control: Introduction to PLCs; PLC architecture and hardware components; Input/output modules; PLC memory organization; PLC programming fundamentals; Ladder logic programming; Timers and counters; PLC interfacing with sensors and actuators; Sequential controllers; Industrial applications of PLCs; Introduction to HMI systems.	8

4.	Robotics and Industry 4.0: Industrial robotics; Robot configurations and applications; Automated material handling systems; Flexible manufacturing systems (FMS); Industry 4.0 concepts	6
5.	Smart Automation: Smart sensors and smart factories; Artificial Intelligence in automation; Predictive maintenance; Future trends in industrial automation.	4

Text Books:

1	Automation, Production Systems and Computer Integrated Manufacturing	Mikell P. Groover	Pearson	2020
2	Introduction to industrial Automation	Manesis, S., & Nikolakopoulos, G	CRC Press	2020
3	Programmable Logic Controllers	W. Bolton	Newnes	2015

References:

1	Computer-Based Industrial Control	Krishna Kant	PHI Learning	2010
2	Automating Manufacturing Systems with PLCs	Hugh Jack	Pearson	2010
3	Industrial Instrumentation and Control	S. K. Singh	Tata McGraw Hill	2009
4	Programmable Logic Controllers: Principles and Applications	John W. Webb and Ronald A. Reis	PHI	2002
5	Programmable Logic Controller	Frank D. Petruzella,	McGraw Hill	2010

Course Code: ME17XXX	Surface and Interface Engineering	Credits: 3-0-0:3
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Pre-requisites: Engineering Material, Manufacturing Science and Technology I and II

Course Outcomes:

S.N.	Outcomes
CO1	Identify the need and understand various Surface and Interface Phenomenon.
CO2	Understand the principles of Surface and Interfaces and its technology.
CO3	Realize the surface and interfaces engineering through various modifications and characterization techniques.
CO4	Apply and analyse the surface and interface concepts in interdisciplinary applications.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Subject Details	No. Hrs
1.	Fundamentals of Surfaces and Interfaces: Concept of surface and Interface, Definitions of surfaces (solid-vacuum/gas) and interfaces (solid-liquid, liquid-liquid, solid-solid). Thermodynamics and Governing equations: Surface energy, surface tension, capillarity, and curved interfaces.	8
2.	Interfacial Phenomena and Colloids: Wetting and Adhesion: Contact angles, Young's equation, cohesion, and spreading coefficients. Electrical Properties: The electrical double layer (EDL), zeta potential, and Stern models. Colloidal Stability: van der Waals forces, DLVO theory, and steric forces.	8
3.	Surface Modification and Coating Technologies: Mechanical Treatments: Shot peening, deep rolling, and surface mechanical attrition treatment (SMAT). Thermal and Chemical Techniques: Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), and atomic layer deposition (ALD). Modifications: Electroplating, electroless plating, laser cladding, texturing, grafting and ion implantation.	8
4.	Advanced Surface Characterization: Microscopy: Scanning Tunnelling Microscopy (STM) and Atomic Force Microscopy (AFM). Spectroscopy: X-ray Photoelectron Spectroscopy (XPS), Ultraviolet Photoelectron	8

	Spectroscopy (UPS), and Auger Electron Spectroscopy (AES). Structure Analysis: Grazing incidence X-ray diffraction (GIXRD) and contact angle goniometry.	
5.	Engineering Applications and Surface Degradation: Tribology: Friction, wear, and lubrication mechanisms at interfaces. Corrosion Control: Types of corrosion (galvanic, pitting) and protective coatings (anodizing, phosphating). Advanced Fields: Microelectronics (thin films for devices), biomaterials (protein-surface interactions), and nanomaterials.	6

Text Books:

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|---|---|-----------------------------------|----------------------|
| 1 | Surface and Interface Science | David L Allara and Robert L Opila | IOP Publishing Ltd |
| 2 | Introduction to Surface Engineering | P. A. Dearnley | Boride Services Ltd. |
| 3 | Materials and Processes for Surface and Interface Engineering | Yves Pauleau | Springer |

References:

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|---|--|---|-------------------|
| 1 | Micro- and Nano-scale Surface and Interface Engineering: Synthesis, Characterization, and Applications | Ajay Kumar, Parveen Kumar, Ajit Behera, Pradeep Menezes | Elsevier |
| 2 | Handbook of Surfaces and Interfaces of Materials | Hari Singh Nalwa | Academic Press |
| 3 | Comprehensive Materials Finishing | M.S.J. Hashmi | Elsevier Science. |
| 4 | Comprehensive Materials Processing | M.S.J. Hashmi | Elsevier Science. |

Course Code: ME17XXX	Advanced Machining Processes	Credits: 3-0-0:3
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Pre-requisites: Manufacturing Science and Technology- II, Unconventional Micro-Nano Machining

Course Outcomes:

S.N.	Outcomes
CO1	Identify the need and understand various Advanced Machining Processes.
CO2	Apply the basic principles of Advanced Machining Processes for product manufacturing/development.
CO3	Realize the applications of Advanced Machining Processes for product development.
CO4	Prepare for future roles in meeting these requirements in advanced manufacturing environment

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Subject Details	No. Hrs
1.	Introduction: Limitations of conventional machining processes. Need, characteristics and classification of Advanced Machining Processes (AMPs).	2
2.	Mechanical Energy based AMPs: Process mechanisms, Parametric effects, Applications and limitations of Jet machining processes such as Abrasive Jet Machining, Water Jet Machining and Abrasive Water Jet Machining. Analysis of Material Removal Rate (MRR) for Abrasive Jet Machining. Process principle, limitations and applications of Ultra-Sonic Machining (USM) process. Analysis of MRR in USM considering throwing and hammering models.	8
3.	Thermal Energy based AMPs: Working Principles, Parametric effects, Limitations, Applications, process mechanisms and analyses of material removal for Electric Discharge Machining (EDM) and Laser Beam Machining (LBM). Working Principles, Applications and process mechanisms of Electron Beam Machining, Ion Beam Machining and Plasma Arc Machining. Introduction to different variants of EDM and LBM.	8
4.	Chemical Energy based AMPs: Process principle, limitations and steps	8

	involved in Chemical Machining; Introduction to photochemical and biochemical machining. Principle of Electrochemical dissolution. Parametric effect, process limitations and analysis of MRR in Electro-Chemical Machining (ECM), Equilibrium gap and self-regulating feature of ECM.	
5.	Hybrid Machining and Advanced Finishing Processes: Limitations of AMPs and concept of Hybrid Machining Processes (HMPs). Classification and characteristics of assisted and mixed type HMPs. Process mechanism and advantages of different HMPs such as Electro-Chemical Grinding (ECG), Electric Discharge Abrasive Grinding (EDAG), Laser-Assisted Turning (LAT), Ultrasonic-Assisted EDM (UAEDM) etc. Micromachining applications of AMPs and HMPs. Process principle and Applications of Abrasive Flow Finishing, Magnetic Abrasive Flow Finishing, Magnetic Abrasive Finishing, Magneto-Rheological Finishing.	8

Text Books:

1	Advanced Machining Processes	V. K. Jain	Allied Publisher Bombay
2	Manufacturing Science	Ghosh and Mallik	EWP Private Ltd

References:

1	Non Traditional Manufacturing Processes	G. F. Benedict	Marcel Dekker Inc, New York
2	Advanced Machining Methods	J. A. McGough	Chapman and Hall, London
3	Advanced Machining and Finishing	Kapil Gupta, Alokesh Pramanik	Elsevier
4	Modern Machining Processes	Pandey and Shan	TMH Publication, New Delhi
5	Unconventional Machining Processes	M. Adithan	Atlantic Publishers and Distributors Pvt Ltd

Course Code: ME17XXX	High Temperature Materials	Credits: 3-0-0:3
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Pre-requisites: Engineering Materials, Mechanics of Materials

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand the need, classification and applications of high temperature materials.
CO2	Students will be able to understand the microstructure and properties of superalloys, Ceramics and Composites for advanced high temperature applications.
CO3	Students will be able to select and use the suitable processing method for developing high temperature materials for various applications.
CO4	Students will be able to evaluate the mechanical properties and creep behaviour of high temperature materials at higher temperatures.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction: Need of high temperature materials, Homologous temperature, Classification of high temperature materials: superalloys, ceramics, high temperature composites, etc. Applications of high temperature materials: Aerospace, automotive, nuclear reactors, power plants, defence and other industries.	4
2.	Microstructure, Properties, and applications of high temperature materials: Nickel-based, cobalt based and iron based Superalloys; Boron carbide, silicon carbide, aluminium oxide Ceramics; MMC, CMC and carbon-based high temperature composites; High temperature protective coatings; Other advanced high temperature materials.	9
3.	Processing of high temperature materials: Solid state processing, liquid-state infiltration, additive manufacturing, chemical vapour infiltration; Processing of Ceramics and Composites; Processing of Superalloys: Melting and refining, casting, powder metallurgy and joining. Challenges in processing, surface stability (oxidation and high temperature	9

	corrosion)	
4.	Testing of high temperature materials: Mechanical behaviour of high temperature materials, deformation mechanism at ambient room temperature and at high temperatures; Creep, creep testing, creep curve, creep mechanism; Life prediction (Serby-Dorn, Larson-Miller Parameters) and Monkman-grant relationship.	9
5.	Ultra-high temperature ceramics, high-temperature superconductors, high-entropy alloys, Smart propulsion materials. Future of high temperature materials	4

Text Books:

7. Materials for High Temperature Engineering Applications by G.W. Meetham & M.H. Van de Voorde, First Edition
8. Engineering Physics of High-Temperature Materials: Metals, Ice, Rocks, and Ceramics by N.K. Sinha and S. Sinha, First Edition
9. Mechanical Metallurgy by G.E. Dieter, Third Edition.

References:

1. Super Alloys II by C.T. Sims, N.S. Stoloff and W.C. Hagel, Second Edition
2. High Temperature Materials and Mechanisms by Y. Bar-Cohen, First Edition

Course Code: ME17XXX	Design against Fatigue and Fracture	Credits: 3-0-0:3
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Prerequisites: Engineering Material, Mechanics of Materials

Course Outcomes:

CO1	Students will be able to understand the concept of fracture mechanics in the design of products and systems.
CO2	Students will be able to formulate the effect of cracks, flaws on mechanical behavior of components.
CO3	Students will be able to analyze and determine the effect of inherent/nucleated cracks and flaws under monotonic and fluctuating load conditions both analytically and experimentally.
CO4	Students will be able to predict the life of components under cyclic loading conditions and apply the knowledge in research and development activity for betterment of the society.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve.	05
2	Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials; Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviors, The stress Intensity factor K, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of K_{IC} with material	07
3	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, Laboratory measurement of K_{IC}	06
4	Micro-mechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design, fail-safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach.	05
5	Cyclic deformation and the strain-life (ϵ -N) approach, Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth.	06
6	Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories, Load interaction and sequence effects, cyclic counting method, crack	06

	growth and life estimation methods.	
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Text Books:

- | | | |
|---|------------------------------|--|
| 1 | Fracture Mechanics | Michael Janssen, Jan Spon
Zuidema and Russell (Taylor & Francis
Wanhill Group) |
| 2 | Metal Fatigue in Engineering | R.I. Stephens, John Wiley
A.Fatemi, R.R.
Stephens and H.O.
Fuchs |

References:

- | | | | |
|---|--|------------------|------------------|
| 1 | Fracture Mechanics: Fundamentals and Applications | T.L.Anderson | CRC Press |
| 2 | Fundamentals of Fracture Mechanics | J.F.Knott | Butterworths |
| 3 | Fatigue Damage, Crack Growth and Life Prediction | F.Ellyin | Chapman & Hall |
| 4 | Elementary Engineering Fracture Mechanics | D. Broek | Kluwer Academic |
| 5 | Fracture Mechanics with an introduction to micromechanics | Gross and Seelig | Springer |
| 6 | Elements of Fracture Mechanics | Prashant Kumar | Tata McGraw Hill |
| 7 | Deformation and Fracture Mechanics of Engineering, Materials | R.W. Hertzberg | John Wiley |

Course Code: ME17XXX	Smart Materials	Credits: 3-0-0:3
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Prerequisites: Engineering Material, Mechanics of Materials, Composite materials

Course Outcomes:

CO1	Student will be able to understand the basics, role, types, design and mechanics of the smart materials.
CO2	Student will be able to understand the various characterization techniques for the smart materials.
CO3	Student will be able to design and develop the smart materials.
CO4	Student will be able to design the novel smart materials for advance applications.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction to Smart Materials: Overview of Smart Materials, Advantages and limitations, Applications, Types of smart materials, Piezoelectric Materials, Electrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials. Magnetorheological Fluids, Electroheological Fluids, Shape Memory Materials, Fiber-Optic Sensors.	06
2	Fabrication and characterization: Additive manufacturing, injection moulding, vapor deposition (PVD), vacuum bag molding process. X-ray diffraction (XRD), Raman scattering spectroscopy (RS), Secondary Ion Mass Spectrometer (SIMS), Transmission electron Microscopy (TEM), Fourier-transform infrared reflection (FTIR), Ultraviolet–visible (UV–Vis), Atomic force microcopy (AFM).	06
3	Ferroelectric materials: Piezoelectric materials- piezoelectric effect, Direct and converse, parameter definitions, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs	05
4	Shape memory materials: Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs.	05
5	Smart polymers and hydrogels: Thermally responsive polymers, Electroactive	05

	polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers, Approaches to molecular imprinting, Drug delivery using smart polymers, Synthesis, Fast responsive hydrogels, Molecular recognition, Smart hydrogels as actuators, Controlled drug release, Artificial muscles, Hydrogels in microfluidics.	
6	Smart systems for sustainable applications: Elastic memory composites, Smart corrosion protection coatings, Self-healing materials, Sensors, Actuators, Transducers, MEMS, Deployment devices, Molecular machines, Nuclear Industries	05

Text Books:

- 1 Smart Structure and Materials Brain Culshaw Artech House – Borton. London
- 2 Smart Materials and Structures M. V. Gandhi and B. So Chapman & Hall, London; Thompson New York

References:

1. Electro ceramics: Materials, Properties A.J. Moulson and Wiley/ 2nd Edition, (ISBN: 0471497479).
2. Piezoelectric Sensories: Force, Strain, G. Gautschi Springer, Berlin; Pressure, Acceleration and Acoustic New York, 2002 Emission Sensors: Materials and Amplifiers (ISBN:3540422595)
3. Piezoelectric Actuators and wtrasonic K.Uchino Academic Publishers, Boston, 1997 (ISBN: 0792398114) Motors
4. <https://archive.nptel.ac.in/courses/112/104/112104251/>
5. <https://www.youtube.com/watch?v=yXHIIowQntk>

Course Code: ME17XXX	Vehicles Dynamics	Credits: 3-0-0:3
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Pre-requisites: Automobile Engineering

Course Outcomes:

S.N.	Outcomes
CO1	To understand the fundamentals of vehicle motion and dynamics.
CO2	To analyse longitudinal, lateral, and vertical vehicle behaviour.
CO3	To study steering, suspension, braking, and tire dynamics.
CO4	To evaluate vehicle stability, ride comfort, and handling characteristics.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Vehicle Dynamics: Vehicle coordinate systems, Forces and moments acting on vehicles, Vehicle resistance: rolling, aerodynamic, and gradient resistance, Tractive effort and power requirement, Weight distribution and load transfer	6
2.	Longitudinal Dynamics: Vehicle acceleration and performance, Traction and tire-road interaction, Braking dynamics, Stopping distance and braking efficiency, Anti-lock Braking System (ABS), Vehicle performance calculations	8
3.	Tire Mechanics and Steering Dynamics: Tire construction and characteristics, Slip angle and cornering force, Tire models, Steering geometry, Understeer, oversteer, and neutral steer, Steering system dynamics	8
4.	Suspension and Ride Dynamics: Suspension system objectives, Types of suspension systems, Ride comfort and vibration analysis, Pitch, bounce, and roll motion, Suspension spring and damping characteristics, Ride quality evaluation	8
5.	Lateral Stability and Handling: Lateral vehicle dynamics, Yaw motion and stability, Cornering characteristics, Rollover dynamics, Electronic Stability Control (ESC), Handling and stability analysis	8

Text Books:

- 1 Fundamentals of Vehicle Dynamics Thomas D. Gillespie SAE International

- | | | | |
|---|--|---------------|-----------------------|
| 2 | Vehicle Dynamics: Theory and Application | Reza N. Jazar | Springer |
| 3 | Advanced Vehicle Technology | Heinz Heisler | Butterworth-Heinemann |

References:

- | | | | |
|---|---------------------------|------------|-----------------------|
| 1 | Theory of Ground Vehicles | J. Y. Wong | Wiley Publications |
| 2 | Vehicle Handling Dynamics | Masato Abe | Butterworth-Heinemann |

Course Code: ME17XXX	Electric Vehicles	Credits: 3-0-0:3
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Pre-requisites: Basic Electrical and Electronics, Electrical Machines –I, Electrical Machines –II, engineering, Automobile Engineering

Course Outcomes:

S.N.	Outcomes
CO1	Understand the fundamentals and architecture of electric vehicles.
CO2	To study battery technologies, energy storage systems, and charging infrastructure.
CO3	To analyse electric propulsion systems and motor drives used in EVs.
CO4	To understand EV power electronics, control strategies, and energy management.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Introduction to Electric Vehicles: History and evolution of electric vehicles, Types of EVs: BEV, HEV, PHEV, FCEV, Comparison between ICE vehicles and EVs, EV market trends and government policies, Advantages and challenges of EVs	8
2.	Energy Storage Systems: Battery fundamentals, Battery parameters and characteristics, Lithium-ion batteries and advanced battery technologies, Battery Management System (BMS), Supercapacitors and fuel cells, Thermal management of batteries	10
3.	Electric Propulsion Systems: Electric traction requirements, DC motors, BLDC motors, PMSM, Induction motors, Motor characteristics and selection, EV transmission systems, Regenerative braking system	10
4.	Power Electronics and Charging Systems: Power electronic converters for EVs, Inverters and converters, Charging methods and standards, On-board and off-board chargers, Wireless charging technology, Smart charging infrastructure	7
5.	Energy Management and Future Trends: Energy management strategies, Vehicle dynamics and performance calculations, Hybrid vehicle control strategies, Environmental impacts and sustainability, Autonomous EVs and connected mobility, Future scope and recent advancements	5

Text Books:

- Electric Vehicle Technology Explained James Larminie and John Lowry Wiley Publications 2nd Edition, 2012

- 2 Modern Electric, Hybrid Electric and Fuel Cell Vehicles Mehrdad Ehsani, CRC Press
Yimin Gao, Sebastien E. Gay and Ali Emadi
- 3 Electric and Hybrid Vehicles: Design Fundamentals Iqbal Husain CRC Press

References:

- 1 Electric Vehicle Battery Systems Sandeep Dhameja Newnes
Publication
- 2 Hybrid Electric Vehicles Chris Mi, M. Abul Masrur Wiley Publications
- 3 Electric Powertrain John G. Hayes and G. Abas Goodarzi Wiley Publications

Course Code: ME17XXX	Mechatronics System Design	Credits: 3-0-0:3
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Prerequisites: Basic knowledge of Automation theory Systems

Course Outcomes:

CO1	Students will understand and identify the different components of a mechatronics system.
CO2	Students will be able to draw the equivalent mechatronics model for mechanical systems and study/analyse the mechanical and electro-mechanical systems.
CO3	Students will be able to identify and classify commonly used sensors for electro-mechanical systems.
CO4	Students will be able to prepare the PLC programming by using Ladder diagram for different mechatronics systems and analyse the functionality. To get familiar with the latest Improvements in mechatronics systems.

Course Articulation Matrix:

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

Units	Details	Nos. of Hrs
1	Introductions, Fundamentals of Mechatronics, Past, Present and Future; definitions and concepts. Conventional vs. Mechatronics Systems. Need of Mechatronics in Mechanical Engineering. Classification of Mechatronics etc.	06
2	Components of Mechatronic systems, Modelling the Mechatronics systems. Mechatronics model of different mechanical systems, their Block diagram with examples.	08
3	Sensors and transducers with special reference to Mechatronics, modeling of commonly used sensors, their design concepts etc.	08
4	Signals system and actuating devices, Real time interfacing. Application of Mechatronics in manufacturing and automation.	08
5	Advance Mechatronics systems such as FMS, PLCs, SCADA, CNC machines, Industrial Robotics. Case studies etc.	08

Text Books:

1. Mechatronics by W. Bolton, Pearson Publication McGraw Hill, 2010

References

1. Mechatronics System Design by Devdas Shetty and Richard A. Kolk, CI-Engineering, 2010
2. Mechatronics by Dan Neculescu, Pearson Publication, 2002
3. Mechatronics by David G. Alciatore and Michael B. Hestand, TMH Edition, 2011.
4. Mechatronics by M. D. Singh and Joshi J. G., PHI Learning, 2006



Course Code: ME17XXX	Nuclear Engineering and Technology	Credits: 3-0-0:3
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Prerequisites: Engineering Thermodynamics, Heat and Mass Transfer

Course outcomes:

CO1	Thermal-hydraulic analysis of nuclear reactor cores
CO2	Application of conservation equations for single and two-phase flow
CO3	Modeling of the reactor cores using sub-channel analysis methods.

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

Unit	Details	No. of Hrs
1	Review of Elementary nuclear physics: Atomic structure, nuclear energy and nuclear forces, Nuclear fission, Nuclear reactions and radiations, Principles of radioactive decay interactions of an ray with matter, Neutron cross sections and reactions, The fission process, Chain reactions	6
2	Basic principles of controlled fission: Nuclear reactor principles, Reactor classification, Critical size, Basic diffusion theory, Slowing down of neutrons, Neutrons – Neutron flux and power, Four factor formula, Criticality condition, Basic features of reactor control .	6
3	PWR, PHWR, Boiling water reactor: Description of reactor system, Main components, Control and safety features, Materials of reactor construction, Fuel, moderator, coolant. Structural materials, Cladding, Radiation damage.	8
4	Nuclear fuels: Metallurgy of Uranium, General principles of solvent extraction, Reprocessing of irradiated fuel, Separation process fuel enrichment. Reactor heat removal / equations of heat transfer as applied to reactor cooling, Reactor heat transfer systems, Heat removed in fast reactors.	8
5	Safety and disposal: Radiation safety, Reactor shielding, Radiation doses, Standards of radiation protection, Nuclear plant safety-safety systems-changes and consequences of accident-criteria for safety-nuclear waste-types of waste and its disposal-radiation hazards and their prevention-weapons proliferation.	8

Books:



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1. Neil E. Todreas and Mujid S. Kazimi, Nuclear Systems I, Thermal Hydraulic Fundamentals, Hemisphere Publishing Corporation, (1990).
2. John R. Lamarsh and Anthony J. Baratta, Introduction to Nuclear Engineering, Prentice Hall (2001).
3. Edited by O.C. Jones, Nuclear Reactor Safety Heat Transfer, Hemisphere Pub (1981).
4. E. E. Lewis, Nuclear reactor Safety, Wiley Interscience, 1977.



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Course Code: ME17XXXX	Total Quality Management	Credits: 3-0-0:3
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Prerequisites: Metrology and Quality Engineering

Course Outcomes:

CO1	Student able to understand the concept of quality management, techniques, models, TQM philosophies and implementation.
CO2	Students able to attain knowledge on TQM principles, team work and continuous improvement process
CO3	Students able to apply the modern quality management tools in developing the business strategy
CO4	Students able to understand the implications of quality management standards and systems

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1.	Introduction: Basic concepts of Total Quality Management, Evolution, Definition, TQM approach. TQM Philosophies: Deming Philosophy, Juran Trilogy, Crosby zero Defect Philosophy, Benefits of TQM, Preparing for TQM, Stages in TQM implementation, TQM Models, Barriers to TQM Implementation, Case studies.	7
2.	TQM Principles: Customer focus – Customer Perception of Quality, Types of customers, Customer satisfaction and retention models, Customer satisfaction measurements, Customer Complaints, Service Quality; Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits; Process approach; Integrated system; Strategic and systematic approach and planning; Continuous Process Improvement; Decision making; Communications.	7
3.	Quality Planning: SWOT Analysis, Strategic Planning, Organization culture, Quality councils, Characteristics of successful quality leader, Leadership theory and practices, Leadership and management, Juran Trilogy, PDCA Cycle, 5S, Kaizen; Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development	7
4.	TQM tools : Benchmarking – Reasons to Benchmark, Benchmarking Process; Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits; Zero defect concepts, Benchmarking, Poke Yoke, Quality Circle, Six sigma concepts, Juran Trilogy, PDCA Cycle, 5S, Kaizen, Problems and Problem solving Methods	7
5.	Reliability analysis, Taguchi Quality Loss Function, Total Productive Maintenance (TPM), Just in time, Business Process Re-engineering, Quality award models.	5
6.	TQM quality systems: Need for Quality and environment management systems, ISO 9000 Quality system, TS 16949, ISO 14000 – Concept, Requirements and Benefits, Implementation of Quality System, Documentation, and Quality Audits.	3



Case studies and discussion of practical industrial and service problems.

Text Books:

- | | | | | |
|---|-------------------|--------------------|---------|---|
| 1 | Besterfiled D. H. | ‘Total Management’ | Quality | Pearson Education Asia – 2005 |
| 2 | SubburajRamasamy | Total Management | Quality | Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005 |

References:

- | | | | | |
|---|---|---|---------|--|
| 1 | Joel E. Ross | Total Management | Quality | Taylor and Franscis Limited |
| 2 | James R. Evans and William M. Lindsay | “The Management and Control of Quality” | | 8th Edition, First Indian Edition, Cengage Learning, 2012. |
| 3 | ISO 9000: Concepts, Methods and Implementation, | | | Tapan P Bagchi, A.H.Wheeler, 1999 |
| 4 | L. Suganthi, Anand A. Samuel, | Total Management 1st Edition | Quality | PHI Learning, 2009 |
| 5 | R. Ashley Rawlins, | Total Management | Quality | Autherhouse, 2008 |



VII Semester: Open Elective Course

Course Code: ME17XXX	Energy Management	Credits: 3-0-0-3
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Prerequisites: Engineering Physics, Engineering Thermodynamics

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy conservation opportunities in different sectors of the economy.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	05
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	03
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	05
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	05
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	03



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Text Books:

- | | | | |
|---|-----------------------------------|-------------|-------------------------|
| 1 | Energy Systems and Sustainability | Boyle et al | Oxford University Press |
| 2 | Renewable Energy | Boyle et al | Oxford University Press |

References:

- | | | | |
|---|-----------------------------------|-------------------|----------------------------------|
| 1 | Energy efficiency | Eastop and Croft | Longman Scientific and Technical |
| 2 | Bureau of Energy Efficiency (BEE) | Ministry of Power | Government of India |
| 3 | Our Choice | Al Gore | Bloomsbury Publishing |
| 4 | An Inconvenient Truth | Al Gore | Oscar winning documentary |
| 5 | Before the flood | Leonardo DiCaprio | National Geographic documentary |



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Course Code: ME17XXX	Non-conventional Energy Sources	Credits: 3-0-0:3
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Pre-requisites: Engineering Thermodynamics, Heat and Mass Transfer, Energy Conversion Technology

Course Outcomes:

CO1	Understand the concept of energy crisis, non-conventional energy resources, availability and their importance.
CO2	Understand various methods to harness non-conventional energy resources.
CO3	Apply the methods for better harness, conversion techniques, and utilization of non-conventional energy resources.
CO4	Analyse various problems, limitations, complexities and performances of power plants based on non-conventional energy resources.

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1	Introduction: The energy crisis – causes and options, various conventional and non-conventional forms of energy and their characteristics, availability of non-conventional energy and land area requirements.	4
2	Solar energy: Introduction, Solar radiation, Sun-Earth angles, Measurement of solar radiation at the earth's surface, Types of collectors such as flat-plate and concentrating collectors, solar thermal power generation, solar ponds and energy storage. Principle of Solar photovoltaic, materials, mono-crystalline, polycrystalline and amorphous silicon cells and their production technology, I-V characteristics, parameters of performance, modules, array and PV plant configurations and power generation.	6
3	Biomass energy: Introduction, Incineration, Thermo-chemical and biochemical conversion to solid, liquid and gaseous fuels; Production technologies for bio-ethanol, biogas and producer gas, Urban waste to energy processes.	5
4	Ocean, Wave and Tidal energy: Introduction, Ocean thermal energy conversion (OTEC) – closed and open cycles and their limitations, Wave energy and its conversion processes, Tidal energy – nature of the tides and tidal barrages for power generation.	5
5	Wind energy: Fundamentals, power in the wind, site selection, maximum power coefficient, wind turbine and its types – horizontal axis and vertical axis machines, performance of wind machines, wind energy farms.	5
6	Geothermal energy: Introduction, Geothermal energy resources, Hot aquifers and	4



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	hot dry rock systems, geothermal electric power plants.	
7	Other Technologies: Magnetohydrodynamics (MHD) Energy conversion, Fuel Cells, Nuclear Energy, Hydrogen, Methanol, Energy Storage.	4

Text Books:

- 1 Renewable Energy Sources and Emerging Technologies D.P. Kothari, K.C. PHI Learning Pvt. Ltd., New Singal and R. Delhi Ranjan
- 2 Solar Energy-Fundamentals, Design, Modeling & Applications' G.N. Tiwari Narosa Publishing House, New Delhi, India

References:

- 1 Advanced Renewable Energy Sources G.N. Tiwari and RSC Publishing, Cambridge, U.K
- 2 Biogas Systems: Principles and Applications R.K. Mishra New Age International Limited Publishers.
- 3 Wind Energy Come of Age K.M Mittal John Wiley and sons, New York.
- 4 Solar Energy Fundamentals S. Kalogirou Academic Press
- 5 Solar Photovoltaics: Fundamentals Technologies and Applications C.S. Solanki PHI Learning Pvt. Ltd., New Delhi
- 6 Energy Technology (Non Conventional, Renewable And Conventional) S. Rao, BB Khanna Publishers Parulekar



Department of Mechanical Engineering

Course Code: ME17XXX	Advance Automotive Technology	Credits: 3-0-0:3
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Pre-requisites: Automobile Engineering

Course Outcomes:

CO1	Students will be able to understand modern developments in automotive technologies.
CO2	Students will be able to know about the advanced engine systems, electronics, and intelligent vehicle systems.
CO3	Students will understand automotive safety, emission control, and autonomous systems.
CO4	Students will be able to evaluate future mobility technologies and sustainable transportation systems

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1	Modern Automotive Systems: Modern vehicle architecture, Drive-by-wire technology, Electronic Control Units (ECUs), Controller Area Network (CAN), Local Interconnect Network (LIN), and FlexRay communication protocols, Sensors and actuators in automobiles	8
2	Advanced Powertrain Technologies: Gasoline Direct Injection (GDI), Common rail diesel injection systems, Variable valve timing and lift systems, Turbocharging and supercharging, Hybrid powertrain systems, Electric vehicle propulsion systems	8
3	Automotive Electronics and Intelligent Systems: Automotive embedded systems, Advanced Driver Assistance Systems (ADAS), Adaptive cruise control Lane departure warning systems, Vehicle navigation and telematics, Automotive cyber security basics	8
4	Automotive Safety and Emission Control: Active and passive safety systems, Antilock braking system (ABS), Electronic Brakeforce Distribution (EBD), traction control, and Electronic Stability Program (ESP), Airbags and crashworthiness, Emission norms and standards, Catalytic converters and particulate filters, Noise, vibration, and harshness (NVH) control	8
5	Autonomous and Future Mobility Technologies: Autonomous vehicles and levels of automation, Connected vehicles and Vehicle-to-everything (V2X) communication, Hydrogen fuel cell vehicles, Sustainable transportation technologies, Future trends in automotive engineering	8

Text Books:

- | | | | |
|---|---|-------------------------------|-----------------------|
| 1 | Advanced Vehicle Technology | Heinz Heisler | Butterworth-Heinemann |
| 2 | Automotive Technology: A Systems Approach | Jack Erjavec and Rob Thompson | Cengage Learning |
| 3 | Understanding Automotive Electronics | William B. Ribbens | Butterworth-Heinemann |



References:

- | | | | |
|---|-------------------------------------|------------------------------|--------------------|
| 1 | Vehicle Powertrain Systems | Wei Liu and Hesham Rakha | Wiley Publications |
| 2 | Bosch Automotive Handbook | Robert Bosch | GmbH |
| 3 | Automotive Engineering Fundamentals | Richard Stone and J K Ball | SAE International |
| 4 | Automotive Control Systems | Uwe Kiencke and Lars Nielsen | Springer |



Course Code: ME17XXX	Quality Engineering	Credits: 3-0-0:3
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Pre-requisites: Metrology and Quality Engineering

COURSE OUTCOME:

S.N.	Outcomes
CO1	Understand control charts for the analysis of observational data. Apply control charts for the real world industry or service organisations problems
CO2	Understand types of sampling plan and apply different sampling plans during the inspection of lots of products.
CO3	Understand and apply the concept of Reliability, Availability and Maintainability
CO4	Apply Quality Design concept for Parameter and Tolerance Design

Course Articulation Matrix:

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

Unit	Details	No. of hours
1	Introduction -Concept of quality, basic statistical concepts, Control of accuracy and precision, Process capability, standardization and interchangeability; Statistical Quality Control: Objectives, Applications, organization, cost aspects, theory of statistical tolerance.	4
2	Control Charts - General theory of Control Charts, Shewhart control chart for process control; Control Charts for variables such as X, R Control Charts for charts for attributes such as c and p charts; Acceptance control chart; Cumulative Sum Control Charts; Process Capability, Cause- Effect and Pareto diagrams.	12
3	Acceptance Sampling - Multiple and Sequential Sampling Plans, Multi-Continuous Sampling Plan, Acceptance Sampling by Variables, Advantages limitations. Sampling plans using different Criteria. Comparison of various types of sampling plans. Rectifying Inspection..	8
4	Reliability, Availability and Maintainability - Introduction to reliability, Bathtub curve, Series and Parallel system; MTBF, Evaluation of Availability and Maintainability.	6
5	Quality Design - Design of experiment concept, System, Parameter and Tolerance Design; Concept of Robust Design, Taguchi Concept - Orthogonal Arrays and S/N ratio.	6



Text/Reference Books:

1. Statistical Quality Control; Eugene L. Grant, Richard S. Leavenworth, Tata Mc Graw Hill, 2000
2. Introduction to quality control, Jamieson A, Reston, 2004.

Reference Books:

1. Statistical Quality control; A Modern Introduction 6th Edition, Douglas C. Montgomery, 2010
2. Juran's Quality Planning and Analysis, by Frank. M. Gryna Jr. McGrawHill
3. Reliability Engineering, by LS Srinath, Affiliated East West Pvt Ltd, 1991.
4. Reliability Engineering, by E Bala Guruswamy, Tata McGraw Hill, 1994.
5. Quality Engineering Using Robust Design, Madhav S. Phadke, Pearson, 2008.
6. Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design. Stapelberg Rudolph Frederick, ISBN: 9781848001749, 9781848001749.
7. James R. Evans and William M. Lindsay, "The Management and Control of Quality", First Indian Edition, Cengage Learning, 2012.



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Course Code: MEN17XXX	Total Quality Management	Credits: 3-0-0:3
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Prerequisites: Metrology and Quality Engineering

Course Outcomes:

CO1	Student able to understand the concept of quality management, techniques, models, TQM philosophies and implementation.
CO2	Students able to attain knowledge on TQM principles, team work and continuous improvement process
CO3	Students able to apply the modern quality management tools in developing the business strategy
CO4	Students able to understand the implications of quality management standards and systems

Course Articulation Matrix:

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

Unit	Details	No. Hrs
1.	Introduction: Basic concepts of Total Quality Management, Evolution, Definition, TQM approach. TQM Philosophies: Deming Philosophy, Juran Trilogy, Crosby zero Defect Philosophy, Benefits of TQM, Preparing for TQM, Stages in TQM implementation, TQM Models, Barriers to TQM Implementation, Case studies.	7
2.	TQM Principles: Customer focus – Customer Perception of Quality, Types of customers, Customer satisfaction and retention models, Customer satisfaction measurements, Customer Complaints, Service Quality; Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits; Process approach; Integrated system; Strategic and systematic approach and planning; Continuous Process Improvement; Decision making; Communications.	7
3.	Quality Planning: SWOT Analysis, Strategic Planning, Organization culture, Quality councils, Characteristics of successful quality leader, Leadership theory and practices, Leadership and management, Juran Trilogy, PDCA Cycle, 5S, Kaizen; Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development	7
4.	TQM tools : Benchmarking – Reasons to Benchmark, Benchmarking Process; Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits; Zero defect concepts, Benchmarking, Poke Yoke, Quality Circle, Six sigma concepts, Juran Trilogy, PDCA Cycle, 5S, Kaizen, Problems and Problem solving Methods	7
5.	Reliability analysis, Taguchi Quality Loss Function, Total Productive Maintenance (TPM), Just in time, Business Process Re-engineering, Quality award models.	5
6.	TQM quality systems: Need for Quality and environment management systems, ISO 9000 Quality system, TS 16949, ISO 14000 – Concept, Requirements and Benefits, Implementation of Quality System, Documentation, and Quality Audits.	3



Case studies and discussion of practical industrial and service problems.

Text Books:

- | | | | | |
|---|-------------------|--------------------|---------|---|
| 1 | Besterfiled D. H. | ‘Total Management’ | Quality | Pearson Education Asia – 2005 |
| 2 | SubburajRamasamy | Total Management | Quality | Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005 |

References:

- | | | | | |
|---|---|---|---------|--|
| 1 | Joel E. Ross | Total Management | Quality | Taylor and Franscis Limited |
| 2 | James R. Evans and William M. Lindsay | “The Management and Control of Quality” | | 8th Edition, First Indian Edition, Cengage Learning, 2012. |
| 3 | ISO 9000: Concepts, Methods and Implementation, | | | Tapan P Bagchi, A.H.Wheeler, 1999 |
| 4 | L. Suganthi, Anand A. Samuel, | Total Management 1st Edition | Quality | PHI Learning, 2009 |
| 5 | R. Ashley Rawlins, | Total Management | Quality | Autherhouse, 2008 |



Department of Mechanical Engineering

Course Code: ME17XXX	Product Design and Development	Credits: 3-0-0: 3
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Pre-requisites: Design Thinking and Product Visualization, Workshop and Product Realization,

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to identify engineering problem and gather information for product development.
CO2	Students will be able to analyse customer and company requirements and develop product design specifications (PDS).
CO3	Students will be able to apply physical laws and systematic design methods to generate and develop product concepts.
CO4	Students will be able to evaluate concepts and perform embodiment and detailed design of engineering products.

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	Problem Definition and Gathering information: Problem statement, Need analysis and engineering characteristics, Product Design Specification (PDS), Benchmarking, Product planning, Quality Function Deployment (QFD), Information gathering techniques. Information related to intellectual properties.	8
2.	Concept Generation: Creative thinking, Functional analysis, Function decomposition, Product decomposition diagram, Solutions for basic functions, Converting requirements into functions and design parameters (Engineering characteristics) Developing function variants and concept variants using Physical laws and Design Parameters (Physical effects), Basics of TRIZ.	10
3.	Concept Evaluation and Decision Making: Absolute and relative evaluation techniques, Decision matrices, Analytic Hierarchy Process (AHP), Concept screening and scoring, Selection of optimum concepts.	6



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4.	Embodiment Design: Product architecture, Configuration design, Parametric design, Materials selection and Design, Modelling and simulation, Design for manufacturability and assembly (DFMA).	10
5.	Detailed Design: Introduction to Detail design, Assembly and Detail drawing, Bill of materials (BOM), Prototype development, Final design review.	6

Text Books:

6. Product Design and Development, **Ulrich K. T, Steven D Eppinger S. D.**, McGraw Hill
7. Engineering Design, **George E. Dieter**, McGraw Hill

References:

3. Mechanical Design Process, **David G Ullman**, McGraw Hill
4. Product Design **Otto K, and Wood K**, Pearson
5. Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving, **Semyon D. Savransky**, CRC Press
6. An Introduction to TRIZ: The Russian Theory of Inventive Problem Solving, Stan Kaplan, Productivity & Quality Publishing Private Limited.
7. Human Factors in Engineering Design, **Mark S sanders & Ernst J. Mc Cornick**, McGraw Hill Publishers.
8. Product Design & Process Engineering, **Benjamin W Nishel & Alan B Draker**, McGraw Hill Publishers
9. Any other reference discussed in class for specific topics.

Along with the above following is also desired: An open mind to feel the quality in a system. Subscription to a quality National News Paper/ Business newspaper /magazines for articles on products technologies/ intellectual property acquired by specific firms etc. - Nationally and internationally.



Department of Mechanical Engineering

Course Code: ME17XXX	Electrical Vehicles Technology	Credits: 2-0-2: 3
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Pre-requisites: Basic Electric and Electronics Engineering, Automobile Engineering

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand about basics of electric vehicle
CO2	Students will be able to understand about drives and control systems of electric vehicles.
CO3	Students will be able to select motor, battery, battery management system for EV applications
CO4	Students will be able to design battery charger for an EV

Course Articulation Matrix (CO-PO-PSO Mapping):

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

Unit	Details	No. Hrs
1.	EV Fundamentals: Internal combustion engine vs EV. Understand major EV components and types.	4
2.	Vehicle Fundamentals: Dynamic analysis and design considerations of EV. Regenerative braking mechanisms. Powertrains	10
3.	Battery Technology and BMS: Define battery types and selection criteria. Manufacturing of batteries. Battery modelling. Failures of batteries. Battery pack and design issues. Battery pack performance and safety testing standards. Battery management systems	14
4.	Motor, Controllers and Charging: Understand motor components, types, and selection criteria. Controllers, types and selection criteria. Converters, EV charger types and charging systems.	8

Text Books:

1. Larminie, J., & Lowry, J. (2012). *Electric vehicle technology explained*. John Wiley & Sons.
2. Enge, P., Enge, N., & Zoepf S. (2021). *Electric Vehicle Engineering*. McGraw Hill
3. Holm-Nielsen, N. P. A. K., & Bo, B. S. P. J. (2021). *Electric Vehicles: Modern Technologies and Trends (Green Energy and Technology)*.
4. Arora, S., Abkenar, A. T., Jayasinghe, S. G., & Tammi, K. (2021). *Heavy-duty electric vehicles: From concept to reality*. Butterworth-Heinemann.

References:

1. Fundamentals of Electric vehicles: Technology & Economics
<https://nptel.ac.in/courses/108106170>