SHRI VISHNU ENGINEERING COLLEGE FOR WOMEN (AUTONOMOUS)
BHIMAVARAM - 534202
Department of Mechanical Engineering
Course Structure – R23
(With effect from 2023-2024)

III Year - I Semester

S.No	Category	Course Code	Course Title	L	T	P	C	IM	EM	TM
1	PC	UGME5T0123	Machine Tools and Metrology	3	0	0	3	30	70	100
2	PC	UGME5T0223	Thermal Engineering	3	0	0	3	30	70	100
3	PC	UGME5T0323	Design of Machine Elements	3	0	0	3	30	70	100
4	PE	UGME5T0423 UGME5T0523 UGME5T0623 UGME5T0723	Professional Elective – I: 1.Design for Manufacturing 2.Conventional and futuristic vehicle technology 3.Renewable Energy Technologies 4.Non-destructive Evaluation 5.MOOCS	3	0	0	3	30	70	100
5	OE		Open Elective-I: 1. Electronic Devices and Circuits 2. Principles of Operating Systems 3. Computer Organization and Architecture	3	0	0	3	30	70	100
6	PC	UGME5P0823	Thermal Engineering Lab	0	0	3	1.5	30	70	100
7	PC	UGME5P0823	Theory of Machines Lab	0	0	3	1.5	30	70	100
8	SOC	UGME5K0923	Machine tools and Metrology Lab	0	0	4	2	30	70	100
9	ES		Tinkering Lab	0	0	2	1	30	70	100
10			Community Service Internship	-	-	-	2	-	50	50
			Total	**15**	**0**	**12**	**23**	**270**	**680**	**950**

III Year - II Semester

S.No	Category	Course Code	Course Title	L	T	P	C	IM	EM	TM
1	PC	UGME6T0123	Heat Transfer	3	0	0	3	30	70	100
2	PC	UGME6T0223	Artificial Intelligence and Machine Learning	3	0	0	3	30	70	100
3	PC	UGME6T0323	Finite Element Methods	3	0	0	3	30	70	100
4	PE	UGME6T0423 UGME6T0523 UGME6T0623 UGME6T0723	Professional Elective-II: 1.Mechanical Vibrations 2.Advanced Manufacturing Processes 3.Micro Electro Mechanical Systems 4.Sensors and Instrumentation 5.MOOCS	3	0	0	3	30	70	100
5	PE	UGME6T0823 UGME6T0923 UGME6T1023 UGME6T1123	Professional Elective-III: 1.Energy Storage Technologies 2.Industrial Hydraulics and Pneumatics 3.Industrial Robotics 4.Refrigeration & Air-Conditioning	3	0	0	3	30	70	100
6	OE		Open Elective – II: 1. Microprocessors & Microcontrollers 2. Fundamentals of Electric Vehicles 3. Principles of Database Management Systems 4. Electrical Wiring Estimation and Costing	3	0	0	3	30	70	100
7	PC	UGME6P1223	Heat Transfer Lab	0	0	3	1.5	30	70	100
8	PC	UGME6P1323	Artificial Intelligence and Machine Learning Lab	0	0	3	1.5	30	70	100
9	SOC	UGME6K1423	Robotics and Drone Technologies Lab	0	0	4	2	30	70	100
10	AC		Technical paper writing and IPR	2	0	0	0	-	-	-
			Total	**20**	**0**	**10**	**23**	**270**	**630**	**900**
Mandatory Community Service Project Internship of 08 weeks duration during summer Vacation										

MACHINE TOOLS & METROLOGY

Subject Code : UGME5T0123	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course objectives:

1. To learn the fundamental knowledge and principles of material removal processes.
2. To understand the basic principles of lathe, shaping, slotting and planning machines
3. To demonstrate the fundamentals of drilling, milling and boring processes.
4. To discuss the concepts of super finishing processes and limits and fits.
5. To understand the concepts of surface roughness and optical measuring instruments

Course Outcomes:

At the end of the course, student will be able to

CO1: Apply the fundamentals of machining to analyze cutting forces, tool geometry, chip formation and machinability.

CO2: Acquire the knowledge on machining operations such as turning, shaping, slotting, and planning processes.

CO3: Capable to operate drilling, boring, milling machines and apply indexing methods for machining operations.

CO4: Apply knowledge of finishing processes, limits and fits, and linear measurement techniques using tools like grinding machines, slip gauges, and micrometers.

CO5: Understand the different types of Surface roughness and Optical measuring instruments.

SYLLABUS:

UNIT – I: FUNDAMENTALS OF MACHINING

Elementary treatment of metal cutting theory – element of cutting process – Single point cutting tools, nomenclature, tool signature, mechanism of metal cutting, types of chips, mechanics of orthogonal and oblique cutting –Merchant's force diagram, cutting forces, Taylor's tool life equation, simple problems - Tool wear, tool wear mechanisms, machinability, economics of machining, coolants, tool materials and properties.

UNIT – II: LATHE MACHINES

Introduction- types of lathe - Engine lathe – principle of working - construction - specification of lathe - accessories and attachments – lathe operations – taper turning methods and thread cutting – drilling on lathes.

SHAPING, SLOTTING AND PLANNING MACHINES: Introduction - principle of working – principle parts – specifications - operations performed - slider crank mechanism - machining time calculations.

UNIT – III: DRILLING & BORING MACHINES

Introduction – construction of drilling machines – types of drilling machines - principles of working – specifications- types of drills - operations performed – machining time calculations - Boring Machines – types.

MILLING MACHINES: Introduction - principle of working – specifications – milling methods - classification of Milling Machines –types of cutters - methods of indexing-machining time calculations

UNIT – IV:

FINISHING PROCESSES: Classification of grinding machines- types of abrasives-bonds, specification and selection of a grinding wheel- Lapping, Honing & Broaching operations- comparison to grinding.

SYSTEMS OF LIMITS AND FITS: Types of fits -Unilateral and bilateral tolerance system, hole and shaft basis systems- interchangeability & selective assembly-International standard system of tolerances, simple problems related to limits and fits,

Taylor's principle – design of go and no go gauges; plug, ring, snap, gap, taper, profile and position gauges.

LINEAR MEASUREMENT: Length standards, end standards, slip gauges- calibration of the slip Gauges, dial indicators, micrometers.

UNIT – V:

ANGULAR MEASUREMENT: Bevel protractor, angle slip gauges- angle dekkor- spirit levels- sine bar- sine table.

SURFACE ROUGHNESS MEASUREMENT: Differences between surface roughness and surface waviness –Numerical assessment of surface finish, Profilograph, Talysurf, ISI symbols.

OPTICAL MEASURING INSTRUMENTS: Tools maker's microscope, Autocollimators, Optical projector, Optical flats-working principle, construction, merits, demerits and their uses. optical comparators.

Mapping of COs to POs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PSO1	PSO2
CO1	3	3	3	3	-	3	-	-	-	-	3	3	3
CO2	3	3	3	3	-	3	-	-	-	-	3	3	3
CO3	3	3	3	3	-	3	-	-	-	-	3	3	3
CO4	3	3	3	3	-	3	-	-	-	-	3	3	3
CO5	3	3	3	3	-	3	-	-	-	-	3	3	3

TEXT BOOKS:

1. Manufacturing Processes / JP Kaushish/ PHI Publishers-2nd Edition
2. Manufacturing Technology Vol-II/P.N Rao/Tata McGraw Hill
3. Engineering Metrology – R.K. Jain/Khanna Publishers

REFERENCES:

1. Metal cutting and machine tools /Geoffrey Boothroyd, Winston A.Knight/ Taylor & Francis
2. Production Technology / H.M.T. Hand Book (Hindustan Machine Tools).
3. Production Engineering/K.C Jain & A.K Chitaley/PHI Publishers
4. Technology of machine tools/S.F.Krar, A.R. Gill, Peter SMID/ TMH
5. Manufacturing Processes for Engineering Materials-Kalpak Jian S & Steven R Schmid/Pearson Publications 5th Edition

THERMAL ENGINEERING

Subject Code: UGME5T0223	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To give insight into basic principles of air standard cycles.
2. To impart knowledge about IC engines and Boilers
3. To make the students learn the working principles of steam nozzles, turbines and compressors.
4. To impart the knowledge about the various types of compressors and gas turbines.
5. To make the students gain insights about, rockets and jet propulsion and solar Engineering

Course Outcomes:

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

CO1: Explain and analyze air-standard and actual engine cycles, including related performance losses. (L2, L4)

CO2: Describe the construction, working, and performance of I.C. engines and boilers. (L2, L3)

CO3: Apply principles of steam nozzles, turbines, and condensers to evaluate performance parameters. (L3)

CO4: Analyze the types of compressors and gas turbine modifications to evaluate their performance and efficiency. (L4)

CO5: Analyze and compare the performance of jet propulsion, rocket engines, and solar energy systems for engineering applications. *(L4)*

SYLLABUS:

UNIT – I:

Air standard Cycles: Otto, diesel and dual cycles, its comparison, Brayton cycle.

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines**.**

UNIT – II:

I.C Engines: Classification - Working principles of SI and CI engines, Valve and Port Timing Diagrams, -Engine systems – Fuel, Carburetor, Fuel Injection System, Ignition, Cooling and Lubrication, principles of supercharging and turbocharging, Measurement, Testing and Performance.

Boilers: Principles of L.P & H.P boilers, mountings and accessories, Draught- induced and forced.

UNIT – III:

Steam nozzles: Functions, applications, types, flow through nozzles, condition for maximum discharge, critical pressure ratio, criteria to decide nozzle shape, Wilson line.

Steam turbines: Classification – impulse turbine; velocity diagram, effect of friction, diagram efficiency, De-leval turbine - methods to reduce rotor speed, combined velocity diagram.

Reaction turbine: Principle of operation, velocity diagram, Parson's reaction turbine – condition for maximum efficiency.

Steam condensers: Classification, working principles of different types – vacuum efficiency and condenser efficiency.

UNIT – IV:

Compressors: Classification, Reciprocating type - Principle, multi-stage compression, Rotary type – Lysholm compressor –principle and efficiency considerations.

Centrifugal Compressors: Principle, velocity and pressure variation, velocity diagrams.

Axial flow Compressors: Principle, pressure rise and efficiency calculations.

Gas Turbines: Simple gas turbine plant – ideal cycle, components –regeneration, inter cooling and reheating.

UNIT – V:

Jet Propulsion: Principle, classification, t-s diagram - turbo jet engines – thermodynamic cycle, performance evaluation.

Rockets: Principle, solid and liquid propellant rocket engines.

Solar Engineering: Solar radiation, Solar collectors, PV cells, storage methods and applications.

Mapping of COs to POs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	2	-	-	2	-	-	-	-	2	-	-
CO3	3	3	3	2	-	-	-	-	-	-	-	-	-
CO4	3	3	3	2	-	2	-	-	-	-	-	-	-
CO5	3	2	2	-	-	3	-	-	-	-	-	-	-

Textbooks:

1. Thermal Engineering - Mahesh Rathore- McGraw Hill publishers
2. Heat Engineering /V.P Vasandani and D.S Kumar/Metropolitan Book Company, New Delhi.

References:

1. I.C. Engines - V. Ganesan- Tata McGraw Hill Publishers
2. Thermal Engineering-M.L.Mathur& Mehta/Jain bros. Publishers
3. Thermal Engineering-P.L.Ballaney/ Khanna publishers.
4. Thermal Engineering / RK Rajput/ Lakshmi Publications
5. Thermal Engineering-R.S Khurmi, &J S Gupta/S.Chand.

DESIGN OF MACHINE ELEMENTS

Subject Code: UGME5T0323	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
2. Provide an introduction to design of bolted and welded joints.
3. Explain design procedures for shafts and couplings.
4. Discuss the principles of design for clutches and brakes and springs.
5. Explain design procedures for bearings and gears.

Course Outcomes:

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

CO1: Apply design principles, material selection criteria, and failure theories to analyze and design mechanical components under static and dynamic loading conditions.

CO2: Design bolted and welded joints considering preload, stress distribution, and strength under different loading conditions.

CO3: Design power transmission shafts and couplings for torsional, bending, and fluctuating loads using appropriate design considerations.

CO4: Analyze and design friction clutches, brakes, and various types of springs based on load requirements and operational conditions.

CO5: Select and design bearings and spur gears considering lubrication, load capacity, fatigue life and failure modes.

Syllabus:

UNIT-I: Introduction, Design for Static and Dynamic loads

Mechanical Engineering Design: Design process, design considerations, codes and standards of designation of materials, selection of materials.

Design for Static Loads: Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

Design for Dynamic Loads: Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

UNIT-II: Design of Bolted and Welded Joints

Design of Bolted Joints: Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints.

Welded Joints: Strength of lap and butt welds, Joints subjected to bending and torsion.

UNIT-III: Power transmission shafts and Couplings

Power Transmission Shafts: Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

Couplings: Design of flange and bushed pin couplings, universal coupling.

UNIT-IV: Design of Clutches, Brakes and Springs

Friction Clutches: Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.

Brakes: Different types of brakes. Concept of self-energizing and self-locking of brake.

Band and block brakes, disc brakes.
Springs: Design of helical compression, tension, torsion and leaf springs.

UNIT-V: Analysis & Selection of Bearings and Design of Gears

Sliding Contact Bearings: Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.

Rolling Contact Bearings: Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

Design of Gears: Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

Note: Data book is not allowed.

Mapping of COs to POs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PSO1	PSO2
CO1	3	3	3	3	-	3	-	-	-	-	3	3	3
CO2	3	3	3	3	-	3	-	-	-	-	3	3	3
CO3	3	3	3	3	-	3	-	-	-	-	3	3	3
CO4	3	3	3	3	-	3	-	-	-	-	3	3	3
CO5	3	3	3	3	-	3	-	-	-	-	3	3	3

Textbooks:

1. R.L. Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2. V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGraw Hill, 2010.
3. Dr. N. C. Pandya &Dr. C. S. Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

Reference Books:

1. R.K. Jain, Machine Design, Khanna Publications, 1978.
2. J.E. Shigley, Mechanical Engineering Design, 2/e, Tata McGraw Hill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.

Online Learning Resources:

https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design-ofmachine-elements-1-npte
https://www.digimat.in/nptel/courses/video/112105124/L01.html
https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html
http://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html

DESIGN FOR MANUFCTURING

(Professional Elective-I)

Subject Code: UGME5T0423	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course Objectives: The students will acquire the knowledge:

1) To understand the basic concepts of design for manual assembly
2) To interpret basic design procedure of machining processes
3) To understand design considerations metal casting, extrusion and sheet metal work
4) To interpret the design considerations of various metal joining process.
5) To interpret the basic design concepts involved in the assembly automation

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

CO1: Understand the basic concepts of design for manual assembly
CO2: Identify basic design procedure of various machining processes
CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work
CO4: Interpret the design considerations of various metal joining process
CO5: Understand the basic design concepts involved in the assembly automation

SYLLABUS:

UNIT-I:

Introduction to DFM, DFMA: 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.

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 and application of the DFA Methodology.

UNIT– II:

Machining processes: Overview of various machining processes-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.

UNIT – III:

Metal casting: Appraisal of various casting processes, selection of casting process,- general design considerations for casting-casting tolerance-use of solidification, simulation in casting design product design rules for sand casting.

Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking.

UNIT– IV:

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. **Forging:** Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.

UNIT– V:

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, and single station assembly lines.

Design for Additive Manufacturing:

Introduction to AM, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features,

Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers.

Mapping of COs to POs:

CO	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO 8	PO 9	P10	P11	PSO1	PSO 2
CO1	3	2	2	-	-	-	-	-	-	-	-	3	3
CO2	3	2	2	-	2	-	-	-	-	-	-	2	3
CO3	3	2	2	2	2	-	-	-	-	-	-	3	3
CO4	3	2	2	2	2	1	-	-	-	-	-	3	3
CO5	3	2	2	2	2	1	-	1	1	1	1	3	3

TEXT BOOKS:

1. Design for manufacture, John Cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla,

REFERENCE:

1. Molloy, E.A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998
2. ASM Hand book Vol.20

CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY
(Professional Elective-I)

Subject Code: UGME5T0523	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

- To study the advanced engine technologies
- To learn various advanced combustion technologies and their benefits
- To learn the methods of using low carbon fuels and its significance
- To learn and understand the hybrid and electric vehicle configurations
- To study the application of fuel cell technology in automotive

Course Outcomes:

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

CO1: Explain advanced internal combustion engine technologies.)

CO2: Compare and analyze various combustion strategies in SI, CI, and dual-fuel engines.

CO3: Explain the characteristics, challenges, and advantages of low-carbon fuels.

CO4: Distinguish between conventional hybrids, modern hybrids, and pure battery electric vehicles in terms of working principles, components, and challenges.

CO5: Describe the working principles of fuel cell systems, onboard hydrogen storage, and control systems used in automotive applications.

SYLLABUS:

UNIT – I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT – II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT – III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT – IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward

UNIT – V: FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.

Mapping of COs to Pos, PSOs:

POs/ COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	-	3	-	-	-	-	3	3	3
CO2	3	3	3	3	-	3	-	-	-	-	3	3	3
CO3	3	3	3	3	-	3	-	-	-	-	3	3	3
CO4	3	3	3	3	-	3	-	-	-	-	3	3	3
CO5	3	3	3	3	-	3	-	-	-	-	3	3	3

TEXT BOOKS:

1.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

2.Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6, SPRINGER

REFERENCES:

1.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

2.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

3.Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

4.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

5.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

RENEWABLE ENERGY TECHNOLOGIES
(Professional Elective-I)

Subject Code: UGME5T0623	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PV modules
2. To understand the principles of storage in PV systems
3. To discuss solar energy storage systems and their applications.
4. To get knowledge in wind energy and bio-mass
5. To gain insights in geothermal energy, ocean energy and fuel cells.

Course Outcomes:

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

CO1: Illustrate the importance of solar radiation and solar PV modules.
CO2: Discuss the storage methods in PV systems.
CO3: Demonstrate the solar energy storage for different applications
CO4: Understand the principles of wind energy, and bio-mass energy.
CO5: Attain knowledge in geothermal energy, ocean energy and fuel cells.

UNIT – I:

SOLAR RADIATION: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULES AND PV SYSTEMS:

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

UNIT – II:

STORAGE IN PV SYSTEMS:

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

UNIT – III:

SOLAR ENERGY COLLECTION: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

UNIT – IV:

WIND ENERGY: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

BIO-MASS: Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

UNIT – V:

GEOTHERMAL ENERGY: Origin, Applications, Types of Geothermal Resources, Relative Merits

OCEAN ENERGY: Ocean Thermal Energy; Open Cycle & Closed Cycle OTEC Plants, Environmental Impacts, Challenges

FUEL CELLS: Introduction, Applications, Classification, Different Types of Fuel Cells Such as Phosphoric Acid Fuel Cell, Alkaline Fuel Cell, PEM Fuel Cell, MC Fuel Cell.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	3	-	-	-	-	-	-	-	3	-	-
CO2	3	3	3	-	-	-	-	-	-	-	3	-	-
CO3	3	3	3	-	-	-	-	-	-	-	3	-	-
CO4	3	3	3	-	-	-	-	-	-	-	3	-	-
CO5	3	3	3	-	-	-	-	-	-	-	3	-	-

Text Books:

1. Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K.Nayak/TMH
2. Non-Conventional Energy Resources- Khan B.H/ Tata McGraw Hill, New Delhi, 2006
3. Green Manufacturing Processes and Systems - J. Paulo Davim/Springer 2013

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth& John F Kreider / Taylor &Francis
2. Non-Conventional Energy - Ashok V Desai /New Age International (P) Ltd
3. Renewable Energy Technologies -Ramesh & Kumar /Narosa
4. Non-conventional Energy Source- G.D Roy/Standard Publishers

NON- DESTRUCTIVE EVALUATION
(Professional Elective-I)

Subject Code: UGME5T0723	**L**	**T**	**P**	**C**
III Year / I Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To apply the basic principles of Non-Destructive Testing (NDT) methods for evaluating materials and components in industrial settings.
2. To analyze ultrasonic testing procedures to determine their effectiveness and limitations for various defect detection scenarios.
3. To apply and compare liquid penetrant and eddy current testing methods for identifying surface and near-surface discontinuities.
4. To implement and evaluate magnetic particle testing techniques for defect detection in ferromagnetic materials.
5. To apply infrared and thermal testing methods and interpret thermal patterns for condition monitoring and fault diagnosis.

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

CO	**Course Outcome Statement**
CO1	Apply the concepts of various non-destructive evaluation (NDE) techniques and assess the safety requirements in radiographic testing.
CO2	Interpret and analyze the principles and procedures of ultrasonic testing for flaw detection.
CO3	Apply the principles and procedures of liquid penetrant and eddy current testing to identify surface and subsurface defects.
CO4	Illustrate and evaluate the procedures involved in magnetic particle testing for defect detection in ferromagnetic materials.
CO5	Analyze and interpret the principles and procedures of infrared and thermal testing for condition monitoring.

SYLLABUS:

UNIT – I: Introduction to non-destructive testing and industrial Applications of NDE

Span of NDE Activities Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions. Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography, neutron ray radiography

UNIT–II: Ultrasonic test

Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection - Effectiveness and Limitations of Ultrasonic Testing.

UNIT–III: Liquid Penetrant Test

Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness, DPI, FPI,Limitations of Liquid Penetrant Testing**.**

Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing

UNIT– IV:Magnetic Particle Test

Magnetic Materials, Magnetization of Materials, Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test

Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test

UNIT – V: Infrared And Thermal Testing

Introduction and fundamentals to infrared and thermal testing–Heat transfer – Active and passive techniques –Lock in and pulse thermography, tomography-Contact and non-contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals –other temperature sensitive coatings –Inspection methods – Infrared radiation and infrared detectors–thermo mechanical behaviour of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Mapping of COs to POs:

PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	-	-	-	3	-	2	-	-	-	2	3
CO2	3	3	-	2	2	-	-	-	-	-	-	2	2
CO3	3	2	2	-	2	-	-	-	-	-	-	2	3
CO4	3	2	2	-	2	-	-	-	-	-	-	2	3
CO5	2	2	-	3	3	-	2	-	-	-	-	2	2

Text Books:

1.Nondestructive test and evaluation of Materials/J Prasad, GCK Nair/TMH Publishers
2.Ultrasonic testing of materials/ H KrautKramer/Springer
3.Nondestructive testing/Warren, J Mc Gonnagle / Godan and Breach Science publishers
4.Nondestructive evaluation of materials by infrared thermography / X. P. V. Maldague, Springer-Verlag, 1st edition, (1993)

References:

1. Ultrasonic inspection training for NDT/E.A.Gingel/PrometheusPress,
2. ASTM Standards,Vol3.01,Metalsandalloys
3. Non-destructive Evaluation, Hand Book – R. Ham Chand

THERMAL ENGINEERING LAB

Subject Code: UGME5P0823	**L**	**T**	**P**	**C**
III Year I Semester	**0**	**0**	**3**	**1.5**

Course objectives:

1) To demonstrate the characteristics of two stroke and four stroke compression and spark ignition engines.
2) To determine flash point, fire point, calorific value of different fuels using various apparatus.
3) To find out engine friction, and conduct load test of petrol and diesel engines.
4) To demonstrate performance test on petrol and diesel engines.
5) To conduct performance test and determine efficiency of air compressor.

Course outcomes:

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

CO1: Experiment with two-stroke and four-stroke compression and spark ignition engines for various characteristics.
CO2: Determine flash point, fire point, calorific value of different fuels using various apparatus.
CO3: Perform engine friction, heat balance test, and load test of petrol and diesel engines.
CO4: Conduct performance test on petrol and diesel engines
CO5: Perform a test and determine the efficiency of the air compressor

Experiments:

1. To determine the actual Valve Timing diagram of a four-stroke Compression/Spark Ignition Engine.
2. To determine the actual Port Timing diagram of a two-stroke Compression/Spark Ignition Engine.
3. Determination of Flash & Fire points of Liquid fuels / Lubricants using (i) Abels Apparatus: (ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Saybolt Viscometer and (ii) Redwood Viscometer.
5. Evaluation of engine friction by conducting the Morse test on a 4-stroke multi-cylinder petrol/diesel engine.
6. To perform the Heat Balance Test on Single Single-Cylinder four-stroke Petrol/Diesel Engine.
7. To conduct a load test on a single-cylinder Petrol/Diesel engine to study its performance under various loads.
8. To conduct a performance test on a VCR engine, under different compression ratios, and determine its heat balance sheet.
9. To conduct a performance test on an air compressor and determine its different efficiencies.
10. Study of boilers with accessories and mountings
11. Experimentation on the installation of Solar PV Cells
12. Demonstration of electronic controls in an automobile.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	3	3	3	3	3	-	-	3	-	-	-	3	-
CO2	3	3	3	3	3	-	-	3	-	-	-	3	-
CO3	3	3	3	3	3	-	-	3	-	-	-	3	-
CO4	3	3	3	3	3	-	-	3	-	-	-	3	-
CO5	3	3	3	3	3	-	-	3	-	-	-	3	-

THEORY OF MACHINES LAB

Subject Code: UGME5P0923	**L**	**T**	**P**	**C**
III Year I Semester	**0**	**0**	**3**	**1.5**

Course objectives:

1. Demonstrate the motion behavior of gyroscopes under dynamic loading.
2. Analyze the characteristics and performance of governors.
3. Determine frequencies of damped and undamped free/forced vibrations in mechanic systems.
4. Evaluate motion parameters in various mechanisms including cams and followers.
5. Understand the operation and classification of gears and simple machines.

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

CO1: Demonstrate the motion behavior and couple of gyroscope systems.

CO2: Analyze governor characteristics and determine controlling force and stability.

CO3: Analyze the natural frequencies of damped and undamped systems through experimental results.

CO4: Analyze motion of cams, slider-crank, and follower mechanisms based on experimental observation.

CO5: Classify and describe gears and simple mechanisms.

List of Experiments:

1. To determine whirling speed of shaft theoretically and experimentally.
2. To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation.
3. To analyse the motion of a motorized gyroscope when the couple is applied along its spin axis
4. To determine the frequency of undamped free vibration of an equivalent spring mass system.
5. To determine the frequency of damped force vibration of a spring mass system
6. To study the static and dynamic balancing using rigid blocks.
7. To find the moment of inertia of a flywheel
8. To plot follower displacement vs cam rotation for various Cam Follower systems.
9. To plot slider displacement, velocity and acceleration against crank rotation for single slider crank mechanism/Four bar mechanism
10. To find the coefficient of friction between the belt and pulley.
11. To study simple and compound screw jack and determine the mechanical advantage, velocity ratio, and efficiency
12. To study various types of gears- Spur, Helical, Worm and Bevel Gears

Mapping of COs to POs:

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

MACHINE TOOLS & METROLOGY LAB

Subject Code: UGME5K1023	**L**	**T**	**P**	**C**
III Year I Semester	**0**	**0**	**4**	**2**

Course objectives:

1. To understand the parts of various machine tools and about different shapes of products that can be produced on them.
2. To measure bores, angles and tapers .
3. To perform alignment tests on various machines.

Course outcomes:

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

CO1: Gain knowledge about the parts of various machine tools and about different shapes of products that can be produced on them.

CO2: Learn measure bores, angles and tapers.

CO3: Perform alignment tests on various machines.

Note: The students have to conduct at least 6 experiments from each lab

MACHINE TOOLS LAB

1. Introduction of general purpose machines -Lathe, Drilling machine, Milling machine, Shaper, Planing machine, Slotting machine, Cylindrical grinder, Surface grinder and Tool and cutter grinder.
2. Operations on Lathe machines- Step turning, Knurling, Taper turning, Thread cutting and Drilling
3. Operations on Drilling machine - Drilling, reaming, tapping, Rectangular drilling, circumferential drilling
4. Operations on Shaping machine - (i) Round to square (ii) Round to Hexagonal
5. Operations on Slotter - (i) Keyway (T –slot) (ii) Keyway cutting
6. Operations on milling machines - (i) Indexing (ii) Gear manufacturing

METROLOGY LAB

1. Calibration of vernier calipers, micrometers, vernier height gauge and dial gauges.
2. Measurement of bores by internal micrometers and dial bore indicators.
3. Use of gear tooth vernier caliper for tooth thickness inspection and flange micrometer for checking the chordal thickness of spur gear.
4. Machine tool alignment test on the lathe.
5. Machine tool alignment test on drilling machine.
6. Machine tool alignment test on milling machine.
7. Angle and taper measurements with bevel protractor, Sine bar, rollers and balls.
8. Use of spirit level in finding the straightness of a bed and flatness of a surface.
9. Thread inspection with two wire/ three wire method & tool makers microscope.
10. Surface roughness measurement with roughness measuring instrument.

Mapping of COs to POs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PSO1	PSO2
CO1	3	3	3	3	-	3	-	-	-	-	3	3	3
CO2	3	3	3	3	-	3	-	-	-	-	3	3	3
CO3	3	3	3	3	-	3	-	-	-	-	3	3	3
CO4	3	3	3	3	-	3	-	-	-	-	3	3	3
CO5	3	3	3	3	-	3	-	-	-	-	3	3	3

TINKERING LAB

Subject Code:	**L**	**T**	**P**	**C**
III Year / I Semester	**0**	**0**	**2**	**1**

The aim of tinkering lab for engineering students is to provide a hands-on learning environment where students can explore, experiment, and innovate by building and testing prototypes. These labs are designed to demonstrate practical skills that complement theoretical knowledge.

Course Objectives:

- Encourage Innovation and Creativity
- Provide Hands-on Learning
- Impart Skill Development
- Foster Collaboration and Teamwork
- Enable Interdisciplinary Learning
- Impart Problem-Solving mind-set
- Prepare for Industry and Entrepreneurship

Course Outcomes:

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

CO1: Construct simple electrical and electronic circuits using breadboards and microcontrollers like Arduino and ESP32.
CO2: Develop basic IoT-based and sensor-interfaced systems using microcontrollers and cloud dashboards
CO3: Demonstrate 3D printing and mechanical prototyping skills through projects like robots and rockets.
CO4: Implement control and automation applications by integrating sensors, actuators, and mobile interfaces.
CO5: Apply the design thinking process to conceptualize innovative solutions for real-world problems, fostering creativity and teamwork

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of Experiments:

1) Make your own parallel and series circuits using breadboard for any application of your choice.
2) Demonstrate a traffic light circuit using breadboard.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinkercad.
5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
6) Interfacing IR Sensor and Servo Motor with Arduino.

7) Blink LED using ESP32.
8) LDR Interfacing with ESP32.
9) Control an LED using Mobile App.
10) Design and 3D print a Walking Robot
11) Design and 3D Print a Rocket.
12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
13) Demonstrate all the steps in design thinking to redesign a motor bike

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	-	-	3	-	-	-	-	-	3	-	-
CO2	3	3	3	3	3	-	-	-	-	3	3	-	-
CO3	3	-	3	-	3	-	-	-	-	-	-	-	-
CO4	3	3	3	-	3	-	-	-	-	-	-	-	-
CO5	-	3	3	-	-	3	-	3	3	3	3	-	-

Students need to refer to the following links:

1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf
2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf

HEAT TRANSFER

Subject Code: UGME6T0123	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To learn the different modes of heat transfer and conduction heat transfer through various solid bodies
2. To learn the one-dimensional steady-state heat conduction and one-dimensional transient heat conduction
3. To learn the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows
4. To learn the free convection heat transfer concepts and heat transfer processes in heat exchangers.
5. To learn the concepts of radiation heat transfer.

Course Outcomes:

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

CO1: Apply the general heat conduction equation and solve steady-state conduction problems in various geometries, including fins and composite systems.

CO2: Use dimensional analysis and non-dimensional numbers to interpret and estimate heat transfer in transient and convective systems.

CO3: Analyze forced and free convection phenomena using boundary layer concepts and empirical correlations for different flow conditions.

CO4: Explain the mechanisms of boiling and condensation heat transfer and apply empirical correlations to evaluate heat exchanger performance using LMTD and NTU methods.

CO5: Analyze radiative heat exchange between black and grey surfaces, using emissivity, shape factors, and radiation networks.

Syllabus:

UNIT – I: Introduction

Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

Conduction Heat Transfer

Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One-Dimensional Steady-State Conduction Heat Transfer

Homogeneous slabs, hollow cylinders, and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat generation- Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip, and Short Fin, Application to error measurement of Temperature.

UNIT – II: One-Dimensional Transient Conduction Heat Transfer

Systems with negligible internal resistance – Significance of Biot and Fourier Numbers – Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

Convective Heat Transfer

Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non-dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations

UNIT – III: Forced convection: External Flows:

Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows:

Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.

Free Convection:

Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT – IV: Heat Transfer with Phase Change:

Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux, and Film boiling

Condensation: Film-wise and drop-wise condensation –Nusselt's Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT – V:

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks

Note: Heat transfer data book is allowed.

Mapping of COs to POs, PSOs:

POs/ COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	-	-	3	3	-
CO2	3	3	3	3	-	-	-	-	-	-	3	3	-
CO3	3	3	3	3	-	-	-	-	-	-	3	3	-
CO4	3	3	3	3	-	-	-	-	-	-	3	3	-
CO5	3	3	3	3	-	-	-	-	-	-	3	-	-

TEXT BOOKS:

1. Heat Transfer by HOLMAN, Tata McGraw-Hill
2. Heat Transfer by P.K.Nag, TMH

REFERENCE BOOKS:

1. Fundamentals of Heat Transfer by Incropera& Dewitt, John Wiley
2. Fundamentals of Engineering, Heat& Mass Transfer by R.C.Sachdeva, New Age.
3. Heat& Mass Transfer by Amit Pal – Pearson Publishers
4. Heat Transfer by Ghoshadastidar, Oxford University press.
5. Heat Transfer by a Practical Approach, YunusCengel, Boles, TMH
6. Engineering Heat and Mass Transfer by Sarit K. Das, Dhanpat Rai Pub
7. Heat transfer data book by C P Kothandaraman and Subrahmanyan

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Subject Code : UGME6T0223	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To apply the fundamental concepts of artificial intelligence for designing intelligent agents and logical reasoning systems.
2. To implement supervised learning algorithms and evaluate their performance using suitable metrics.
3. To apply unsupervised learning techniques and Bayesian models for real-world data classification and clustering.
4. To develop models using neural networks and genetic algorithms for solving optimization and pattern recognition problems.
5. To analyze and apply deep learning architectures and ensemble methods in advanced machine learning applications.

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

CO1	Apply the foundational concepts of artificial intelligence for designing intelligent agents and systems.
CO2	Implement supervised learning algorithms and evaluate their effectiveness on real-world datasets.
CO3	Differentiate between unsupervised learning techniques and Bayesian models for pattern discovery.
CO4	Construct neural network architectures and utilize genetic algorithms for complex problem-solving.
CO5	Evaluate deep learning models and ensemble methods for advanced machine learning applications.

SYLLABUS:

Unit-1: Introduction:

Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents

Knowledge–Representation and Reasoning: Logical Agents: Knowledge-based agents, the Wumpus world, logic. Patterns in Propositional Logic, Inference in First-Order Logic-Propositional vs first order inference, unification.

UNIT– II:

Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, overfitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.

UNIT– III:

Unsupervised Learning: Clustering, K-means, Dimensionality Reduction, PCA and Kernel.

Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning-K-Nearest neighbour learning.

UNIT– IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and backpropagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.

UNIT– V:

Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks. Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods - Boosting, Bagging, and Random Forests.

Mapping of COs to POs:

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	3	2	-	-	-	-	2	-	2	-	-	2	2
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2
CO3	3	3	3	2	2	-	-	-	-	-	-	2	3
CO4	3	2	3	2	2	-	-	-	-	-	-	3	3
CO5	2	2	2	3	3	2	-	-	-	-	-	3	2

TEXT BOOKS:

1) Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2) Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3) Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCE BOOKS:

1) Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2) Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.

ONLINE RESOURCES:

https://www.tpointtech.com/artificial-intelligence-ai
https://www.geeksforgeeks.org/

FINITE ELEMENT METHODS

Subject Code: UGME6T0323	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. Understand the fundamental concepts of stress, strain, and equilibrium equations in FEM.
2. Apply variational and weighted residual methods to develop element formulations.
3. Solve 1D bar and truss problems using shape functions and stiffness matrices.
4. Analyze beam and 2D problems with axisymmetric and isoparametric elements.
5. Evaluate steady-state heat transfer and dynamic problems using FEM.

Course Outcomes:

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

CO1	Explain stress-strain relations, equilibrium, and basic FEM concepts.
CO2	Apply variational and weighted residual techniques in FEM formulation.
CO3	Formulate and solve 1D bar and truss problems using FEM.
CO4	Analyze beam and 2D structural elements using FEM and apply suitable boundary conditions.
CO5	Evaluate thermal and dynamic systems using finite element methods.

SYLLABUS:

UNIT – I:

Introduction to finite element method, stress and equilibrium, strain–displacement relations, stress–strain relations, plane stress and plane strain conditions, variational and weighted residual methods, concept of potential energy, one-dimensional problems.

UNIT – II:

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

Analysis of Trusses: Finite element modeling, coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations

UNIT – III:

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT – IV:

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axisymmetric problems. Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

UNIT – V:

Steady state heat transfer analysis: one dimensional analysis of a fin.

Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, free vibration analysis.

CO–PO Mapping

CO\PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	-	-	2	-	-	-	-	-	-	3	-
CO2	3	2	-	-	3	-	-	-	-	-	-	3	-
CO3	3	3	2	2	3	-	-	-	-	-	-	2	-
CO4	3	3	2	3	3	-	-	-	-	-	-	3	-
CO5	3	3	2	3	3	-	-	-	-	-	-	3	-

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition/ Tirupati Reddy Chandrupatla/Prentice-Hall.

2. The Finite Element Methods in Engineering /S.S.Rao/Pergamon.

REFERENCES:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho & Shah /Pearson publishers

2. An introduction to Finite Element Method /JNReddy/McGraw-Hill

3. The Finite Element Method for Engineers–Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. By rom/John Wiley & sons (ASIA) Pvt Ltd.

4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education

5. Finite Element Analysis: for students & Practicing Engineers / G.LakshmiNarasaiah

MECHANICAL VIBRATIONS
(Professional Elective-II)

Subject Code: UGME6T0423	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To learn basic principles of mathematical modeling of vibrating systems
2. To understand the basic concepts free and forced multi degree freedom systems
3. To get concepts involved in the torsional vibrations
4. To learn the principles involved in the critical speed of shafts
5. To understand the basic concepts of Laplace transformations response to different inputs

Course Outcomes:

At the end of the course, student will be able to

CO1: Understand the concepts of vibrational analysis

CO2: Understand the concepts of free and forced multi degree freedom systems

CO3: Summarize the concepts of torsional vibrations

CO4: Solve the problems on critical speed of shafts

CO5: Apply and Analyze the systems subjected to Laplace transformations response to different inputs

SYLLABUS:

UNIT – I:

Introduction: Relevance of and need for vibrational analysis – Basics of SHM - Discrete and continuous systems - Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

UNIT – II:

Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle- Energy methods, Eigen values and Eigen vectors, modal analysis, Vibration isolation and transmissibility.

UNIT – III:

Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non- linear and random vibrations.

UNIT – IV:

Vibration Measuring Instruments and Critical Speeds of Shafts: Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT – V:

Transient Vibrations: Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	3	3	-	-	-	-	-	-	3	3	-
CO2	3	3	3	3	-	-	-	-	-	-	3	3	-
CO3	3	3	3	3	-	-	-	-	-	-	3	3	-
CO4	3	3	3	3	-	-	-	-	-	-	3	3	-
CO5	3	3	3	3	-	-	-	-	-	-	3	3	-

Text books:

1. S.S.Rao, "Mechanical Vibrations ", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, "Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York, 1985.

References:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5thEdition,Pearson Education, 2008.
2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications",JohnWiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.

ADVANCED MANUFACTURING PROCESSESS
(Professional Elective-II)

Subject Code: UGME6T0523	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To learn the basic principle of advanced machining processes
2. To know about the various additive manufacturing processes
3. To understand the principles of coating and processing of ceramics.
4. To get insights about processing of composites and nanomaterials
5. To know the fabrication of microelectronic components.

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

CO1: Describe the working principles and applications of non-conventional machining processes.

CO2: Compare different additive manufacturing methods based on their working principles.

CO3: Evaluate laser-based material processing techniques for specific engineering applications.

CO4: Apply advanced coating processes to real-world industrial scenarios.

CO5: Select appropriate fabrication methods for microelectronic device manufacturing.

SYLLABUS:

UNIT – I:

ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT – II:

ADDITIVE MANUFACTURING: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.

UNIT – III:

SURFACE TREATMENT: Scope, Cleaners, Methods of cleaning, Surface coating types, Electro forming, Chemical vapour deposition, Physical vapour deposition, thermal spraying methods, Ion implantation, diffusion coating, ceramic and organic methods of coating, and cladding methods.

PROCESSING OF CERAMICS: Applications, characteristics, classification Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application.

UNIT – IV:

PROCESSING OF COMPOSITES: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, processing methods for MMC, CMC, Polymer matrix composites.

PROCESSING OF NANOMATERIALS: Introduction, Top down Vs Bottom up techniques-Ball milling, Lithography, Plasma Arc Discharge, Pulsed Laser Deposition, Sputtering, Sol-Gel, Molecular beam Epitaxy.

UNIT – V:

FABRICATION OF MICROELECTRONIC DEVICES:

Crystal growth and wafer preparation, Film Deposition, oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, surface mount technology, Integrated circuit economics.

Mapping of COs to POs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	PSO1	PSO2
CO1	3	3	3	3	-	3	-	-	-	-	3	3	3
CO2	3	3	3	3	-	3	-	-	-	-	3	3	3
CO3	3	3	3	3	-	3	-	-	-	-	3	3	3
CO4	3	3	3	3	-	3	-	-	-	-	3	3	3
CO5	3	3	3	3	-	3	-	-	-	-	3	3	3

TEXT BOOKS:

1. Manufacturing Engineering and Technology / Kalpakijian / AdissonWesley, 1995.
2. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

REFERENCES:

1 Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold,

2 MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH

3 Advanced Machining Processes / V.K.Jain / Allied Publications.

4 Introduction to Manufacturing Processes / John A Schey / McGraw Hill.

5 Introduction to Nanoscience and NanoTechnology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learing

MICRO ELECTRO MECHANICAL SYSTEMS
(Professional Elective-II)

Subject Code: UGME6T0623	**L**	**T**	**P**	**C**
III Year II Semester	**3**	**0**	**0**	**3**

Course Objectives:

- To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators
- To illustrate thermal sensors and actuators used in MEMS.
- To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
- To analyze applications and considerations on micro fluidic systems.
- To illustrate the principles of chemical and bio medical micro systems.

Course Outcomes:

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

CO1: Explain the basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors, and actuators.

CO2: Illustrate the working of thermal sensors and actuators used in MEMS.

CO3: Apply the principles of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors, and actuators.

CO4: Analyze the applications and design considerations of microfluidic systems.

CO5: Illustrate the principles and working of chemical and biomedical microsystems.

SYLLABUS:

UNIT – I: INTRODUCTION:

Definition of MEMS, MEMS history and development, micro machining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micro machining, wafer bonding, LIGA. MECHANICAL SENSORS AND ACTUATORS: Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inchworm technology.

UNIT – II: THERMAL SENSORS AND ACTUATORS:

Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, data storage cantilever.

UNIT – III: MICRO-OPTO-ELECTRO MECHANICAL SYSTEMS:

Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement. MAGNETIC SENSORS AND ACTUATORS: Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOKE, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.

UNIT – IV: MICRO FLUIDIC SYSTEMS:

Applications, considerations on micro scale fluid, fluid actuation methods, dielectro-phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. RADIO FREQUENCY (RF) MEMS: RF – based communication systems, RF MEMS, MEMS inductors, tuner/filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT – V:

CHEMICAL AND BIO MEDICAL MICRO SYSTEMS: Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo-resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

Mapping of COs to Pos, PSOs:

POs/ COs	PO 1	PO 2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2
CO1	3	2	-	-	-	2	-	-	-	-	-	-	2
CO2	3	2	-	-	-	2	-	-	-	-	-	-	2
CO3	3	2	2	-	2	2	-	-	-	-	2	3	3
CO4	2	3	2	2	2	2	-	-	-	-	2	2	3
CO5	3	2	-	-	-	2	-	-	-	-	-	2	3

TEXTBOOKS:

1.MEMS, Nitaigour Premchand Mahalik, TMH

REFERENCE BOOKS:

1. Foundation of MEMS, Chang Liu, Prentice Hall Ltd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
4. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.

SENSORS AND INSTRUMENTATION
(Professional Elective-II)

Subject Code: UGME6T0723	**L**	**T**	**P**	**C**
III Year II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To understand the concepts of measurement technology.
2. To learn the various sensors used to measure various physical parameters.
3. To learn the fundamentals of signal conditioning, data acquisition and
4. communication systems used in mechatronics system development
5. To learn about the optical, pressure and temperature sensor
6. To understand the signal conditioning and DAQ systems

Course Outcomes:

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

CO1: Recognize various calibration techniques and signal types for sensors.
CO2: Describe the working principles and characteristics of force, magnetic, heading, pressure, temperature, smart, and other sensors and transducers.
CO3: Apply various sensors and transducers in real-time applications.
CO4: Select appropriate sensors for different engineering applications.
CO5: Explain the process of acquiring signals from different sensors using Data Acquisition Systems (DAS).

SYLABUS:

UNIT I: INTRODUCTION

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

UNIT II: MOTION, PROXIMITY AND RANGING SENSORS

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III: FORCE, MAGNETIC AND HEADING SENSORS

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT IV: OPTICAL, PRESSURE AND TEMPERATURE SENSORS

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT V : SIGNAL CONDITIONING AND DAQ SYSTEMS

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

Mapping of COs to Pos, PSOs:

POs/ COs	PO 1	PO 2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2
CO1	3	3	-	-	2	-	-	-	-	-	2	-	2
CO2	3	3	-	-	2	-	-	-	-	-	2	-	2
CO3	3	3	2	2	3	2	-	-	-	-	2	3	3
CO4	3	3	2	2	3	2	-	-	-	-	2	3	3
CO5	3	3	2	2	3	-	-	-	-	-	2	3	3

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw- Hill, 2009.
2. Sawney A K and Puneet Sawney, "A Course in Mechanical Measurements and Instrumentation and Control", Dhanpat Rai & Co, 12th edition New Delhi, 2013.

REFERENCES:

1. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001.
2. Hans Kurt Tönshoff (Editor), Ichiro, "Sensors in Manufacturing" Volume 1, Wiley-VCH April 2001.
3. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.
4. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2011.
5. Richard Zurawski, "Industrial Communication Technology Handbook" 2nd edition, CRC Press, 2015.

ENERGY STORAGE TECHNOLOGY
(Professional Elective-III)

Subject Code: UGME6T0823	**L**	**T**	**P**	**C**
III Year II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. Get the insights into importance of energy storage systems
2. Understand the chemical and electromagnetic storage systems
3. Know the principles of electrochemical storage systems
4. Learn the working of supercapacitors and fuel cells
5. Know how to design batteries for transportation

Course Outcomes:

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

CO1: Learn the importance of energy storage systems
CO2: Gain knowledge on chemical and electromagnetic storage systems
CO3: Understand the principles of electrochemical storage systems
CO4: Know the working of supercapacitors and fuel cells
CO5: Learn how to design batteries for transportation

SYLLABUS:

UNIT I:

Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market, Thermal storage system-heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT II:

Chemical storage system- hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems. Electromagnetic storage systems - double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT III:

Electrochemical storage system, Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery & amp; Metal hydride battery vs lead-acid battery

UNIT IV:

Supercapacitors- Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors Fuel cell- Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.

UNIT V:

Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery, Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

Mapping of COs to POs:

POs/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2
CO1	3	2	2	2	-	-	-	-	-	-	3	2	3
CO2	3	2	3	2	-	-	-	-	-	-	2	3	2
CO3	3	3	2	3	-	-	-	-	-	-	3	2	3
CO4	3	2	3	3	-	-	-	-	-	-	3	2	2
CO5	3	3	3	3	-	-	-	-	-	-	3	3	2

Text books:

1. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
2. Ralph Zito, Energy storage: A new approach, Wiley (2010)

References:

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)

INDUSTRIAL HYDRAULICS AND PNEUMATICS
(Professional Elective-III)

Subject Code: UGME6T0923	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To learn basic concepts of fluid power
2. To understand the functions and working of basic elements of Hydraulic and Pneumatic system
3. To get knowledge about the basic components and their functions of Hydraulic and Pneumatic circuits
4. To learn the operating principles and working of hydraulic and pneumatic devices
5. To gain knowledge about the procedures of installation, maintenance and troubleshooting of Hydraulic and pneumatic systems

Course Outcomes:

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

CO1: Describe the fundamental principles and characteristics of fluid power systems.
CO2: Identify and explain the functions of key components in hydraulic and pneumatic systems
CO3: Analyze hydraulic and pneumatic circuits to determine their functionality and performance.
CO4: Demonstrate the working of various hydraulic and pneumatic devices used in industrial applications.
CO5: Evaluate and outline the procedures for installation, troubleshooting, and maintenance of hydraulic and pneumatic systems

SYLLABUS:

UNIT – I:

Fluid Power: Power transmission modes, hydraulic systems, pneumatic systems, laws governing fluid flow: Pascal's law, continuity equation, Bernoulli's theorem, Boyle's, Charles', Gay-Lussac' laws, flow through pipes - types, pressure drop in pipes, working fluids used in hydraulic and pneumatic systems- types, ISO/BIS standards and designations, properties.

UNIT – II:

Hydraulic and Pneumatic Elements: Hydraulic pipes-Types, standards, designation methods and specifications, pressure ratings, applications and selection criteria, pumping theory, Hydraulic Pumps - types, construction, working principle, applications, selection criteria and comparison, hydraulic Actuators, Control valves, Accessories - their types, construction and working, pneumatic Pipes - materials, designations, standards, properties and piping layout, air compressors, Air receivers, air dryers, Air Filters, Regulators, Lubricators (FRL unit): their types, construction, working, specifications and selection criteria of following air preparation and conditioning elements, pneumatic Actuators and Control valves - types, construction, working, materials and specifications

UNIT – III:

Hydraulic and Pneumatic Circuits:

ISO symbols used in hydraulic and pneumatic circuit, basic Hydraulic Circuits – types (such as intensifier, regenerative, synchronizing, sequencing, speed control, safety), circuit diagram, components, working and applications, basic Pneumatic Circuits – types (such as speed control, two step feed control, automatic cylinder reciprocation, time delay, quick exhaust), circuit diagram, components, working and applications,

pneumatic Logic circuit design - classic method, cascade method, step counter method, Karnaugh- veitch maps and combinational circuit design.

UNIT – IV:

Hydraulic and Pneumatic Devices:

Hydraulic and Pneumatic devices – Concept and applications, construction, working principle, major elements, performance variables of: Automotive hydraulic brake, Industrial Fork lift, Hydraulic jack, Hydraulic press, Automotive power steering, Automotive pneumatic brake, Automotive air suspension, Pneumatic drill, Pneumatic gun.

UNIT – V:

Installation, Maintenance and Trouble-Shooting:

Installation of hydraulic and pneumatic system causes and remedies for common troubles arising in hydraulic elements, maintenance of hydraulic systems, causes and remedies for troubles arising in pneumatic elements, maintenance of pneumatic systems.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	-	3	-	-	-	-	-	-	-	-
CO3	3	3	-	-	3	-	-	-	-	-	-	-	-
CO4	-	-	3	-	3	-	-	3	-	-	-	-	-
CO5	-	3	3	3	3	3	-	3	3	3	3	-	-

Textbooks:

1. Majumdar, S.R. Oil Hydraulic Systems Tata McGraw-Hill Publication, New Delhi,3/e, 2013
2. Majumdar, S.R. Pneumatic Systems Tata McGraw-Hill Publication, New Delhi,3/e, 2013

References:

1. Srinivasan, R. Hydraulic and Pneumatic Controls Vijay Nicole Imprints Private, New Delhi, Limited, 2/e, 2008
2. Jagadeesha, T. Fluid Power Generation, Transmission and Control Universities Press (India) Private Limited, New Delhi,1/e, 2014
3. Jagadeesha, T. Pneumatics Concepts, Design and Applications Universities Press (India) Private Limited, New Delhi,1/e, 2014
4. Parr, Andrew Hydraulic and Pneumatics, A Technician's and Engineer's Guide, Jaico Publishing House, New Delhi,2/e, 2013
5. Shanmuga Sundaram, K. Hydraulic and Pneumatics Controls - Understanding Made Easy S. Chand Company Ltd., New Delhi, 1/e, 2006

INDUSTRIAL ROBOTICS

(Professional Elective-III)

Subject Code: UGME6T1023	**L**	**T**	**P**	**C**
III Year II Semester	**3**	**0**	**0**	**3**

Course Objectives: The Students will acquire the knowledge to

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

Course Outcomes:

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

CO1: Explain the various applications and components of industrial robot systems

CO2: Classify and compare different types of actuators used in robotics

CO3: Calculate the forward and inverse kinematics of robotic systems

CO4: Demonstrate the programming principles and languages used for robot control systems

CO5: Analyze the applications of image processing and machine vision in robotics.

SYLLABUS:

UNIT – I:

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms –– requirements and challenges of end effectors, determination of the end effectors.

UNIT – II:

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric& stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – III:

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – IV:

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion–Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – V:

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

Mapping of COs to Pos, PSOs:

POs/ COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	2	-	2	2	3
CO2	3	3	-	-	2	-	-	-	-	-	-	3	3
CO3	3	3	-	2	3	-	-	-	-	-	-	3	3
CO4	2	2	2	2	3	-	-	-	2	-	-	3	2
CO5	2	3	2	3	3	-	-	-	2	-	2	3	3

TEXTBOOKS:

1. Industrial Robotics/Groover MP/Pearson Edu.
2. Robotics and Control /Mittal R K &Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGraw Hill.
2. Robotic Engineering /Richard D. Klafter, Prentice Hall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/PearsonEdu

REFRIGERATION AND AIR CONDITIONING
(Professional Elective-III)

Subject Code: UGME6T1123	**L**	**T**	**P**	**C**
III Year / II Semester	**3**	**0**	**0**	**3**

Course Objectives:

1. To illustrate the operating cycles and different systems of refrigeration.
2. To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics.
3. To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
4. To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
5. To describe different component of refrigeration and air conditioning systems

Course Outcomes:

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

CO1: Explain the principles of refrigeration cycles and distinguish between various refrigeration systems.

CO2: Analyze the cooling capacity and coefficient of performance (COP) of vapor compression systems; Explain cryogenics fundamentals

CO3: Determine the COP by conducting performance tests on vapor absorption and steam jet systems; Classify refrigerants based on properties.

CO4: Compute cooling loads for air conditioning applications and identify thermal comfort requirements.

CO5: Demonstrate the operation and function of various components used in refrigeration and air conditioning systems

UNIT – I:

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT – II:

VAPOUR COMPRESSION REFRIGERATION SYSTEM &COMPONENTS: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures**,** multi stage vapour compression refrigeration.

UNIT – III:

REFRIGERANTS– Desirable properties – classification - refrigerants –green refrigerants- nomenclature – ozone depletion – global warming.

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH_3 – water system and Li Br –water (Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.

UNIT – IV:

INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads –– need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF- problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature- comfort chart – comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT – V:

AIR CONDITIONING SYSTEMS: Classification of equipments, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

Note: Refrigeration and Psychrometric tables and charts are allowed.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	-	-	3	3	-	-	-	-	-	3	-	-
CO4	3	3	3	-	3	3	-	-	-	3	-	-	-
CO5	-	-	3	-	3	-	-	3	3	3	-	-	-

Textbooks:

1. A Course in Refrigeration and Air conditioning / SC Arora & Domkundwar / Dhanpatrai.
2. Refrigeration and Air Conditioning / CP Arora / TMH

References:

1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration /Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH.

HEAT TRANSFER LAB

Subject Code: UGME6P1223	**L**	**T**	**P**	**C**
III Year / II Semester	**0**	**0**	**3**	**1.5**

Course Objective: The laboratory course is aimed to provide the practical exposure to the students with regard to the determination of amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

Course Outcomes:

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

CO1: Experiment with different modes of heat transfer: conduction, convection, and radiation.

CO2: Apply the concepts of heat transfer & validate the results with theoretical values.

CO3: Compare the emissivity of different bodies in radiation Heat transfer.

CO4: Identify the procedures for finding material constants in the area of heat transfer.

CO5: Analyse the experimental results of condensation.

CO6: Analyze experimental data for different types of heat exchangers to evaluate their performance.

PART-A

1. Determination of overall heat transfer co-efficient of a composite slab
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin
6. Determination of heat transfer coefficient in natural and forced convection
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan-Boltzmann constant.
10. Determination of heat transfer rate in drop and film wise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

PART-B

Virtual labs (https://mfts-iitg.vlabs.ac.in/) on

(i) Conduction Analysis of a Single Material Slab
(ii) Conduction Analysis of a single Material Sphere
(iii) Conduction Analysis of a single Material Cylinder
(iv) Conduction Analysis of a Double Material Slab
(v) Conduction Analysis of a Double Material Sphere
(vi) Conduction Analysis of Double Material Cylinder
(vii) To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger
(viii) To investigate the Lambert's distance law.
(ix) To investigate the Lambert's direction law (cosine law).

Note: Virtual labs are only for learning purpose, and are not for external examination.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	3	3	3	3	3	-	-	3	-	-	-	3	-
CO2	3	3	3	3	3	-	-	3	-	-	-	3	-
CO3	3	3	3	3	3	-	-	3	-	-	-	3	-
CO4	3	3	3	3	3	-	-	3	-	-	-	3	-
CO5	3	3	3	3	3	-	-	3	-	-	-	3	-
CO6	3	3	3	3	3	-	-	3	-	-	-	3	-

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LAB

Subject Code: UGME6P1323	**L**	**T**	**P**	**C**
III Year / II Semester	**0**	**0**	**3**	**1.5**

Course Objectives: Students will acquire the knowledge of artificial intelligence and machine learning models using various software tools.

Course Outcomes: Students at the end of the course will be able to

CO1: Learn various Python libraries.

CO2: Do programming for regression methods

CO3: Write coding for different types of neural networks

CO4: Write a program for decision tree, Naïve Bayes and SVM

CO5: Generate code for autoencoders

List of Experiments

1. Learning of Python libraries – Numpy, Pandas, Matplotlib, Seaborn and TensorFlow
2. Numerical examples on Python libraries
3. Data Preprocessing and data cleaning using Python
4. Write a program for Linear regression
5. Write a program for Logistic regression
6. Write a program for ANN
7. Write a program for CNN
8. Write a program for RNN
9. Write a program to build a Decision tree
10. Write a program to build a Naïve Bayes classifier
11. Write a program for SVM
12. Write a program for Auto-encoder

NOTE: Any 10 experiments from above

Mapping of COs to Pos/PSOs:

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	3	2										2	2
CO2	3	3	3	3								3	3
CO3	3	3	3	3								3	3
CO4	3	3	3	3								3	3
CO5	3	3	3	3								3	3

Note: Databases can be taken from https://www.kaggle.com/datasets.

ROBOTICS AND DRONE TECHNOLOGIES LAB

Subject Code: UGME6K1423	**L**	**T**	**P**	**C**
III Year / II Semester	**0**	**0**	**4**	**2**

Course Objective: Robotics and Drone Technologies Laboratory offers the students hands-on experience in robotics, and unmanned aerial systems.

Course Outcomes:
At the end of the course, the students will be able to
CO1: Describe the basic components, working principles, and applications of robots and drones.
CO2: Explain the mathematical models and dynamics of robotic manipulators and drones.
CO3: Illustrate the construction and working of simple robotic and drone prototypes for basic tasks.
CO4: Summarize the role of sensors and controllers in enabling autonomous operations in robots and drones.
CO5: Describe the design considerations for building robots and drones for specific applications.

List of experiments:
Robotics:
1) Simulation of Mathematical Model of Robot.
2) Forward and Inverse Dynamic Analysis of a 2-DOF Robotic Manipulator using Software Tools.
3) Building and Programming a Simple Arduino-Based Robot for basic movement.
4) Build a robot that can navigate through a maze or an environment by using sensors to detect obstacles and avoid them.
5) Construct a robotic arm using servo motors or stepper motors and program the arm to perform various tasks, such as picking up objects, sorting the colour, or drawing shapes.
6) Build a robot that follows a black line on a contrasting surface using line-following sensors.
7) Designing a 3D Model of a Robotic Arm and Grippers Using Software
8) Implement a PID controller for a robotic arm or mobile robot and simulate its performance in tracking a desired trajectory.

Drone technologies:
1) Demonstration of parts and functions of a drone.
2) Demonstration of effects of forces, manoeuvres of a drone by roll, pitch and yaw.
3) Demonstration of various sensors and battery management used in drones.
4) Build a prototype drone to record videos and photos.
5) Make a drone for a certain payload.

Students need to refer to the following links:
1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf
2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf
6) https://aim.gov.in/pdf/ATL_Drone_Module.pdf

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	3	-	-	-	-	3	3	3
CO5	3	3	3	3	3	3	-	-	3	-	3	3	3

TECHNICAL PAPER WRITING AND IPR

Subject Code:	L	T	P	C
III Year / II Semester	2	0	0	0

Course objectives:

1) To understand the structure of the technical paper and its components.
2) To review the literature and acquire the skills to write a technical paper for first submission.
3) To understand the process and development of IPR.
4) To create awareness about the scope of patent rights.
5) To analyze the new developments in IPR include latest software.

Course outcomes:

Upon completion of course, students will be able to:

CO1: Understand the structure of the technical paper and its components.
CO2: Review the literature and acquire the skills to write a technical paper for first submission.
CO3: Understand the process and development of IPR.
CO4: Create awareness about the scope of patent rights.
CO5: Analyze the new developments in IPR include latest software.

UNIT-I: Planning and preparation

Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness. Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

UNIT-II: Literature review

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.
Key skills needed when writing a Title, Abstract, Introduction, a Review of the Literature, the Methods, the Results, the Discussion, and the Conclusions. Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

UNIT-III: Process and Development

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

UNIT-IV: Patent Rights

Scope of Patent Rights. Licensing and transfer of technology, Patent information and databases, Geographical Indications.

UNIT-V: New Developments In IPR

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies.

Mapping of COs to POs:

POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	3	3	3	3	-	-
CO2	3	-	-	-	-	-	-	3	3	3	3	-	-
CO3	3	-	-	-	-	-	-	3	3	3	3	-	-
CO4	3	-	-	-	-	-	-	3	3	3	3	-	-
CO5	3	-	-	-	-	-	-	3	3	3	3	-	-

Text Books:

1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.

References:

1) Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2) Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
3) Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

4) Mayall, "Industrial Design", McGraw Hill, 1992.
5) Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age" 2016.
6) T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.