B.Tech. – III Year I Semester

S. No	Category	Subject Code	Title	L	T	P	C
1	Professional Core	V231310331	Machine Tools and Metrology	3	0	0	3
2	Professional Core	V231310332	Thermal Engineering	3	0	0	3
3	Professional Core	V231310333	Design of Machine Elements	3	0	0	3
04	Professional Elective - I	V231310341	Design for Manufacturing	3	0	0	3
		V231310342	Conventional and futuristic vehicle technology				
		V231310343	Renewable Energy Technologies				
		V231310344	Non-destructive Evaluation				
5	Open Elective-I	OR Entrepreneurship Development & Venture Creation		3	0	0	3
		V231310351	1. Sustainable Energy Technologies				
		V231310352	2. Applied Operations Research				
		V231310353	3. Nano Technology				
		V231310354	4. Thermal Management of Electronic systems				
		V231310355	5. Entrepreneurship				
6	Professional Core	V231310361	Thermal Engineering Lab	0	0	3	1.5
7	Professional Core	V231310362	Theory of Machines Lab	0	0	3	1.5
8	Skill Enhancement course	V231310363	Machine tools and Metrology Lab	0	0	4	2
9	Engineering Science	V231310364	Tinkering Lab	0	0	2	1
10	Evaluation of Community Service Internship	V23131CC81	Community Service Internship	-	-	-	2
	Total			15	0	10	23
MC			Minor Course (Student may select from the same specialized minors pool)	3	0	3	4.5
MC			Minor Course through SWAYAM / NPTEL (Minimum 12 Week, 3 credit course)	3	0	0	3
HC			Honors Course (Student may select from the same Honors pool)	3	0	0	3
HC			Honors Course (Student may select from the same Honors Pool)	3	0	0	3

Professional Elective – I

1. Design for Manufacturing
2. Conventional and futuristic vehicle technology
3. Renewable Energy Technologies
4. Non-destructive Evaluation

B.Tech. III Year II Semester

S.No.	Category	Subject Code	Title	L	T	P	C
1	Professional Core	V231320331	Heat Transfer	3	0	0	3
2	Professional Core	V231320332	Artificial Intelligence and Machine Learning	3	0	0	3
3	Professional Core	V231320333	Finite Element Methods	3	0	0	3
4	Professional Elective-II	V231320341	Mechanical Vibrations	3	0	0	3
		V231320342	Advanced Manufacturing Processes				
		V231320343	Micro Electro Mechanical Systems				
		V231320344	Sensors and Instrumentation				
5	Professional Elective-III	V231320345	Energy Storage Technologies	3	0	0	3
		V231320346	Industrial Hydraulics and Pneumatics				
		V231320347	Industrial Robotics				
		V231320348	Refrigeration & Air-Conditioning				
6	Open Elective - II	V231320351	1.Introduction to Industrial Robotics	3	0	0	3
		V231320352	2. Industrial Management				
		V231320353	3. Additive Manufacturing				
		V231320354	4.Vechicle Technology				
		V231320355	5. Industrial Safety				
7	Professional Core	V231320361	Heat Transfer Lab	0	0	3	1.5
8	Professional Core	V231320362	Artificial Intelligence and Machine Learning Lab	0	0	3	1.5
9	Skill Enhancement course	V231320363	Robotics and Drone Technologies Lab	0	0	4	2
10	Audit Course	V2313203C1	Technical paper writing and IPR	2	0	0	-
	Total			20	0	10	23
	Mandatory Industry Internship of 08 weeks duration during summer vacation						

MC	Student may select from the same minors pool	3	0	3	4.5
MC	Minor Course (Student may select from the same specialized minors pool)	3	0	0	3
HC	Student may select from the same honors pool	3	0	0	3
HC	Honors Course (Student may select from the honors pool)	3	0	0	3

Professional Elective-II

- Mechanical Vibrations
- Advanced Manufacturing Processes
- Micro Electro Mechanical Systems
- Sensors and Instrumentation

Professional Elective-III

- Energy Storage Technologies
- Industrial Hydraulics and Pneumatics
- Industrial Robotics
- Refrigeration & Air-Conditioning

Professional Elective-IV

- Mechatronics
- Computational Fluid Dynamics
- Advanced Material Science
- Embedded Systems and Programming
- Professional Elective-V
- Hydrogen and Fuel Cell Technology
- Smart manufacturing
- Cryogenics
- Electrical drives and actuators

For Honors:

Mechanical Engineering design and Robotics (Any 5 theory and 2 Labs)

- Advanced Mechanics of solids
- Design of Machine Members
- Theory of machines
- Advanced Finite element methods
- Mechanical vibrations
- Robotics
- Product design
- Design for manufacturing
- CAD Lab
- Mechanisms and Robotics Lab

II. Smart Manufacturing (Any 5 theory and 2 Labs)

- Automation in manufacturing
- MEMS
- Mechatronics
- CIM
- Smart manufacturing
- Robotics
- Manufacturing processes
- Artificial intelligence and Machine learning
- AI & ML Lab
- Mechatronics Lab

III. Thermal Systems Engineering (Any 5 theory and 2 Labs)

- Advanced Thermodynamics
- Thermal Engineering
- Advanced Heat transfer
- Refrigeration and Air-conditioning
- Power plant engineering
- Advanced Fluid mechanics
- Automobile Engineering
- Computation fluid dynamics
- Heat transfer Lab
- Advanced Thermal Engineering Lab

For Minors (Any 5 theory and 2 Labs):

- Advanced Mechanics of Solids
- Advanced Finite Element Methods
- Advanced CAD
- Advanced Manufacturing Processes
- Advanced Fluid Mechanics
- Advanced Heat Transfer
- Advanced Mechanisms & Robotics
- Optimization & Reliability
- Mechanisms and Robotics Lab
- Advanced Manufacturing Processes lab
- Modeling & Simulation of Manufacturing Systems Lab
- Computational Fluid Dynamics Lab

III Year I Semester	MACHINE TOOLS & METROLOGY	L	T	P	C
	(V231310331)	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	Learned the fundamental knowledge and principals in material removal process.
CO2	Acquire the knowledge on operations in conventional, automatic, Capstan and turret lathes
CO3	Capable of understanding the working principles and operations of shaping, slotting, planning, drilling and boring machines.
CO4	able to make gear and keyway in milling machines and understand the indexing mechanisms
CO5	Understand the different types of Surface roughness and Optical measuring instruments

UNIT – 1
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, machine ability, economics of machining, coolants, tool materials and properties.

UNIT – 2
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 – 3
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 – 4

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 – 5

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, Profile graph, 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.

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

III Year I Semester	THERMAL ENGINEERING (V231310332)	L	T	P	C
		3	0	0	3

Course Objectives:

1) To give insight in to 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: At the end of the course, student will be able to
CO1: Explain the basic concepts of air standard cycles.
CO2: Get knowledge about IC Engines and Boilers.
CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.
CO4: Gain knowledge about the concepts of compressors and gas turbines.
CO5: Acquire insights about jet propulsion, rockets and solar engineering.

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 Blow down-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 super charging and turbo charging, 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-level 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

Text Books:

1. Thermal Engineering - Mahesh Rathore- McGraw Hill publishers

2. Heat Engineering /V.PVasandani 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 Raj put/ Lakshmi Publications

5. Thermal Engineering-R.S Khurmi, &J S Gupta/S.Chand.

III Year-I Semester	DESIGN OF MACHINE ELEMENTS	L	T	P	C
	(V231310333)	3	0	0	3

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

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

CO1: Design the machine members subjected to static and dynamic loads.
CO2: Design shafts and couplings for power transmission
CO3: Learn how to design bolted and welded joints.
CO4: Know the design procedures of clutches, brakes and springs.
CO5: Design bearings and gears.

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, tensional 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

Design of Bearings and Gears

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

Design of 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.

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

III Year-I Semester	DESIGN FOR MANUFCTURING (Professional Elective-I) **(V231310341)**	L	T	P	C
		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 metals joining process.
CO5: Understand the basic design concepts involved in the assembly automation

UNIT-1
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– 2
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 – 3
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– 4
Metal joining: Appraisal of various welding processes, factors in design of elements – 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– 5

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.

TEXT BOOKS:

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

REFERENCE:

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

III Year I Semester	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY **(V231310342)**	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To study the advanced engine technologies
2. To learn various advanced combustion technologies and its benefits
3. To learn the methods of using low carbon fuels and its significance
4. To learn and understand the hybrid and electric vehicle configurations
5. To study the application of fuel cell technology in automotive

Course Outcomes: At the end of the course the students would be able to
CO1: Discuss the latest trends in engine technology
CO2: Discuss the need of advanced combustion technologies and its impact on reducing Carbon foot-print on the environment.
CO3:Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
CO4:Discuss the working and energy flow in various hybrid and electric configurations.
CO5: Analyzing the need for fuel cell technology in automotive applications

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, Di methyl 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.

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

<table>
<tr><td rowspan="2">III Year I Semester</td><td rowspan="2">RENEWABLE ENERGY TECHNOLOGIES
(V231310343)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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Course objectives:

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

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

CO1	Illustrate the importance of solar radiation and solar PV modules.
CO2	Discuss the storage methods in PV systems
CO3	Explain 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 – 1

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 – 2

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 – 3

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 – 4

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 – 5

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.

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.YogiGoswami, 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

III Year I Semester	NON- DESTRUCTIVE EVALUATION	L	T	P	C
	(V231310344)	3	0	0	3

Course Objectives:
To learn basic concepts of non-destructive testing and industrial applications
To understand the elements of ultrasonic test and limitations of ultrasonic test
To learn the concepts involved in the liquid penetrant test and eddy current test
To know the basic principles and operating procedures of magnetic particle testing
To understand the basic concepts involved in the infrared and thermal testing.

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

CO1	Understand the concepts of various NDE techniques and the requirements of radiography techniques and safety aspects.
CO2	Interpret the principles and procedure of ultrasonic testing
CO3	Understand the principles and procedure of Liquid penetration and eddy current testing
CO4	Illustrate the principles and procedure of Magnetic particle testing
CO5	Interpret the principles and procedure of infrared testing and thermal testing

UNIT – 1
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 – 2
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 – 3
Liquid Penetrate Test: Liquid Penetrate Test, Basic Concepts, Liquid Penetrate System, Test Procedure, Effectiveness, DPI, FPI, Limitations of Liquid Penetrate Testing.
Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing

UNIT – 4

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 – 5

Infrared And Thermal Testing: Introduction and fundamentals to infrared and thermal testing–Heat transfer –Active and passive techniques –Lock in and pulse thermograph, 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 behavior of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Text Books:

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

References:

Ultrasonic inspection training for NDT/E.A.Gingel/ Prometheus Press,
ASTM Standards,Vol3.01, Metal sand alloys
Non-destructive Evaluation, Hand Book – R. HamChand

III Year I Semester	SUSTAINBLE ENERGY TECHNOLOGIES	L	T	P	C
	(V231310351)	3	0	0	3

Course objectives:

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

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

CO1	Illustrate the importance of solar radiation and solar PV modules.
CO2	Discuss the storage methods in PV systems
CO3	Explain 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 – 1

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 – 2

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 – 3

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 – 4

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 – 5

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.

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.YogiGoswami, 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

III Year I Semester	APPLIED OPERATIONS RESEARCH (V231310352)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Understand Linear Programming models
2. Learn Transportation and sequencing problems
3. Solve replacement problems and analyze games theory models
4. Understand waiting line and project management problems
5. Learn dynamic programming and simulation.

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

CO1: Understand Linear Programming models

CO2: Interpret Transportation and sequencing problems

CO3: Solve replacement problems and analyze queuing models

CO4: Understand game theory and inventory problems

CO5: Interpret dynamic programming and simulation.

UNIT – 1

INTRODUCTION - definition– characteristics and phases – types of operation research models – applications.
Linear programming: Problem formulation – graphical solution – simplex method – artificial variables techniques -two–phase method, big-M method – duality principle.

UNIT – 2

TRANSPORTATION PROBLEM: Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- travelling salesman problem.
SEQUENCING – Introduction – flow –shop sequencing – *n* jobs through two machines – *n* jobs through three machines – job shop sequencing – two jobs through 'm' machines.

UNIT – 3

REPLACEMENT THEORY: Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.
GAME THEORY: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.

UNIT – 4

WAITING LINES: Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel.
PROJECT MANAGEMENT: Basics for construction of network diagram, Program

Evaluation and Review Technique (PERT), Critical Path Method (CPM) – PERT Vs. CPM, determination of floats- Project crashing and its procedure.

UNIT – 5

DYNAMIC PROGRAMMING: Introduction – Bellman's principle of optimality – applications of dynamic programming-shortest path problem – linear programming problem.

SIMULATION: Definition – types of simulation models – phases of simulation– applications of simulation – inventory and queuing problems – advantages and disadvantages

Text Books:

Operations Research-An Introduction/Hamdy A Taha/Pearson publishers
Operations Research –Theory & publications / S.D. Sharma Kedarnath/McMillan publishers India Lt

References:

Introduction to O.R/Hiller &Libermann/TMH
Operations Research /A.M. Natarajan, P. Balasubramani, A. Tamilarasi /Pearson Education.
Operations Research: Methods & Problems / Maurice Saseini, ArhurYaspan& Lawrence Friedman/Wiley
Operations Research / R.Pannerselvam/ PHI Publications.
Operations Research / Wagner/ PHI Publications.
Operation Research /J.K.Sharma/Macmillan Publ.
Operations Research/ Pai/ Oxford Publications
Operations Research/S Kalavathy / Vikas Publishers
Operations Research / DS Cheema/University Science Press
Operations Research / Ravindran, Philips, Solberg / Wiley publishers

III Year I Semester	NANO TECHNOLOGY (V231310353)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the classification of Nano structured Materials
2. To understand the unique properties of Nano materials
3. To interpret the Synthesis Routes - Bottom up and Top down approaches
4. To identify the tools to characterize Nano materials
5. To understand the applications of Nano materials

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

CO1: Understand the classification of nano structured Materials

CO2: Understand the unique properties of nano materials

CO3: Interpret the Synthesis Routes - Bottom up and Top down approaches

CO4: Identify the tools to characterize nano materials

CO5: Understand the applications of nano materials

UNIT – 1

INTRODUCTION: History and Scope, Classification of Nano structured Materials, Fascinating Nanostructures, and applications of nano-materials, challenges and future prospects.

UNIT – 2

UNIQUE PROPERTIES OF NANO MATERIALS: Microstructure and Defects in Nano crystalline Materials: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and disclamations. Effect of Nano-dimensions on Materials Behavior: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nano crystalline alloy, Permanent magnetic nano crystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

UNIT – 3

SYNTHESIS ROUTES: Bottom up approaches: Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly. Top down approaches: Mechanical alloying, Nano-lithography. Consolidation of Nano powders: Shock wave consolidation, Hot iso-static pressing and Cold iso-static pressing, Spark plasma sintering.

UNIT – 4

TOOLS TO CHARACTERIZE NANOMATERIALS: X-Ray Diffraction (XRD), Small Angle X-ray scattering, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP),Nano indentation.

UNIT – 5

APPLICATIONS OF NANO MATERIALS: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS),Nano sensors, Nano catalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water- Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defense and Space Applications, Concerns and challenges of Nanotechnology

TEXT BOOKS:

1. Introduction to Nano Technology by Charles. P. Poole J r& Frank J. Owens. Wiley India Pvt. Ltd.
2. Nan Materials- A K.Bandyopadhyay/ New Age Publishers.Nano Essentials- T.Pradeep/TMH

REFERENCE BOOKS:

1. Solid State physics by Pillai, Wiley Eastern Ltd.
2. Introduction to solid state physics 7th edition by Kittel. John Wiley & sons (Asia) Pvt Ltd.

III YearI Semester	THERMAL MANAGEMENT OF ELECTRONIC SYSTEMS (V231310354)	L	T	P	C
		3	0	0	3

Course Objective:
To understand the basics of heat transfer and analyze heat transfer through fins
To acquire the knowledge on Free and forced convective systems.
To understand the air cooling and single phase liquid cooling systems with case studies.
To demonstrate the concepts of two phase cooling and heat pipes.
To understand thermo electric coolers, mini and micro channels.

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

CO1	Understand the basics of heat transfer and analyze heat transfer through fins
CO2	Acquire the knowledge on Free and forced convective systems
CO3	Understand the air cooling and single phase liquid cooling systems with case studies
CO4	Demonstrate the concepts of Two phase cooling and heat pipes
CO5	Understand thermo electric coolers, mini and micro channels

UNIT – 1
Introduction of Heat Transfer: Modes – Conduction, Convection and Radiation – Basic Laws – Applications of Heat Transfer.
Basics of Conduction –Conduction equation – Thermal analogy – Lumped heat capacity analysis - Heat conduction with phase change - Thermal Resistance – Extended Surfaces – Uniform cross section fins – Fin efficiency – Selection and design of fins

UNIT – 2
Forced and Free Convection – Heat transfer coefficient - Parameters effecting heat transfer – Thermal Properties of fluids - Combined Modes.
Radiation – Stefan- Boltzmann Law – Kirchhoff’s law and Emissivity – Radiation between Black Isothermal Surfaces – Radiation between Grey Isothermal Surfaces – Extreme Climatic conditions - Radiation at normal ambient Temperature measurement and its Instrumentation.

UNIT – 3
Printed Circuit boards – Chip packaging – thermal Resistance – Board Cooling **methods** – Board thermal Analysis – Equivalent thermal Conductivity.
Air Cooling – Fans – Heat transfer Enhancement – Air handling systems - Blowers
Single Phase Cooling – Coolant Selection – Natural Convection – Forced Convection - Air Cooling - Convective cooling in Small systems – Forced cooling in medium and large systems – Liquid cooling in high power modules – Case Studies.

UNIT – 4
Two Phase Cooling – Direct Immersion Cooling – Basics of Pool Boiling – Enhancement of Pool Boiling – Flow Boiling.

Heat Pipes – Operation Principles – Useful Characteristics – Operating Limits and Temperatures – Operation Methods – Applications – Micro Heat Pipes.

UNIT – 5

Thermo Electric coolers: Basics theories – Thermo electric effect – Operation Principles.

Phase change materials, Thermal Interface materials, Heat Spreaders and Heat Sinks – Working Principles

Mini and Micro Channels. Use of nano fluids in electronic cooling.

Text Books:

1. Thermal Analysis and Control of Electronic Equipment – Allan D. Kraus and Avram Bar Cohen, McGraw Hill, New York, NY, 1983.
2. Fundamentals of Microelectronics Packaging – Ed: Rao Tummala, McGraw Hill, New York, NY, 2001.
3. Packaging of Electronic Systems – James W. Dally, McGraw Hill, New York, NY, 1990.

III YearI Semester	ENTREPRENEURSHIP **(V231310355)**	L	T	P	C
		3	0	0	3

Course objective:
To develop and strengthen entrepreneurial quality and motivation in students.
To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.

UNIT-I : ENTREPRENEURAL COMPETENCE
Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.

UNIT-II: ENTREPRENEURAL ENVIRONMENT
Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organizational Services.

UNIT-III: INDUSTRIAL POLACIES
Central and State Government Industrial Policies and Regulations - International Business.

UNIT-IV: BUSINESS PLAN PREPARATION
Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.

UNIT- V: LAUNCHING OF SMALL BUSINESS
Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.
Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.

TEXT BOOKS
1. His rich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.
REFERENCES
1. Mathew Manimala, Entrepreneurship Theory at the Crossroads, Paradigms &Praxis, Biztrantra ,2nd Edition ,2005
2. Prasanna Chandra, Projects – Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill, 1996.
3. P.Saravanavel, Entrepreneurial Development, Ess Pee kay Publishing House, Chennai -1997.
4. Arya Kumar. Entrepreneurship. Pearson. 2012 5. Donald F Kuratko, T.V Rao. Entrepreneurship: A South Asian perspective. Cengage Learning. 2012

III Year I Semester	THERMAL ENGINEERING LAB **(V231310361)**	L	T	P	C
		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 OUTCOME:

Students will gain knowledge and skills needed to run a business

At the end of the course, student 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, load test of petrol and diesel engines.

CO4: Conduct performance test on petrol and diesel engines

CO5: Perform test and determine efficiency of air compressor

LIST OF 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) Say bolt Viscometer and (ii) Redwood Viscometer.
5. Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
6. To perform the Heat Balance Test on 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 installation of Solar PV Cells
12. Demonstration of electronic controls in an automobile.

III YearI Semester	THEORY OF MACHINES LAB	L	T	P	C
	(V231310362)	0	0	3	1.5

Course Objectives

- To demonstrate the motion of a gyroscope
- To study the characteristics of governors
- To find the frequencies of damped and undamped free and forced vibrations
- To analyze different mechanisms
- To demonstrate various types of gears

Course Outcomes:

CO1: Get knowledge about the motion of a gyroscope

CO2: Discuss the characteristics of governors

CO3: Find the frequencies of damped and undamped free and forced vibrations

CO4: Analyze different mechanisms

CO5: Demonstrate various types of gear

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 analyze 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

III Year I Semester	MACHINE TOOLS & METROLOGY LAB (V231310363)	L	T	P	C
		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

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

Course Outcomes: At the end of the course, student 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

MACHINE TOOLS LAB

1. Introduction of general purpose machines -Lathe, Drilling machine, Milling machine, Shaper, Planning 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

Course Outcomes: At the end of the course, student 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

1. Calibration of vernier calipers, micrometers, vernier height gauges and dials 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 choral 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 maker’s microscope.
10. Surface roughness measurement with roughness measuring instrument.

III YearI Semester	TINKERING LAB **(V231310364)**	L	T	P	C
		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:

- To 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: The students will be able to experiment, innovate, and solve real-world challenges.

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 Aurdino LED blinking activity in Tinker cad.
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.

Students need to refer to the following link:

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

III Year I Semester	COMMUNITY SERVICE INTERNSHIP **(V23131CC81)**	L	T	P	C
		--	--	--	2

III Year II Semester	HEAT TRANSFER (V231320331)	L	T	P	C
		3	0	0	3

Course Objectives:

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

Course Outcomes:

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

CO1	Find heat transfer rate for 1D, steady state composite systems with heat generation and performance of pins.
CO2	Understand the concepts transient heat conduction and basic laws involved in the convection heat transfer.
CO3	Apply the empirical equations for forced convection and free convection problems
CO4	Examine the rate of heat transfer with phase change and in the heat exchangers.
CO5	Illustrate the concepts of radiation heat transfer

UNIT – 1

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 – 2

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 – 3

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 – 4

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 – 5

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 by C P Kothandaraman and Subrahmanyan is allowed.

TEXT BOOKS:

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

REFERENCE BOOKS:

- Fundamentals of Heat Transfer by Incropera& Dewitt, John Wiley
- Fundamentals of Engineering, Heat& Mass Transfer by R.C.Sachdeva, NewAge.
- Heat& Mass Transfer by Amit Pal – Pearson Publishers

- Heat Transfer by Ghoshadastidar, Oxford University press.
- Heat Transfer by a Practical Approach, YunusCengel, Boles, TMH
- Engineering Heat and Mass Transfer by Sarit K. Das, DhanpatRai Pub

<table>
<tr><td rowspan="2">III Year II Semester</td><td rowspan="2">ARTIFICIALINTELLIGENCE&MACHNE LEARNING
(V231320332)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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Course objectives:

- To impart the basic concepts of artificial intelligence and the principles of knowledge representation and reasoning.
- To introduce the machine learning concepts and supervised learning methods
- To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
- To make the students learn about neural networks and genetic algorithms.
- To understand the machine learning analytics and deep learning techniques.

Course outcomes:

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

CO1: Explain the basic concepts of artificial intelligence

CO2: Learn about the principles of supervised learning methods

CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms

CO4: Get knowledge about neural networks and genetic algorithms.

CO5: Understand the machine learning analytics and apply deep learning techniques.

UNIT– I:

Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behavior - 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, over fitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbors, 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 neighbor learning.

UNIT– IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation, steepest descent method, Convolution 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.

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 Shiva Shankar 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/

III Year II Semester	FINITE ELEMENT METHODS **(V231320333)**	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn basic principles of finite element analysis procedure
- To learn how to solve the bar and truss problems
- To learn how to solve beam problems
- To understand the formulation of 2D problems
- To get knowledge in heat transfer analysis and dynamic analysis

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

CO1: Understand the concepts behind variational methods and weighted residual methods in FEM

CO2: Solve bar and truss problems.

CO3: Solve beam problems.

CO4: Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements

CO5: Evaluate the concepts of steady state heat transfer analysis and dynamic analysis

UNIT – 1

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 – 2

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 – 3

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

UNIT – 4

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

UNIT – 5

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.

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. 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.Lakshmi Narasaiah

III Year II Semester	MECHANICAL VIBRATIONS	L	T	P	C
	(V231320341)	3	0	0	3

Course Objectives:

- To learn basic principles of mathematical modeling of vibrating systems
- To understand the basic concepts free and forced multi degree freedom systems
- To get concepts involved in the torsion vibrations
- To learn the principles involved in the critical speed of shafts
- 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 torsion vibrations
CO4	Solve the problems on critical speed of shafts
CO5	Apply and Analyze the systems subjected to Laplace transformations response to different inputs

UNIT – 1

Relevance of and need for vibration analysis – Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undammed systems.

UNIT – 2

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

UNIT – 3

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 – 4

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 – 5

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

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", 5th Edition, Pearson Education, 2008.

2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.

3. Beranek and Veer, "Noise and Vibration Control Engineering: Principles and Applications", John Wiley and Sons, 2006.

4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, 2003.

III Year II Semester	ADVANCED MANUFACTURING PROCESSESS **(V231320342)**	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn the basic principle of advanced machining processes
- To know about the various additive manufacturing processes
- To understand the principles of coating and processing of ceramics.
- To get insights about processing of composites and nano materials
- To know the fabrication of microelectronic components.

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

CO1: Explain the working principle of various nonconventional machining processes and their applications.

CO2: Explain the working principles of additive manufacturing methods.

CO3: Understand various laser material processing techniques.

CO4: Gainon Advanced coating processes

CO5: Describe various fabrication methods for microelectronic devices

UNIT – 1

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

UNIT – 2

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 – 3

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 – 4

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, and Molecular beam Epitaxial.

UNIT – 5

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.

TEXT BOOKS:

1. Manufacturing Engineering and Technology*I*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 Nostr and 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*I*McGraw Hill.
5. Introduction to Nanoscience and NanoTechnology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learing

III Year II Semester	MICRO ELECTRO MECHANICAL SYSTEMS **(V231320343)**	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators
- To illustrate the rmal sensors and actuators used in MEMS.
- ToapplytheprincipleandvariousdevicesofMicro-Opto-ElectroMechanicalSystems
- (MOEMS), magnetic sensors and actuators.
- To analyze applications and considerations on micro fluidic systems.
- To illustrate the principles of chemical and biomedical micro systems.

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

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

CO2: Illustrate thermal sensors and actuators used in MEMS.

CO 3: To apply the principle and various devices of Micro-Opto Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.

CO 4: Analyze applications and considerations on micro fluidic systems.

CO5: Illustrate the principles of chemical and biomedical micro systems.

UNIT–I:

INTRODUCTION: Definition of MEMS,MEMS history and development, micro machining, litho graphy principles&methods,structuralandsacrificialmaterials,thinfilmdeposition,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 ,Inch worm technology.

UNIT–II:

THERMAL SENSORS AND ACTUATORS: Thermal energy basics and heat transfer processes,thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Pettier effect the at pumps, thermal flow sensors, micro hotplate gas sensors, MEMS the rmo 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 ELECTROMECHANICAL SYSTEMS: Principle of MOE MS 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,magnetotransistor,MEMSmagneticsensor,pressuresensorutilizingMOKE,magMEMSactuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage dev

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 microfluidicchannel,microfluiddispenser,microneedle,moleculargate,micropumps.**RADIOF REQUENCY (RF) MEMS:** RF – based communication systems, RF MEMS, MEMS inductors,tuner/filter,resonator,clarificationoftuner,filter,resonator,MEMS switches, phase shifter.

UNIT– V:

CHEMICALANDBIOMEDICALMICROSYSTEMS: Sensingmechanism&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.

TEXTBOOK:

1. MEMS, Nitaigour Prem chandMahalik, TMH

REFERENCEBOOKS:

1. Foundation of MEMS, ChangLiu, PrenticeHallLtd.
2. MEMS and NEMS, Sergey EdwardLyshevski, CRCPress, IndianEdition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-RanHsu, TMH Publishers.
4. Introductory MEMS, Thomas Madams, Richard ALayton, Springer International Publishers.

III Year-II Semester	SENSORS AND INSTRUMENTATION **(V231320344)**	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

CO1: Recognize with various calibration techniques and signal types for sensors.

CO2: Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers.

CO3: Apply the various sensors and transducers in various applications

CO4: Select the appropriate sensor for different applications.

CO5: Acquire the signals from different sensors using Data acquisition systems.

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.

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw- Hill, 2009.
2. Sawney A K and PuneetSawney, "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.

III B.Tech II Semester	ENERGY STORAGE TECHNOLOGIES **(V231320345)**	L	T	P	C
		3	0	0	3

Course Objectives: To

- Get the insights into importance of energy storage systems
- Understand the chemical and electromagnetic storage systems
- Know the principles of electrochemical storage systems
- Learn the working of super capacitors and fuel cells
- Know how to design batteries for transportation

Course Outcomes: At the end of the course, students will be able to Learn the importance of energy storage systems

CO1: Gain knowledge on chemical and electromagnetic storage systems

CO2: Understand the principles of electrochemical storage systems

CO3: Know the working of super capacitors and fuel cells

CO4: Learn how to design batteries for transportation

UNIT 1:

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 2:

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 electro statically charge storage, super conducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT 3:

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& Metal hydride battery vs lead-acid battery

UNIT 4:

Super capacitors- Working principle of super capacitor, types of super capacitors, cycling and performance characteristics, difference between battery and super capacitors, Introduction to Hybrid electrochemical super capacitors Fuel cell- Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-super capacitor systems.

UNIT 5:

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, and Thermal management of battery systems, State of Charge and State of Health Estimation over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

Text books:

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

References:

1. Pistoia, Gianfranco, and BoryannLiaw. 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)

III Year-II Semester	INDUSTRIAL HYDRAULICS AND PNEUMATICS **(V231320346)**	L	T	P	C
		3	0	0	3

Course Objectives:

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

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

CO1	Illustrate the basic concepts of fluid power
CO2	Understand the functions of elements of Hydraulic and Pneumatic systems
CO3	Analyze the functions of hydraulic and Pneumatic circuits
CO4	Illustrate the working of various hydraulic and pneumatic devices.
CO5	Interpret the procedure of installation, maintenance of hydraulic and pneumatic systems.

UNIT – 1

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-Lussec' 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 – 2

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 – 3

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 – 4

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 – 5

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.

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

III Year II Semester	INDUSTRIAL ROBOTICS	L	T	P	C
	(V231320347)	3	0	0	3

Course Objectives:
- The Students will acquire the knowledge to
- Discuss various applications and components of industrial robot systems
- Learn about the types of actuators used in robotics
- Calculate the forward kinematics and inverse kinematics.
- Learn about programming principles and languages for a robot control system
- Discuss the applications of image processing and machine vision in robotics.

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

CO1: Discuss various applications and components of industrial robot systems

CO2: Learn about the types of actuators used in robotics

CO3: Calculate the forward kinematics and inverse kinematics.

CO4: Learn about programming principles and languages for a robot control system

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

UNIT – 1
INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.
COMPONENTSOFTHE INDUSTRIALROBOTICS:
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 – 2
ROBOTACTUATORSANDFEEDBACKCOMPONENTS:
Actuators: Pneumatic, Hydraulic actuators, electric& steppe motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.
Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – 3
MOTIONANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.
MANIPULATORKINEMATICS: Specifications of matrices, D-Hnotation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4
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 – 5

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

TEXTBOOKS:

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

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, PrenticeHall
3. Robot AnalysisandControl/ H. Asada and J.J.E. Slotine/BSP Books Pvt.Ltd.
4. IntroductiontoRobotics/John JCraig/PearsonEdu.

III Year II Semester	REFRIGERATION & AIR-CONDITIONING (V231320348)	L	T	P	C
		3	0	0	3

Course Objectives:

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

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

CO1	Illustrate the operating cycles and different systems of refrigeration.
CO2	Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
CO3	Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants
CO4	Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
CO5	Demonstrate different components of refrigeration and air conditioning systems.

UNIT – 1

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 – 2

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 – 3

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 – 4

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 – 5

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 Psychometric tables and charts are allowed.

Text Books:

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 / Anantha narayanan / TMH

III YearII Semester	INTRODUCTION TO INDUSTRIAL ROBOTICS **(V231320351)**	L	T	P
		3	0	0

Course Objectives:

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

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

CO1: Discuss various applications and components of industrial robot systems

CO2: Learn about the types of actuators used in robotics

CO3: Calculate the forward kinematics and inverse kinematics.

CO4: Learn about programming principles and languages for a robot control system

CO5: Discuss the applications of image processing and machine vision in rob

UNIT – 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An over view 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 – 2

ROBOT ACTUATORS AND FEEDBACK 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 – 3

MOTIO ANANALYSIS: Homo generous transformations as applicable to rotation and translation –problems.
MANIPULATOR KINEMATICS: Specifications of matrices, D-Hnotation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4

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 – 5

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

TEXTBOOKS:

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

REFERENCES:

1. Robotics/Fu KS/ Mc GrawHill.
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 Robotics/John JCraig/PearsonEdu.

III YearII Semester	INDUSTRIAL MANAGEMENT (V231320352)	L	T	P	C
		3	0	0	3

Cou rse

Objectives:

The objectives of the course are to

- Introduce the scope and role of industrial engineering and the techniques for optimal design of layouts.
- Illustrate how work study is used to improve productivity
- Explain TQM and quality control techniques
- Introduce financial management aspects and
- Discuss human resource management and value analysis.

Course Outcomes:

After completing this course, students will be able to:

CO1: Learn about how to design the optimal layout

CO2: Demonstrate work study methods

CO3: Explain Quality Control techniques

CO4: Discuss the financial management aspects and

CO5: Understand the human resource management methods.

UNIT– I

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayal's principles of management.

PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and breakdown maintenance.

UNIT–II

WORK STUDY: Importance, types of production, applications, work study, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

UNIT–III

STATISTICAL QUALITY CONTROL: Quality control, Quality assurance and its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – $\bar{X}$ and R –charts X and S charts and their applications, numerical examples.

TOTALQUALITYMANAGEMENT: zero defect concept, quality circles, implementation, applications, ISO quality systems. Six Sigma–definition, basic concepts

UNIT– IV

FINANCIAL MANAGEMENT: Scope and nature of financial management, Sources of finance, Ratio analysis, Management of working capital, estimation of working capital requirements, stock management, Cost accounting and control, budget and budgetary control, Capital budgeting – Nature of Investment Decisions – Investment Evaluation criteria- NPV, IRR, PI, Payback Period, and ARR, numerical problems.

UNIT–V

HUMAN RESOURCEMANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, and types.

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

Text Books:

1. Industrial Engineering and Management/ O.P Khanna /Khanna Publishers.
2. Industrial Engineering and Production Management/Mart and Telsang / S.Chand&Company Ltd. New Delhi.

Reference Books:

1. Industrial Management/ Bhattacharya DK/ Vikas publishers
2. Operations Management/ J.GMonks / McGrawHilPublishers.
3. Industrial Engineering and Management Science/T.R. Banga, S.C.Sharma, N. K. Agarwal /Khanna Publishers
4. Principles of Management / Koontz O'Donnell/ McGraw Hill Publishers.
5. Statistical Quality Control / Gupta/ Khanna Publishers
6. Industrial Engineering and Management/ NVSRaju/ CengagePublishers

III Year II Semester	ADDITIVE MANUFACTURING **(V231320353)**	L	T	P	C
		3	0	0	3

Course Objectives:
- To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
- To understand and apply different types of solid-based RP systems.
- To understand and apply powder-based RP systems.
- To understand and apply various rapid tooling techniques.
- To understand different types of data formats and to explore the applications of AM processes in various fields.

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

CO1	Understand the principles of prototyping, classification of RP processes and liquid-based RP systems.
CO2	Understand and apply different types of solid-based RP systems.
CO3	Apply powder-based RP systems.
CO4	Analyze and apply various rapid tooling techniques.
CO5	Understand different types of data formats and explore the applications of AM processes in various fields.

UNIT – 1
INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.
LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 2
SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modeling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 3
POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 4
RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need

for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.

UNIT – 5

RAPID PROTOTYPING DATA FORMATS: STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

Text Books:

1. Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific publications

References:

1. Rapid Manufacturing / D.T. Pham and S.S. Dimov/Springer
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates
3. Rapid Prototyping & Manufacturing / Paul F.Jacobs/ASME Press
4. Rapid Prototyping / Chua and Liou

III Year II Semester	VEHICLE TECHNOLOGY (V231320354)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To study the advanced engine technologies
- To learn various advanced combustion technologies and its 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 automotives

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

CO1: Discuss the latest trends in engine technology

CO2: Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.

CO3: Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.

CO4: Discuss the working and energy flow in various hybrid and electric configurations.

CO5: Analyzing the need for fuel cell technology in automotive applications.

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.

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. 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

III Year II Semester	INDUSTRIAL SAFETY **(V231320355)**	L	T	P	C
		3	0	0	3

Course objectives:

- To understand the concepts of industrial safety and management.
- To demonstrate the accident preventions and protective equipment.
- To understand and apply the knowledge of safety acts
- To have the knowledge about fire prevention and protection systems
- To understand and apply fire safety principles in buildings

Course outcomes:

CO1: Students learn the concepts of industrial safety and management.

CO2: Learn about the smart machines and smart sensors

CO3: Apply to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry

CO4: Students learn about fire prevention and protection systems.

CO5: Students learn and apply the fire safety principles in buildings

UNIT-I

INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETY AND MANAGEMENT: History and development of Industrial safety: Implementation of factories act, Safety and productivity, Safety organizations. Safety committees and structure, Role of management and role of Govt.in industrial safety.

UNIT-II

ACCIDENTPREVENTIONS AND PROTECTIVE EQUIPMENT: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training insafety,Preventioncausesandcostofaccident,Housekeeping,Firstaid,Accidentreporting,Investigations.Industrialpsychologyinaccidentprevention,Safetytrials,Safetyrelatedtooperations.

UNIT-III

SAFETY ACTS: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act,Workman'scompensationAct,Industrialhygiene,Occupationalsafety,Diseasesprevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical environment, Engineering methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it, Code and regulations for worker safety and health, codes for safety of systems.

UNIT-IV

FIRE PREVENTION AND PROTECTION: Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E-Fire extinguishing agents- Water, Foam, Dry chemical powder, Carbon-dioxide Holon alternatives Halocarbon compounds-Inert gases, dry powders – types of fire extinguishers – fire stoppers –hydrant pipes – hoses – monitors – fire watchers –

layout of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills –first aid for burns.

UNIT-V

BUILDINGFIRESAFETY: Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design -exit– width calculations –fire certificates – fire safety requirements for high rise buildings.

TEXT BOOKS:

1. Industrial Maintenance Management Sri vastava,S.K.-S.ChandandCo.
2. OccupationalSafetyManagementandEngineeringWillieHammer–PrenticeHall
3. PurandareD.D&AbhayD.Purandare,“HandbookonIndustrialFireSafety”P&Apublications,NewDelhi,2006.
4. McElroy,FrankE.,“AccidentPreventionManualforIndustrialOperations”,NSC,Chicago,1988.
5. Green, A.E.,“HighRisk Safety Technology”, John Wiley and Sons, 1984.

REFERENCEBOOKS:

1. Installation, Servicing and Maintenance Bhattacharya, S.N.-S.Chand and Co.
2. Jain VK“Fire Safety in Building”NewAgeInternational1996.
3. Reliability, Maintenance and Safety Engineering by Dr.A. K. Guptha
4. A Text book of Reliability and Maintenance Engineering by Alakesh Manna

III Year II Semester	HEAT TRANSFER LAB (V231320361)	L	T	P	C
		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.

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

1. Virtual labs (https://mfts-iitg.vlabs.ac.in/) on
2. Conduction Analysis of a Single Material Slab
3. Conduction Analysis of a single Material Sphere
4. Conduction Analysis of a single Material Cylinder
5. Conduction Analysis of a Double Material Slab
6. Conduction Analysis of a Double Material Sphere
7. Conduction Analysis of Double Material Cylinder
8. To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger
9. To investigate the Lambert's distance law.

10. To investigate the Lambert's direction law (cosine law

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

III Year II Semester	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LAB **(V231320362)**	L	T	P	C
		0	0	3	1.5

Course Objectives:
Students will acquire the knowledge of artificial intelligence and machine learning models

Course Objectives:
- To enable the students write coding for various artificial intelligence and machine learning algorithms.
- Learning of Python libraries – Numpy, Pandas, Matplotlib, Sea born and Tensor Flow
- Numerical examples on Python libraries
- Data Preprocessing and data cleaning using Python
- Write a program for Linear regression
- Write a program for Logistic regression
- Write a program for ANN
- Write a program for CNN
- Write a program for RNN
- Write a program to build a Decision tree
- Write a program to build a Naïve Bayes classifier
- Write a program for SVM
- Write a program for Auto-encoder

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

CO4: Generate code for auto encoders

using various software tools
Course Outcomes:
- At the end of the course, student will be able to apply the knowledge of artificial intelligence and machine learning models along with image classifiers using various software tools.

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

III Year II Semester	ROBOTICS AND DRONE TECHNOLOGIES LAB (V231320363)	L	T	P	C
		0	0	4	2

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

Course outcome:

- Students at the end of the course will get enough knowledge and knowhow about how to design a variety of robots and drones for diversified applications.

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, man oeuvres 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:

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

<table>
<tr><td rowspan="2">III Year II Semester</td><td rowspan="2">TECHNICAL PAPER WRITING AND IPR
(V2313203C1)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>2</td><td>0</td><td>0</td><td>--</td></tr>
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Course objectives:

- To understand the structure of the technical paper and its components.
- To review the literature and acquire the skills to write a technical paper for first submission.
- To understand the process and development of IPR.
- To create awareness about the scope of patent rights.
- 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.

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:

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

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

III Year II Semester	INDUSTRY INTERNSHIP	L	T	P	C
		2	0	0	--

<table>
<tr><td rowspan="2">Minors Course</td><td rowspan="2">MECHANICS OF SOLIDS
(Mechanical Engineering Design and Robotics)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives: The objectives of the course are to

- Understand the behavior of basic structural members subjected to uni-axial loads.
- Apply the concept of stress and strain to analyze and design and structural members and machine parts under axial, shear and bending loads, and moment.
- Students will learn all the methods to analyze beams, frames for normal, shear to solve deflection problems in preparation for the design of such structural components.
- Students are able to analyze beams and draw correct and complete shear and bending moment diagrams for beams.
- Students attainder per understanding of the loads, stresses, and strains acting on a structure and the irrelations in the elastic behavior
- Design and analysis of Industrial components like pressure vessels.

Course outcomes:
On the completion of the course the student willable to
CO1: Model & Analyze the behavior of basic structural members subjected to various loading and support conditions based on principles of equilibrium.
CO2: Understand the apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moment.
CO3: Students will learn all the methods to analyze beams, columns, frames for normal, shear, to solve deflection problems in preparation for the design of such structural components. Students are able to analyze beams and draw correct and complete shear and bending moment diagrams for beams.
CO4: Students attain a deeper understanding of the loads, stresses, and strains acting on a structure and the irrelations in the elastic behavior

UNIT– I
SIMPLE STRESSES &STRAINS : Elasticity and plasticity – Types of stresses & strains– Hooke's law – stress-strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Bars of varying section – composite bars – Temperature stresses-Relation between elasticconstants,Strainenergy–Resilience–Gradual,sudden,impactandshockloadings.

UNIT–II
SHEAR FORCE AND BENDING MOMENT : Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, (UDL) uniformly varying loads

and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT–III

FLEXURAL STRESSES: Theory of simple bending – Assumptions – Derivation of bending equation: M/ I = f/y = E/R Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections

SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, Tangle sections.

UNIT–IV

DEFLECTION OF BEAMS: Bending into a circular arc – slope, deflection and radius of curvature–Differential equation for the elastic line of abeam –Double integration andMacaulay'smethods–Determinationofslopeanddeflectionforcantileverandsimplysupported beams subjected to point loads, - U.D.L uniformly varying load. Mohr's theorems –Moment area method – application to simple cases including overhanging beams.

UNIT– V

THIN AND THICK CYLINDERS: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains –changes in dia, and volume of thin cylinders – Riveted boiler shells – Thin spherical shells. Wire wound thin cylinders .Lame's equation–cylinders subjected to inside& outside pressures - compound cylinders.

TEXTBOOKS:

- Strength of materials/GHRyder/McMillan publishers India Ltd.
- Strength of materials by B.C.Punmia, Lakshmi publications Pvt. Ltd, New Delhi.

REFERENCES:

- Mechanics of Materials by Gere &Timoshenko
- Strength of Materials-By Jindal, Umesh Publications.
- Strength of Materials by S.Timshenko-PHI Publishers
- Strength of Materials by Andrew Pytel and Ferdinand L. Singer Longman-Harper Collins College Division
- Solid Mechanics by Popov
- Mechanics of Materials/Gere and Timoshenko, CBS Publishers

Minors Course	DESIGN OF MACHINE MEMBERS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives:

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

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

CO1: Design the machine members subjected to static and dynamic loads.
CO2: Design shafts and couplings for power transmission
CO3: Learn how to design bolted and welded joints.
CO4: Know the design procedures of clutches, brakes and springs.
CO5: Design bearings and gears.

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. Soder berg, 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: Design of Bearings and Gears

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

Design of 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.

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:

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

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Minors Course	THEORY OF MACHINES (MECHANICAL ENGINEERING DESIGN AND ROBOTICS)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To identify and enumerate different link based mechanisms with basic understanding of motion
- Tointerpretandanalysevariousvelocityandaccelerationdiagramsforvariousmechanisms
- To understand about balancing of masses
- To learn about governors and gyroscope
- To design and evaluate the performance of different cams and followers.

COURSE OUTCOMES:

At the end of the course, students will be able

CO1:To learn different link based mechanisms

CO2:Toanalysevariousvelocityandaccelerationdiagramsforvariousmechanisms

CO3:To learn about how to balance the masses

CO4:To gain knowledge in governors and gyroscope.

CO5:To design and evaluate the performance of different cams and followers.

UNIT-I

Links and Mechanisms:

Definitions Link or Element, Kinematic Pairs, Degrees of Freedom, Grumbler’s Criterion (without derivation), Kinematic Chain, Mechanism, Structure, Mobility of Mechanism, Inversion, Machine. Kinematic Chains and Inversions: Inversions of Four Bar Chain; Single Slider Crank Chain and Double Slider Crank Chain.

Static force analysis: Introduction: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, free body diagrams, principle of virtual work Static force analysis of four bar mechanism and slider-crank mechanism with and without friction.

UNIT-II

Force principle:

Alembert’s principle Inertia force, inertia torque Dynamic force analysis of four-bar mechanism and slider crank mechanism.

Friction and Belt Drives Definitions:

Types of friction: laws of friction, Friction in pivot bearings.

Belt drives: Flat belt drives, ratio of belt tensions, centrifugal tension, and power transmitted.

Turning moment diagrams: Turning moment diagrams – fluctuation of energy – fly wheels and their design.

UNIT-III

Balancing of Rotating Masses:

Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in

same plane and in different planes.
Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinder engine

UNIT-IV

Governors: Types of governors; force analysis of Porter and Hornell governors. Controlling force, Stability, sensitiveness, isochronisms, Effort and power.
Gyroscope: Victoria representation of angular motion, gyroscopic couple. Effect of gyroscopic couple on ship, plane disc, aeroplane, Stability of two wheelers.

UNIT- 5

Cams: Types of Cams, Types of Followers. Displacement, Velocity& Acceleration Time Curves for Cam Profiles. Disc Cam with Reciprocating Follower Having Knife- Edge, Roller & Flat-Face Follower, And Disc Cam With Oscillating Roller Follower. Follower Motions including, SHM, Uniform Velocity, Uniform Acceleration &Retardation and Cycloid Motion.

TEXT BOOKS:

"Theory of Machines", Rattan S.S,TataMcGraw-HillPublishingCompanyLtd.,NewDelhi,and3rdEd-2009
"Theory of Machines",Sadhu Singh,PearsonEducation(Singapore)Pvt.Ltd,IndianBranchNewDelhi,2ndEd2006/

REFERENCE BOOKS

1. "TheoryofMachines&Mechanisms",J.J.Uicker,,G.R.Pennock,J.E.Shigley,OXFORD3rdEd.2009.
2. "Theory of Machines"byThomas Bevan,CBS Publication1984.
3. "DesignofMachinery"byRobertL.Norton,McGrawHill,2001.
4. "Mechanisms and Dynamics"of Machinery byJ.Srinivas,Scitech Publications,Chennai,2002.
1. "Dynamics of machinery" by J.B.K. Das&P.L.S.Murthy.

Minors Course	FINITE ELEMENT METHODS (MECHANICAL ENGINEERING DESIGN AND ROBOTICS)	L	T	P	C
		3	0	0	3

Course Objectives:
1. To learn basic principles of finite element analysis procedure
2. To learn how to solve the bar and truss problems
3. To learn how to solve beam problems
4. To understand the formulation of 2D problems
5. To get knowledge in heat transfer analysis and dynamic analysis.

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

CO1: Understand the concepts behind variational methods and weighted residual methods in FEM

CO2: Solve bar and truss problems.

CO3: Solve beam problems.

CO4: Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements

CO5: Evaluate the concepts of steady state heat transfer analysis and dynamic analysis

UNIT – 1

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 – 2

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, and 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, and strain and support reaction calculations

UNIT – 3

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

UNIT – 4

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axi symmetric 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 – 5

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.

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition/ Tirupati Reddy Chandru patla/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
1. 2.An introduction to Finite Element Method /JNReddy/McGraw-Hill
2. 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.
3. 4.Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education

Minors Course	MECHANICALVIBRATIONS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn basic principles of mathematical model in go vibrating systems
- To learn the basic concepts free and forced multi degree freedom systems
- To learn concepts involved in the torsional vibrations
- To learn the principles involved in the critical speed of shafts
- To learn 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

UNIT–I:

Relevance of and need for vibration analysis– Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and un damped systems.

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.

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: Vibro meters, 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 attested.

UNIT–V:

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

TEXTBOOKS:

1. S.S.Rao, “Mechanical Vibrations", 5thEdition,PrenticeHall, 2011.
2. L.Meirovitch,“ElementsofvibrationAnalysis",2ndEdition,McGraw-Hill,NewYork,1985.

REFERENCES:

1. W.T.Thomson, M.D. Dahl hand CPadmanabhan,“TheoryofVibrationwithApplications”,5thEdition,PearsonEducation,2008.
2. M.L.Munjal, “Noise and Vibration Control”, World Scientific,2013.
3. BeranekandVer,“NoiseandVibrationControlEngineering:PrinciplesandApplications”, JohnWileyandSons,2006.
4. RandallF.Barron,“IndustrialNoiseControlandAcoustics”,MarcelDekker, Inc.,2003.

Minors Course	ROBOTICS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives: The Students will acquire the knowledge to

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

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

CO1: Discuss various applications and components of industrial robot systems

CO2: Learn about the types of actuators used in robotics

CO3: Calculate the forward kinematics and inverse kinematics.

CO4: Learn about programming principles and languages for a robot control system

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

UNIT – 1
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 – 2
ROBOT ACTUATORS AND FEEDBACK 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 – 3
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 – 4
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 – 5
IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision,

Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

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

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, Prentice Hall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt. Ltd.
4. Introduction to Robotics/John JCraig/Pearson Edu.

Minors Course	PRODUCT DESIGN (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understanding of materials, processes, ergonomics, human behavior and systems with reference to product design.
- To develop conceptual thinking, and workshop and computer skills for modeling and simulation of a variety of individual and group projects ranging from basic to the complex.
- To understand various risks involved through various techniques and perform reliability analysis.
- To acquaint with different product testing procedures under thermal, vibration, electrical and combined environments.
- To learn about how to design a component for manufacturability

COURSE OUTCOMES:

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

CO1: Apply creative thinking skills for idea generation
CO2: Translate conceptual ideas into clear sketches
CO3: Able to identify causes of failure through fault free analysis and perform failure analysis
CO4: Test a product under thermal, vibration, electrical and combined environments.
CO5: Know how to design for manufacturability

UNIT – I:
PRODUCT DESIGN PROCESS:
Design Process Steps, Morphology of Design. Problem Solving and Decision Making: Problem-Solving Process, Creative Problem Solving, Invention, Brainstorming, Morphological Analysis, Behavioural Aspects of Decision Making, Decision Theory, Decision Matrix, Decision Trees.

MODELING AND SIMULATION:
Triz, Role of Models in Engineering Design, Mathematical Modelling, Similitude and Scale Models, Computer Simulation, Geometric Modelling on Computer, Finite-Element Analysis.

UNIT – II:
PRODUCT MANAGEMENT:
The operation of product management: Customer focus of product management, product planning process, Levels of strategic planning, Wedge analysis, Opportunity search, Product life cycle Life cycle theory and practice.
PRODUCT DEVELOPMENT:
Managing new products, generating ideas, Sources of product innovation, Selecting the best

ideas, the political dimension of product design, Managing the product launch and customer feedback.

PRODUCT MANAGERS AND MANUFACTURING:
Need for effective relationships, Impact of manufacturing processes on product decisions, Proto type planning,, Productivity potentials, Management of product quality, Customer service levels.

UNIT – III:
RISK AND RELIABILITY:
Risk and Reliability: Risk and Society, Hazard Analysis, Fault Tree Analysis. Failure Analysis and Quality: Causes of Failures, Failure Modes, Failure Mode and Effect Analysis, FMEA Procedure, Classification of Severity, Computation of Criticality Index, Determination of Corrective Action, Sources of Information, Copyright and Copying. Patent Literature.

UNIT – IV:
PRODUCT TESTING:
Thermal, vibration, electrical, and combined environments, temperature testing, vibration testing, test effectiveness. Accelerated testing and data analysis, accelerated factors. Weibull probability plotting, testing with censored data.

UNIT – V:
DESIGN FOR MANUFACTURABILITY:
Maintenance Concepts and Procedures, Component Reliability, Maintainability and Availability, Fault Isolation in design and Self-Diagnostics.

Product Design for Safety, Product Safety and User Safety Concepts, Examples of Safe Designs.

DESIGN STANDARDIZATION AND COST REDUCTION:
Standardization Methodology, Benefits of Product Standardization; International, National, Association and Company Level Standards; Parts Modularization

TEXTBOOKS:
Engineering Design, George E. Dieter, McGraw-Hill
Product Integrity and Reliability in Design, John W. Evans and Jillian Y. Evans, Springer Verlag.

REFERENCE BOOKS:
The Product Management Handbook, Richard S. Handscombe, McGraw-Hill
New Product Design, Ulrich Eppinger
Product Design, Kevin Otto.

Minors Course	DESIGN FOR MANUFACTURING (Mechanical Engineering Design and Robotics)	L	T	P	C
		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

UNIT-1

Introduction to DFM, DFMA: How Does DFMA Work? Reasons for No 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– 2

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 recommendation for machined parts.

UNIT – 3

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– 4

Metal joining: Appraisal of various welding processes, factors in design of elements – 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– 5

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: Design considerations, allowances

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. ASM Hand book Vol.20

Minors Course	CAD LAB (Mechanical Engineering Design and Robotics)	L	T	P	C
		0	0	3	1.5

Course Objectives:
- To develop skill to use software to create 2D models.
- T learn how to use software 3D models.
- To use software Assembly.

LIST OF EXPERIMENT:

1. DRAFTING: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.
2. SURFACE MODELING - Generation of various Surfaces using surface modeling.
A) DRAFTING: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.
B) SURFACE MODELING - Generation of various Surfaces using surface modeling.
C) The following contents to be done by any 3D software package:
(i) PART MODELING: Generation of various 3D models through Pad, revolve, shell, sweep, parent child relation, Boolean operations and various standard translators.
(ii) Assembly drawings: (Any four of the following using solid model software) Generation of various Parts/assemblies: like Screw Jack, Oldham's Coupling, Foot step bearing, Couplings, knuckle and cotter joints, Crankshaft, Connecting Rod, Piston and Cylinder.
Course Outcomes: At the end of the course, students learn drafting, surface modeling and 3D modeling

Minors Course	MECHANISMS AND ROBOTICS LAB (Mechanical Engineering Design and Robotics)	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVE:

- The student will learn to design RRRR and RRRP planar mechanisms for function and path generation applications and verify the designs using simulations through ADAMS/CATIA software packages.
- To program robot manipulators to do pick and place operations and trace a given path.

COURSE OUTCOMES:

After successfully completing this course, the student will be able to:

CO1: Write programs to perform the pick and place operations and trace a path for arc welding process using any articulated robot

CO2: Demonstrate the procedure for forward and inverse kinematic analysis any articulated robot

CO3: Design planar mechanisms using procedures for path generation and rigid body guidance and simulate the motions using ADAMS software

LIST OF EXPERIMENTS

ROBOTICS LAB

- To demonstrate Forward and inverse Kinematics of articulated robot.
- To program and perform the following operations by using an articulated robot:
- Pick and place operation
- To traverse given path (for arc welding)

KINEMATICS AND DYNAMICS OF NISMS LABORATORY

Design the following mechanisms and simulate using CATIA Software/ADAMS Software:

1. A '*RRRR'* mechanism whose coupler curve will pass through 3 given point.
2. A '*RRRR*' mechanism whose coupler will guide a straight line segment through at least three given positions.
3. A '*RRRR*' mechanism whose input and output motion is coordinated at at least three given positions.
4. A '*RRRR*' mechanism whose coupler will guide a straight line segment through at least three given positions.
5. A '*RRRP*' mechanism whose input and output motion is coordinated at least two given positions
6. A '*RRRP*' mechanism whose input and output motion is coordinated at least three given positions.
7. A '*RRRR*' mechanism whose input and output motion is coordinated at least two given positions.
8. A '*RRRR*' mechanism whose coupler curve will pass through 4 given points.
9. A '*RRRR*' mechanism whose coupler curve will pass through 3 given points.

Minors Course	AUTOMATION IN MANUFACTURING (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the types and strategies and various components in Automated Systems
- To classify the types of automated flow lines and analyze automated flow lines
- To solve the line balancing problems in the various flow line systems with and without buffer storage
- To interpret different automated material handling systems, storage and retrieval systems and automated inspection systems
- To understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

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

CO1: Understands the types and strategies and various components in Automated Systems.
CO2: Classify the types of automated flow lines and analyze automated flow lines
CO3: Solves the line balancing problems in the various flow line systems with and without buffer storage
CO4: Interpret different automated material handling systems, storage and retrieval systems and automated inspection systems
CO5: Understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

UNIT – 1
INTRODUCTION: Types and strategies of automation, pneumatic and hydraulic components, circuits, automation in machine tools, power transmission in CNC machines, optical encoders, other sensors, mechanical feeding and tool changing and machine tool control.

UNIT – 2
AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT – 3
ASSEMBLY SYSTEM AND LINE BALANCING: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.
AUTOMATED INSPECTION: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision

UNIT – 4

AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS:
Types of equipment, functions, analysis and design of material handling systems, conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT – 5

ADAPTIVE CONTROL SYSTEMS: Introduction, adaptive control with optimization, adaptive control with constraints, application of adaptive control in machining operations. Consideration of various parameters such as cutting force, temperatures, vibration and acoustic emission in the adaptive controls systems.

TEXT BOOK:

Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover/ PE/PHI.

Automation by W. Buckingham.

REFERENCES:

1. Computer Control of Manufacturing Systems by YoramCoren.
2. CAD / CAM/ CIM by Radhakrishnan.

Minors Course	MICRO ELECTRO MECHANICAL SYSTEMS (Smart Manufacturing)	L	T	P	C
		3	0	0	3

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

Course Outcomes:
At the end of the course, student will be able to
CO 1: To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
CO 2: Illustrate thermal sensors and actuators used in MEMS.
CO 3: To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
CO 4: Analyze applications and considerations on micro fluidic systems.
CO 5: Illustrate the principles of chemical and bio medical micro systems.

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.

TEXT BOOK:
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.

Minors Course	MECHATRONICS (Smart Manufacturing)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand various elements of a mechatronics system
- Model and simulate simple physical systems
- Suggest appropriate sensors and actuators for an engineering application
- Write simple microcontroller programs
- Build simple homemade projects using electronic devices integrating with mechanical systems

COURSE OUTCOMES:

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

Course Outcome

CO1: Identification and demonstration of key elements of mechatronics system and its representation in terms of block diagram.

CO2: Describe the use of solid-state electronic devices, diodes, amplifiers, etc. in designing the mechatronics systems and MEMS.

CO3: Illustrate the applications of various hydraulic, pneumatic, mechanical, electrical actuating systems and valves in designing the mechatronic systems.

CO4: Develop the PLC ladder programming for the creation of real-time mechatronic system.

CO5: Develop dynamic models using system interfacing and data acquisition methods to design mechatronics systems for future applications.

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

UNIT – I:

Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion , force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

UNIT – II:

Solid state electronic devices, PN junction diode, BJT, FET, DIA and TRIAC. Analog signal conditioning, amplifiers, filtering. Introduction to MEMS & typical applications.

UNIT – III:

Hydraulic and pneumatic actuating systems, Fluid systems, Hydraulic and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems.

UNIT – IV:

Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

UNIT – V:

System and interfacing and data acquisition, DAQS, SCADA, A-D and D-A conversions; Dynamic models and analogies, System response. Design of mechatronics systems & future trends.

TEXTBOOKS:

1. Mechatronics Integrated Mechanical Electronics Systems/KP Ramachandran & G K Vijaya Raghavan/WILEY India Edition/2008
2. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.

REFERENCE BOOKS:

1. Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.
2. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
3. Mechatronics System Design / Devdas Shetty/Richard/Thomson.
4. Mechatronics/M. D. Singh/J. G. Joshi/PHI.

Minors Course	CIM (SMART MANUFACTURING)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand the basic fundamentals of computer aided manufacturing.
- To understand the principles of flexible manufacturing systems
- To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication
- To learn the overall configuration and elements of computer integrated manufacturing systems.
- To learn the part programming, importance of group technology, computer aided process planning, computer aided quality control

COURSE OUTCOMES:

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

CO1: Gain knowledge about the fundamentals of computer aided manufacturing.

CO2: Learn the principles of flexible manufacturing systems

CO3: Gain knowledge about different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication

CO4: Learn the overall configuration and elements of computer integrated manufacturing systems.

CO5: Understand the part programming, importance of group technology, computer aided process planning, computer aided quality control

UNIT- 1

MANUFACTURING IN A COMPETITIVE ENVIRONMENT: Automation of manufacturing process - Numerical control - Adaptive control - material handling and movement - Industrial robots - Sensor technology - flexible fixtures - Design for assembly, disassembly and service.

UNIT- 2

GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS: Part families - classification and coding - Production flow analysis - Machine cell design - Benefits. Components of FMS - Application work stations - Computer control and functions - Planning, scheduling and control of FMS - Scheduling - Knowledge based scheduling - Hierarchy of computer control - Supervisory computer.

UNIT- 3

COMPUTER SOFTWARE, SIMULATION AND DATABASE OF FMS: System issues - Types of software - specification and selection - Trends - Application of simulation - software - Manufacturing data systems - data flow - CAD/CAM considerations - Planning FMS database.

UNIT- 4

COMPUTER INTEGRATED MANUFACTURING SYSTEMS: Types of manufacturing systems, machine tools and related equipment, material handling systems, material requirement planning, computer control systems, human labor in manufacturing systems, CIMS benefits.

UNIT- 5

COMPUTER AIDED QUALITY CONTROL: Terminology used in quality control, use of computers in Quality control. Inspection methods- contact and noncontact types, computer aided testing, integration of CAQC with CAD/CAM.

REFERENCES:

1. Grover M.P., "Automation, Production Systems and Computer Integrated Manufacturing ", Third Edition, Prentice-Hall, 2007.
2. Jha, N.K. "Handbook of Flexible Manufacturing Systems ", Academic Press Inc., 1991.
3. Kalpkjian, "Manufacturing Engineering and Technology ", Addison-Wesley Publishing Co., 1995.
4. Pascal Dennis, "Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System", (Second edition), Productivity Press, New York, 2007.
5. TaiichiOhno, Toyota, "Production System beyond Large-Scale production Productivity Press (India) Pvt.Ltd. 1992.

Minors Course	SMART MANUFACTURING (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course objectives:

- To apply knowledge of smart manufacturing systems' components in the context of Industry 4.0
- To understand the concepts of smart machines and smart sensors
- To understand and apply the concepts of IoT connectivity to Industry 4.0
- To understand the concepts of Digital Twin and apply Machine Learning and Artificial Intelligence concepts in Manufacturing
- To understand the concepts of Met averse platform

Course Outcomes:

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

CO1: Learn about smart manufacturing systems' components and can handle it more effectively in context of Industry 4.0

CO2: Learn about the smart machines and smart sensors

CO3: Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry

CO4: Learn about concepts of Digital Twin and able to apply Machine Learning and Artificial Intelligence concepts in Manufacturing

CO5: Learn the concepts of AR/VR and Met averse platform

UNIT – 1

Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.

UNIT – 2

Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Introduction to IoT, IoT, and Cyber physical systems, Sensing for Manufacturing Process in IoT, Block Diagram of an IoT Sensing Device, Sensors in IoT Applications, Smart Machine Interfaces,

UNIT – 3

IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

UNIT – 4

Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology

Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML.

UNIT – 5

Met averse – Basic concepts, AR/VR, Social Met averse, Industrial Met averse, How Web 3.0 is changing the Internet, Asset Classes Inside the Met averse, Land, Coins, Characters/ Avatars, Skins, Utility, Industries Disrupted by the Met averse, Smart wearable's,

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. EthemAlpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.
4. Aurelian Gerona, Hands on Machine Learning with Scikit-Learn and TensorFlow [Concepts, Tools, and Techniques to Build Intelligent Systems], Published by O'Reilly Media, 2017.
5. Artificial Intelligence and Machine Learning, Principles and applications by Vinod Chandra S.S., Anand Hareendran S., PHI

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.
3. M.C. Trivedi, A Classical Approach to Artifical Intelligence, Khanna Publishing House,New Delhi, 2018.
4. S. Kaushik, Artificial Intelligence, Cengage Learning India, 2011.

Minors Course	ROBOTICS (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objectives:

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

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

CO1	Discuss various applications and components of industrial robot systems
CO2	Learn about the types of actuators used in robotics
CO3	Calculate the forward kinematics and inverse kinematics.
CO4	Learn about programming principles and languages for a robot control system
CO5	Discuss the applications of image processing and machine vision in robotics.

UNIT – 1
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 – 2
ROBOT ACTUATORS AND FEEDBACK 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 – 3
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 – 4
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 – 5

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

TEXTBOOKS:

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

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, Prentice Hall
3 .Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt. Ltd.
4 .Introduction to Robotics/John JCraig/Pearson Edu.

Minors Course	MANUFACTURING PROCESSES (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objective:
To impart basic knowledge and understanding about the primary manufacturing processes such as casting, welding, bulk forming, sheet metal forming, and additive manufacturing and their relevance in the current manufacturing industry.

Course Outcomes:
Students will be able to

CO1: design the patterns and core boxes for metal casting processes
CO2: understand the different welding processes
CO3: know the different types of bulk forming processes
CO4: understand sheet metal forming processes
CO5: learn about the different types of additive manufacturing processes.

UNIT– I
Casting: Steps involved in making a casting – Advantage of casting and its applications. Patterns and Pattern making – Types of patterns – Materials used for patterns, pattern allowance sand their construction, Molding, different types of cores , Principles of Gating, Risers, casting design considerations. Methods of melting and types of furnaces, Solidification of castings and Casting defects. Basic principle sand applications of special casting processes - Centrifugal casting – True, semi and centrifuging, Die casting, Investment casting and shell molding.

UNIT–II
Welding: Classification of welding processes, types of welded joints and their characteristics, Gas welding, Different types of flames and uses, Oxy – Acetylene Gas cutting. Basic principles of Arc welding, power characteristics, Manual metal arc welding, submerged arc welding, TIG&MIG welding. Electro–slag welding. Resistance welding, Friction welding, Friction stir welding, Forge welding, Explosive welding; hermit welding, Plasma Arc welding, Laser welding, electron beam welding, Soldering & Brazing. Heat affected zones in welding; pre & post heating, Weld ability of metals, welding defects – causes and remedies –destructive and non destructive testing of welds.

UNIT–III
Bulk Forming: Plastic deformation in metals and alloys-recovery recrystallization and grain growth.
Hot working and Cold working-Strain hardening and Annealing. Bulk forming processes: Forging –Types of Forging, Smith forging, Drop Forging, Roll forging, Forging hammers, Rotary for ging,forging defects; Rolling – fundamentals, types of rolling mills and products, Forces in rolling and power requirements. Extrusion and its characteristics. Types of extrusion, Impact extrusion, Hydrostatic extrusion; Wire drawing and Tube drawing

UNIT– IV
Sheet metal forming-Blanking and piercing, Forces and power requirement in the reoperations, Deep drawing, Stretch forming, Bending, Spring back and its remedies, Coining, Spinning, Types of presses and press tools.

High energy rate forming processes: Principles of explosive forming, electromagnetic forming, Electro hydraulic forming, rubber pad forming, advantages and limitations.

UNIT –V

Additive manufacturing - Steps in Additive Manufacturing (AM), Classification of AM processes, Advantages of AM, and types of materials for AM, VAT photo polymerization AM Processes, Extrusion - Based AM Processes, Powder Bed Fusion AM Processes, Directed Energy Deposition AM Processes, Post Processing of AM Parts, Applications

TEXT BOOKS:

ManufacturingProcessesforEngineeringMaterials–KalpakjianSandStevenR Schmid-PearsonPubl,5thEdn.

Manufacturing Technology-VolI-P.N.Rao-TMH

REFERENCES:

1. Manufacturing Science–A.Ghosh&A.K.Malik–EastWestPressPvt.Ltd
2. Process and materials of manufacture- Lindberg-PHI
3. Production Technology-R.K.Jain-Khanna
4. Production Technology-PCSharma-S.Chand
5. Manufacturing Processes-H.S.Shaun-Pearson
6. Manufacturing Processes-J.P.Kaushish-PHI
7. Workshop Technology-WAJChapman/CBS Publishers & Distributors Pvt.Ltd.
8. Production Technology-HMT-Tata Mc Graw Hill
9. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015

Course	Minors Course	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (Smart Manufacturing)	L	T	P	C
			3	0	0	3

objectives:

- To impart the basic concepts of artificial intelligence and the
- Principles of knowledge representation and reasoning.
- To introduce the machine learning concepts and supervised learning methods
- To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
- To make the students learn about neural networks and genetic algorithms.
- To understand the machine learning analytics and deep learning techniques.

Course outcomes: At the end of the course, student will be able to
CO1: Explain the basic concepts of artificial intelligence
CO2: Learn about the principles of supervised learning methods
CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms
CO4: Get knowledge about neural networks and genetic algorithms.
CO5: Understand the machine learning analytics and apply deep learning techniques.

UNIT– I:
Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behavior - 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, over fitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbors, 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 neighbor learning.

UNIT– IV:
Neural Networks and Genetic Algorithms: Neural network representation, problems, perception, multilayer networks and back propagation, 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.

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 Shiva Shankar 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:

1) **https://www.tpointtech.com/artificial-intelligence-ai**
2) **https://www.geeksforgeeks.org/**

Minors Course	Artificial Intelligence and Machine Learning Lab (Smart Manufacturing)	L	T	P	C
		0	0	3	1.5

Course Objectives: To enable the students write coding for various artificial intelligence and machine learning algorithms.

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
CO4: Generate code for auto encoders

Course Outcomes: At the end of the course, student will be able to apply the knowledge of artificial intelligence and machine learning models along with image classifiers using various software tools.

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

1) Learning of Python libraries – Numpy, Pandas, Mat plot lib, Sea born and Tensor Flow
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

Minors Course	MECHATRONICS LAB (Smart Manufacturing)	L	T	P	C
		0	0	3	1.5

Course Objectives:

- Measure load, displacement and temperature using analogue and digital sensors.
- Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
- Simulate and analyze PID controllers for a physical system using MATLAB.
- Develop pneumatic and hydraulic circuits using Automation studio.

Course Outcomes: At the end of the course, student will be able to.
CO1: Understand the Characteristics of LVDT
CO2: Measure load, displacement and temperature using analogue and digital sensors.
CO3: Develop PLC programs for control of traffic lights, water level, lifts and conveyor belt
CO4: Simulate and analyze PID controllers for a physical system using MATLAB.
CO5: Develop pneumatic and hydraulic circuits using Automaton studio.

List of Experiments

1. Transducers Kit :-
    a. Characteristics of LVDT
    b. Principle & Characteristics of Strain Gauge
    c. Characteristics of Summing Amplifier
    d. Characteristics of Reflective Opto Transducer
2. PLC PROGRAMMING & Simulation of Allen Bradley, Siemens or IEC Ladder Using Automation Studio
    a. Ladder programming on Logic gates ,Timers (TON,TOFF) &counters (UP,DOWN)
    b. Ladder Programming for digital &Analogy sensors
    c. Ladder programming & Simulations of Virtual System such as Traffic Light control, Washing machine, Garage Door, Water level control, Lift control, Conveyor Belt etc.
    d. Ladder programming to control circuits such as single solenoid spring return latch circuit, double solenoid Hydraulic / Pneumatic circuits, Self-Reciprocating Hydraulic / Pneumatic Circuit.
3. AUTOMATION STUDIO SOFTWARE (Design, Simulate &Analyze)
    a. Introduction to Automation studio & its control.
1. b. Draw& Simulate Hydraulic circuits for series &parallel cylinders connection, Accumulator circuit, Pressure intensifier circuit, Simple Electro- Hydraulic Electro -Pneumatic circuits (Plot Waveforms for different parameters).
    b. Design & Simulate Meter-in, Meter-out, Regenerative circuit, sequencing circuit, traverse and feed hydraulic circuit, hydraulic press and clamping.
    c. Position Control of Proportional Servo Valve Circuit using PID Feedback controller.
4. MATLAB Programming
    a. Sample programs on Mat lab
    b. Simulation and analysis of PID controller using SIMULINK

Minors Course	THERMODYNAMICS (THERMAL SYSTEMS ENGINEERING)	L	T	P	C
		3	0	0	3

Course Objectives:
To impart the knowledge of the thermodynamic laws and principles so as to enable the student to prepare an energy audit of any mechanical system that exchange heat and work with the surroundings.

COURSEOUTCOMES:

After undergoing the course the student is expected to learn

CO1: Basic concepts of thermodynamics

CO2: Laws of thermodynamics

CO3: Concept of entropy

CO4: Property evaluation of vapors and their depiction in tables and charts

CO5: Evaluation of properties of perfect gas mixtures.

UNIT– I
Introduction: Basic Concepts : System, boundary, Surrounding, Universe, control volume, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermo dynamic Equilibrium, State, Property, Process -Reversible, Quasi static &Irreversible Processes, cycle, Causes of Irreversibility. Energy in State and in Transition-Types, Work and Heat, Point and Path function. Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Reference Points – Const. Volume gas Thermometer – Scales of Temperature.

UNIT–II
Joule's Experiments – First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system –Energy balance for closed systems-Specific heats-Internal energy, Enthalpy and Specific heats of Solids, liquids and Ideal gases, Some steady flow energy equation applied to Nozzle, Turbine, Compressor and heat exchanger devices, PMM-I.

UNIT-III
Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM of Second kind, Carnot cycle and its specialties, Carnot's theorem, Thermodynamic scale of Temperature.
Clausius Inequality, Entropy, Principle of Entropy Increase, Availability and Irreversibility (Basic definitions) – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

UNIT-IV
Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point and critical point, properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation, Property tables. Various Thermodynamic processes and energy Transfer – Steam Calorimetry.

UNIT–V

Ideal Gas equation of state- Compressibility factor- Van der Waals equation of state- Beattie-Bridgeman equation of state- Benedict-Webb-Rubin equation of state- Viral equation of state- compressibility charts – variable specific heats.

Mixtures of perfect Gases – Dalton's Law of partial pressure, Avogadro's Laws of additive volumes- Equivalent Gas constant and Molecular Internal Energy, Enthalpy, Specific Heat and Entropy of Mixture of Perfect Gases and Vapour. Psychometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, Saturated Air, Vapour pressure, Degree of saturation – Adiabatic Saturation , Carrier's Equation – Psychometric chart.

TEXTBOOKS:

1. EngineeringThermodynamics, PKNag6thEdn, McGrawHill.
2. Fundamentals of Thermodynamics–Sonntag, Borgnakke, Van Wylen, 6thEdn, Wiley

REFERENCES:

1. Thermodynamics by Parson a Kumar, Pearson Publishers
2. Engineering Thermodynamics–Jones & Dugan PHI
3. Thermodynamics, an Engineering Approach, Yens ACenegel, Michael Abeles, 8thEdninSI Units, McGraw Hill.
4. Thermodynamics–J.P. Holman, Mc Graw Hill
5. An Introduction to Thermodynamics-Y.V.C.Rao– Universities press.
6. Thermodynamics–W.Z. Black& J.G.Hartley, 3rd Edn Pearson Publ.
7. Engineering Thermodynamics–D.P.Misra,CengagePubl.
8. Engineering Thermodynamics–P. Chattopadhyay–Oxford Higher EdnPubl.

Minors Course	THERMALENGINEERING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:

- To give insight into basic principles of air standard cycles.
- To impart knowledge about IC engines and Biolers
- To make the students learn the working principles of steam nozzles, turbines and compressors
- To impart the knowledge about the various types of compressors and gas turbines
- To make the students gain insights about, rockets and jet propulsion and solar engineering.

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

CO1: Explain the basic concepts of air standard cycles.

CO2: Get knowledge about IC Engines and Boilers.

CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.

CO4: Gain knowledge about the concepts of compressors and gas turbines.

CO5: Acquire insights about jet propulsion, rockets and solar engineering.

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 Blow down-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 turbo charging, 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-level 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 – Lysol 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

Text Books:

1. Thermal Engineering - Mahesh Rathore- McGraw Hill publishers
2. Heat Engineering /V.PVasandani 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.SKhurmi, &J S Gupta/S.Chand.

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

CO1: Explain the basic concepts of air standard cycles.

CO2: Get knowledge about IC Engines and Boilers.

CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.

CO4: Gain knowledge about the concepts of compressors and gas turbines.

CO5: Acquire insights about jet propulsion, rockets and solar engineering.

Minors Course	HEAT TRANSFER (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course objectives:

- To gain knowledge about mechanism and modes of heat transfer.
- To understand the concepts of conduction and convective heat transfer.
- To gain knowledge about the forced and free convection.
- To understand the concepts of heat transfer with phase change and condensation along with heat exchangers.
- To gain knowledge about radiation mode of heat transfer.

Course outcomes: At the end of the course, student will be able to
CO1: Apply knowledge about mechanism and modes of heat transfer.
CO2: Understand the concepts of conduction and convective heat transfer.
CO3: Learn about forced and free convection.
CO4: Analyze the concepts of heat transfer with phase change and condensation along with heat exchangers.
CO5: Interpret the knowledge about radiation mode of heat transfer.

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 long 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'sTheoryofCondensationona 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.

TEXTBOOKS:

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

REFERENCEBOOKS:

1. Fundamentals of Heat Transfer by In cropera &Dewitt, John Wiley.
2. Fundamentals of Engineering, Heat& Mass Transfer by R.C. Sachdeva, New Age.
3. Heat &Mass Transfer by A mit Pal– Pearson Publishers.
4. Heat Transfer by Ghosha dastidar, Oxford University press.
5. Heat Transfer by a Practical Approach, Yunus Cengel, Boles, TMH.
6. Engineering Heat and Mass Transfer by Sarit K.Das, Dhanpat Rai Pub.

Note: Heat and Mass transfer Data Book by CP Kothanda ramanand Subrahmanyanis used to design and analyze various thermal processes and thermal equipment.

Minors Course	REFRIGERATION&AIR-CONDITIONING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:

- To illustrate the operating cycles and different systems of refrigeration
- Toanalyzecoolingcapacityandcoefficientofperformanceofvapourcompression refrigeration systems and understand the fundamentals of cryogenics
- To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
- To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
- Todescribedifferentcomponentofrefrigerationandairconditioningsystems

Course Outcomes: At the end of the course, student will be able to
CO1: Illustrate the operating cycles and different systems of refrigeration.
CO2: Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
CO3: Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants.
CO4: Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
CO5: Demonstrate different components of 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 craft's and problems.

UNIT–II:
VAPOURCOMPRESSIONREFRIGERATIONSYSTEM&COMPONENTS:Workingprinciple 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 NH3– 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 thermo electric 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 equipment, cooling, heating humidification and dehumidification, filters, grills and registers fans and blowers. Heat pump – heat sources – different heat pump circuits.

TEXTBOOKS:

1. A Course in Refrigeration and Air conditioning /SCArora& 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/Anantha narayanan/TMH

Minors Course	POWERPLANTENGINEERING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:
To understand the sources of energy and concepts of steam power plant.
To design of components of steam, gas and diesel power plants.
To explain the principles of hydro power plant and nuclear power station.
To apply theconceptsofnuclearreactorsandunderstandtheoperationsofdifferentpower plants.
Tounderstandtheprinciplesandconceptsrelevanttopowerplantinstrumentation,control, economics and environmental considerations.

Course outcomes: At the end of the course,students will be able to
CO1: Illustrate the functions of different components of steam power plant
CO2;Describe basicworkingprinciples,performancecharacteristicsandcomponentsofgas turbine and diesel power plants
CO3: Illustrate basic workingprinciplesofhydroelectricpowerplantsandanalyzetheimportance of hydrological cycles, measurements and drainage characteristics
CO4: Learn about the principal components and types of nuclear reactors
CO5: Analyze the working of power plant instrumentation and estimate the economics of power plants

UNIT– I
Introductiontothe sourcesofenergy–resources anddevelopmentofpowerinIndia.
STEAM POWER PLANT: Plant layout, working of different circuits, fuel handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems. Combustion: properties ofcoal– overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components,

UNIT– II
STEAM POWER PLANT: Combustion needs and draught system, cyclone furnace, design and Construction, dust collectors,coolingtowersandheatrejection. Corrosionand feedwatertreatment. INTERNAL COMBUSTION AND GAS TURBINE POWER PLANTS: DIESELPOWERPLANT:Plantlayoutwithauxiliaries–fuelsupplysystem,airstarting equipment, super charging.
GASTURBINEPLANT:Introduction–classification-construction–layoutwithauxiliaries, combined cycle power plants and comparison.

UNIT– III
HYDRO ELECTRIC POWER PLANT: Waterpower–hydrologicalcycle / flow measurement – drainage area characteristics – hydrographs – storage and pondage – classification of dams and spillways.
HYDROPROJECTSANDPLANT:Classification–typicallayouts–plantauxiliaries–plantoperation pumped storage plants.
NUCLEAR POWER STATION: Nuclear fuel– breeding and fertile materials – nuclear reactor – reactor operation.

UNIT– IV
TYPES OF NUCLEAR REACTORS: Pressurized water reactor, boiling water reactor, sodium- graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazardsand shielding – radioactive waste disposal.

COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co-ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.

UNIT– V

POWER PLANT INSTRUMENTATION AND CONTROL: Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O2and CO2measurements, measurement ofsmoke and dust,measurement ofmoisture incarbondioxide circuit, nuclear measurements, smart grids, power plant control room.

POWERPLANTECONOMICSANDENVIRONMENTALCONSIDERATIONS:Capitacost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment –pollutants and pollution standards – methods of pollution control.

TEXTBOOKS:

AcourseinPowerPlantEngineering/AroraandDomkundwar/Dhanpatrai;Co.
PowerPlant Engineering/P.C.Sharma/S.K.Kataria Pub

REFERENCES:

PowerPlantEngineering:P.K.Nag/IIEdition/TMH.
PowerstationEngineering–ElWakil/McGraw-Hill.
AnIntroductiontoPowerPlantTechnology/G.D.Rai/KhannaPublishers

Minors Course	FLUID MECHANICS (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:
To understand the general concepts of in viscid flow of incompressible fluids.
To apply the concepts of viscous flow.
To analyze the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
To understand fundamental concept of turbulence.
To illustrate the compressible fluid flow and supersonic wave drag

CourseOutcomes: At the end of the course ,student will be able to
CO1:Understand the general concepts of inviscid flow of incompressible fluids. CO 2:Apply the concepts of viscous flow.
CO3:Analyse the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
CO4:Understand fundamental concept of turbulence.
CO5: Illustrate the compressiblefluidflowandsupersonicwavedrag.

UNIT– I:
Introduction: Basics of Fluid Mechanics – Continuity Equation – Euler’s Equation – Bernoulli’s equation
Viscous Flow: Derivation of Navier-Stoke’s Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poiseuille flow, Couette flow with and without pressure gradient, Hagen Poiseuille flow

UNIT– II:
Boundary Layer Concepts: Prandtl contribution to real fluid flows – Prandtl boundary layer theory, Boundary layer thickness for flow over a flat plate – Blasius solution. Von-Karman momentum integral equation for laminar boundary layer –– Expressions for local and mean drag coefficients for different velocity profiles.

UNIT– III:
Introduction to Turbulent Flow: Fundamentalconcept ofturbulence – Time Averaged Equations – BoundaryLayer Equations, PrandtlMixing LengthModel - UniversalVelocityDistributionLaw - Van Driest Model – k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.

UNIT– IV:
nternal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody’s diagram.
Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy , Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State.

UNIT– V:
Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Rayleigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXTBOOKS:
FluidMechanics/L.VictorStreeter/TMH
FluidMechanics/FrankM. White/MGH

REFERENCES:
FluidMechanicsand Machines/ Modiand Seth/Standard BookHouse
FluidMechanics/CohenandKundu/Elsevier/5thedition
FluidMechanics/Potter/CengageLearning
FluidMechanics/WilliamSJanna/CRCPress
FluidMechanics/ Y.ACengelandJ.MCimbala/MGH
BoundaryLayerTheory/SchlichtingH/Springer Publications
Dynamics&TheoryandDynamicsofCompressibleFluidFlow/ Shapiro.
FluidDynamics/WilliamF. Hughes&JohnA.Brighton/TMH
FluidMechanics/K.LKumar/SChand&Co.

Minors Course	AUTOMOBILEENGINEERING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES
1.To study the advanced engine technologies
2.To learn various advanced combustion technologies and its benefits
3.To learn the methods of using low carbon fuels and its significance
4.To learn and understand the hybrid and electric vehicle configurations
5.To study the application of fuel cell technology in automotive

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

CO1: Discuss the latest trends in engine technology
CO2 : Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.
CO3: Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
C04:.Discuss the working and energy flow in various hybrid and electric configurations.
CO5:.Analyzing the need for fuel cell technology in automotive applications.

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.

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

Minors Course	COMPUTATIONAL FLUID DYNAMICS (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:
Develop an understanding of introductory concepts in computational fluid mechanics with emphasis on the numerical solution of ordinary and partial differential equations
Able to find solution of ODEs by numerical integration; finite difference and finite volume methods for parabolic, elliptic, and hyperbolic PDEs (techniques for single and multi-dimensional problems); numerical linear algebra
Able to implement and utilize various numerical methods and basic mathematical analysis for canonical problems in fluid mechanics.
Able to understand formulation of 2D & 3D problems using FVM
To get acquainted with the application of standard variational problems

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

Course Outcome

CO1 Explain classification of PDEs and differential solutions and methods for elliptical, parabolic and hyperbolic equations.
CO2 Explain basic principles and Derive governing equations of CFD
CO3 Apply finite differential method for incompressible viscous flow problems and compressible flow problems.
CO4 Apply finite volume formulations for two dimensional and three dimensional problems
CO5 Apply finite element methods for steady state and transient fluid flow problems

UNIT – I:
INTRODUCTION:
Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

SOLUTION METHODS:
Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination.

UNIT – II:
PARABOLIC EQUATIONS:
Explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

HYPERBOLIC EQUATIONS:
Explicit schemes and Von Neumann stability analysis, implicit schemes, multi-step

methods, nonlinear problems, second order one-dimensional wave equations.

BURGERS EQUATIONS:
Explicit and implicit schemes, Runge-Kutta method.

UNIT – III:
FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS:
Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

FORMULATIONS OF COMPRESSIBLE FLOWS:
Potential equation, Euler equations-Central schemes, Navier-stokes system of

equations, boundary conditions, example problems..

UNIT – IV:
FINITE VOLUME METHOD:
Finite volume method via finite difference method, formulations for two and three-dimensional problems.

UNIT – V:
FINITE ELEMENT METHODS:
Introduction to Finite Element Methods, Finite Element Interpolation Functions, Linear Problems-Steady-State Problems – Standard Galerkin's Methods, Transient Problems – Generalized Galerkin's Methods, Example Problems.

TEXTBOOKS:
Computational fluid dynamics, T. J. Chung, Cambridge University press, 2002.

REFERENCE BOOKS:
Text book of fluid dynamics, Frank Chorlton, CBS Publishers &distributors, 1985.
Patankar, S. V., 2017, Numerical Heat Transfer and Fluid Flow, Special Indian ed., CRC Press.
Muralidhar K., and Sundararajan T. (Editors), 2017, Computational Fluid Flow and Heat Transfer, 2nd ed. tenth reprint, Narosa.
Anderson Jr., J. D., 2017, Computational Fluid Dynamics: The Basics with Applications, Indian ed., McGraw Hill Education.
Donea, J., and Huerta, A., 2003, Finite Element Methods for Flow Problems, John Wiley & Sons, Ltd.
Zienkiewicz, O. C, Nithiarasu, P., and Taylor, R. L, 2013, The Finite Element Method for Fluid Dynamics, 7th ed., Butterworth-Heinemann Ltd.

Minors Course	HEATTRANSFERLAB (Thermal Systems Engineering)	L	T	P	C
		0	0	3	1.5

Course objectives:
To determine the heat transfer rate and coefficient.
To determine the thermal conductivity, efficiency and effectiveness.
To determine the emissivity and Stefan-Boltzman constant.
To determine critical heat flux and investigate Lambert'scosinelaw.
To experiment with Virtual labs and analyze conduction, HT coefficient.
To experiment with Virtual labs and investigate Lambert's laws.

Courseoutcomes: Studentsareexpectedtolearntheconceptsandto
CO1:Determinetheheattransferrateandcoefficient.
CO2: Determinethethermalconductivity,efficiencyandeffectiveness.
CO3: Determine the emissivity and Stefan-Boltzman constant.
CO4: Determine critical heat flux and investigate Lambert's cosine law.
CO5:ExperimentwithVirtuallabsandanalyseconduction,HTcoefficient.
CO6: Experiment with Virtual labs and investigate Lambert's laws.

PART-A
Determination of over all heattransferco-efficientofacompositeslab
Determinationofheattransferratethrougha laggedpipe.
Determinationofheat transferratethroughaconcentric sphere
Determinationofthermalconductivityofametalrod.
Determinationofefficiencyofapin-fin
Determinationofheattransfercoefficientinnaturalandforcedconvection
Determinationofeffectivenessofparalleland counterflowheatexchangers.
Determinationofemissivityofagivensurface.
DeterminationofStefan-Boltzmannconstant.
Determinationofheat transferrateindropandfilmwise condensation.
Determinationofcriticalheatflux.
DeterminationofThermalconductivityofliquidsandgases.
InvestigationofLambert'scosinelaw.
PART-B
Virtuallabs(https://mfts-iitg.vlabs.ac.in/)on
ConductionAnalysisofaSingleMaterialSlab
ConductionAnalysisofaSingleMaterialSphere
ConductionAnalysisofaSingleMaterialCylinder
ConductionAnalysisofaDoubleMaterialSlab
ConductionAnalysisofaDoubleMaterialSphere
Conduction AnalysisofDoubleMaterialCylinder
Todeterminetheoverallheattransfercoefficient(U)inthe(i)parallelflowheatexchangerand (ii)Counterflowheatexchanger
ToinvestigatetheLambert'sdistancelaw.
ToinvestigatetheLambert'sdirectionlaw(cosinelaw).
Note:Virtuallabsareonlyfor learningpurpose,andarenotforexternalexami

Minors Course	THERMALENGINEERINGLAB (Thermal Systems Engineering)	L	T	P	C
		0	0	3	1.5

Course objectives:
Todemonstratethecharacteristicsoftwostrokeandfourstrokecompressionandsparkignition engines.
Todetermineflashpoint,firepoint,calorificvalueofdifferentfuelsusingvariousapparatus.
Todetermineenginefriction, heatbalancetest, volumetricefficiency, loadtestofpetrolanddiesel engines.
Todemonstratespeedtest,performancetest andcoolingtemperatureonpetrolanddiesel engines.
Todemonstrateperformancetestanddetermineefficiencyofaircompressor.
Tounderstandtheprinciplesthroughassemblyanddisassemblyof2/3wheelers, 2/4strokeengines, tractor, heavy duty engines and boilers and their mountings and accessories.
Experiments :
TodeterminetheactualValveTimingdiagramofafourstrokeCompression/SparkIgnition Engine.
TodeterminetheactualPortTimingdiagramofatwostrokeCompression/SparkIgnition Engine.
Determinationof Flash &Fire points ofLiquid fuels / Lubricants using (i) Abels Apparatus;(ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
DeterminationofViscosityofLiquidlubricants/Fuelsusing(i)SayboltViscometerand(ii) Redwood Viscometer.
DeterminationofCalorificvalueofGaseousFuelsusingJunkersGas Calorimeter.
Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
EvaluationofEngineFrictionbyMotoring/RetardationTestonaSingleCylinder4Stroke Petrol/Diesel Engine.
ToperformtheHeatBalanceTestonSingleCylinderfourStrokePetrol/DieselEngine.
DeterminationofAir/FuelRatioandVolumetricEfficiencyonafourStrokePetrol/Diesel Engine.
To conduct a load test on a single cylinder Petrol/Diesel engine to study its performance under various loads.
Todetermine the optimumcoolingtemperatureofa Petrol/Dieselengine.
Toconducteconomicalspeedtestonafour strokePetrol/Dieselengine.
To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.

Toconductaperformancetestonanair compressor anddetermineitsdifferentefficiencies.

Dis-assembly / assemblyofdifferent partsoftwo wheelers. 3 wheelers & 4 wheelers. Tractor & Heavy duty engines covering 2-stroke and 4 stroke, SI and CI engines.Study of Boilers with mountings and accessories.

Courseoutcomes:Attheendofthecourse,studentwill beableto
CO1:Experiment withtwostrokeandfour strokecompressionandsparkignitionenginesfor

various characteristics.

CO2:Perceiveflashpoint, firepoint,calorificvalueofdifferentfuelsusingvarious apparatus.

CO3:Performenginefriction, heatbalancetest, volumetric efficiency, loadtestofpetrolanddiesel engines.

CO4:Performspeedtest, performancetest andcoolingtemperatureonpetrolanddiesel engines.

CO5: Utilize air compressor for its performance test and to determine efficiency.

CO6: Discuss the principles through assembly and disassembly of 2/3 wheelers, 2/4 stroke engines, tractor, heavy duty engines, boilers and their mountings and accessories.

HONORS

Honors Course	ADVANCED MECHANICS OF SOLIDS	L	T	P	C
		3	0	0	3

Course Objectives: To

CO1	Learn about how to calculate stresses in the machine components and analyzing the failure modes.
CO2	Identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures
CO3	Calculate bending stresses in curved beams and beams subjected to non symmetrical bending
CO4	Compute torsional stresses in circular and non circular cross section members and multi walled thin walled tubes
CO5	Analyze contact stresses when two bodies are in contact.

UNIT – 1	Theories of stress and strain, Definition of stress at a point, stress notation, principal stresses, other properties, differential equations of motion of a deformable body, deformation of a deformable body, strain theory, principal strains, strain of a volume element, small displacement theory. Stress –strain temperature relations, Elastic response of a solid, Hooke's Law, isotropic elasticity, Anisotropic elasticity, initiation of Yield, Yield criteria.
UNIT – 2	Failure criteria: Modes of failure, Failure criteria, Excessive deflections, Yield initiation, fracture, Progressive fracture, High Cycle fatigue for number of cycles $N > 10^6$, buckling. Application of energy methods: Elastic deflections and statically indeterminate members and structures: Principle of stationary potential energy, Castiglione's theorem on deflections, Castiglione's theorem on deflections for linear load deflection relations, deflections of statically determinate structures.
UNIT – 3	Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending; Deflection of straight beams due to nonsymmetrical bending. Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors –Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.
UNIT – 4	Torsion : Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section ;Hollow thin wall torsion members ,Multiply connected Cross Section.
UNIT – 5	Contact stresses: Introduction; problem of determining contact stresses; Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Method of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular area (Line contact), Loads normal to area; Stresses for two bodies in line

contact, Normal and Tangent to contact area.

Text Books:
1.Advanced Mechanics of materials by Boresi& Sidebottom-Wiely International.
2. Theory of elasticity by Timoschenko S.P. and Goodier J.N. McGraw-Hill Publishers 3rd Edition
3. Advanced Mechanics of Solids, L.S Srinath

Reference Books:
1. Advanced strength of materials by Den Hortog J.P.
2. Theory of plates – Timoshenko.
3. Strength of materials & Theory of structures (Vol I & II) by B.C Punmia
4. Strength of materials by Sadhu singh

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

CO1	Able to calculate stresses in the machine components and analyzing the failure modes.
CO2	Able to identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures
CO3	Able to calculate bending stresses in curved beams and beams subjected to non symmetrical bending
CO4	Able to calculate torsional stresses in circular and non circular cross section members and multi walled thin walled tubes
CO5	Able to calculate and analyze contact stresses when two bodies are in contact.

Honors Course	ADVANCED FINITE ELEMENT METHODS	L	T	P	C
		3	0	0	3

Course Objectives: To

Learn the methodology, applications and types of finite element method.
Solve the problems of bars, trusses, beams and frames
Solve plates and axisymmetric problems
Learn about isoparametric formulation
Solve the dynamic problems

UNIT – 1	Formulation Techniques: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.
UNIT – 2	One-dimensional elements: Bar, trusses, beams and frames, displacements, stresses and temperature effects.
UNIT – 3	Two dimensional problems: CST, LST, four noded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems:Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin.
UNIT – 4	Isoparametric formulation: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test. Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages.
UNIT – 5	Introduction to Non-linear finite element Analysis (Syllabus from Ref. 3) Nonlinear Material Problems(Syllabus from Ref. 2): Introduction ,General procedure for solutions of Non- linear Discrete Problems, Nonlinear Constitutive problems in solid mechanics. Non-linear elasticity, Plasticity. Geometrically Non-linear problems(Syllabus from Ref. 2): General considerations

TEXT BOOKS:
Chandrubatla&Belagondu,Finite element methods .
S.S. Rao ,The Finite Element Method in Engineering, Fifth Edition
REFERENCES:
1.J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994.

2. Zienckiwicz O.C. Finite Element Method, McGraw-Hill,Third Edition, 1977.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996.

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

CO1	Understand the methodology, applications and types of finite element method.
CO2	Solve the problems of bars, trusses, beams and frames using finite element method
CO3	Apply the finite element method to plates and axisymmetric problem
CO4	Understand the isoparametric formulation and requirements for convergence.
CO5	Solve the dynamic problems and learn about the commericial finite element packages.

Course Objectives: To

CO1 Write parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.
CO2 Learn about Bezier curve.
CO3 Know about B-Spline curve

CO4 Develop parametric representation of analytic and synthetic surfaces

Honors Course	ADVANCED CAD	L	T	P	C
		3	0	0	3

CO5 Learn various schemes used for construction of solid models

UNIT – 1	Introduction: Definition, Explicit and implicit equations, parametric equations.
UNIT – 2	Cubic Splines-1: Algebraic and geometric form of cubic spline, tangent vectors, parametric space of a curve, blending functions, four point form, reparametrization, truncating and subdividing of curves. Graphic construction and interpretation, composite pc curves.
UNIT – 3	Bezier Curves: Bernstein basis, equations of Bezier curves, properties, derivatives. B-Spline Curves: B-Spline basis, equations, knot vectors, properties, and derivatives.
UNIT – 4	Surfaces: Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.
UNIT – 5	Solids: Tricubic solid, Algebraic and geometric form. Solid modeling concepts: Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem.

TEXT BOOKS:

1. CAD/CAM by Ibrahim Zeid, Tata McGraw Hill.
Elements of Computer Graphics by Roger & Adams Tata McGraw Hill.
REFERENCES:
Geometric Modeling by Micheal E. Mortenson, McGraw Hill Publishers
Computer Aided Design and Manufacturing, K.Lalit Narayan, K.MallikarjunaRao, MMM Sarcar, PHI Publishers

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

CO1 Develop parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.

CO2 Develop equations for Bezier curve.

CO3 Develop equations for B-Spline curve

CO4 Develop parametric representation of analytic and synthetic surfaces

CO5 Understand and implement various schemes used for construction of solid models

Honors Course	ADVANCED MANUFACTURING PROCESSESS	L	T	P	C
		3	0	0	3

Course Objectives:
To learn the basic principle of advanced machining processes
To know about the various additive manufacturing processes
To understand the principles of coating and processing of ceramics.
To get insights about processing of composites and nanomaterials
To know the fabrication of microelectronic components.

UNIT – 1
ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT – 2

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 – 3

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 – 4

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 – 5

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.

TEXT BOOKS:

1.Manufacturing Engineering and Technology*I*Kalpakijian / Adisson Wesley, 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 NostrandRenihold,
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*I*McGraw Hill.
5.Introduction to Nanoscience and NanoTechnology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learning

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

CO1: Explain the working principle of various nonconventional machining processes and their applications.
CO2: Explain the working principles of additive manufacturing methods.
CO3: Understand various laser material processing techniques.
CO4: Gainon Advanced coating processes
CO5: Describe various fabrication methods for microelectronic devices

Honors Course	ADVANCED FLUID MECHANICS	L	T	P	C
		3	0	0	3

CourseObjectives: To

Learn the principles of Inviscid flow of incompressible fluid flow
Transform the physics of viscous fluid flow problems into its equivalent mathematical model.
Solve laminar boundary layer problems for the flow over a flat plate.
Solve fundamental problems of turbulent flows
Understand principles and techniques for solving compressible flow problems.

UNIT -I:
INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerian descriptions of fluid motion, Path lines, Streamlines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three-dimensional continuity equation, Stream and Velocity potential functions, Condition for irrotationality,

circulation & vorticity, accelerations in Cartesian systems, normal and tangential accelerations.

UNIT -II:
VISCOUS FLOW: Derivation of Navier-Stoke’s Equations for viscous compressible flow – Exact solutions to certain cases: Plain Poiseuille flow, Couette flow with and without pressure gradient , Hagen Poiseuille flow.

UNIT -III:
BOUNDARY LAYER CONCEPTS :Prandtl’s contribution to real fluid flows – Prandtl’s boundary layer theory, Boundary layer thicknessfor flow over a flat plate, Blasius solution – Approximate solutions, Von-Karman momentum integral equation for laminar boundary layer –– Expressions for local and mean drag coefficients for different velocity profiles.

UNIT- IV:
INTRODUCTION TO TURBULENT FLOW: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model, Universal Velocity Distribution Law: Van Driest Model, k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.
INTERNAL FLOW: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody’s diagram.

UNIT -V:
COMPRESSIBLE FLUID FLOW: Thermodynamic basics – Equations of continuity, Momentum and Energy, Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State, Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Raleigh Lines– Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXT BOOKS:
1. L. Victor Steeter, Fluid Mechanics, 10th Edition, Tata McGraw-Hill, 1996.
2. Frank M. White, Fluid Mechanics, 8th Edition, McGraw-Hill Education, 2016.

REFERENCES:
1. Modi and Seth, Fluid Mechanics and Machines, Standard Book House
2. Pijush K. Kundu, Ira M. Cohen, and David R. Dowling, Fluid Mechanics, 5th Edition, Elsevier
3. David R. Dowling, Ira M. Cohen, and Pijush K. Kundu, Fluid Mechanics, 5th Edition, Cengage Learning, 2011
4. William S Janna, Fluid Mechanics, CRC Press, 3rd Edition, 2019
5. Y.A Cengel and J.M Cimbala, Fluid Mechanics, MGH, 4th Edition, 2018
6. Schlichting H, Boundary Layer Theory, Springer Publications, 9th Edition, 2017
7. Shapiro, Dynamics & Theory and Dynamics of Compressible Fluid Flow, 2nd

Honors Course	ADVANCED HEAT TRANSFER	L	T	P	C
		3	0	0	3

Edition
8. William F. Hughes & John A. Brighton, Fluid Dynamics, TMH, 2nd Edition, 2018

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

CO1	Understand the principles of Inviscid flow of incompressible fluid flow
CO2	Develop the capability to transform the physics of viscous fluid flow problems into its equivalent mathematical model.
CO3	Attain the ability to solve laminar boundary layer problems for the flow over a flat plate.
CO4	Develop an ability to solve fundamental problems of turbulent flows
CO5	Understand principles and techniques for solving compressible flow problems.

Course Objectives: To

Transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.
Solve external forced and natural convection problems using analytical methods
Analyze internal forced convection problems using analytical methods.
Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.
Evaluate radiant energy exchange.

UNIT-I:
INTRODUCTION: Review of basic concepts of conduction. Method of formulation: lumped, differential and integral formulations. Initial and boundary conditions
TRANSIENT HEAT CONDUCTION:
Differential formulation of transient heat conduction problems with time independent boundary conditions in different geometries and their analytical solutions: method of separation of variables, method of Laplace transforms. Differential formulation of

steady two-dimensional heat conduction problems in different geometries and their analytical solutions: method of separation of variables, method of superposition.

UNIT II:
CONVECTION: Review of basics concepts and different non-dimensional numbers; Three-dimensional differential energy equation in Cartesian and Cylindrical coordinates.
FORCED CONVECTION: External flow:
External laminar forced convection for flow over a semi-infinite flat plate; Integral and similarity solutions for different thermal boundary conditions; Viscous dissipation effects in laminar boundary layer flow over a semi-infinite flat plate.

UNIT III:
FORCED CONVECTION: Internal flow:
Internal laminar forced convection: exact solutions to solution for rectilinear flows, axisymmetric rectilinear flows, and axisymmetric torsional flows; Solution for fully developed flow through a pipe with different thermal boundary conditions, Flow in the thermal entrance region of a circular duct: Graetz solution for uniform velocity, Graetz solution for parabolic velocity profile.

UNIT IV:
FREE CONVECTION:
External laminar free convection: integral and similarity solutions for semi-infinite vertical plate with different thermal boundary conditions
HEAT EXCHANGERS: Classification, LMTD and NTU methods
UNIT V:
RADIATION:
Basic definitions, Radiant energy exchange between two differential area elements. Radiation shape factor: properties and algebra. Radiant energy exchange between two surfaces. Reradiating surfaces. Radiation Shield.
Radiant energy exchange in enclosures: enclosures composed of black and diffuse-grey surfaces. Electrical network analogy. Radiation in participating media: Radiative heat transfer equation, Radiant energy exchange in presence of absorbing and transmitting media, radiant energy exchange in presence of transmitting, reflecting, and absorbing media.

TEXT BOOKS:

Myers, G.E., 1971, Analytical methods in conduction heat transfer, McGraw Hill, New York.
2. Kays, W. M. and Crawford, M. E., 2005, Convective Heat and Mass Transfer, 3rd ed., McGraw Hill.
3. Howell, J.R., Mengüc, M.P., Daun, K., and Siegel, R., 2020, Thermal radiation heat transfer, CRC press, New York.

REFERENCES:
Arpaci, V.S.,1966, Conduction heat transfer, Addison-Wesley,Reading, Massachusetts.

Honors Course	ADVANCED MECHANISMS AND ROBOTICS	L	T	P	C
		3	0	0	3

Janna, W.S., 2018, Engineering heat transfer, CRC press, Boca Raton.
Fundamentals of Heat and Mass Transfer,5th Ed. / Frank P. Incropera/John Wiley
Sparrow, E.M., 2018, Radiation heat transfer, Routledge, New York.
Modest, M.F., and Mazumder, S., 2021, Radiative heat transfer, Academic press, New York.
Introduction to Heat Transfer/SK Som/PHI
Oostuizen, P. H. and Naylor, D., 1999, Introduction to Convective Heat Transfer Analysis, International ed., McGraw Hill.
Kakac, S. Yener, Y., and Pramuanjaroenkij. A., 2014, Convective Heat Transfer, 3rd ed., CRC Press

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

CO1	Develop the capacity to transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.
CO2	Demonstrate the ability to solve external forced and natural convection problems using analytical methods.
CO3	Develop the ability to analyze internal forced convection problems using analytical methods.
CO4	Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.
CO5	Evaluate radiant energy exchange in the presence of a participating medium.

Course Objectives: To

Find the degree of freedom of various mechanisms.
Develop the Euler-Savary equations
locate the relative rotocentre
Design the Freudenstein's equation
Study the kinematics of different manipulators

UNIT – 1	Advanced Kinematics of plane motion- I: The Inflection circle; Euler – Savary Equation; Analytical and graphical determination of d_i; Bobillier's Construction; Collineastionaxis ; Hartmann's Construction. Advanced Kinematics of plane motion - II: Polode curvature; Hall's Equation; Polode curvature in the four bar mechanism; coupler motion; relative motion of the output and input links; Determination of the output angular acceleration and its Rate of change.
UNIT – 2	Introduction to Synthesis-Graphical Methods - I: The Four bar linkage; Guiding a body through Two distinct positions; Guiding a body through Three distinct positions; The Rotocentertriangle ; Guiding a body through Four distinct positions; Burmester's curve. Introduction to Synthesis-Graphical Methods - II: Function generation-

	General discussion; Function generation: Overlay's method; Path generation: Roberts's theorem.
UNIT – 3	Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstien's equation, Precision point approximation, Precision – derivative approximation; Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition; Method of components; Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link; Method of components.
UNIT – 4	Manipulator Kinematics: D-H transformation matrix ; Direct and Inverse kinematic analysis of Serial manipulators: Articulated, spherical & industrial robot manipulators- PUMA, SCARA,STANFORD ARM, MICROBOT
UNIT – 5	Differential motions and Velocities: Introduction, differential relationship, Jacobian, differential motions of a frame-translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian.

TEXT BOOKS:

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms,McGraw-Hill,1962.
2. L.Sciavicco and B.Siciliano, Modelling and control of Robot manipulators, Second edition ,
Springer -Verlag,London,2000.
3. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines. E.W.P.Publishers.

REFERENCES:

1. Allen S.Hall Jr., Kinematics and Linkage Design, PHI,1964.
2. J.E Shigley and J.J . Uicker Jr., Theory of Machines and Mechanisms , McGraw-Hill, 1995.
3. Joseph Duffy, Analysis of mechanisms and Robot manipulators, Edward Arnold,1980

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

CO1	Develop the mobility criteria and use the criteria to find the degree of freedom of various mechanisms.
CO2	Develop the Euler savary equations using Hartmanns construction to determine the centre of curvature
CO3	To locate the relative rotocentre using the function generation approach for 2-positions and 3-positions scenarios.
CO4	Design the Freudenstein's equation to find the lengths of the links in a four bar mechanism
CO5	To study the kinematics of different manipulators in daily life applications

Honors Course	OPTIMIZATION AND RELIABILITY	L	T	P	C
		3	0	0	3

Course Objectives: To
Understand the classical optimization techniques
Learn numerical methods for optimization
Get insights into genetic algorithm and its variants
Know the applications of optimization in mechanical engineering
Understand the concept of reliability

UNIT – 1	CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – method of Lagrange multipliers, Kuhn-Tucker conditions, merits and demerits of classical optimization techniques.
UNIT – 2	NUMERICAL METHODS FOR OPTIMIZATION: Nelder Mead's Simplex search method, Gradient of a function, Steepest descent method, Newton's method, Pattern search methods, conjugate method, types of penalty methods for handling constraints, advantages of numerical methods.
UNIT – 3	GENETIC ALGORITHM (GA) : Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA, GENETIC PROGRAMMING (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP. MULTI-OBJECTIVE GA: Pareto's analysis, Non-dominated front, multi – objective GA, Non-dominated sorted GA, convergence criterion, applications of multi-objective problems .
UNIT – 4	APPLICATIONS OF OPTIMIZATION IN DESIGN AND MANUFACTURING SYSTEMS: Some typical applications like optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model of a machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.
UNIT – 5	RELIABILITY: Concepts of Engineering Statistics, risk and reliability, probabilistic approach to design, reliability theory, design for reliability, numerical problems, hazard analysis.

TEXT BOOKS:
Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers

Engineering Optimization – S.S.Rao, New Age Publishers

Honors Course	MECHANISMS AND ROBOTICS LAB	L	T	P	C
		3	0	0	3

Reliability Engineering by L.S.Srinath
Multi objective genetic algorithm by Kalyanmoy Deb, PHI Publishers.

REFERENCES:

Genetic algorithms in Search, Optimization, and Machine learning – D.E.Goldberg, Addison-Wesley Publishers
Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publishers
Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers
An Introduction to Reliability and Maintainability Engineering by CE Ebeling, Waveland Printers Inc., 2009
Reliability Theory and Practice by I Bazovsky, Dover Publications, 2013

Course Outcomes: Students will be able to

Learn the classical optimization techniques
Understand numerical methods for optimization
Gain knowledge about genetic algorithm and its variants
Solve the applications of optimization in mechanical engineering
Design for reliab

Course Objectives: To enable the students get practical knowledge about various mechanisms and robotic configurations

ROBOTICS LAB
To demonstrate Forward and inverse Kinematics of articulated robot
To program and perform the following operation by using an articulated robot.
Pick and place operation
To traverse given path (for arc welding)

KINEMATICS AND DYNAMICS OF MECHANISMS LABORATORY
Design the following mechanisms and simulate using CATIA Software /ADAMS Software

1. RRRR mechanism whose coupler curve will pass through 3 given point .
2. RRRR mechanism whose coupler will guide a straight line segment through at least three given positions .

3. RRRR mechanism whose input and output motion are coordinated at least three given positions.
4. RRRP mechanism whose coupler will guide a straight-line segment through at least three given positions.
5. RRRP mechanism whose input and output motion are coordinated at at least two

Honors Course	ADVANCED MANUFACTURING PROCESSES LAB	L	T	P	C
		3	0	0	3

given positions
6. RRRP mechanism whose input and output motion are coordinated at at least three given positions.
7. RRRR mechanism whose input and output motion are coordinated at at least two given positions.
8. RRRR mechanism whose coupler curve will pass through 4 given points.
9. RRRR mechanism whose coupler curve will pass through 3 given points

Course Outcomes: The students will be able to understand the kinematics and dynamics of a variety of mechanisms and robots.

Course Objectives: The students will acquire knowledge about the various manufacturing processes and also the advanced characterization of materials.

Experiments (Any 10 out of 16):

1) To prepare the cup/ hole shape from the given work piece using deep drawing press
2) study of cutting ratio/chip thickness ratio in orthogonal cutting with different materials
3) Determination of cutting Forces and roughness on machined surface in orthogonal cutting with different materials
4) Study of arc, and spot welding processes
5) Study of TIG, MIG welding and Friction stir welding processes
6) Study of sintered density and relative density of given samples using Archimedes principle
7) Study of simple parts in 3D printing
8) Study of MRR and roughness on Wire EDM
9) Estimation of particle size using top down approaches and image analyser.
10) To find the ultimate tensile strength of given specimen using UTM
11) To find the Vickers/ Rockwell hardness of given specimen using hardness tester
12) To find the wear rate of a given specimen using Pin-on Disc apparatus
13) Study of roughness on machines surfaces for different materials using abrasive flow finishing.
14) To find the fatigue strength of a given specimen using fatigue-testing machine
15) To find the crystallite size and miller indices planes of a given specimen using X-ray diffractometer.
16) Study of Raman/FTIR spectroscopy

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

CO1	Perform different manufacturing operations such as joining and forming
CO2	Determine the chip thickness ratio, shear angle, cutting forces, temperatures and surface roughness of machined surface during orthogonal turning operation
CO3	Determine Green Density and sintering density of P/M samples
CO4	Produce simple parts using a 3D printing machine
CO5	Perform destructive testing methods of materials to determine Brinell, Vickers Micro hardness, Tensile strength, bending strength and wear resistance, Fatigue strength.
CO6	Demonstrate different characterization methods for bulk materials (polymers, ceramics, composites etc.) using XRD, spectroscopic methods – UV-Vis, FTIR, Raman, microscopic – optical, SEM etc.

Honors Course	MODELLING AND SIMULATION OF MANUFACTURING SYSTEMS LAB	L	T	P	C
		3	0	0	3

Honors Course	COMPUTATIONAL FLUID DYNAMICS LAB	L	T	P	C
		3	0	0	3

Course Objectives: To make the students learn how to model various manufacturing processes using Finite Element software.
Students shall carry out the modeling and FE analysis of the following:
1. Casting processes - Study of Solidification, temperatures, Residual stresses, metallurgical phases etc.
2. Forging processes - Study of cold working and hot working processes for extrusion, drawing, rolling, etc.
3. Forming Processes – Study of blanking, bending, deep drawing, etc.
4. Welding Processes – Study of arc, spot, laser welding, etc
Course Outcomes:Students at the end of the course will get knowledge about the analysis of manufacturing processes using pertinent FE tools.

Course Objectives: To make the students learn about how to analyze real-life engineering applications using CFD methods using Python coding.

Using any Programming Language, code the following methods with an example:
Solution of 1-D parabolic equations
Explicit (FTCS, DuFort-Frankel)
Implicit (Laasonen)
Fin problem with insulated and Convective end
Couette Problem with and without pressure Gradient
Solution of Elliptic Equations
With Point Gauss-Seidel method
With Point Successive Over Relaxation Method
■ Examples: (i) Temperature Distribution over a rectangular plate with different Boundary conditions on the sides.
Solution of Parabolic Equations
Solution of Linear Hyperbolic Equations.
Using upwind and Lax explicit methods
Using BTCS and Crank-Nicolson implicit methods
■ Examples: Wave propagation at a high altitude
Solution of Nonlinear Hyperbolic Equations.
Lax Method
MacCormack Method
■ Examples: Shock Tube Problem ➢ Solution of Incompressible NSEs Vorticity-Stream function formulation
Primitive Variable Formulation

■ Examples:
● Lid Driven Cavity Problem
● Mass entering and leaving a square chamber

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

CO1	Develop codes for solution of algebraic and differential equations
CO2	Develop skills in the actual implementation of CFD methods with their own codes
CO3	Analyze real-life engineering applications with the help of CFD.
CO4	Design thermal engineering equipment using CFD
CO5	DesignandanalysisofIndustrialcomponentslikepressurevessels