PRAKASAM ENGINEERING COLLEGE
(AUTONOMOUS)
KANDUKUR
MECHANICAL ENGINEERING

B.Tech–III Year I Semester

S.No.	Category	Title	L	T	P	Credits
1	Professional Core	Machine tool& metrology	3	0	0	3
2	Professional Core	Thermal engineering	3	0	0	3
3	Professional Elective-I	Design of machine elements	3	0	0	3
4	Open Elective- I	1.Design for manufacturing 2.Conventional and futuristic vehicle technology 3.Renewable energy technology 4.Non- destructive evalution	3	0	0	3
5	Open Elective- II	PRINCIPLES OF OPERATING SYSTEM	3	0	0	3
6	Professional Core	Thermal engineering lab	0	0	3	1.5
7	Professional Core	Theory of machines lab	0	0	3	1.5
8	Skill Enhancement course	Machine tools and matrology lab	0	1	2	2
9	BS&H	TinkeringLab	0	0	2	1
10	Evaluation of Community Service Internship		-	-	-	2
Total			**15**	**1**	**10**	**23**

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B.Tech-III Year II Semester

S.No.	Category	Title	L	T	P	C
1	Professional Core	Heat Transfer	3	0	0	3
2	Professional Core	Artificial Intelligence and Machine Learning	3	0	0	3
3	Professional Core	Finite Element Methods	3	0	0	3
4	Professional Elective	Professional Elective-II	3	0	0	3
5	Professional Elective	Professional Elective-III	3	0	0	3
6	Open Elective- II	1. Introduction to Industrial Robotics 2. Industrial Management 3. Additive Manufacturing 4. Vechicle Technology 5. Industrial Safety	3	0	0	3
7	Professional Core	Heat Transfer Lab	0	0	3	1.5
8	Professional Core	Artificial Intelligence and Machine Learning Lab	0	0	3	1.5
9	Skill Enhancement course	Robotics and Drone Technologies Lab	0	0	4	2
10	Audit Course	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

1. Mechanical Vibrations
2. Advanced Manufacturing Processes
3. Micro Electro Mechanical Systems
4. Sensors and Instrumentation

Professional Elective-III

1. Energy Storage Technologies
2. Industrial Hydraulics and Pneumatics
3. Industrial Robotics
4. Refrigeration &Air-Conditioning

Professional Elective-IV

1. Mechatronics
2. Computational Fluid Dynamics
3. Advanced Material Science
4. Embedded Systems and Programming

Professional Elective-V

1. Hydrogen and Fuel Cell Technology
2. Smart manufacturing
3. Cryogenics
4. Electrical drives and actuators

III Year I Semester	MACHINE TOOLS& METROLOGY	L	T	P	C
		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

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, machinability, 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 limitsandfits,Taylor'sprinciple–designofgoandnogogauges;plug,ring,snap, gap,

taper, profile and position gauges.

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

UNIT–5

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

SURFACE ROUGHNESS MEASUREMENT: Differences between surface roughness and surface waviness –Numerical assessment of surface finish, Profilo 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/PHIPublishers-2nd Edition
2. Manufacturing Technology Vol-II/P.NRao/ 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. HandBook (Hindustan Machine Tools).
3. Production Engineering/K.CJain &A.KChitaley/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

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	UnderstandthedifferenttypesofSurfaceroughnessandOpticalmeasuring instruments

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

Course Objectives:

1) To give insight into basic principles of air standard cycles.
2) To impart knowledge about IC engines and Boilers
3) To make the students learn the working principles of steam nozzles, turbines and compressors
4) To impart the knowledge about the various types of compressors and gas turbines
5) To make the students gain insights about,rockets and jetpropulsion 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-leval turbine-method store ducerot or 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 is 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– Thermo dynamic cycle,performance evaluation.
Rockets: Principle, solid and liquid propel an trocket 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/Jainbros. Publishers
3. Thermal Engineering-P.L.Ballaney/Khanna publishers.
4. Thermal Engineering/RKRajput/LakshmiPublications
5. Thermal Engineering-R.SKhurmi, &JS Gupta/S.Chand.

Course out comes: at the end of the course, student will be able to

CO1: Explain the basic concept so fair standard cycles.
CO2: Get knowledge about IC Engines and Biolers.
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.

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

Course Objectives:

- Familiarize with fundamental approach esto failure prevention for static nd 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.

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

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

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

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

UNIT-II: Design of Bolted and Welded Joints

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

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

UNIT-III:Power transmission shafts and Couplings

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

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

UNIT-IV: Design of Clutches, Brakes and springs

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

Brakes: Different types of brakes.Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

Springs : Design of helical compression,tension,torsion and leaf springs.

UNIT-V: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,PearsonEducation,2004.
2. V.B.Bhandari,Design of Machine Elements,3/e,TataMcGraw 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-nptehttps://www.digimat.in/nptel/courses/video/112105124/L01.htmlhttps://dokumen.tips/documents/nptel-design-of-machine-elements-1.htmlhttp://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html

Course Outcomes:

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

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

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III Year-I Semester	DESIGN FOR MANUFCTURING (Professional Elective-I)	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

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

UNIT–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,JohnCobert,AdissonWesley.1995
2. Design for Manufacture by Boothroyd,
3. Design formanufacture,James Bralla,

REFERENCE:

1. Molloy,E.A.Warman,S.Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998

2. ASM HandbookVol.20

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 metalwork
CO4: Interpret the design considerations of various metal joining process.
CO5:Under stand the basic design concepts involved in the assembly automation

III Year I Semester	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES

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

UNIT–I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbo charged Engines, Electric Turbo chargers, 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 FUELTECHNOLOGY

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

Fuelcellsforautomotiveapplications-Technologyadvancesinfuelcellvehiclesystems - 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, HybridElectric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. RakeshKumarMaurya,CharacteristicsandControlofLowTemperatureCombustion Engines. ISBN 978-3-319-68507-6 , SPRINGER

REFERENCES:

1. IqbalHussein,Electric andHybridVehicles:DesignFundamentals,CRCPress, 2003.
2. JamesLarminie,John Lowry,ElectricVehicleTechnologyExplained,Wiley,2003
3. RandD.A.J,Woods,R&DellRMBatteriesforElectricvehicles,JohnWiley&Sons, 1998

4. IqbalHussein,Electric andHybridVehicles:DesignFundamentals,CRCPress, 2003.
5. JamesLarminie,John Lowry,ElectricVehicleTechnologyExplained,Wiley,2003

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

1. Discuss the latest trends in engine technology
2. Discusstheneedofadvancedcombustiontechnologiesanditsimpactonreducing carbon foot-print on the environment.
3. Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.

III Year I Semester	RENEWABLE ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course objectives:

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

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, extraterrestrialandterrestrialsolarradiation,solarradiationontitledsurface,instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULE SAND 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,gasyield,utilizationforcooking,biofuels,I.C.engineoperationandeconomic 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-KhanB.H/TataMcGrawHill,NewDelhi,2006
3. Green Manufacturing Processes and Systems -J.Paulo Davim/Springer2013

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth& John F Kreider / Taylor &Francis
2. Non-Conventional Energy-AshokVDesai/NewAge International(P) Ltd
3. Renewable EnergyTechnologies -Ramesh&Kumar /Narosa
4. Non-conventional Energy Source-G.DRoy/Standard Publishers

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

CO1	Illustrate the importance of solar radiation and solar PVmodules.
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 fuelcells.

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

Course Objectives:

1. To learn basic concepts of non-destructive testing and industrial applications
2. To understand the elements of ultrasonic test and limitations of ultrasonic test
3. To learn the concepts involved in the liquid penetrant test and eddy current test
4. To know the basic principles and operating procedure so fmagnetic particle testing
5. To understand the basic concepts involved in the infrared 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 Penetrante Test: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness, DPI, FPI,Limitations of Liquid Penetrant Testing**.**

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

UNIT–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 thermo graphy, 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–IRimaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Text Books:

1. Non destructive test and evaluation of Materials/ J Prasad,GCK Nair/TMH Publishers
2. Ultrasonic testing of materials /HKrautKramer/Springer
3. Non destructive testing/Warren, JMc Gonnagle/ Godan and Breach Science publishers
4. Non destructive evaluation of materials by infrared thermo graphy/X.P.V. Maldague, Springer-Verlag, 1st edition, (1993)

References:

1. Ultrasonic in spection training for NDT/E.A.Gingel/Prometheus Press,

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

2. ASTM Standards,Vol3.01,Metal sand alloys
3. Non-destructive Evaluation, HandBook–R.Ham Chand

Course out comes: at the end of the course, student will be able to

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III Year I Semester	SUSTAINBL EENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course objectives:

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

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.

SOLARPVMODULESANDPV 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

STORAGEINPVSYSTEMS:

Battery Operation,Types ofBatteries,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.

SOLARENERGYSTORAGE 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

FUELCELLS: Introduction,Applications,Classification,DifferentTypesofFuelCells

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-KhanB.H/Tata McGrawHill,NewDelhi,2006
3. Green Manufacturing Processes and systems -J.Paulo Davim/Springer2013

References:

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

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.

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

Course Objectives: To

1. 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.

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, un balanced 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 –2x2 games–dominance principle–m x 2& 2x 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:

1. Operations Research-An Introduction/ Hamdy ATaha/Pearson publishers
2. Operations Research –Theory & publications / S.D.Sharma Kedarnath/McMillan publishers India Ltd

References:

1. Introduction to O.R/ Hiller& Libermann/ TMH
2. Operations Research /A.M.Natarajan,P.Balasubramani,A.Tamilarasi/ Pearson Education.
3. Operations Research: Methods & Problems / Maurice Saseini, Arhur Yaspan& Lawrence Friedman/Wiley
4. Operations Research/R.Pannerselvam/PHI Publications.
5. Operations Research/Wagner/PHI Publications.
6. Operation Research/J.K.Sharma/MacmillanPubl.
7. Operations Research/Pai/Oxford Publications
8. Operations Research/S Kalavathy/Vikas Publishers
9. Operations Research/DS Cheema/ University Science Press
10. Operations Research/Ravindran, Philips, Solberg/Wiley publishers

Course Out comes: 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.

III Year I Semester	NANO TECHNOLOGY	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 tool stocharacterize Nano materials
5. To 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 disclinations. Effect of Nano-dimensions on Materials Behavior: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nanocrystalline 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

TOOLSTO CHARACTERIZENANOMATERIALS: 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.PooleJr& FrankJ.Owens.Wiley India Pvt. Ltd.
2. Nano Materials-A.K.Bandyopadhyay /New Age Publishers.
3. Nano Essentials- T.Pradeep /TMH

REFERENCEBOOKS:

1. Solid State physics by Pillai,Wiley Eastern Ltd.
2. Introduction to solid state physics7the dition by Kittel.John Wiley& sons (Asia)Pvt Ltd.

Course Out comes: 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 tool stocharacterize nano materials

CO5 Understand the applications of nano materials

III Year I Semester	THERMAL MANAGEMENT OF ELECTRONIC SYSTEMS	L	T	P	C
		3	0	0	3

Course Objective:

1. To understand the basics of heat transfer and analyze heat transfer through fins
2. To acquire the knowledge on Free and forced convective systems.
3. To understand the air cooling and single phase liquid cooling systems with case studies.
4. To demonstrate the concepts of two phase cooling and heat pipes.
5. To 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-BoltzmannLaw–Kirchoff'slawandEmissivity–Radiationbetween 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.

HeatPipes – 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 Analys is and Control of Electronic Equipment –AllanD.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, NewYork, NY, 1990.

Course Out comes: 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

III Year I Semester	ENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

Course objective:

1) To develop and strength an entrepreneurial quality and motivation in students.
2) To impart basic entrepreneurial skills and understanding storuna 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: BUSINESSPLAN PREPARATION

Sources of Product for Business –Pre feasibility 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. Hisrich, Entrepreneurship, Tata McGraw Hill,NewDelhi,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,EssPeekay Publishing House,Chennai -1997.
4. AryaKumar.Entrepreneurship.Pearson.20125.DonaldFKuratko,T.VRao. Entrepreneurship: A South Asian perspective. Cengage Learning. 2012

III Year I Semester	THERMAL ENGINEERING LAB	L	T	P	C
		0	0	3	1.5

COURSE OUT COME: Students will gain knowledge and skills needed toruna business.

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.

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) C level and' 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 multicylinder 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.

Course outcomes: 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

III Year I Semester	THEORY OF MACHINES LAB	L	T	P	C
		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 un damped free and forced vibrations
- To analyze different mechanisms
- To demonstrate various types of gears

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 Hart nell 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 un damped free vibration of an equivalent spring mass system.
5. Todeterminethefrequencyofdampedforcevibrationofaspringmasssystem
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

Course Outcomes:

- Get knowledge about the motion of a gyroscope
- Discuss the characteristics of governors
- Find the frequencies of damped and undamped free and forced vibrations
- Analyze different mechanisms
- Demonstrate various types of gears

III Year I Semester	MACHINE TOOLS& METROLOGY LAB	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 6experiments from each lab

MACHINE TOOLS LAB

1. Introduction of general purpose machines -Lathe, Drilling machine, Milling machine, Shaper, Planing machine,Slotting machine,Cylindrical grinder,Surface grinder and Tool and cutter grinder.
2. OperationsonLathemachines-Stepturning,Knurling,Taperturning,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)Key way(T–slot)(ii) Key way cutting
6. Operations on milling machines- (i)Indexing(ii) Gear manufacturing

METROLOGY LAB

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

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

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

III Year I Semester	TINKERING LAB	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

1. **Encourage Innovation and Creativity**
2. **Provide Hands-on Learning**
3. **Impart Skill Development**
4. **Foster Collaboration and Teamwork**
5. **Enable Interdisciplinary Learning**
6. **Impart Problem-Solving mind-set**
7. **Prepare for Industry and Entrepreneurship**

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leadingtostart-upsorinnovation-drivencareers.Tinkeringlabsaimtocultivatethenext 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 bread board for any application of your choice.
2) Demonstrate a traffic light circuit using breadboard.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinker cad.
5) Build and demonstratean 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 3Dprint a Walking Robot
11) Design and3D 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 tore design a motorbike.

Students need to refer to the following links:

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

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

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

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

Course Objectives:

1. To learn the different modes of heat transfer and conduction heat transfer through various solid bodies
2. To learn the one dimensional steady state heat conduction heat transfer and one dimensional transient heat conduction
3. To learn the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows
4. To learn the free convection heat transfer concepts and heat transfer processe sin heat exchangers
5. To learn 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,un steady 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.VariableThermal 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 –Bucking hamπTheorem and method,application for developing semi–empiricalnon- 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 hydro dynamic 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 Hydro dynamic 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 CP Kothandaraman and Subrahmanyan **is allowed.**

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Fundamentals of Heat Transfer by Incropera & Dewitt,John Wiley
2. Fundamentals of Engineering, Heat & MassT ransfer by R.C.Sachdeva,New Age.
3. Heat & Mass Transfer by Amit Pal–Pearson Publishers
4. Heat Transfer by Ghoshadastidar,Oxford University press.
5. Heat Transfer by a Practical Approach,Yunus Cengel,Boles,TMH
6. Engineering Heat and Mass Transfer by SaritK. Das,DhanpatRaiPub

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

III Year II Semester	ARTIFICIAL INTELLIGENCE& MACHINE LEARNING	L	T	P	C
		3	0	0	3

Course objectives:

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

UNIT–I:

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

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

UNIT–II:

IntroductiontoMachineLearning(ML): Definition,Evolution,Need,applicationsof ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, overfitting and under fitting.

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

UNIT–III:

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

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

UNIT–IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary codedGA, 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) EthemAlpaydin,Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCEBOOKS:

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, PHILearning, 2012.

ONLINE RESOURCES:

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

https://www.geeksforgeeks.org/

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

CO1:Explain the basic concept so fartificial intelligence
CO2:Learn about the principles of supervised learning methods
CO3:Gain knowledge in un supervised learning method and Bayesianalgorithms
CO4: Get knowledge about neural networks and genetic algorithms.
CO5:Understand the machine learning analytics and apply deepl earning techniques.

III Year II Semester	FINITE ELEMENT METHODS	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.

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

UNIT–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 Methodsin 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 Elemen tMethod/JNReddy/McGraw-Hill
3. The FiniteElement Method for Engineers–Kenneth H.Huebner,Donald L. Dewhirst, DouglasE.Smith and Ted G.Byrom/John Wiley&sons(ASIA) Pvt Ltd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education
5. Finite Element Analysis: for students & Practicing Engineers / G.LakshmiNarasaiah

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

CO1 Understand the concepts behind variation almethods and weighted residual methods in FEM

CO2 Solve barand truss problems.

CO3 Solve beam problems.

CO4 Apply suitable boundary conditions for 2D stress analysis and develop the formulation foraxi-symmetric problems and higher orderiso-parametric elements

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

III Year II Semester	MECHANICALVIBRATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn basic principles of mathematical modeling of vibrating systems
2. To understandthebasicconceptsfreeandforcedmultidegreefreedomsystems
3. To get concepts involved in the torsional vibrations
4. To learn the principles involved in the critical speed of shafts
5. To understandthebasicconceptsofLaplacetransformationsresponsetodifferent inputs

UNIT–1

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

UNIT–2

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–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 multiplediscs, secondary critical speed,critical speed slight 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

Textbooks:

1. S.S.Rao,“Mechanical Vibrations",5thEdition,PrenticeHall, 2011.
2. L.Meirovitch,“Elements of vibrationAnalysis",2ndEdition,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,“NoiseandVibrationControl”,WorldScientific,2013.
3. BeranekandVer,“NoiseandVibrationControlEngineering:Principlesand Applications”,JohnWiley and Sons, 2006.

4. RandallF.Barron,"IndustrialNoiseControlandAcoustics",MarcelDekker, Inc.,2003.

Course Out comes: 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

III Year II Semester	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 nano materials
- 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

ADDITIVEMANUFACTURING: Working Principles, Methods,Stereo Litho graphy, 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,hotcompaction, 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 MICRO ELECTRONIC DEVICES:

Crystal growth and wafer pre paration, 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 Nostrand Renihold,
2 MEMS & Micro Systems Design and manufacture/Tai—RunHsu/ TMGH
3 Advanced Machining Processes/V.K.Jain/AlliedPublications.
4 Introduction to Manufacturing Processes/JohnA Schey*I*McGraw Hill.
5 Introduction to Nano science and Nano Technology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learing

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

CO1: Explain the working principle of various non conventional machining processes and their applications.
CO2: Explain the working principles of additive manufacturing methods.
CO3: Understand various lase rmaterial processing techniques.
CO4: Gain on Advanced coating processes
CO5: Describe various fabrication methods for micro electronic devices

III Year II Semester	MICRO ELECTRO MECHANICAL SYSTEMS	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 biomedical micro systems.

UNIT–I:

INTRODUCTION: Definition of MEMS, MEMS history and development, micro machining, lithography principles& methods,structural and sacrificial materials,thin film deposition, impuritydoping, etching, surface micromachining, waferbonding, 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,Peltiereffectheatpumps,thermalflowsensors,microhotplategassensors,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, datastorage cantilever.

UNIT–III:

MICRO-OPTO-ELECTROMECHANICALSYSTEMS: 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,thermocapillaryeffect,electroosmosisflow,optoelectrowetting(OEW),tuning usingmicrofluidics,typicalmicrofluidicchannel,microfluiddispenser,microneedle, molecular gate, micro pumps. RADIOFREQUENCY (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 BIOMEDICAL 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,ChangLiu,Prentice HallLtd.
2. MEMS and NEMS,Sergey EdwardLyshevski, CRCPress, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture,Tai-RanHsu, TMHPublishers.
4. Introductory MEMS, Thomas MAdams, RichardALayton, Springer International Publishers.

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.

III Year-II Semester	SENSORS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNITII

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).

UNITIII

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.

UNITIV

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.

UNITV

SIGNAL CONDITIONING AND DAQ SYSTEMS

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channelandmulti-channeldataacquisition–Datalogging-applications-Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

TEXT BOOKS:

1. Ernest ODoebelin,"Measurement Systems–Applications and Design",Tata McGraw-Hill, 2009.
2. Sawney AK and Puneet Sawney,"A Course in Mechanical
3. Measurements and Instrumentation and Control",Dhanpat Rai&Co,12th
4. editionNewDelhi,2013

REFERENCES

1. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, JohnWiley & Sons, Canada, 2001.
2. Hans KurtTönshoff(Editor),Ichiro,"Sensors in Manufacturing"Volume1, Wiley-VCHApril2001.
3. John Turnerand MartynHill,"Instrumentation for Engineers and Scientists", OxfordSciencePublications,1999.
4. PatranabisD,"SensorsandTransducers",2ndEdition,PHI,NewDelhi,2011.
5. RichardZurawski,"IndustrialCommunicationTechnologyHandbook"2nd edition,CRCPress,2015.

COURSE OUT COMES: 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

III B.Tech II Semester	ENERGY STORAGE TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course Objectives: To

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

UNIT1:

Energy storage systems over view –Scope of energy storage,needs and opportunities in energy storage,Technology over view 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.

UNIT2:

Chemical storage system- hydrogen, methane etc., concept of chemical storage of solarenergy,applicationofchemicalenergystoragesystem,advantagesandlimitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

Electromagnetic storage systems - double layer capacitors with electro statically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT3:

Electro chemical 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

UNIT4:

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

Fuelcell-Operationalprincipleofafuelcell,typesoffuelcells,hybridfuelcell-battery systems, hybrid fuel cell-super capacitor systems.

UNIT5:

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-awayforbatterysystems,Thermalmanagementofbatterysystems,StateofChargeand State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

Textbooks:

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

References:

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

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

- Learn the importance of energy storage systems
- Gain knowledge on chemical and electro magnetic storage systems
- Understand the principles of electro chemical storage systems
- Know the working of super capacitors and fuel cells
- Learn how to design batteries for transportation

III Year-II Semester	INDUSTRIAL HYDRAULICS AND PNEUMATICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn basic concepts of fluid power
2. To understand the functions and working of basic elements of Hydraulic and Pneumatic system
3. To get knowledge about the basic components and their functions of Hydraulic and Pneumatic circuits
4. To learn the operating principles and working of hydraulic and pneumatic devices
5. To gain knowledge about the procedures of installation,maintenance and trouble shooting 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, Workingfluidsusedinhydraulicandpneumaticsystems-types,ISO/BISstandardsand 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,propertiesandpipinglayout,aircompressors,Airreceivers,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, pneumaticLogiccircuitdesign-classicmethod,cascademethod,stepcountermethod, 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.OilHydraulicSystemsTataMcGraw-HillPublication,NewDelhi,3/e, 2013
2. Majumdar,S.R.PneumaticSystemsTataMcGraw-HillPublication,NewDelhi,3/e, 2013

References:

1. Srinivasan,R.HydraulicandPneumaticControlsVijayNicoleImprintsPrivate,New Delhi, Limited, 2/e, 2008
2. Jagadeesha,T.FluidPowerGeneration,TransmissionandControlUniversitiesPress (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,AndrewHydraulicandPneumatics,ATechnician'sandEngineer'sGuide, JaicoPublishingHouse,NewDelhi,2/e,2013
5. ShanmugaSundaram,K.HydraulicandPneumaticsControls-UnderstandingMade Easy S. Chand Company Ltd., New Delhi, 1/e, 2006

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.

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

Course Objectives: The Students will acquire the knowledge to

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

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

GENERALCONSIDERATIONSINPATHDESCRIPTIONAND GENERATION: Trajectory planning and avoid anceofobstacles,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 RK& NagrathiJ/TMH.

REFERENCES:

1. Robotics/FuKS/McGraw Hill.

2. Robotic Engineering/Richard D.Klafter,Prentice Hall
3. Robot Analysis and Control/H. Asadaand J.J.E.Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/Pearson Edu.

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.

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

Course Objectives:

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

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: Workingprincipleandessentialcomponentsoftheplant–simplevapourcompression 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 LiBr–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 Psychrometric tables and charts are allowed.

Text Books:

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

References:

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

Course Out comes: 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 airc onditioning systems.

III Year II Semester	INTRODUCTION TO INDUSTRIAL ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives: To

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learna bout programming principles and languages for a robot control system
5. 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-robo tdrive 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: Homogeneous 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 /GrooverMP/Pearson Edu.
   Robotics and Control/Mittal RK &Nagrathi J /TMH

REFERENCES

1. Robotics/ FuKS/McGraw Hill.
2. Robotic Engineering /RichardD.Klafter,Prentice Hall
3. Robot Analysisand Control/H. Asadaand J.J.E.Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John JCraig/Pearson Edu.

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 fo ra robot control system

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

III Year II Semester	INDUSTRIAL MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives: The objectives of the course are to

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

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, scientificmanagement,Taylor'sprinciples,theoryXandtheoryY,Fayol'sprinciples 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 break down maintenance.

UNIT–II

WORK STUDY: Importance, types of production, applications, workstudy, 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 $\bar{X}$ and S charts and their applications, numerical examples.

TOTALQUALITYMANAGEMENT:zerodefectconcept,qualitycircles,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 workingcapitalrequirements,stockmanagement,Costaccountingandcontrol,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 RESOURCE MANAGEMENT: 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.PKhanna/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/ McGrawHil Publishers.
3) Industrial Engineering and Management Science/T.R. Banga,S.C.Sharma, N. K.Agarwal/Khanna Publishers
4) Principles of Management/ KoontzO'Donnel/McGraw Hill Publishers.
5) Statistical Quality Control/Gupta/ Khanna Publishers
6) Industrial Engineering and Management/ NVS Raju/ Cengage Publishers

Course Outcomes: After completing this course, students will be able to:

1) Learn about how to design the optimal layout
2) Demonstrate work study methods
3) Explain Quality Control techniques
4) Discuss the financial management aspects and
5) Understand the human resource management methods.

III Year II Semester	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
2. To understand and apply different types of solid-based RP systems.
3. To understand and apply powder-based RP systems.
4. To understand and apply various rapid tooling techniques.
5. To understand different types of data formats and to 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,advantagesanddisadvantages,casestudies.SolidGroundCuring(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 modelling (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 castings and 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 in valid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, auto motive industry,jewelry industry,coin industry,GIS application,RP

Medical and bio engineering 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.PhamandS.S. Dimov/Springer
2. Wohlers Report2000/TerryT Wohlers/ Wohlers Associates
3. Rapid Prototyping& Manufacturing/PaulF.Jacobs /ASME Press
4. Rapid Prototyping/ Chuaand Liou

Course Outcomes:A the end of th ecourse,student will be abl eto

CO1	Understand the principles of prototyping,classification of RP processes and liquid-based RP systems.
CO2	Understandand 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.

III Year II Semester	VEHICLE TECHNOLOGY	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 on figurations
5. To study the application of fuel cell technology in automotives

UNIT–I: ADVANCED ENGINETECHNOLOGY

GasolineDirectInjection,CommonRailDirectInjection,VariableCompressionRatio 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 DualFuel 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. RakeshKumarMaurya,CharacteristicsandControlofLowTemperatureCombustion Engines. ISBN 978-3-319-68507-6 , SPRINGER

REFERENCES:

1. IqbalHussein,ElectricandHybridVehicles:DesignFundamentals,CRC Press, 2003.
2. JamesLarminie,JohnLowry,ElectricVehicleTechnologyExplained,Wiley, 2003

3. RandD.A.J,Woods,R&DellRMBatteriesforElectricvehicles,JohnWiley & Sons, 1998

4. Iqbal Hussein, Electric and Hybrid Vehicles :Design Fundamentals, CRC Press, 2003.
5. JamesLarminie,JohnLowry,ElectricVehicleTechnologyExplained,Wiley, 2003

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

1. Discuss the latest trends in engine technology
2. Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.
3. Analyzing the basic characteristics of low carbon fuels,its impact over conventional fuels and in achieving sustainable development goals.
4. Discusstheworkingandenergyflowinvarioushybridandelectricconfigurations.

Analyzing the need for fuel cell technology in automotive applications

III Year II Semester	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

Course objectives:

1) To understand the concepts of industrial safety and management.
2) To demonstrate the accident preventions and protective equipment.
3) To understand and apply the knowledge of safety acts
4) To have the knowledge about fire prevention and protection systems
5) To understand and apply fire safety principles in buildings

UNIT-I

INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETYAND 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

ACCIDENT PREVENTIONS AND PROTECTIVE EQUIPMENT: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education andtraininginsafety,Preventioncausesandcostofaccident,Housekeeping,Firstaid,Accident reporting, Investigations. Industrial psychology in accident prevention, Safety trials, Safety related to operations.

UNIT-III

SAFETYACTS:FeaturesofFactoryAct,IntroductionofExplosiveAct,BoilerAct, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseasesprevention,Ergonomics,Occupationaldiseases,stress,fatigue,health,safety and the physical environment, Engineering methods ofcontrolling chemical hazards, safetyandthephysicalenvironment,Controlofindustrialnoiseandprotectionagainst 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 classesoffires–A,B,C,D,E-Fireextinguishingagents-Water,Foam,Drychemical powder, Carbon-dioxide Halon alternatives Halocarbon compounds-Inert gases, dry powders–typesoffireextinguishers–firestoppers–hydrantpipes–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

BUILDING FIRE SAFETY: Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – conceptofegressdesign-exit–widthcalculations–firecertificates–firesafety

Requirements for high rise buildings.

TEXT BOOKS:

1. Industrial Maintenance Management Srivastava,S.K.-S.Chand and Co.
2. Occupational Safety Management and Engineering Willie Hammer– PrenticeHall
3. Purandare D.D& AbhayD. Purandare,"Handbook on Industrial Fire Safety" P&A publications, NewDelhi, 2006.
4. McElroy,FrankE.,"Accident Prevention Manual for Industrial Operations",NSC, Chicago,1988.
5. Green, A.E.,"HighRiskSafetyTechnology",JohnWileyandSons,1984.

REFERENCEBOOKS:

1. Installation, Servicing and Maintenance Bhattacharya ,S.N.-S.Chand and Co.
2. JainVK" Fire Safety in Building "New Age International 1996.
3. Reliability, Maintenance and Safety Engineering by Dr.A.K.Guptha
4. A Textbook of Reliability and Maintenance Engineering by A lakesh Manna

Course outcomes:

CO1: Students learn the concepts of industrial safety and management.
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: Students learn about fire prevention and protection systems.
CO5: Students learn and apply the fire safety principles in buildings

III Year II Semester	HEAT TRANSFER LAB	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 composites lab
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-Boltz mann constant.
10. Determination o fhea ttransfer 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

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

(i) Conduction Analysis of a Single Material Slab

(ii) Conduction Analysis of a single Material Sphere

(iii) Conduction Analysis of a single Material Cylinder

(iv) Conduction Analysis of a Double Material Slab

(v) Conduction Analysis of a Double Material Sphere

(vi) Conduction Analysis of Double Material Cylinder

(vii) To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger

(viii) To investigate the Lambert's distance law.

(ix) To investigate the Lambert's direction law(cosine law).

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

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

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

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

1. Learning of Python libraries–Numpy, Pandas, Matplotlib, Seaborn 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

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:Databasescanbetakenfrom https://www.kaggle.com/datasets

III Year II Semester	ROBOTICS AND DRONE TECHNOLOGIES LAB	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:

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 amazeor an environment by using sensors to detect obstacles and avoid them.
5) Construct a robotic arm using servomotors or step per 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 a3D Model of a Robotic Arm and Grippers Using Software
8) Implement a PID controller for a robotic arm or mobile robot and simulate its performance in tracking a desired trajectory.

Drone technologies:

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

Studentsneedtorefertothefollowinglinks:

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

Courseoutcome:Studentsattheendofthecoursewillgetenoughknowledge and knowhow about how to design a variety of robots and drones for diversified applications

III Year II Semester	TECHNICAL PAPER WRITING AND IPR	L	T	P	C
		2	0	0	--

Course objectives:

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

UNIT-I:Planning andpreparation

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 cooperationon 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, Geo graphical 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 toWrite and Publish a Scientific Paper, Cambridge University Press.
2. Halbert, “Resisting Intellectual Property”, Taylor& FrancisLtd, 2007.

References:

1) Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

2) Highman N(1998),Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
3) Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

4) Mayall,"IndustrialDesign",McGrawHill,1992.
5) RobertP. Merges,PeterS.Menell,MarkA.Lemley,"Intellectual Property in New Technological Age" 2016.
6) T.Ramappa,"IntellectualPropertyRightsUnderWTO",S.Chand,2008.

Course out comes: Upon completion of course, students will be able to:

1) Understand the structure of the technical paper andits components.
2) Review the literature and acquire the skills to write a technical paper for first submission.
3) Understand the process and development of IPR.
4) Create awareness about the scope of patent rights.
5) Analyze the new developmentsinIPRincludelatestsoftware.

IIIYearII Semester	**INDUSTRYINTERNSHIP**				

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