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

LINEAR MEASUREMENT: Length standards, end standards, slip gauges- calibration of the slip

Gauges, dial indicators, micrometers.

UNIT – 5

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

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

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

TEXT BOOKS:

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

REFERENCES:

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

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

CO1	Learned the fundamental knowledge and principals in material removal process.
CO2	Acquire the knowledge on operations in conventional, automatic, Capstan and turret lathes
CO3	Capable of understanding the working principles and operations of shaping, slotting, planning , drilling and boring machines.
CO4	able to make gear and keyway in milling machines and understand the indexing mechanisms
CO5	Understand the different types of Surface roughness and Optical measuring instruments

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 jet propulsion 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 Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT–II

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

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

UNIT -III

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

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

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

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

UNIT -IV

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

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

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

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

UNIT -V

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

Rockets: Principle, solid and liquid propellant rocket engines.

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

Text Books:

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

References:

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

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

CO1: Explain the basic concepts of air standard cycles.
CO2: Get knowledge about IC Engines and 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.

III Year-I Semester		**3**	**0**	**0**	**3**

Course Objectives:

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

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

Reference Books:

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

Online Learning Resources:

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

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.

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 guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking.

UNIT– 4
Metal joining: Appraisal of various welding processes, factors in design of 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, John Cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla,

REFERENCE:

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

2. ASM Hand book Vol.20

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

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

III Year I Semester	CONVENTIONAL AND FUTURISTIC 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 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 Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

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

UNIT – III: LOW CARBON FUEL TECHNOLOGY
Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT – IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)
Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward

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

TEXT BOOKS:
1.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER
REFERENCES:
1.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3.Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

4.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
5.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

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.Discuss the working and energy flow in various hybrid and electric configurations.
5.Analyzing the need for fuel cell technology in automotive applications.

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 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.

SOLAR PV MODULES AND PV SYSTEMS:

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

UNIT – 2

STORAGE IN PV SYSTEMS:

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

UNIT – 3

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

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

UNIT – 4

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

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

UNIT – 5

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

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

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

Text Books:

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

References:

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

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

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

UNIT – 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 thermography, tomography-Contact and non-contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals –other temperature sensitive coatings – Inspection methods –Infrared radiation and infrared detectors–thermo mechanical

behaviour of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Text Books:

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

References:

1. Ultrasonic inspection training for NDT/E.A.Gingel/PrometheusPress,

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

2. ASTM Standards,Vol3.01,Metalsandalloys
3. Non-destructive Evaluation, Hand Book – R. Ham Chand

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

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

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PVmodules
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.

SOLAR PV MODULES AND PV SYSTEMS:

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

UNIT – 2

STORAGE IN PV SYSTEMS:

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

UNIT – 3

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

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

UNIT – 4

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

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

UNIT – 5

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

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

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

Text Books:

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

References:

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

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, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- travelling salesman problem.

SEQUENCING – Introduction – flow –shop sequencing – *n* jobs through two machines – *n* jobs through three machines – job shop sequencing – two jobs through 'm' machines.

UNIT – 3

REPLACEMENT THEORY: Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.

GAME THEORY: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.

UNIT – 4

WAITING LINES: Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel.

PROJECT MANAGEMENT: Basics for construction of network diagram,Program Evaluation and Review Technique (PERT), Critical Path Method (CPM) – PERT Vs. CPM, determination of floats- Project crashing and its procedure.

UNIT – 5

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

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

Text Books:

1. Operations Research-An Introduction/Hamdy A Taha/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, ArhurYaspan& Lawrence Friedman/Wiley
4. Operations Research / R.Pannerselvam/ PHI Publications.
5. Operations Research / Wagner/ PHI Publications.
6. Operation Research /J.K.Sharma/Macmillan Publ.
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 Outcomes: At the end of the course, student will be able to

CO1 Understand Linear Programming models

CO2 Interpret Transportation and sequencing problems

CO3 Solve replacement problems and analyze queuing models

CO4 Understand game theory and inventory problems

CO5 Interpret dynamic programming and simulation.

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 tools to characterize 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 nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

UNIT – 3

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

UNIT – 4

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

UNIT – 5

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

TEXT BOOKS:

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

REFERENCE BOOKS:

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

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

CO1 Understand the classification of nanostructured Materials

CO2 Understand the unique properties of nano materials

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

CO4 Identify the tools to characterize nano materials

CO5 Understand the applications of nano materials

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- Boltzmann Law – Kirchoff's law and Emissivity – Radiation between Black Isothermal Surfaces – Radiation between Grey Isothermal Surfaces – Extreme Climatic conditions - Radiation at normal ambient Temperature measurement and its Instrumentation.

UNIT – 3

Printed Circuit boards – Chip packaging – thermal Resistance – Board Cooling methods – Board thermal Analysis – Equivalent thermal Conductivity.

Air Cooling – Fans – Heat transfer Enhancement – Air handling systems - Blowers

Single Phase Cooling – Coolant Selection – Natural Convection – Forced Convection - Air Cooling - Convective cooling in Small systems – Forced cooling in medium and large systems – Liquid cooling in high power modules – Case Studies.

UNIT – 4

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

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

UNIT – 5

Thermo Electric coolers: Basics theories – Thermo electric effect – Operation Principles. Phase change materials, Thermal Interface materials, Heat Spreaders and Heat Sinks – Working Principles

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

Text Books:

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

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

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

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

Course objective:

1) To develop and strengthen entrepreneurial quality and motivation in students.
2) To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.

UNIT-I : ENTREPRENEURAL COMPETENCE

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.

UNIT-II: ENTREPRENEURAL ENVIRONMENT

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organisational Services.

UNIT-III: INDUSTRIAL POLACIES

Central and State Government Industrial Policies and Regulations - International Business.

UNIT-IV: BUSINESS PLAN PREPARATION

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

UNIT- V: LAUNCHING OF SMALL BUSINESS

Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.

Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.

TEXT BOOKS

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.

REFERENCES

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

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

COURSE OUTCOME: Students will gain knowledge and skills needed to run a 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) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Saybolt Viscometer and (ii) Redwood Viscometer.
5. Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
6. To perform the Heat Balance Test on Single Cylinder four Stroke Petrol/Diesel Engine.
7. To conduct a load test on a single cylinder Petrol/Diesel engine to study its performance under various loads.
8. To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.
9. To conduct a performance test on an air compressor and determine its different efficiencies.
10. Study of boilers with accessories and mountings
11. Experimentation on installation of Solar PV Cells
12. Demonstration of electronic controls in an automobile.

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

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 6 experiments from each lab

MACHINE TOOLS LAB

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

METROLOGY LAB

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

Course Outcomes: 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 leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of experiments:

1) Make your own parallel and series circuits using breadboard for any application of your choice.
2) Demonstrate a traffic light circuit using breadboard.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinkercad.
5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
6) Interfacing IR Sensor and Servo Motor with Arduino.
7) Blink LED using ESP32.
8) LDR Interfacing with ESP32.
9) Control an LED using Mobile App.
10) Design and 3D print a Walking Robot
11) Design and 3D Print a Rocket.
12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
13) Demonstrate all the steps in design thinking to redesign a motor bike.

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**