

VI Semester Syllabi – Mechanical Engineering

Sr. No.	Course Code	Course Name	L	T	P	Credits
1.	ME3CO14	CAD/CAM/CIM	4	0	2	5
2.	ME3CO15	I C Engines	3	1	2	5
3.	ME3CO16	Refrigeration and Air	3	1	2	5
4.		EL-03	3	0	0	3
5.		EL-04	3	0	0	3
6.	EN3MC01	Self Study(MOOC)	1	0	0	0
7.		OE-02	3	0	0	3
		Total	20	2	6	24
		Total Contact Hours	28			

Program Elective VI-1

ME3EL02 Mechanical Vibrations

Program Elective VI-2

ME3EC02 Flexible Manufacturing Systems
ME3EI01 Production Planning and Control
ME3EE03 Energy Auditing and Management
ME3EM05 Sensors and Actuators

Open Elective – II (Offered by Mechanical Department

Advanced Entrepreneurship
Renewable Sources of Energy
Building Maintenance & Repairs
Water & Waste Water Engineering
Engineering Geology
Transportation Engineering
Linear Integrated Circuit
Data Communication
Introduction to System Automation



Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3CO14	CAD/CAM/CIM	4	0	2	5

UNIT I

Introduction: Information requirements of mfg organizations; business forecasting and aggregate production plan; MPS, MRP and shop floor/ Production Activity Control (PAC); Mfg as a system, productivity and wealth creation; production processes on volume-variety axes; importance of batch and job shop production; CIM definition and CIM wheel, evolution and benefits.

UNIT II

Product Life Cycle (PLC) mgt: Design for mfg (DFM) and concurrent engg; product design in conventional and CIM environment; terms like CAD, CAE, CAM, CAP, CAPP, CATD and CAQ.

UNIT III

Numeric control and part programming: Principles of NC machines, CNC, DNC; NC modes of point to point, -line and 2D, 3D contouring; NC part programming; ISO standard for coding, preparatory functions(G)- motion, dwell, unit, preset, cutter compensation, coordinate and plane selection groups; miscellaneous (M) codes; CLDATA and tool path simulation; ISO codes for turning tools and holders; ATC, modular work holding and pallets; time and power estimation in milling, drilling and turning; adaptive control, sequence control and PLC; simple part programming examples.

UNIT IV

Group Technology: Importance of batch and job shop production; merits of converting zigzag process layout flow to smooth flow in cellular layout, Production Flow Analysis (PFA) and clustering methods; concept of part families and coding; hierarchical, attribute and hybrid coding; OPITZ, MICLASS and DCLASS coding; FMS; material handling; robots, AGV and their programming; agile mfg; Computer Aided Process PLANNING (CAPP), variant/ retrieval and generative approach

UNIT V

Rapid Prototyping: Introduction, basic concepts, Need - Development of Rapid Prototyping systems, Rapid Prototyping process chain - Impact of Rapid Prototyping on Product Development - Digital prototyping - Virtual prototyping- Rapid Tooling - Benefits-Applications. Stereolithography (SLA), Solid Ground Curing (SGC), Fused deposition Modeling (FDM), Laminated object manufacturing (LOM), Selective Laser Sintering (SLS), Powder based 3DP systems.

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Text Books

1. S.Kant Vajpay; Principles of CIM; PHI
2. PN Rao CAD/CAM;TMH
3. MP Groover ; Automation, Production Systems & CIM; P.I.I.L.

Reference Books

1. PN Rao , NK Tiwari , TK Kundra ; Computer Aided Manufacturing; TMH
2. A Alavudeen, N Venkateshwar; Computer Integrated Mfg; PHI
3. P Radhakrishnan, S Subramanian and V Raju ; CAD/CAM/CIM; New age Pub

List of Practical

1. Basic concepts of CAD/CAM
2. Study and development of 2 D model on CAD software (SolidEdge).
3. Study and development of 3 D model on CAD software (SolidEdge).
4. Study of Part Programming fundamentals and G & M codes.
5. Manual part programming for CNC lathe and simulation.
6. Manual part programming for CNC milling and simulation.
7. Part program generation by CAM software (UGCAM).
8. Study of Group technology and part families.
9. Study of Computer Aided Process Planning.
10. Study of Flexible Manufacturing System
11. A Case study on 'CIM model for a modern industry CNC application.



Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3CO15	IC Engines	3	1	2	5

UNIT I

Introduction: Basic components and terminology of IC engines, working of four stroke/two stroke - petrol/diesel engine, cylinder arrangement, determination of engine dimensions, speed and engine hypothetical/actual performance parameters of IC Engines, Valve timing diagram and firing order.

Fuel Air Cycles and Actual Cycles; Assumptions for fuel-air cycles, Reasons for variation of specific heats of gases, isentropic expansion with variable specific heats, effect of variable specific heats on Otto, Diesel and Dual cycle, dissociation, comparison of air standard and fuel air cycles, effect of operating variables, comparison of air standard and actual cycles, effect of time loss, heat loss and exhaust loss in Petrol and Diesel engines.

UNIT II

Combustion in SI engines: Stages of combustion – Normal and Abnormal combustion - Flame development and propagation, ignition lag, effect of air density, temperature, engine speed, turbulence and ignition timings, Knock - Factors affecting knock, physical and chemical aspects of knocking, effect of engine and fuel variables on knocking tendency, H.U.C.R., action of dopes, pre-ignition, its causes and remedy, salient features of various type combustion chambers,

UNIT III

Combustion in CI engines: Stages of combustion – Normal and Abnormal combustion - delay period, factors affecting delay period as compression ratio, injection timing, its duration, Detonation in C.I. engines, factors affecting detonation, controlling detonation, comparison of abnormal combustion in SI and CI engine, Salient features of various types of combustion chambers (DI and IDI type)

UNIT IV

Measurement and Testing of IC engines: Measurement of indicated power, brake power, fuel consumption and emission, Measurement of friction power by Willan's Line Method and Morse Test, and heat balance sheet of IC Engines. Octane and Cetane number.

UNIT V

Supercharging: Need for supercharging, Effect of supercharging, types of supercharger, methods of supercharging, limitations of supercharging, low and high pressure super charging, turbo charging.

Text Books

1. V. Ganeshan, Internal Combustion Engines, McGraw Hill Education Pvt Ltd.
2. P.W Gill, J.H. Smith, E.J. Ziury Fundamentals of Internal Combustion Engines
3. H.N. Gupta, Fundamentals of Internal Combustion engine, PHI Learning.

J.K. Law

Reference Books

1. J.B.Heywood, Internal Combustion Engine Fundamentals
2. C.F.Taylor, The Internal Combustion Engine in Theory and Practice: Vol. 1 & 2
3. W.W Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine
4. S.S.Thapse, Alternate Fuels, JAICO Publishing House.

List of Practical

1. Study of Carburetor.
2. Study of Fuel Injection System in SI engine (MPFI System)
3. Study of Battery Ignition System.
4. Study of Electronic Ignition System.
5. Study of Diesel Fuel pump.
6. Study of Diesel fuel injector.
7. Study of Lubrication System in IC Engine.
8. Study of Determination valve timing Diagram (4 stroke CI Engine)
9. Draw a Heat balance sheet for a 4 stroke diesel engine and determine its performance parameters.
10. To Carry out Morse test on a multi cylinder spark ignition engine at constant speed to find out its Indicated power & Mechanical efficiency.

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3CO16	Refrigeration and Air Conditioning	3	1	2	5

UNIT I

Introduction and Air Refrigeration cycles: Different methods of refrigeration, COP, Tone of refrigeration, Carnot cycle with air as a refrigerant, Joule's cycle or Bell Coleman cycle, Boot-strap cycle, reduced ambient cycle and regenerative cooling cycles. Refrigerants: nomenclature & classification, desirable properties, common refrigeration, Environment friendly refrigerants.

UNIT II

VCR Cycles: Carnot cycle with vapor as a refrigerant, VCR cycle with p-v and T-s diagram, p-h diagram, sub-cooling and super heating, effects of condenser and evaporator pressure on cop, Actual VCR cycle on T-s and p-h diagram.

UNIT III

Multi Pressure system, Control Device and Vapor Absorption System: Removal of flash gas, Multiple expansion & compression with flash inter cooling; Low temperature refrigeration: Production of low temperatures, Cascade system. Thermostatic expansion valve, Automatic expansion valve, capillary tube. Vapour absorption system: Theoretical and practical systems such as aqua-ammonia, Electrolux & other systems.

UNIT IV

Psychrometric and Comfort Air Conditioning: Air properties, Psychrometric chart, Psychrometric processes: Sensible heating and cooling, Evaporative cooling, Cooling and dehumidification, Heating and humidification, Mixing of air stream, Sensible heat factor. Comfort Air Conditioning; Mechanism of Body Heat Loss, Unit of Metabolic Heat Generation, Comfort Index, Effective Temperature, Comfort Chart & Thermal Sensation, Comfort chart.

UNIT V

Air Conditioning system and Air Conditioning Loads: Air conditioning system & its Types, Air conditioning loads: calculation of summer & winter air conditioning load, bypass factor of coil, calculation of supply air rate & its condition, room sensible heat factor, grand sensible heat factor, effective sensible heat factor, dehumidified air quantity. Problems on cooling load calculation.

Text Books:

1. C.P. Arora, Refrigeration and Air conditioning, TMH
2. E.G. Pita, Air Conditioning Principles and systems, Parson Education Pte. Ltd.
3. R.Rajpt, Refrigeration and Air conditioning

AKL

Reference Books:

1. M. Prasad, Refrigeration & Air Conditioning, New Age International (P) Limited,
2. PL Balani, Refrigeration & Air conditioning, Khanna Publishers, 2-B Nath Market, Nai Sadak, Delhi - 110006
3. W.F. Stoecker, Refrigeration and Air conditioning, McGraw-Hill Book Company

List of Practicals:

1. Determination of COP of three fluid ELECTROLUX absorption refrigeration systems.
2. Study of various components and working of simple vapor compression cycle refrigeration trainer.
3. Determination of COP of simple vapor compression cycle refrigeration system on the trainer.
4. Study of various components and working of thermoelectric based refrigeration system on TCL hot & cold water dispenser.
5. Study of various components and working of air conditioning system on re-circulated type trainer.
6. Plotting the change in the psychometric properties of air under sensible heating, sensible cooling and heating with humidification; on re-circulated type air conditioning trainer
7. Study the various components and working of window air conditioning system.
8. Study the various components and working of three fluid ELECTROLUX absorption refrigeration system.
9. Study of Steam Jet Refrigeration system.
10. Study of control devices

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3EC02	Program Elective VI-2 Flexible Manufacturing Systems	3	0	0	3

UNIT I FMS Introduction and Description

Limitations with conventional manufacturing, Need for FMS Introduction, Definition, Basic Component of FMS, Significance of FMS, General layout and configuration of FMS, Principle Objectives of FMS, Benefits and limitations of FMS, Area of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology, Hierarchy of CIM, FMS Justification

UNIT II Manufacturing Cell

Introduction, Description and Classifications of Cell, Unattended Machining, Cellular versus Flexible Manufacturing, JIT and KANBAN System

UNIT III Automated Material Movement and Storage System

Introduction, Types of AGV and Their principle of working, Advantages, Limitation and General AGV Guide path, Robots, Benefits of using Industrial Robots, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet Flotation System, Queuing Carrousel and Automatic Work Changers, Coolant and Chip Disposal and Recovery system

UNIT IV Coordinate Measuring Machines

Introduction, Types, Construction and General Functions of CMM, Operational Cycle Description, CMM Applications, Importance to Flexible Cells and Systems

UNIT V FMS Installation and Implementation

Methods and practical applications, FMS Installation, FMS Implementation, Case Studies

Text Books

1. Vikash Sharma, "Fundamental of CAD/CAM/CIM", S K Katariya Sons, 2010
2. David J. Parrish, "Flexible Manufacturing" Butterworth-Heinemann, 1990.
3. H K Shivanand, M M Benal, V Koti, "Flexible Manufacturing System" New Age International

Reference Books:

1. Paul Ranky, "The design and operation of FMS", IFS publication, 1983.
2. Computer Aided Manufacture by Chien Chang and Richard A Wysk, Prentice HALL.
3. G.T. in the engineering industry Burbridge.

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3EM05	Program Elective VI-2Sensors and Actuators	3	0	0	3

To be prepared by EC Department

Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3EI01	Program Elective VI-2 Production Planning and Control	3	0	0	3

UNIT I

Introduction: Objectives and benefits of planning and control-Functions of production control, Types of production, job, batch and continuous, Product development and design, Marketing aspect, Functional aspects, Operational aspect, Durability and dependability aspect aesthetic aspect, Profit consideration, Standardization, Simplification.

UNIT II

Process Design: Systems approach to process planning and design, linkage between product planning and process planning, distinction between process planning and facilities planning, types of process design, process design procedure. Break even analysis-Economics of a new design.

UNIT III

Forecasting: characteristics of demand over time, forecasting qualitative model: Delphi, naive quantitative models: simple average, simple moving average, weighted moving average, exponential smoothing, smoothing coefficient selection, adaptive exponential smoothing, incorporating trend and seasonal components, linear regression, selection of forecasting models.

UNIT IV

Production Scheduling: Production Control Systems, Loading and scheduling, Master Scheduling, Scheduling rules, Gantt charts-Perpetual loading, Basic scheduling problems, Line of balance, Flow production scheduling, Batch production scheduling, Product sequencing, Production Control systems, Periodic batch control, Routing, Loading, Scheduling, forward and backward, Dispatching, priority rules, Sequencing, Johnson's algorithm for n jobs and two machines, Gantt's chart, Bar chart, Flow process chart.

UNIT V

Work Study: Method study, basic procedure, Selection-Recording of process, Critical analysis, Development, Implementation, Micro motion and memo motion study, work measurement, Techniques of work measurement, Time study, Production study, Work sampling, Synthesis from standard data, Predetermined motion time standards.

Text Books

1. V. Thomas , B. William, D Clay, "Manufacturing Planning and Control Systems" Galgotia Publications, New Delhi.
2. W.J. Stevensons, Operations Management, Mc-Graw Hills.
3. M.Telsang, Industrial Engineering and Production Management, S. Chand Publications.

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References

1. Introduction to Work Study by ILO.
2. S.N. Chapman, Fundamentals of Production Planning and Control, Pearson
3. L. C. Jhamb, Production Planning and Control, Everest Publishing House

Jhamb

Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3EE03	Program Elective VI-2Energy Auditing and Management	3	0	0	3

UNIT-I

Energy Audit Methodology and recent trends.: General Philosophy, need of Energy Audit and Management. Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy. Economics of implementation of energy optimization projects. Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy

UNIT-II

Electrical Distribution and Utilization: Electrical Systems, Transformers loss reductions, parallel operations, T & D losses, P.F. improvements, Demand Side management (DSM), Load Management, Harmonics & its improvements, Energy efficient motors and Soft starters, Automatic power factor Controllers, Variable speed drivers, Electronic Lighting ballasts for Lighting, LED Lighting, Trends and Approaches.

UNIT-III

Thermal Systems: Boilers performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Advances in boiler technologies, FBC and PFBC boilers, Heat recovery, Boilers limitations and constraints.

UNIT-IV

System Audit of Mechanical Utilities: Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems. Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages.

UNIT-V

Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system & economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers.

Text Books

1. Energy Audit and Management, Volume-I, IECC Press
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press
3. W.R.Murphy, G.Mckay, Energy Management, Butterworths Scientific
4. C.B Smith, Energy Management Principles, Pergamon Press

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Reference Books

1. D.A. Reay , Industrial Energy Conservation, Pergammon Press
2. W.C. Turner , Energy Management Handbook, John Wiley and Sons,
3. L.C. Witte, P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington, 1988
4. A. Thumann, P.E., C.E.M. William J. Younger, C.E.M Hand Book of Energy Audits,, CRC Press

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
EN3MC01	Open Learning Course	1	0	0	0

Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
ME3EL02	Program Elective VI-IMechanical Vibrations	3	0	0	3

UNIT I

Basics Of Vibration: Basic concepts of vibrations, causes and effects of vibrations, applications of vibration Classification of Vibrations, Basic elements of vibratory system - spring, mass, damper. Degree of freedom, Mathematical modeling of physical systems, Formulation of differential equations by various principles and determination of natural frequency of undamped SDOF vibratory system

UNIT II

FreeDampedVibration : Damping and its Classification- viscous, coulomb, slip and structural damping, derivation of differential equation under damped, critically damped and over damped SDOF vibratory system, Logarithmic decrement. Derivation for coulomb's damping and rate of decay of amplitude.

UNIT III

Forced Vibration System: Forced single degree of freedom vibration system, analysis of linear and torsional vibratory systems subjected to harmonic force, vector representation of forces in the system, vibration isolation and transmissibility ratio for systems subjected to excitation of support, concept of absolute and relative motion.

UNIT IV

Two and Multi Degree of Freedom System : Derivation of governing equations, natural frequencies and mode shapes for 2 DOF vibratory system, concept of semidefinite system and coordinate coupling, Determination of natural frequency of multi degree of freedom system using - matrix method, method of Influence coefficients and Rayleigh's method

UNIT V

Vibration Measuring Instruments: Principle of seismic instruments- Vibrometer, accelerometer, sensors used in vibration measurement. Introduction to FFT analyser, Introduction to condition Monitoring and Fault diagnosis.

Text Books:

1. S. S. Rao, Mechanical Vibrations, Pearson Education, Fourth edition, 2009.
2. A. G. Ambekar, Mechanical Vibrations, PHI Learning, First edition, 2010.
3. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, Eighth Edition, 2009.

Reference Books

1. V. Rao Dukkipati and J. Srinivas, Mechanical Vibrations, Second Edition, PHI Learning
2. G. Kelly, Mechanical Vibrations, Schaum's outline series, Tata McGraw Hill, Special Edition, 2007.
3. W.T. Thomson, Theory of vibrations with applications, CBS Publishers, Delhi, 2003.

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
OE00035	Open Elective -IIAdvanced Entrepreneurship	3	0	0	3

UNIT I

Orientation to Growth: Getting Ready for Growth, Why growth stage is different compared to startup phase, Why Product-Market fit is not enough, Case study, To assess readiness for growth, To chart a growth path

UNIT II

Customers: Expanding Customer Base-Revisit your business model and develop few variants (more business model types), Identify additional customer segments that your solution can address, Evaluate business models for the new customer segments, Re-look at the Problem Statement (can you expand the scope and scalability of your business by repositioning your problem statement?), Explore additional ways to monetize

UNIT III

Traction: Scaling-How to gain traction beyond early customers, Defining traction (in quantifiable terms) and identifying the most important metrics to measure traction, Calculate cost of new customer acquisition, Estimate your customer lifetime value (LTV), Identifying waste in your operations and focusing your team on what is important for traction

Channels and Strategy- The Bullseye framework Identify Channels using Bulls Eye Framework Measuring the effectiveness of selected channels Budgeting and planning

UNIT IV

Money:Growing Revenues-Stabilizing key revenue streams, Developing additional revenue streams (licensing, franchising), Exploring new channels and partnerships

Sales Planning-Understanding why customers buy and how buying decisions are made; Listening skills, Sales planning, setting targets, Unique Sales Proposition (USP); Art of the sales pitch (focus on customer's needs, not on product features) Follow-up and closing a sale; Asking for the sale

Strengthening Sales-Building a professional sales team, Sales compensation and incentives, Sales planning, setting targets

Improving Margins-Testing price elasticity, Optimizing costs and operational expenses, Advanced concepts of unit costing

Financial Modeling-Financial modeling of your venture's growth, Analyzing competitor and peer's financial models

UNIT V

Support: Legal-Overview of legal issues and their impact on entrepreneurs, Importance of getting professional help (legal and accounting), Importance of being compliant and keeping proper documentation, Patents and Intellectual property, Trademarks

Mentors, Advisors, and Experts-The importance of a Mentor and how to find one, Role of business advisors and experts for specific targets in your growth plan

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Text Books

1. A. Mathur, Entrepreneurship, Taxmann, 2017 edition.
2. V. Desai, Fundamentals of Entrepreneurship & small business management, Himalaya Publishing House.
3. Entrepreneurial Development by S.S. Khanka, S. Chand Publication.
4. Dr. P.T. Vijayashree & M. Alagammai, Entrepreneurship Development & small business management, Margham Publications; 2016 edition.

References

1. S.Shane, A General theory of entrepreneurship: The individual opportunity nexus, Edward Elgar Publication.
2. J. A. Timmons & S. Spinelli, New Venture Creation: Entrepreneurship for the 21st century, McGraw-Hill
3. R.D Hisrich and M Peters, Entrepreneurship (6th Edition), McGraw-Hill.

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Course Code	Course Name	Hours per Week			Total
		L	T	P	Credits
OE00036	Open Elective –II Renewable Sources of Energy	3	0	0	3

Unit-I

Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Unit-II

Solar Energy: Energy from Sun, Types of Solar Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish, Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Solar Cookers, Solar pond. Solar Cells: Components of Solar Cell System

Unit-III

Wind Energy: Windmills, Wind Turbines, Wind Resources, Wind Turbine Site Selection. **Geothermal Energy:** Geothermal Systems, Classifications, Geothermal Resource Utilization Geothermal Based Electric Power Generation
Solid waste and Agricultural Refuse: Waste Recovery Management Scheme, Advantages and Disadvantages of Waste Recycling, Sources and Types of Waste, Recycling of Plastics.

Unit-IV

Biomass Energy: Biomass Production, Energy Plantation, Biomass Gasification, Updraft and Downdraft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier.

Biogas Energy: Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas,

Unit-V

Ocean Thermal Energy: Introduction, Principles of Ocean Thermal Energy Conversion (OTEC), Ocean Thermal Energy Conversion plants,

Tidal Energy: Introduction, Tidal Energy Resource, Tidal Energy Availability, Tidal Power Generation in India

Text Books

1. Kothari, Singal & Rajan; Renewable Energy Sources and Emerging Technologies, PHI
2. B.H Khan, Non Conventional Energy, TMH.

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3. Sukhatme and Nayak, Solar Energy, Principles of Thermal Collection and Storage, TMH.
4. Tiwari and Ghosal, Renewable Energy Resources: basic principle & application, Narosa Publication.

Reference Books

1. K. Rao, Energy Resources, Conventional & Non-Conventional, BSP Publication.
2. C.S.Solanki, Solar Photovoltaics: Fundamental, technologies and Application, PHI
3. A.Tasneem and SA Abbasi, Renewable Energy Sources; PHI Learning.

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