COURSE STRUCTURE & DETAILED SYLLABUS

MECHANICAL ENGINEERING

B. TECH FOURTH YEAR SECOND SEMESTER

(Applicable for the batches admitted from 2020-2021)

ACE

Engineering College

Ankushapur(V), Ghatkesar(M), Medchal Malkajgiri (Dist.), Telangana - 501 301.

(An Autonomous Institution, Affiliated to JNTUH ,Hyderabad)

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Ankushapur(V), Ghatkesar(M), Medchal Malkajgiri Dist - 501 301
(Autonomous)

B.TECH. FOURTH YEAR SECOND SEMESTER
MECHANICAL ENGINEERING
COURSE STRUCTURE

IV Year							II Semester
S.No.	Course Type	Course Code	Course Title	Periods Per Week			Credits
				L	T	P	
1	PEC		Professional Elective – V	3	0	0	3
2	PEC		Professional Elective - VI	3	0	0	3
3	OEC		Open Elective - III	3	0	0	3
4	PROJ	ME801PC	Project Stage - II	0	0	14	7
Total				**9**	**0**	**14**	**16**

Professional Elective – I	
ME611PE	Unconventional Machining Processes
ME612PE	Machine Tool Design
ME613PE	Production Planning & Control

Professional Elective – II	
ME711PE	Additive Manufacturing
ME712PE	Automation in Manufacturing
ME713PE	MEMS

Professional Elective – III	
ME721PE	Power Plant Engineering
ME722PE	Automobile Engineering
ME723PE	Renewable Energy Sources

Professional Elective – IV	
ME731PE	Computational Fluid Dynamics
ME732PE	Turbo Machinery
ME733PE	Fluid Power Systems

Professional Elective – V	
ME811PE	Industrial Robotics
ME812PE	Mechanical Vibrations
MM813PE	Composite Materials

Professional Elective – VI	
ME821PE	Industrial Management
ME822PE	Production and Operations Management
ME823PE	Tribology

Open Elective -I	
ME600OE	Quantitative Analysis for Business Decisions

Open Elective-II	
ME700OE	Basic Mechanical Engineering

Open Elective-III	
ME800OE	Non-Conventional Sources of energy

ME811PE: INDUSTRIAL ROBOTICS (PE – V)

B.Tech.IV Year II Semester

Course Code	Category	Hours/Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
ME811PE	Core	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

Prerequisite: Basic principles of Kinematics and mechanics

Course Objectives:

1. To enable the students to acquire practical experience in the field of Robotics through design projects and case studies.
2. To make the students to understand the importance of robots in various fields of engineering.
3. To expose the students to various robots and their operational details.
4. To learn robot programming and industrial applications of robots.
5. To make the understand the application of robots in manufacturing.

Course Outcomes:

Upon Completion of this course, students will be able to:

1. Understand the basic components of robots.
2. Differentiate types of robots and robot grippers.
3. Model forward and inverse kinematics of robot manipulators.
4. Analyze forces in links and joints of a robot.
5. Programme a robot to perform tasks in industrial applications. Design intelligent robots using sensors.

UNIT – I

Introduction: Automation and Robotics – An over view of Robotics – present and future applications. **Components of the Industrial Robotics:** common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity.

UNIT – II

Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems.

Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and

world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulators.

UNIT – III

Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.

Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion

-straight line motion.

UNIT – IV

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors – End Effectors and Tools.

UNIT – V

Robot Application in Manufacturing: Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

Text Books:

1. Industrial Robotics / Groover M P /Mc Graw Hill.
2. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson.

Reference Books:

1. Robot Dynamics and Controls / Spony and Vidyasagar / John Wiley.
2. Robot Analysis and control / Asada, Slotine / Wiley Inter-Science.
3. Robotics – Fu et al / TMH Publications.

ME812PE: MECHANICAL VIBRATIONS (PE – V)

B.Tech.IV Year II Semester								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
ME812PE	**Core**	3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		

Prerequisite: Engineering Mechanics

Course Objective:

1. To Understand various levels of vibrations and remedies for each of them.
2. To learn the concept of simple harmonic motion, basics of mechanical vibrations.
3. To determine a complete solution of modeled mechanical vibration problems.
4. To be able to mathematically model real-world mechanical vibration problems.
5. To compute the natural frequencies and mode shapes of a multi degree of freedom system and explain the modal analysis of a vibrating system.

Course Outcomes:

Upon Completion of this course, students will be able to:

1. Determine the natural frequency of transverse vibrations of the shaft and torsional vibrations of rotor systems.
2. Understand the causes and effects of vibration in mechanical systems.
3. Develop schematic models for physical systems and formulate governing equations of motion.
4. Understand the role of damping, stiffness and inertia in mechanical systems Analyze rotating and reciprocating systems and compute critical speeds.
5. Analyze and design machine supporting structures, vibration isolators and absorbers.

UNIT – I

Single degree of Freedom systems - I: Undamped and damped free vibrations; forced vibrations coulomb damping; Response to excitation; rotating unbalance and support excitation; vibration isolation and transmissibility.

UNIT - II

Single degree of Freedom systems - II: Response to Non-Periodic Excitations: unit impulse, unit step and unit Ramp functions; response to arbitrary excitations, The Convolution Integral; shock spectrum; System response by the Laplace Transformation method.

UNIT – III

Two-degree freedom systems: Principal modes- undamped and damped free and forced vibrations; undamped vibration absorbers;

Multi degree freedom systems: Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time systems.

UNIT – IV

Continuous system: Free vibration of strings – longitudinal oscillations of bars- traverse vibrations of beams- Torsional vibrations of shafts.

Critical speeds of shafts: Critical speeds without and with damping, secondary critical speed. **Numerical Methods:** Rayleigh's stodola's, Matrix iteration, Rayleigh- Ritz Method and Holzer's methods.

Vibration measuring instruments: Vibrometers, velocity meters & accelerometers.

UNIT – V

Sound level and subjective response to sound: Subjective response to sound, frequency dependent human response to sound, sound-pressure dependent human response, the decibel scale, relationship among sound power, sound intensity and sound pressure level, relationship between sound power level and sound intensity, relationship between sound intensity level and sound pressure level, sound measuring instruments.

Textbooks:

1. Elements of Vibration Analysis / Meirovitch/ Mc Graw Hill.
2. Principles of Vibration / Benson H. Tongue/Oxford.

Reference Books:

1. Mechanical Vibrations / SS Rao / Pearson.
2. Mechanical Vibration /Rao V. Dukkipati, J Srinivas/ PHI.
3. Mechanical Vibrations/ G.K. Grover/ Nemchand & Brothers.

MM813PE: COMPOSITE MATERIALS (PE – V)

B.Tech.IV Year II Semester								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
MM813PE	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		

Course Objectives:

1. Develop understanding of the structure of ceramic materials on multiple length scales.
2. Develop knowledge of point defect generation in ceramic materials, and their impact on transport properties.
3. Enlighten the students in different types of reinforcement.
4. To describe key processing techniques for producing metal, ceramic, and polymer-matrix composites.
5. To demonstrate the relationship among synthesis, processing, and properties in composite materials.

Course Outcomes:

1. Knowledge of the crystal structures of a wide range of ceramic materials and glasses.
2. Know various types of composite materials and their practical importance.
3. Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure.
4. Able to select matrices for composite materials in different applications.
5. Able to describe key processing methods for fabricating composites.

UNIT – I

Introduction: Definition, Classification of Composite materials based on structure, based on matrix, Advantages of composites, Applications of composites, Functional requirements of reinforcement and matrix.

UNIT – II

Types of reinforcements and their properties: Fibers: Carbon, Boron, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres, Comparison of fibres. Role of interfaces: Wettability and Bonding, The interface in Composites, Interactions and Types of bonding at the Interface, Tests for measuring Interfacial strength.

UNIT – III

Fabrication of Polymeric Matrix Composites, Structure and properties of Polymeric Matrix Composites, Interface in Polymeric Matrix Composites, Applications; Fabrication of Ceramic Matrix Composites, Properties of Ceramic Matrix Composites, Interface in Ceramic Matrix Composites, Toughness of Ceramic Matrix Composites Applications of Ceramic Matrix Composites.

UNIT – IV

Fabrication of Metal Matrix Composites: Solid state fabrication, Liquid state fabrication and In-situ fabrication techniques; Interface in Metal Matrix Composites: Mechanical bonding, Chemical bonding and Interfaces in In-situ Composites; Discontinuously reinforced Metal Matrix Composites, Properties and Applications. Fabrication of Carbon fiber composites, properties, interface and applications.

UNIT – V

Micromechanics of Composites: Density, Mechanical Properties: Prediction of Elastic constants, Micro mechanical approach, Halpin-Tsai equations, Transverse stresses; Thermal properties: Hydrothermal stresses and Mechanics of Load transfer from matrix to fiber.

Text Books:

1. Composite Materials – Science & Engineering, K.K. Chawla, Springer-Verlag, New York, 1987.
2. An Introduction to Composite Materials, Hull, Cambridge, 2nd Edt. 1997.

Reference Books:

1. Composites, Engineered Materials Handbook, Vol. 1, ASM International, Ohio, 1988.
2. Structure and Properties of Composites, Materials Science and Technology, Vol. 13, VCH, Weinheim, Germany, 1993.
3. Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London, 1994.

ME821PE: INDUSTRIAL MANAGEMENT (PE – VI)

B.Tech.IV Year II Semester								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
ME821PE	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		

Prerequisite: None

Course Objective:

1. Understand the philosophies of management gurus.
2. Understand the various types of organization structures and their features, and Their advantages and disadvantages.
3. Understand plant location and plant layout.
4. Understand value analysis.
5. Learning various Industrial Engineering Practices like Operations Management techniques, work study, statistical quality control techniques, Job evaluation techniques and network analysis techniques.

Course Outcomes:

1. Able to apply principles of management.
2. Able to design the organization structure.
3. Able to apply techniques for plant location, design plant layout and valueanalysis.
4. Able to carry out work study to find the best method for doing the work and establish standard time for a given method.
5. Able to apply various quality control techniques and sampling plans.
6. Able to do job evaluation and network analysis.

UNIT – I

Introduction to Management: Entrepreneurship and organization – Nature and Importance of Management, Functions of Management, Taylor's Scientific Management Theory, Fayol's Principles of Management, Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation, Systems Approach to Management, Leadership Styles, Social responsibilities of Management.

UNIT – II

Designing Organizational Structures: Departmentalization and Decentralization, Types of Organization structures –

Line organization, Line and staff organization, functional organization, Committee organization, matrix organization, Virtual Organization, Cellular Organization, team structure, boundary less organization, inverted pyramid structure, lean and flat organization structure and their merits, demerits and suitability.

UNIT – III

Operations Management: Objectives- product design process- Process selection-Types of production system (Job, batch and Mass Production), Plant location-factors- Urban-Rural sites comparison- Types of Plant Layouts- Design of product layout- Line balancing (RPW method) Value analysis-Definition-types of values- Objectives- Phases of value analysis-Fast diagram.

UNIT - IV:

Work Study: Introduction — definition — objectives — steps in work study — Method study — definition, objectives —steps of method study. Work Measurement — purpose — types of study — stop watch methods — steps — key rating — allowances — standard time calculations — work sampling.

Statistical Quality Control: variables-attributes, Shewart control charts for variables- chart, R chart,

– Attributes- Defective-Defect- Charts for attributes-p-chart -c chart (simple Problems), Acceptance Sampling- Single sampling- Double sampling plans-OC curves.

UNIT – V

Job Evaluation: Methods of job evaluation — simple routing objective systems — classification method factor comparison method, point method, benefits of job evaluation and limitations. **Project Management (PERT/CPM):** Network Analysis, Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Identifying critical path, Probability of Completing the project within given time, Project Cost Analysis, Project Crashing. (simple problems)

Text Books:

1. Industrial Engineering and Management/O.P. Khanna/Khanna Publishers.
2. Industrial Engineering and Management Science/T.R. Banga and S.C. Sarma/Khanna Publishers.

Reference Books:

1. Motion and Time Study by Ralph M Barnes! John Willey & Sons Work Study by lLO.
2. Human factors in Engineering & Design/Ernest J McCormick /TMH.
3. Production & Operation Management /Paneer Selvam/PHI
4. Industrial Engineering Management/NVS Raju/Cengage Learning.
5. Industrial Engineering Hand Book/Maynard.
6. Industrial Engineering Management I Ravi Shankar/Galgotia.

ME822PE: PRODUCTION AND OPERATIONS MANAGEMENT (PE – VI)

B.Tech.IV Year II Semester								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
ME822PE	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		

Prerequisite: None

Course Objective:

1. Learn the importance of studying the subject: Production and Operations Management.
2. Learn the characteristics of various types of production systems and understand the current issues of operations Management.
3. Understand the procedure for product design & approaches for product development.
4. Learn the procedure to carry out value analysis by different methods.
5. Learn the methods for location of plant and plant layouts.
6. Understand the procedures for aggregate planning, MRP and JIT.
7. Learn the procedures for scheduling.
8. Learning the techniques for network analysis.

Course Outcomes:

1. Able to execute operations management functions.
2. Able to carry out value analysis.
3. Able to carry out aggregate planning and implement MRP Or JIT.
4. Able to schedule the jobs so as to complete them in minimum make span time.
5. Able to carry out network analysis.

UNIT – I

Operation Management – Definition – Objectives – Types of production systems – historical development of operations management – Current issues in operation management.

Product design – Requirements of good product design – product development – approaches – concepts in product development – standardization – simplification – Speed to market – Introduction to concurrent engineering.

UNIT - II

Value engineering – objective – types of values – function & cost – product life cycle- steps in value engineering – methodology in value engineering – FAST Diagram – Matrix Method.

Location – Facility location and layout – Factors considerations in Plant location- Comparative Study of rural and urban sites – Methods of selection plant layout – objective of good layout – Principles – Types of layout – line balancing.

UNIT – III

Aggregate Planning – definition – Different Strategies – Various models of Aggregate Planning – Transportation and graphical models.

Advance inventory control systems push systems – Material Requirement – Terminology – types of demands – inputs to MRP- MRP logic – Lot sizing methods – benefits and drawbacks of MRP – Manufacturing Resources Planning (MRP – II), Pull systems – Vs Push system – Just in time (JIT) philosophy Kanban System – Calculation of number of Kanbans Requirements for implementation JIT-JIT Production process – benefits of JIT.

UNIT – IV

Scheduling – Policies – Types of scheduling – Forward and Backward Scheduling – Grant Charts – Flow shop Scheduling – n jobs and 2 machines, n jobs and 3 machines – job shop Scheduling – 2 jobs and n machines – Line of Balance.

UNIT – V

Project Management – Programming Evaluation Review Techniques (PERT) – three times estimation – critical path – probability of completion of project – critical path method – crashing of simple nature. – Total Quality Management – ISO 9000 Series Standards – Six Sigma.

Text Books:

1. Operations Management/ Chase/ TMH.
2. Production and Operations Management/ S.N. Chary/ TMH.

Reference Books:

1. "Operations Management / E.S. Buffs/ Wiley.
2. "Operations Management "Theory and Problems/Joseph G. Monks.
3. "Production Systems Management /James I. Riggs.
4. "Production and Operations Management /Panner Selvam/ PHI.
5. "Production and Operations Analysis/ Nahima.
6. Operations Management/ William J. Stevenson/ Mc Graw Hill.

ME833PE: TRIBOLOGY (PE – VI)

B.Tech.IV Year II Semester

Course Code	Category	Hours/Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
ME833PE	Core	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

Prerequisite: Fluid mechanics, Design of machine members-II

Course Objectives:

1. To provide the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
2. To expose the student to different types of bearings, bearing materials.
3. To understand friction characteristics and power losses in journal bearings.
4. To learn theory and concepts about different types of lubrication.
5. To select the proper grade lubricant for specific application.

Course Outcomes:

1. Understanding friction characteristics in journal bearings.
2. Knowledge about different theories of lubrication to reduce friction and wear.
3. Students will be able to identify and describe the theories of friction and the factors affecting the coefficient of friction between contacting surfaces in relative motion.
4. Students will be able to identify the lubrication modes such as hydrodynamic lubrication.
5. Students will be able to know requirements of bearing materials, Types of bearing materials.

UNIT – I

Study of various parameters: Viscosity, flow of fluids, viscosity and its variation, absolute and kinematic viscosity, temperature dependent variation, viscosity index, determination of viscosity, different viscometers used.

Hydrostatic lubrication: Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing.

UNIT – II

Hydrodynamic theory of lubrication: Various theories of lubrication, petroffs equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro-dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl anti -friction bearing.

UNIT – III

Friction and power losses in journal bearings: Calibration of friction loss, friction in concentric bearings, bearing modulus, Sommer-field number, heat balance, practical considerations of journal bearing design.

UNIT – IV

Air lubricated bearing: Advantages and disadvantages, application to Hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydrostatic thrust bearings. Hydrostatic bearing Analysis including compressibility effect. Study of current concepts of boundary friction and dry friction.

UNIT – V

Types of bearing oil pads: Hydrostatic bearing wick oiled bearings, oil rings, pressure feed bearing, partial bearings - externally pressurized bearings. Bearing materials: General requirements of bearing materials, types of bearing materials.

Text Books:

1. Engineering Tribology/ Gwidon W. Stachowiak & Andrew W. Batchelor/Elesevier.
2. Engineering Tribology/ Prasanta Sahoo / PHI.

Reference Books:

1. Tribology – B.C. Majumdar.
2. Fundamentals of Tribology, Basu, Sen Gupta and Ahuja/PHI.
3. Tribology in Industry: Sushil Kumar Srivatsava, S. Chand &Co.

ME800OE: NON-CONVENTIONAL SOURCES OF ENERGY (Open Elective – III)

B.Tech.IV Year II Semester

Course Code	Category	Hours/Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
ME800OE	Core	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

Prerequisite: Thermodynamics, Fluid Mechanics and Heat Transfer

Course Objectives:

1. Understand about different types of Non-Conventional Energy Sources.
2. Understand about different equipment's used in generation of energy.
3. Understand about design and fabrication of equipment's for collection and conversion of energy.
4. Understand the basic concepts and operation of renewable energy systems.
5. To exploit renewable energy resources and effective technologies.

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

1. Identify renewable energy sources and their utilization. Understand the basic concepts of solar radiation and analyze the working of solar and thermal systems.
2. Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas and hydrogen.
3. Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.
4. Identify methods of energy storage for specific applications.

UNIT – I

Principles of Solar Radiation: Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power - Physics of the sun, the solar constant, extra-terrestrial and terrestrial solar radiation, Solar radiation on titled surface, Instruments for measuring solar radiation and sun shine, solar radiation data.

Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

UNIT - II

Solar Energy Storage and Applications: Different methods, sensible, latent heat and stratified storage, solar ponds. Solar applications - solar heating/cooling techniques, solar distillation and drying, photovoltaic energy conversion.

Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria.

UNIT – III

Bio-Mass: Principles of Bio-Conversion, Anaerobic /aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of biogas, utilization for cooking, I.C. Engine operation, and economic aspects.

UNIT - IV

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. **Ocean Energy** – OTEC, Principles, utilization, setting of OTEC plants, thermodynamic cycles. Tidal and Wave energy: Potential and conversion techniques, mini-hydel power plants, their economics.

UNIT – V

Direct Energy Conversion: Need for DEC, Carnot cycle, limitations, Principles of DEC. Thermo- electric generators, Seebeck, Peltier and Joule Thompson effects, figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cells, principle, faraday's laws, thermodynamic aspects, selection of fuels and operating conditions.

Text Books:

1. Renewable Energy Resources / Tiwari and Ghosal / Narosa.
2. Non- conventional Energy Sources / G.D. Rai/ Khanna Publishers.
3. Biological Energy Resources/ Malcolm Fleischer & Chris Lawis/ E&FN Spon.

Reference Books:

1. Renewable Energy Sources / Twidell & Weir.
2. Solar Power Engineering / B.S. Magal Frank Kreith & J.F. Kreith.
3. Principles of Solar Energy / Frank Krieth & John F Kreider.
4. Non-Conventional Energy / Ashok V Desai / Wiley Eastern.
5. Non-Conventional Energy Systems / K Mittal / Wheeler.
6. Renewable Energy Technologies / Ramesh & Kumar / Narosa.