DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH, LUCKNOW

Evaluation Scheme & Syllabus

For

B. Tech. -4th Year

Electrical Engineering (EE)

&

Electrical and Electronics Engineering (EN)

Based On

AICTE Model Curriculum & NEP2020

[Effective from the Session: 2025-26]

EVALUATION SCHEME - B. TECH 4th YEAR

SEMESTER- VII														
S. No.	Code	Subject	Learning Mode	LTP			Evaluation Scheme						Total	Credit
				L	T	P	CT	TA	Total	PS	TE	PE		
1	BEE701	Power System Protection	Offline	3	0	0	20	10	30	-	70	-	100	3
2	BEE07*	Departmental ElectiveIV	Offline	3	0	0	20	10	30	-	70	-	100	3
3	BOEM**	Open Elective-II	Offline/ MOOCs	3	0	0	20	10	30	-	70	-	100	3
4	BEE751	Power Systems Protection Lab	Offline	0	0	2	-	-	-	50	-	50	100	1
5	BEE752	Mini Project or Internship Assessment*		0	0	4	-	-	-	100	-	-	100	2
6	BEE753	Project I		0	0	10	-	-	-	150	-	-	150	5
7	BEE754	Startup and Entrepreneurial Assessment#		0	0	4	-	-	-	100	-	-	100	2
		Total		**9**	**0**	**20**							**750**	**19**

*The Mini Project or internship (4 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

The Startup and Entrepreneurial activity assessment will be done in 7th semester under which a student will have to undergo a startup/ Entrepreneurial activity of at least 60 hours still 6th semester.

Departmental Elective – IV

BEE071: Energy Conservation & Auditing.
BEE072: HVDC & AC Transmission
BEE073: Power Quality and FACTS
BEE074: Electric Drives
BEE075: Utilization of Electrical Energy & Electric Traction
BEE076: Renewable Energy Resources

EVALUATION SCHEME - B. TECH 4th YEAR

SEMESTER- VIII														
S. No.	**Code**	**Subject**	**Learning Mode**	**Periods**			**Evaluation Scheme**						**Tot al**	**Credit**
				L	**T**	**P**	**C T**	**T A**	**Tota l**	**PS**	**TE**	**PE**		
1	BOEM**	Open Elective-III	MOOCs	3	0	0	20	10	30	30	70	-	100	3
2	BOEM**	Open Elective-IV	MOOCs	3	0	0	20	10	30	30	70	-	100	3
3	BEE851	Project-II		0	0	18	-	-	-	100	-	350	450	10
		Total		**6**	**0**	**18**							**650**	**16**

The Internal Assessment of MOOCs will be done by the respective institute and the External Assessment (End Semester Examination) will be done by the University.

BEE701: POWER SYSTEM PROTECTION

Pre-requisites of the course: Power System-I, Power System-II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the characteristics and essential qualities of relays and the classification of protective schemes.	**K2**
CO2	Compare different types of relays and their applications. Also, analyze the performance of various relays by testing their distinct characteristics.	**K2**
CO3	Describe the types of faults and the protection scheme for major components of the power system.	**K2**
CO4	Describe the circuit breaker operation, testing and types. Also, test and analyze the performance of various circuit breakers used for power system protection, by comparing their operational characteristics and effectiveness.	**K2**
CO5	Explain the electronic relay, microprocessor and computer-based protection schemes.	**K2**

Unit-I: Protection Scheme

Need for Protective systems, Evolution of protective relays - Zones of protection - Primary and Back -up Protection - Essential qualities of Protection - Classification of Protective schemes -Automatic reclosing – current transformer for Protection - potential transformer - summation transformer -phase – sequence current - segregating network **Unit-II: Relays**:

Electromagnetic, attracted and induction type relays, thermal relay, gas actuated relay, design considerations of electromagnetic relay. Relay Application and Characteristics: Amplitude and phase comparators, over current relays, directional relays, distance relays, differential relay, Static Relays: Comparison with electromagnetic relay, classification and their description, over current relays, directional relay, distance relays, differential relay.

Unit-III: Protection of Components

Types & detection of faults and their effects, alternator protection scheme (stator, rotor, reverse power protection etc.) - Power transformer protection (external and internal faults protection), generator- transformer unit protection scheme, bus bar protection - Transmission line protection (current/time grading, distance), Pilot relaying schemes, power line carrier protection.

Unit-IV: Circuit Breaking

Properties of arc, arc extinction theories, re-striking voltage transient, current chopping, resistance switching, capacitive current interruption, short line interruption, circuit breaker ratings. Testing of Circuit Breaker: Classification, testing station and equipment, testing procedure, direct and indirect testing, selection of circuit breakers.
constructional features and operation of Bulk Oil, Minimum Oil, Air Blast, SF6, Vacuum and d. c. circuit breakers.

UNIT V- Modern Trends in Protection

Electronic relays, static relays, functional circuits: comparators, level detectors, logic and training circuits, microprocessor and computer-based protection schemes- software development for protection, security, and reliability.

Text Books:

1. S. S. Rao, "Switchgear and Protection", Khanna Publishers.
2. B. Ravindranath and M. Chander, Power system Protection and Switchgear, Wiley Eastern Ltd.
3. B. Ram and D. N. Vishwakarma, "Power System Protection and Switchgear", Mc Graw Hill

BEE751: Power System Protection Laboratory

Pre-requisites of course: Power System-I Lab, Power System-II Lab and basic understanding of Scilab/MATLAB /Simulink/ PSCAD/MiPower

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able:		
CO1	To analyze the performance of various relays by testing their distinct characteristics.	**K4**
CO2	To test and evaluate the performance of various circuit breakers used for power system protection, comparing their operational characteristics and effectiveness.	**K4**
CO3	To formulate a program/simulation model for the analysis of various power system protection schemes using programming tools /software such as Scilab/MATLAB /Simulink/ PSCAD/ MiPower or any other open source software platform.	**K6**

Note: A Minimum of 10 experiments are to be performed from the following list by using hardware or on a software platform, preferably on Scilab/MATLAB /Simulink/ PSCAD/ MiPower or any any other equivalent open-source software platform.

1. To observe and plot characteristics of:
   - Overcurrent relay (IDMT)
   - Directional relay
2. To observe and plot characteristics of:
   - Differential relay • Distance relay
3. To study the operation and characteristics of the electro-mechanical type over-voltage relay.
4. To study the gas-actuated Buchholz relay for an oil-filled transformer.
5. To simulate the various shunt faults in the transmission line using a three-phase fault simulator.
6. To study the effect of different shapes of electrodes on dielectric (air) breakdown.
7. Exponential impulse current test for determination of residual voltage like, as surge arresters.
8. To determine the critical flash-over voltage of a sphere gap assembly under varying atmospheric conditions.
9. To analyze capacitive current and short-line fault interruptions.
10. To implement protection schemes for alternators: stator, rotor, and reverse power protection.
11. To test and compare the performance of SF_6, vacuum, and air circuit breakers.
12. Testing of MCB, MCCB and ELCB by load test.
13. To study the differential protection of a three-phase delta-delta connected transformer.
14. To study the protection of a three-phase induction motor using a numerical relay.

15. To simulate an overcurrent protection scheme with CT/PT.
16. To study of transmission line fault detection, classification and location estimation using distance relays by simulating different faults on the IEEE 9-bus test power system through PSCAD software or MATLAB/Simulink.
17. Study of Power Swing and its impact on distance relaying-based transmission line protection scheme through PSCAD software or MATLAB/Simulink.
18. Microprocessor/microcontroller-based overcurrent protection scheme using MATLAB or Arduino IDE.
19. To develop simple relay coordination logic using embedded systems or protection software.
20. To simulate digital relay operation for overcurrent, differential, or distance protection.

*** Some of the Experiments from the above list can be performed on the virtual lab via the following virtual lab link:** http://vlab.co.in/

Textbooks:

1. L.P. Singh, "Digital Protection: Protective Relaying from Electromechanical to Microprocessor", John Wiley & Sons, Inc.
2. Badri Ram & D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Education Private Limited
3. T.S. Madhav Rao, "Microprocessor-Based Protection Systems" .
4. M.S. Naidu and V. Kamaraju , *"High Voltage Engineering"*, McGraw Hill Education (India) Private Limited
5. Sunil S. Rao , *"Switchgear and Protection"*, Khanna Publishers.
6. Y.G. Paithankar & S.R. Bhide , "Fundamentals of Power System Protection", PHI; Second Edition. 7. K. Umarao, "Computer Techniques and Models in Power System", Wiley

BEE071: ENERGY CONSERVATION AND AUDITING

Pre-requisites of course: Basic Electrical Engineering, Power System-I

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO1	Identify and assess the energy conservation/saving opportunities in different electric system and understand related legislations.	**K1**
CO2	Identify and assess the energy saving behavior of utilities through implementation of DSM and EMIS.	**K1**
CO3	Explain energy audit & management and to prepare energy audit report for different energy conservation instances.	**K2**
CO4	Illustrate the energy audit for Mechanical Utilities.	**K3**
CO5	Describe cost-effective measures towards improving energy efficiency and energy conservation by implementation of energy efficient technologies.	**K2**

UNIT-1: Energy Scenario: Classification of Energy, Indian energy scenario, Sectorial energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, energy security, energy conservation and its importance, energy strategy for the future. **Energy Conservation Act 2001 and related policies:** Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Electricity Act 2003, Integrated energy policy, National action plan on climate change, ECBC code for Building Construction.

UNIT-2: Demand Side Management (DSM): Concept and Scope of Demand Side Management, Difference between Energy Efficiency and DSM, Evolution of Demand Side Management, DSM Strategy, Planning, Implementation and its application, Customer Acceptance & its implementation issues, National and International Experiences with DSM, UDAY scheme and other government initiatives for DISCOMs.
Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques –energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS)

UNIT-3: Energy Audit: Aim of energy Audit, Strategies of Energy Audit, Energy management Team Consideration in implementing energy conservation Programme, Process flow diagram, Energy Audit report format, Benchmarking and Energy Performance, Instruments for energy audit, Economic analysis.

UNIT-4: System Audit of Mechanical Utilities: Pumps, types and application, unit 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. 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. Case studies related to Energy Audit & Management in Industries

UNIT-5: Energy Efficient Technology: Need for Energy Efficient Devices, Life Cycle Assessment, Comparison between simple pay-back and life cycle cost assessment, Energy Efficient Motors-motor losses and loss reduction techniques, determining and comparing motor efficiencies, motor efficiency testing standards, BIS specification for Energy Efficient Motors, efficiency as a function of load, Energy Efficient Lighting Sources-compact fluorescent lamp, light emitting diode, LED lamp, role of voltage on the efficiency of lighting system, Importance of Automatic power factor controllers, Variable Frequency Drives.

Reference Books:

1. Energy Conservation Guidebook,Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press.
2. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
3. Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience publication
4. Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation edited by E J Wilson and D Gerard, Blackwell Publishing
5. Heating and Cooling of Buildings -Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994.

BEE072: HVDC & AC TRANSMISSION

Pre-requisites of the course: Power System-I & II

Course Outcome:		**Knowledge Level, KL**
CO1	Describe the comparison of EHVAC and HVDC transmission while understanding various issues related to transmission.	K1
CO2	Calculate and study the corona loss and its impacts. Cite examples of the causes of switching overvoltage, Ferro-resonance.	K3
CO3	Explain the generation and measurement circuits for impulse, high DC & AC voltages. While considering the design parameters evaluate the effect on the performance of the EHV lines.	K2
CO4	Classify the DC links and choice of converter configuration to investigate the impact of inductance on operation of converters and identify different control schemes as well as starting and stopping methods of DC links.	K4
CO5	Describe the converter faults, protections, including MTDC types and applications.	K2

UNIT-I: EHV transmission, standard transmission voltage, comparison of EHV AC & DC transmission systems and their applications & limitations, surface voltage gradients in conductor, distribution of voltage gradients on sub-conductors, mechanical considerations of transmission lines, modern trends in EHV AC and DC transmission, UHVAC transmission system.

UNIT-II: EHV AC Transmission: Corona loss formulas, corona current, audible noise – generation and characteristics corona pulses their generation and properties, radio interference (RI) effects, over voltage due to switching, ferro-resonance, reduction of switching surges on EHV system, principle of half wave transmission.

UNIT-III: Extra High Voltage Testing: Characteristics and generation of impulse voltage, generation of high AC and DC voltages, measurement of high voltage by sphere gaps and potential dividers.

Consideration for Design of EHV Lines: Design factors under steady state limits, EHV line insulation design based upon transient over voltages. Effects of pollution on performance of EHV lines.

UNIT-IV:EHV DC Transmission – I: Types of dc links, converter station, choice of converter configuration and pulse number, effect of source inductance on operation of converters, working principle and characteristics of a 6 pulse converter with two & three valve conduction mode, three valve conduction mode and three and four valve conduction mode, Principle of DC link control, converter controls characteristics, firing angle control, current and excitation angle control, power control, starting and stopping of DC link.

UNIT-V:EHV DC Transmission – II: Converter faults, protection against over currents and over voltages, smoothing reactors, generation of harmonics, AC and DC filters, Multi Terminal DC systems (MTDC): Types, control, protection and applications.

Text Books:

1. R. D. Begamudre, “Extra High Voltage AC Transmission Engineering” Wiley Eastern.
2. K. R. Padiyar, “HVDC Power Transmission Systems: Technology and System Reactions” New AgeInternational.
3. J. Arrillaga, “High Voltage Direct Current Transmission” IFFE Power Engineering Series 6, Peter Peregrinus Ltd, London.
4. M. S. Naidu & V. Kamaraju, “High Voltage Engineering” Tata Mc Graw Hill.

Reference Books:

5. M. H. Rashid,“Power Electronics: Circuits, Devices and Applications” Prentice Hall of India.
6. S. Rao, “EHV AC and HVDC Transmission Engineering and Practice” Khanna Publisher.
7. “EPRI, Transmission Line Reference Book, 345 KV and above” Electric Power Research Institute. PaloAlto, California, 1982.

BEE073: POWER QUALITY AND FACTS

Pre-requisites of the course: Power System-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Classify the power quality issues in the electrical distribution network	K2
CO2	Describe the sources of voltage sag and protective devices, including voltage regulators, active series compensators, and UPS.	K1
CO3	Describe the different phenomena causing electrical transients and devices for overvoltage protection.	K2
CO4	Explain the working and application of different types of FACT devices like SSC, SVC, TSC, SSS, TCSC, UPFC.	K2
CO5	Explain the causes of harmonics, its effect on motor, capacitor, cables, and mitigation techniques.	K2

Unit-I: Introduction to Power Quality:
Terms and definitions of transients, Long duration Voltage Variations: under Voltage, Under Voltage and Sustained Interruptions; Short Duration Voltage Variations: interruption, Sag, Swell; Voltage Imbalance; Notching D C offset, waveform distortion; voltage fluctuation; power frequency variations.

Unit-II: Voltage Sag:
Sources of voltage sag: motor starting, arc furnace, fault clearing etc; estimating voltage sag performance and principle of its protection; solutions at end user level- Isolation Transformer, Voltage Regulator, Static UPS, Rotary UPS, and Active Series Compensator.

Unit-III: Electrical Transients:
Sources of Transient Over voltages- Atmospheric and switching transients- motor starting transients, pf correction capacitor switching transients, ups switching transients, neutral voltage swing etc; devices for over voltage protection.

Unit-IV: FACT Systems:
Introduction – Terms & Definition, Fact Controllers, Type of FACT devices i.e. SSC, SVC, TSC, SSSC, TCSC, UPFC Basic relationship for power flow control.

Unit- V: Harmonics:
Causes of harmonics; current and voltage harmonics: measurement of harmonics; effects of harmonics on – Transformers, AC Motors, Capacitor Banks, Cables, and Communication Lines etc., Harmonic Mitigation Techniques.

Text Books:

1. Roger C Dugan, McGrahan, Santoso&Beaty, “Electrical Power System Quality” McGraw Hill
2. Arindam Ghosh & Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices” Kluwer Academic Publishers
3. C. Sankaran, “Power Quality” CRC Press.
4. S. Sivanagaraju& S. Satyanarayana, “Electric Power Transmission and Distribution” Pearson Education
5. Narain G. Hingorani& Laszlo Gyugyi “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems” Wiley

BEE074: ELECTRIC DRIVES

Pre-requisites of the course: Power Electronics, Electrical Machines-I & II

Course Outcome		Knowledge Level
Upon the completion of the course, the student will be able to:		
CO1	Describe the operation of electric drives and its classification.	**K1**
CO2	Explain the electric drive stability and selection of motor power rating.	**K2**
CO3	Illustrate electric braking and its dynamics.	**K3**
CO4	Describe the types of DC drives and its control.	**K2**
CO5	Describe the types of AC drives and its control.	**K2**

UNIT-I: Fundamentals of Electric Drive:

Electric Drives and its parts, advantages of electric drives, Classification of electric drives, Speed-torque conventions and multi-quadrant operations, Constant torque and constant power operation, Types of load, Load torque: components, nature and classification.

UNIT-II: Dynamics of Electric Drive:

Dynamics of motor-load combination, Steady state stability of Electric Drive, Transient stability of electric Drive.

Selection of Motor Power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of motor power rating for continuous duty, short time duty and intermittent duty., Load equalization.

UNIT-III: Electric Braking:

Purpose and types of electric braking, braking of dc, three phase induction and synchronous motors

Dynamics During Starting and Braking: Calculation of acceleration time and energy loss during starting of dc shunt and three phase induction motors, methods of reducing energy loss during starting. Energy relations during braking, dynamics during braking.

UNIT-IV: Power Electronic Control of DC Drives:

Single phase and three phase controlled converter fed separately excited dc motor drives (continuous conduction only), dual converter fed separately excited dc motor drive, rectifier control of dc series motor. Supply harmonics, power factor and ripples in motor current Chopper control of separately excited dc motor and dc series motor.

UNIT-V: Power Electronic Control of AC Drives:

Three Phase induction Motor Drive: Static Voltage control scheme, static frequency control scheme (VSI, CSI, and cyclo – converter based) static rotor resistance and slip power recovery control schemes.
Three Phase Synchronous motor: Self-controlled scheme
Special Drives: Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications

Text Books:

1. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa publishing House.
2. S.K.Pillai, “A First Course on Electric Drives”, New Age International.

Reference Books:

1 M.Chilkin, “Electric Drives”,Mir Publishers, Moscow.
2 Mohammed A. El-Sharkawi, “Fundamentals of Electric Drives”, Thomson Asia, Pvt. Ltd. Singapore.
3 N.K. De and Prashant K.Sen, “Electric Drives”, Prentice Hall of India Ltd.
4 V.Subrahmanyam, “Electric Drives: Concepts and Applications”, Tata McGraw Hill.

BEE075: UTILIZATION OF ELECTRICAL ENERGY & ELECTRIC TRACTION

Pre-requisites of course: Basic Electrical Engineering, Electrical Machines-I & II

Course Outcomes:		**Knowledge Level, KL**
Upon the completion of the course, the student will be able to:		
CO1	Describe the methods of electric heating and their advantages.	K1
CO2	Explain the types of Electric welding and the principle of Electro-deposition laws of electrolysis and its applications	K2
CO3	Explain the laws of illumination and the principle of refrigeration and airconditioning.	K2
CO4	Describe the different types of Electric traction, system of track electrification and its related mechanics	K2
CO5	Describe the salient features of traction drive and concept of energy saving using power electronic control of AC and DC drives	K2

Unit-I: Electric Heating: Advantages and methods of electric heating, Resistance heating, Electric arc heating, Induction heating and Dielectric heating

Unit-II: Electric Welding: Electric Arc Welding Electric Resistance Welding Electronic welding controls Electrolyte Process: Principles of electro deposition, Laws of electrolysis, and applications of electrolysis

Unit-III: Illumination: Various definitions, Laws of illumination, requirements of good lighting Design of indoor lighting and outdoor lighting systems Refrigeration and Air Conditioning: Refrigeration systems, domestic refrigerator, water cooler Types of air conditioning, Window air conditioner

Unit-IV: Electric Traction – I: Types of electric traction, Review of existing electric traction systems in India, systems of track electrification Traction mechanics- types of services, speed time curve and its simplification, average and schedule speeds Tractive effort, specific energy consumption, mechanics of train movement, coefficient of adhesion and its influence

Unit-V: Electric Traction – II: Salient features of traction drives Series – parallel control of dc traction drives (bridge transition) and energy saving Power Electronic control of dc and ac traction drives Diesel electric traction.

Text Books:

1. H. Partab, "Art and Science of Electrical Energy" Dhanpat Rai & Sons.
2. J.B. Gupta, "Utilization of Electric Power and Electric Traction", Kataria & Sons publishers, Delhi, IX Edtion, 2004.
3. C.L. Wadhwa, "Generation, Distribution and Utilization of electrical Energy", New Age International (P) Limited Publishers, 3rd Edition, 2010.

Reference Books:

1. H. Partab, " Modern Electric Traction" Dhanpat Rai & Sons.
2. G.K. Dubey, "Fundamentals of Electric Drives" Narosa Publishing House.

BEE076: RENEWABLE ENERGY RESOURCES

Pre-requisites of course:

Course Outcomes:		Knowledge Level, KL
Upon the completion of the course, the student will be able to:		
CO1	Understand the classification of various non-conventional energy resources and theory of solar cells.	K2
CO2	Analyze various solar thermal energy applications and their performances.	K4
CO3	Analyze resources of geothermal energy**,** Magneto-hydrodynamics power plant performances and various types of fuel cells.	K4
CO4	Analyze the performance of Thermo-electrical and thermionic Conversions and wind energy conversion systems.	K4
CO5	Understand biomass conversion, Ocean Thermal Energy Conversion, Wave and Tidal Wave theory.	K2

Unit-1: Introduction: Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits. Solar Cells: Theory of solar cells. Solar cell materials, solar cell array, solar cell power plant, limitations.

Unit-2: Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focusing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

Unit-3: Geothermal Energy: Resources of geothermal energy, thermodynamics of geothermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations.

Magneto-hydrodynamics (MHD): Principle of working of MHD Power plant, performance and limitations. Cells: Principle of working of various types of fuel cells and their working, performance and limitations.

Unit-4: Thermo-electrical and thermionic Conversions: Principle of working, performance and limitations. **Wind Energy:** Wind power and its sources, site selection, criteria, momentum theory, classification of rotors, concentrations and augments, wind characteristics. Performance and limitations of energy conversion systems.

Unit-5: Biomass: Availability of biomass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Wave: Principle of working, performance and limitations. Waste Recycling Plants.

Text Book:

1. Raja etal, “Introduction to Non-Conventional Energy Resources” Scitech Publications.
2. John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006.
3. M.V.R. Koteswara Rao, “Energy Resources: Conventional & Non-Conventional” BSPPublications,2006.
4. D.S. Chauhan,”Non-conventional Energy Resources” New Age International.
5. C.S. Solanki, “Renewal Energy Technologies: A Practical Guide for Beginners” PHI Learning.
6. Peter Auer, "Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press.
7. Godfrey Boyle,“ Renewable Energy Power For A Sustainable Future”, Oxford University Press.