DEPARTMENT OF MECHANICAL ENGINEERING

Syllabus and Scheme of Examination

M.Tech in Energy Systems Engineering

2017-18

Institution

***Vision* -Pursuing Excellence, Empowering people, Partnering in Community Development.**

***Mission* - To develop NMAM Institute of Technology, Nitte as a Center of Excellence by imparting Quality Education to generate Competent, Skilled and Human Manpower to face emerging Scientific, Technological, Managerial and Social challenges with Credibility, Integrity, Ethics and Social concern**

Department

Vision - To produce Mechanical engineers of the highest quality who are professionally competent and highly qualified to suit the needs of industries and organizations by promoting excellence in teaching, learning and research.

Mission - The Dept. of Mechanical Engineering is committed to –

- Provide high quality education to the students, to fulfill the requirements of a ‘Global Engineer’.
- Constantly strive to improve the teaching-learning methods, in order to deliver good academic programs.
- To respond to the fast evolving scientific and technological challenges in a highly competitive world.
- To inculcate, ethics, integrity, honesty, credibility, social and environmental consciousness.

Programme Educational Objectives

PEO1: The Programme is designed to produce teachers and researchers to work in the area of new and renewable energy which is a field having great impact on society.

PEO2: The programme is expected to produce man power who can become entrepreneurs in the area of energy system and renewable energy.

PEO3: The programme is designed to train students to take up employment in the area of solar energy, wind energy and conventional energy sectors.

Programme Outcomes

1. Able to Model and analyze energy systems
2. Able to Design solar thermal systems
3. To be able to carry out Auditing of energy equipments
4. To be able to carry out numerical methods for designing & analysis of an system
5. Able to determine performance of energy systems experimentally
6. Able to communicate energy topics and prepare reports effectively
7. Have the knowledge of different alternative IC engines design
8. Possess basic knowledge of combustion aspects & Environmental pollution control
9. Have knowledge of wind solar and other alternative energies.

NMAM INSTITUTE OF TECHNOLOGY, NITTE

SCHEME OF TEACHING AND EXAMINATION FOR M. TECH. ENERGY SYSTEMS ENGINEERING (ESE)

(AUTONOMY SCHEME)

Revised at the BOS meeting on 20.05.2017

I SEMESTER

Sub. Code	**Name of the Subject**	**Contact hours/week L/T/P/S**	**Duration of Sem. End Exam in hours**	**Marks for CIE**	**Marks for SEE**	**Total Credits**
17ESE101	Alternative Energy Systems	3/2/0/4	3	50	50	5
17ESE102	Applied Mathematics	4/2/0/0	3	50	50	5
17ESE103	Combustion Engineering	4/2/0/0	3	50	50	5
17ESE11X	Elective - I	4/0/0/0	3	50	50	4
17ESE12X	Elective -II	4/0/0/0	3	50	50	4
17ESE104	Research Experience through Practice-I	0/0/4/0	0	100	--	2
TOTAL			15	350	250	25

ELECTIVE –I		**ELECTIVE-II**	
17ESE111	Wind Energy Conversion Systems	17ESE121	Biomass Energy for IC Engines
17ESE112	Steam and Gas Turbines	17ESE122	Energy from Wastes
17ESE113	Direct Energy Conversion	17ESE123	Advanced IC Engines
17ESE114	Power Electronics -I	17ESE124	Switched Mode PowerConvertors
17ESE115	Power systems Dynamics & Control Converters		
17ESE116	Solid State Power Controllers		

M.TECH. ENERGY SYSTEMS ENGINEERING (ESE)
(AUTONOMY SCHEME)

II SEMESTER

Sub. Code	Name of the Subject	Teaching hours/week	Duration of Sem. End Exam in hours	Marks for		Total Credits
		L/T/P/S		CIE	SEE	
17ESE 201	Utilization of Solar Energy	4/2/0/0	3	50	50	5
17ESE 202	Energy Conservation and Management	3/2/0/4	3	50	50	5
17ESE 203	Energy System Modeling and Analysis	4/2/0/0	3	50	50	5
17ESE 21X	Elective - III	4/0/0/0	3	50	50	4
17ESE 22X	Elective -IV	4/0/0/0	3	50	50	4
17ESE 204	Research Experience through Practice-II	0/0/4/0	0	100	--	2
TOTAL			15	350	250	25

ELECTIVE –III		ELECTIVE - IV	
17ESE211	Combustion Engine Design Principles	17ESE221	Instrumentation and Control in energy systems
17ESE212	Energy Storage	17ESE222	Nuclear Engineering
17ESE213	Design of Heat Transfer Equipment’s	15ESE223	Pollution control in thermal power stations.
17ESE215	HVDC Transmission	17ESE224	Power Generation & System Planning
17ESE216	Design of Solar PV Systems	17ESE226	Power electronics for Renewable Energy systems
Audit course currently offered in second semester is **Acoustic Emission science and its applications (17AP007)**			

(AUTONOMY SCHEME)

III SEMESTER

Revised at the BOS meeting on**20.05.2017**

Sub. Code	Name of the Subject	Duration	Marks for		Total Credits
		Practical/Field Work/Assignment	CIE	SEE	
17ESE 301	Industrial Training Mini-Project	Full time 8 weeks	50 (report) 50(presentation)	--	8
17ESE 302	Seminar on special topics	----	100	--	2
17ESE 303	Project-part I	Full time 10 weeks	100 (report) 100(presentation)	--	10
TOTAL			400		20

IV SEMESTER

Sub. Code	Name of the Subject	Duration	Duration of Exam in Hrs.	Marks for		Total Credits
		Practical Field work		CIE	SEE	
17ESE 401	Project -part II	Full time 20 weeks		200 [PPE*-I – 100 PPE-II – 100]	200	30
TOTAL				400		30
GRAND TOTAL From 1st to 4th semester: 100 credits (2000 marks)						

PPE – Project Progress Evaluation

DETAILED COURSE CONTENTS

ALTERNATIVE ENERGY SYSTEMS

Course code:**17**ESE 101 Credits: 05

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. To create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2. Able to estimate and measure solar radiations, know about the applications of solar energy.
3. To design the storage of bio gas required for a particular engine and use of bio gas for water pumping and power generation.
4. To design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
5. To understand the working of OTEC system and different possible ways of extracting energy from ocean, know about mini-micro hydro systems and geothermal and nuclear energy.

UNIT-I

Introduction: Introduction and overview, Sociological, political and economic aspects, review of basic thermodynamics and thermal sciences. **(06 Hrs)**

Solar Energy Systems:

Solar radiation geometry, and estimation and measurement of solar energy. Thermal systems: Water heating, Drying, Cooking, Desalination, Solar refrigeration, solar ponds. Photovoltaic systems: Types and characteristics of Photovoltaic cells, Solar cell arrays, Balance of system (BOS), PV powered pumps. **(08 Hrs)**

UNIT-II

Biomass Energy Systems:

Gasifier engine system. The biogas engine as a module integrated into an energy system. Dimensioning of biogas plant and gas storage, Choice of engine, driven machine and transmission, Biogas engine and water pump, Biogas engine and electric generator. Case study of existing biomass gasifier engines generator system. Generations of Bio-fuels.Numerical problems. **(10Hrs)**

UNIT-III

Wind Energy Systems:

Orientation systems and Regulating devices, Design of blades: Aerodynamic configuration of rotor and Determination of the blade structure. Description and performance of vertical axis wind mills. Use of wind energy for water pumping and generation of electricity. **(10 Hrs)**

UNIT-IV

Ocean Energy systems:

OTEC-Principle of operation, Open & Closed OTEC cycles; Wave energy, Wave energy conversion machines and recent advances Tidal Energy, Single basin and double basin tidal systems. **Hydrogen energy systems** **(08 Hrs)**

UNIT-V

Other energy sources:

Small-Mini-Micro hydro system, concepts, Types of turbines, hydrological analysis, Geothermal Energy Conversion. Elements of nuclear fission and fusion energy conversion **(10 Hrs)**

Environment, Energy and global climate change (self study)

Course Outcomes

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1									
CO2									
CO3									
CO4									
CO5									

L: Low M: Medium H: High

TEXTS / REFERENCE BOOKS:

1. S. P. Sukhatme "Solar Energy,-Principles of Thermal Collection & Storage", TMHPublishing Co., New Delhi.
2. John A Duffie& William A Beckman "Solar energy Thermal Processes" Wiley Inter science publication, New York
3. G. D.Rai,-"Non Conventional Energy Sources", Khanna publisher, New Delhi
4. Klaus Von Mitzlaff "Engine for biogas", Published by FriedrVielveg and Sohnraunschweig, Germany -1988.
5. Desire Le Gouriers: "Wind Power Plants: Theory & Design", Pergamon Press,1982
6. H P Garg& J Prakash: "Solar Energy - Fundamentals and Applications", TataMcGraw Hill Publishing company limited, New Delhi
7. Srivatsava, Shukla and Ojha: "Technology and Application of Biogas", Jain Brothers, New Delhi, 1993
8. Chetan Singh Solanki : Solar photovoltaics: Fundamentals Technology and Applications, Second Edition, PHI, 2012
9. D.P.Kothari,K.C.Singal and RakeshRanjan "Renewable Energy Sources and Emerging Technologies",Second Edition Published by PHI Learning private limited, New Delhi.

APPLIED MATHEMATICS

Course code:17ESE 102 Credits: 05

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT- I

Vector Calculus:

Vector algebra, vector differentiation-gradient-fundamental principle of Lagrangean multiplier, divergence and curl of a vector point function.Curvilinear, spherical and cylindrical co-ordinates. (9 Hours)

UNIT- II

Concept of errors and propagation.Solution of algebraic and transcendental equations by Newton-Raphson method and order of convergence.

Solution of linear system of equations: Direct Methods-Gauss elimination, method of factorization, iterative methods – Jacobi and Gauss Seidel method. Eigen value by iteration-power method.(8 Hours)

UNIT- III

Interpolation:Finite differences - Newton's forward and backward formulae for interpolation(review), central differences, Gauss central difference interpolation formula, interpolation with unevenly spaced points – Lagrange's interpolation formula.

Numerical differentiation:Numerical differentiation- High accuracy differentiation formulae, Richardson extrapolation. (10 Hours)

UNIT- IV

Numerical integration:Newton-Cote's integration formulae, Trapezoidal rule- a composite formula, Romberg integration, Simpson's rules- $1/3^{rd}$ rule and $3/8^{th}$ rule, Gaussian quadratue formula.

Numerical solution of first order initial value problems: Taylor's series method, Euler's method, modified Euler's method, R.K. methods, multistep methods, Milne's method and Adam's Moulton method, R.K. method for system of first order equations. (12 Hours)

UNIT-V

Numerical solution of first order boundary value problems

Introduction to Finite element method: Steps involved in FEM, comparison between finite difference and finite element method.

Optimization:

Linear programming-formulation of the problem, general linear programming problem, simplex method, artificial variable technique-Big M-method.Geometric programming and search method(fundamental principles only), simple problems.**(13 Hours)**

Course Outcomes

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1									
CO2									
CO3									
CO4									
CO5									

L: Low M: Medium H: High

Text Books

1. S.C.Chapra and R.P.Canale: "Numerical methods for Engineers" 3rd edition, MGH- 1998.
2. S.S. Sastry: "Introductory Method of Numerical Analysis", 3rd edition, PHI New Delhi- 1998.
3. C.E.Gerald and P.O.Wheatley : " Applied Numerical Analysis", 5th edition, Addison – Wesley publication- 1994.
4. Rao S.S., "Engineering Optimization", New Age International.

Reference Books

1. M.K.Jain, S.R.K. Iyengar and R.K. Jain: "Numerical methods for Scientific and Engineering Computations", 1985 edition, Wiley Eastern.

COMBUSTION ENGINEERING

Course code:17ESE103 Credits: 05
Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. To make the student understand the concepts of thermochemistry of combustion.
2. To train the student in calculations of reaction kinetics, chemical equilibrium and heat release encountered in practical combustion systems.
3. To make the student understand principles of laminar and turbulent flames, flame propagation, flame stability, flame quenching and droplet combustion. To know the effect of physico-chemical parameters on the above as applicable to practical combustion systems such as reciprocating combustion engines, and gas turbines.
4. To make the student understand the difference between detonation and deflagration and calculate droplet burning time.
5. To expose the students to various practical application of combustion

UNIT-I

Chemical Thermodynamics: Introduction, Heat of Reaction and formation, free energy, chemical equilibrium, Flame temperature calculations. Combustion stoichiometry. Numericals.(04 Hrs)
Chemical Kinetics: Introduction, Elementary reactions, Rate of reactions, Chain reactions.Numericals. 06 Hrs)

UNIT-II

Flame Phenomenon in Premixed Combustion Gases: Introduction, Laminar flame structure;the laminar flame speed, The theory of Mallard and Lechatelier, Theory of Zeldovich,, and Samenov, Comparison of different theories.Flame speed measurements. Numericals.(06 Hrs)
Stability limit of laminar flames:Flammabilitylimits,quenchingdistance,flamestabilization,stabilitylimits.Numericals (04 Hrs)

UNIT-III

Turbulent Flames: Turbulent flame speed, Factors influencing turbulent flame speed, Flame stabilization in high velocity streams (06 Hrs)
Detonation: Introduction, premixed and diffusion flames, explosion, deflagration and detonation (03 Hrs)
Ignition: Forced Ignition and other ignition concepts. (03 Hrs)

UNIT-IV

Diffusion Flames: Gaseous fuel jets, burning of droplet clouds. Numericals. (05hrs)

Combustion Application-Liquid Fuel: Oil –fired Furnace Combustion-Pressure atomized nozzle for distillate fuel oil, spray combustion in furnace and boilers. Gas Turbine Spray Combustion-Combustor design, Ignition, flame stabilization. (05 Hrs)

UNIT-V

Combustion Application- Solid Fuel: Fixed Bed Combustion-Biomass Cook Stoves, Space heating stoves with logs,Grate burning systems for heat and power,Combustion efficiency. Suspension Burning-Pulversided coal burning system, Pulversided coal combustion,Carbon dioxide capture and sequestration. Fluidised Bed Combustion-Fluidisation Fundamentals, Bubbling bed, Atmospheric Pressure Fluidised Bed Combustion System, Circulating fluidized beds. (10 Hrs)

Course Outcomes

At the end of the course, the student should be able to

i) perform stoichiometric calculations and flame temperature calculations
ii) perform reaction time calculation
iii) aware of principles of reaction kinetics and carry out flame speed measurements
iv) Should be able determine the electrode gap and electrode type considering various factors
v) Aware of applications of combustion.

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**L**	**---**	**---**	**L**	**---**	**---**	**M**	**H**	**---**
CO2	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**H**	**H**
CO3	**L**	**---**	**---**	**---**	**---**	**---**	**---**	**H**	**---**
CO4	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**H**	**---**
CO5	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**H**	**---**

L: Low M: Medium H: High

TEXT/REFERENCE BOOKS

1. Combustion, 4thEdition,Irvin Glassman and Richard A Yetter, Academic Press, India, 2009.
2. Combustion Engineering, 2nd Edition, Ragland and Bryden, CRC Press, Newyork, 2011.
3. Engineering Thermodynamics, 3rd Ed., P.K.Nag,TMH, 2005
4. Fuels and Combustion, S.P.Sharma and Chander Mohan, TMH, 1984

WIND ENERGY CONVERSION SYSTEMS

Course code:17ESE 111 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. To make the student know various methods of measuring wind speed and facilities available for storage of such data.
2. To train the students to design the blade of a wind turbines.
3. To make the student understand methods for siting a wind farm.
4. To make the student understand economics of establishing wind system
5. To make the student know the applications of wind turbine

UNIT-I

Introduction: Modern wind turbines, wind resources, wind vs. traditional electricity generation, technology advancements, material Usage. Applications: grid connected power, industrial applications, stand-alone system, water pumping, offshore prospects. (05Hrs)

Wind Resource Assessment: Introduction, spatial variation, time variations, seasonal and monthly variability, diurnal variations. Characteristics of steady wind: turbulence, types of turbulence models, turbulence intensity, wind power density. Weibull wind speed distribution function: Estimating Weibull distribution factor. (05Hrs)

UNIT-II

Wind Measurement: Vertical profiles of the steady wind. Wind speed measurement parameters, Monitoring station instrumentation, cup anemometer, propeller anemometer, Ultrasound anemometer, wind vane, data loggers, remote wind speed sensing techniques- Sodar, Lidar, SAR, LWS, Satellite remote sensing, (05Hrs)

Aerodynamics: Aerofoil, two dimensional airfoil theory, relative wind velocity. Wind flow models, wind flow pattern. Axial momentum theory, Momentum theory, blade element theory. Wind machine characteristics. (05 Hrs)

UNIT-III

Wind Turbines: Historical development. Classification of wind turbines.Turbine components. (04 Hrs)

Wind turbine design:Introduction, rotor torque and power, Power control, braking systems. Turbine blade design. Blade material, SERI blade sections,.Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations. (06 Hrs)

UNIT-IV

Electrical and Control systems: Introduction to electricity and magnetism. Classification of generators, AC circuits, Synchronous generators, Induction generators, Variable speed generators. Control systems. Power Collection system. Power quality, wind farm and generation protection, interface protection, losses in generation. (05 Hrs)

Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries. (05 Hrs)

UNIT-V

Wind Farm Design: Introduction, wind flow modeling, use of capacity factor for wind farm design, planning of wind farm. Siting of wind turbines, ecological indicators, layout of wind farm, initial site selection, micrositing, wake model. (06 Hrs)

Economics of Wind Systems: Cost calculation, annual energy output, time value of money, capital recovery factor, depreciation. Cost of wind energy, present value of annual costs, value of wind generated electricity, Wind energy economics worksheet, Project appraisal, project finance Economic Revenues requirements, Value of wind generated electricity (06 Hrs.)

Course Outcomes

At the end of the course, the student should be able to

1. Choose a method for measuring wind speed,
2. Identify ideal wind site for wind farm,
3. Design the wind turbine ,
4. Use the turbine for a particular application, and
5. Start a wind turbine farm

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**M**	**L**	**---**	**---**	**L**	**L**	**---**	**---**	**L**
CO2	**W**	**M**	**M**	**---**	**---**	**L**	**---**	**---**	**L**
CO3	**H**	**M**	**M**	**---**	**---**	**---**	**---**	**---**	**L**
CO4	**---**	**----**	**---**	**----**	**---**	**L**	**---**	**---**	**M**
CO5	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**M**

L: Low M: Medium H: High

TEXT/ REFERENCE BOOKS:

1. SirajAhmed:"Wind Energy-Theory and Practice" Second Edition, PHI Learning Pvt. Ltd, New Delhi, 2011.

2. Garg L Johnson: "Wind Energy Systems" Prentice Hall. Inc, New Jersey,1985.

STEAM AND GAS TURBINES

Course code:17ESE 112 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Steam turbines: power plant cycles. Cycle analysis and design.

UNIT-II

Losses in steam turbine.Design of a stage.

UNIT-III

Design of multistage axial flow turbines. Vortex flow and lower pressure stage design.

UNIT-IV

Performance at varying loads governing, Calculation of design point efficiency uses cascade data.

UNIT-V

Gas Turbines - Performances of practical gas turbine cycles. Design point performance of simple and series flow cycles, factors affecting performance.

TEXT REFERENCE BOOKS:

W.J.Kearton, Steam Turbine Theory and Practice.

Lee, Theory and design of Steam and Gas Turbine, McGraw Hill.Cohen and Roger, Gas Turbine Theory; Longmans London.

Jennings and Rogers, Gas turbine analysis and Practice, McGraw Hill.

DIRECT ENERGY CONVERSION

Course code:17ESE 113	Credits: 04
Hrs/Week: 4 hours	Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Basic science of energy conversion	(06 Hrs)
Thermionic Converters	(06 Hrs)

UNIT-II

Thermoelectric Engines	(10 Hrs)

UNIT-III

Magneto hydrodynamic Engines	(08 Hrs)

UNIT-IV

Photovoltaic Effect and Solar cells	(06 Hrs)

UNIT-V

Free Energy and Fuel cells	(08 Hrs)
Typical layout and constructions, Current developments	(08 Hrs)

TEXTS *I* REFERENCE BOOKS:

1. Sheldon S.L. Chang: "Energy Conversion", Prentice Hall Inc.
2. George W. Sutton: "Direct Energy Conversion", McGraw Hill.
3. S. L. Soo: "Direct Energy Conversion".
4. Archie W. Culp: "Principle of Energy Conversion"
5. G. D. Rai: "Non-Conventional Sources of Energy", Khanna Publications

Power Electronics - I

Course code:17ESE114 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Introduction: History to power electronics development, power electronic systems, power electronics converters, power electronics, applications 04 Hrs

Power Devices: Phase controlled thyristors, Inverter grade thyristors, Inverter grade thyristors, RCT, DIAC, TRIAC, BJT, Power MOSFETs, IGBTs, GTOs, MCT operating characteristics and gate drive requirements and circuits. 08 Hrs

UNIT-II

Phase Controlled Converters:

Introduction, Control Techniques, 1-φ half wave / full wave controlled rectifier, 1-φ half controlled bridge rectifier, performance facors of line commutated converters, performance measures of tw0 pulse converters, 3-φ controlled converter, 3-pulse/ 6-pulse converter, 3-φ fully controlled bridge converter, external performance measures, effect of input source impedance, performance of converter with battery load, selection of converter circuit, power factor improvement 10 Hrs

UNIT-III

Inverters:

Introduction, classification, 1-φ half bridge, full bridge VSI, performance parameters, voltage control of 1-φ inverter, charge controllers applicable to solar PV: shunt type charge controller, series type charge controller, MPPT charge controller and DC to DC converter type charge controller. 3-φ Inverters, voltage control of 3-φ Inverter, Series / parallel inverter, self commutated inverters, 1-φ SCR bridge inverter, CSI, performance comparison, Harmonic reduction, filters. 10 Hrs

UNIT-IV

AC voltage Regulators

Introduction, 1-φ AC Regulators, sequence control, 3-φ AC regulators, AC regulator to feed transformers. 04Hrs

Cycloconverters

Introduction, basic principle, 1-φ to 1-φ cycloconverters, 3-φ half-wave cycloconverters, cycloconverters circuit for 3-φ output, output voltage equation, control circuit, comparison between cycloconverters and DC link converter, load commutated cycloconverters. 06 Hrs

UNIT-V

Power Electronic Applications:

UPS, SMPS (bridge configuration), HVDC, Static VAR compensators, RF Heating, Switched Mode Welding, Electronic Lamp Ballast, Battery Charger, Emergency Lighting System, Static circuit breaker, time delay circuit, flasher circuit, integral cycle triggering. 10 Hrs

Course Outcomes

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**H**	**H**	**M**	**M**	**M**	**–**	**–**	**–**	**--**
CO2	**H**	**H**	**M**	**L**	**L**	**–**	**–**	**–**	**–**
CO3	**H**	**H**	**H**	**L**	**M**	**–**	**–**	**–**	**–**
CO4	**H**	**H**	**M**	**L**	**M**	**–**	**–**	**–**	**–**
CO5	**M**	**H**	**M**	**L**	**S**	**–**	**–**	**–**	**--**

L: Low M: Medium H: High

TEXT/ REFERENCE BOOKS:

1. MD Singh, KB Khanchandani: “Power Electronics”, Tata McGraw-Hill Publication Company Limited, 2nd Edition 2008.
2. Ned Mohan Tore. M. Undeland and William. P. Robbins; “Power Electronics: Converters, Applications and Design”, John Wiley and Sons, 1995
3. Rashid M. H, Power Electronics – Circuits, Devices and Applications”, Prentice Hall India, Second Edition, 2001
4. Joseph Vithayathil, “Power Electronics: Principles and Applications”, McGraw Hill Inc, 1995.
5. B.K.Bose, “Power Electronics & A.C. Drives”, Prentice Hall, 1986.
6. ChethansinghSolanki “Solar Photovoltaics-Fudmentals, technologies and applications”- PHI II Edition -2012 (for chapter on balance of solar PV systems charge controller)

Power System Dynamics and Control

Course code:17ESE 115 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT I

Introduction: Power System Stability, States of Operation and System Security, Stability and Control of a Dynamic System **4 hrs**

Analysis of Dynamical Systems: Concept of Equilibria, Small and Large Disturbance Stability, Example: Single Machine Infinite Bus System, Modal Analysis of Linear Systems, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff Systems **8 hrs**

UNIT II

Modeling of a Synchronous Machine: Synchronous machine(Flux Linkage equations, Voltage equations, Torque equations), Park's transformation, Analysis of Steady State Performance, Transient Analysis of a Synchronous Machine, Model with Standard parameters **12 hrs**

UNIT III

Excitation and Prime Mover Controllers: Excitation System, Excitation System Modelling, Excitation Systems- Standard Block Diagram, System Representation by State Equations, Prime-Mover Control System. **5 hrs**

Transmission Lines and Loads: Transmission Line: Transmission Line Modeling, Transformation to D-Q components and steady state equation, D-Q Transformation using α -β Variables, Load Models - induction machine model. **5 hrs**

UNIT IV

Stability Issues in Interconnected Power Systems: Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Single Machine Load Bus System: Voltage Stability, Torsional Oscillations (Phenomena of subsynchronous resonance). **10 hrs**

UNIT V

Enhancing System Stability: Planning Measures, Stabilizing Controllers (Power System Stabilizers), Operational Measures- Preventive Control, Emergency Control. **8 hrs**

Text Books:

1. K.R.Padiyar, 'Power System Dynamics: Stability & Control', 2nd Edition, B.S. Publications, Hyderabad, 2002.
2. P.M. Anderson and A.A.Fouad, 'Power System Control and Stability', Galgotia Publications, New Delhi, 2003.

Reference Books :

7. P.Kundur, 'Power System Stability and Control', McGraw Hill Inc., USA, 1995.
8. P.Sauer&M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997.
9. Jan Machowski, Janusz W. Bialek and James R. Bumby, 'Power System Dynamics: Stability & Control', 2nd Edition, John wiley& Sons Ltd, 2008.

SOLID STATE POWER CONTROLLERS

Course code:17ESE116 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Line Commutated Converters: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter, dual converters, power factor improvement methods, effect of source inductance, single phase series converters, twelve pulse converter and design of converter circuits. **12 Hours**

UNIT-II

Inverters: Principle of operation, performance parameters, single phase bridge inverters and three phase inverters. **9 Hours**

UNIT-III

Voltage Control of Single Phase Inverters: Single/multiple, pulse/SPWM/ modified SPWM methods, voltage control of three phase inverter, SPWM/third harmonic PWM/Space vector modulation, harmonic reduction, current source inverter, comparison between VSI & CSI. **11 Hours**

UNIT-IV

Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, features & applications. **9 Hours**

UNIT-V

DC-DC Chopper: Principle of operation, analysis of step-down and step-up chopper, classification of chopper, chopper circuit design. **11 Hours**

REFERENCE BOOKS

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rdEdition,Wiley India Pvt Ltd, 2011
2. Rashid M.H,“Power Electronics: Circuits Devices and Applications”,3rdEdition, Pearson,2011.
3. B. K. Bose, “Modern Power Electronics & AC Drives”, PHI,2012.

BIOMASS ENERGY FOR IC ENGINES

Course code:17ESE 121 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. The student should be able to understand the parameters associated with setting up of energy plantation.
2. The student should be able to design a community biogas plant and gasifier.
3. The student should be able to understand combustion in CI and SI engine
4. The student should be aware of problem associated with the use of production gas in the IC engine.
5. Should have the ability to understand the intricacies of water pumping biogas engine combination.

UNIT-I

Introduction: Relevance of biomass as an energy source, Biomass Resources, Cultivated biomass resources, Water-to-biomass resources, Advantages associated with biomass resources, Availability of biomass for energy generation.Energy plantation: Concept, Objectives and advantages (08 Hrs)

Biomass Conversion Processes: Combustion, Biochemical and Thermo chemical. Gasification: Fuels for gasification, Properties of biomass - size, size distribution, bulk density, volatile matter, ash and ultimate analysis. (05 hrs)

UNIT-II

Types of gasifiers, design of a down draft gasifiers, cooling, cleaning systems, performance evaluation of a downdraft gasifier. Production of alcohols from biomass. (05 hrs)

Bio-conversion Process: The process, Types of biogas plants, Design of biogas plants, Factors affecting gas generation rate. (06 Hrs)

UNIT-III

Combustion in Compression Ignition Engines:

Stages of combustion in CI Engines, factors affecting the different stages, Delay period and knock, factors controlling diesel knock. Direct injection systems and indirect injection systems. Fuel spray characteristics, Fuel injection, overall spray structure, atomization, spray penetration, droplet size distribution and spray evaporation, knock rating of diesel fuels, method of Cetane rating, anti-knock agents. (08 Hrs)

UNIT-IV

Combustion in Spark Ignition Engines:

Stages of Combustion in the SI engine, factors affecting these stages, flame propagation relations, misfire and engine stability, lean bum techniques, abnormal Combustion, Knock and surface ignition, factors controlling knock, knock rating of SI fuels, methods of Octane rating, anti-knock additives, combustion chamber design. (08 Hrs)

UNIT-V

Engines for Renewable Fuels: Biogas engines for water pumping and electric power generation, Government programs. Gasifier engines system, Use of producer gas in SI and CI engines. Reasons for derating, problems associated with gasifier engine system and its efficiency. Biodiesel and dual fuel engine: Power capacity, diesel substitution, thermal efficiency, Diesel substitution, Thermal efficiency, Smoothness of operation, Load following capability, Maintenance and durability, Exhaust emissions. (12 Hrs)

Course Outcomes

1. The student should be able to set up energy plantation.
2. Design a community biogas plant and gasifier.
3. Distinguish combustion quality in CI and SI engine
4. Able to use producer gas in the IC engine.
5. Identify areas where centrifugal water pumps can be run with IC engines powered by Biogas.

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	--	--	--	--	--	–	**H**	–	**M**
CO2	--	--	--	**M**	**M**	**M**	**H**	–	**M**
CO3	--	--	--	--	--	**M**	--	**M**	–
CO4	--	--	--	--	--	--	**H**	**M**	–
CO5	--	--	--	--	--	--	--	–	**M-**

L: Low M: Medium H: High

TEXT *I* REFERENCE BOOKS:

1. Kaupp and J. R.Goss: "State of Art Report for small scale Gas Producer Engine Systems", FriedrVieweg&SohnVerlags, Gmbh, Braunschweig, 1984.

2. T. B. Reed: "Biomass Gasification Principles and Technology", Noyes Data Corporation,Energy Technology Review, No.6, U.S.A., 1981.

3. O. P. Vimal& M S Bhatt: "Wood Energy Systems", K L Publications, NewDelhi– 1989

4.S Rao & B BParulekar: "Energy Technology" Khanna Publishers Delhi – 1999

5.M.L.Mathur, R.P. Sharma:"A Course vin Internal Combustion Engines" DhanpatRai and Sons- 1989

ENERGY FORM WASTES

Course code:**17**ESE122 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Sources & types of wastes (Industrial, Municipal, agro, domestic).Generation of wastes, Pollution standards, Wastes characterization. Functional elements of waste management, technological aspects related to waste generation, on site handling, storage, collection, transfer, and transport. **(**04 Hrs)

Processing techniques and equipment (volume reduction, size reduction, component separation, dewatering, drying). (04 Hrs)

UNIT-II

Recovery of value added components: Recycling, conversion products and energy. (06 Hrs)

Conversion technologies: Incineration, Thermo-chemical conversions. (06 Hrs)

UNIT-III

Biochemical conversion: Biogas & ethanol (06 Hrs)

Conventional Chemical & biological treatment (04 Hrs)

UNIT-IV

Waste disposal, Environmental impact (toxic & non-toxic) (06 Hrs)

Utilization of energy generated, , power generation (04 Hrs)

UNIT-V

Waste management issues: Planning, organization & control Hazardous & toxic wastes, hazard & its management, classification, generation, handling, processing and disposal. (04 Hrs)

Industrial safety (04 Hrs)

TEXTS / REFERENCE BOOKS:

1. P. N. Cheremisinoff& A. C. Morresi: "Energy from Solid Wastes", Marcel Dekker Inc, New York & Base., 1978.
2. Bhinde A. D., Sundaresan 8. 8.: "Solid Waste Management in Developing Countries, NEERI, 1988.
3. T. Bonner, 8. Desai et. al: "Hazardous Waste Incineration Engineering", Noyes Data Co. 1981.
4. C. L. Mantell: "Solid Wastes Origin, Collection Processing and Disposal, John Wiley & Sons.
5. Ed. Brian D. Clark & Alexander Gilard: "Perspective on Environmental Impact Assessment", D. Reidal Publishing Co.
6. Sarkanen&Tillvnan: "Progress in Biomass Conversion", Vol-II.
7. Baum & Parker: "Solid waste disposal_ Incineration and Landfill

ADVANCED IC ENGINES

Course code:17ESE 123 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. Understand the concepts of actual combustion cycles and associated losses,
2. Study the different stages and factors affecting SI engine combustion
3. Understand the different stages and factors affecting CI engine combustion
4. Understand the mechanism of pollutants' formation and study the different techniques of controlling them.
5. Study the use of different alternative engine designs and alternative fuels for IC engines

UNIT-I

Thermodynamic cycles:

Brief review of Ideal air standard cycles & their comparison, effect of variable specific heat and dissociation, ideal fuel-air cycles, actual cycles, causes for deviation, comparison of SI and CI engines, principles of I.C.Engine process simulation.Numerical problems. (08 Hrs)

UNIT-II

Combustion in Spark Ignition Engines:

Stages of Combustion in the SI engine, factors affecting these stages, flame propagation relations, Cyclic variations in combustion, causes and remedies of cycle-by-cycle and cylinder to cylinder variations, misfire and engine stability, lean bum techniques, abnormal Combustion, Knock and surface ignition, factors controlling knock, knock rating of SI fuels, methods of Octane rating, anti-knock additives, combustion chamber design (10 Hrs)

UNIT-III

Combustion in Compression Ignition Engines:

Stages of combustion in Cl Engines, factors affecting the different stages, Delay period and knock, factors controlling diesel knock, methods of generating swirls, their relative merits and demerits, combustion chamber designs for the CI engines, Direct injection systems, Indirect injection systems, Comparison of combustion chambers, heat release rate diagrams, Fuel spray characteristics, Fuel injection, overall spray structure, atomization, pray penetration, droplet size distribution and spray evaporation, knock rating of diesel fuels, method of Cetane rating, anti-knock agents. (10 Hrs)

UNIT-IV

Pollutant Formation and Control:

Nature and extent of problem, types of pollutants, their ill effects, evaporation loss and its control UBHC, CO and NOx emissions from SI engines, mechanism of formation of UBHC, CO and NO in engine combustion, factors affecting their formation and emission, control methods, comparison of methods, total emission control packages, alternative fuels for low emissions, driving cycles and emission standards. Particulate Emission, Characteristics of Diesel exhaust particulates, causes and methods of control, soot formation fundamentals, soot oxidation, adsorption and condensation, Exhaust Gas Treatment, Available options, Catalytic converters, thermal reactors, particulate traps, odour control in I.C. Engine exhaust. (08 Hrs)

UNIT-V

Alternative Fuels for Combustion Engines:

Use of Biogas, LPG, CNG, H_2, Biodiesels, Alcohol and producer gas in SI and CI engines. Reasons for derating, problems associated with gasifier engine system and its efficiency. Biodiesel and dual fuel engine: Power capacity, thermal efficiency, Diesel substitution, Smoothness of operation, Load following capability

Alternative combustion engine designs:

Dual fuel engines, multi-fuel engines, stratified charge engines, VCR engine, Rotary combustion engine, Homogeneous charge compression ignition (HCCI) engine. (10Hrs)

Course Outcomes

At the end of the course, the student should be able to

1. Differentiate Air standard, Fuel – air and Actual cycles
2. Analyze the different factors affecting the stages of SI engine combustion
3. Analyze the different factors affecting CI engine combustion and able differentiate the combustion phenomenon in SI and CI engines.
4. Explain the mechanism of pollutants' formation in IC engines and trained with the different techniques of controlling them.
5. Evaluate different alternative engine designs and suitability of different alternative fuels for IC engines

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**-**	**-**	**-**	**M**	**-**	**-**	**L**	**M**	**-**
CO2	**-**	**-**	**-**	**-**	**H**	**-**	**-**	**H**	**-**
CO3	**-**	**-**	**-**	**-**	**H**	**-**	**-**	**H**	**-**
CO4	**-**	**-**	**-**	**-**	**-**	**-**	**L**	**M**	**-**
CO5	**-**	**-**	**-**	**-**	**-**	**-**	**H**	**M**	**-**

L: Low M: Medium H: High

TEXTS / REFERENCE BOOKS:

1. E.F.Obert: "Internal Combustion Engine and air pollution" , International Students Edition, 3rd Edition, 1973
2. John B. Heywood: "Internal Combustion Engines Fundamentals", McGraw Hill International Edition, 1988.
3. M.L.Mathur& R.P Sharma: "A Course in Internal Combustion Engines",

DhanpatRai&Sons, 7th Edition, 1994
4. Klaus Von Mitzlaff "Engine for biogas", Published by FriedrVielveg and Sohnraunschweig, Germany – 1988
5. Kaupp and J. R.Goss: "State of Art Report for small scale Gas Producer Engine Systems", FriedrVieweg&SohnVerlags, Gmbh, Braunschweig, 1984.
6. T. B. Reed: "Biomass Gasification Principles and Technology", Noyes Data Corporation,Energy Technology Review, No.6, U.S.A., 1981.

Switched Mode Power Converters

Course code:**17**ESE 124 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

Unit – I

DC – DC Converters (Basic Converters): Linear voltage regulators (LVRs), a basic switching converter(SMPC), comparison between LVR & SMPC, principle of operation and analysis of buck converter analysis, inductor current ripple and output voltage ripple, capacitor resistance effect, synchronous rectification, design considerations, buck converter for discontinuous current operation, principle of operation and analysis of boost converter, inductor current ripple and output voltage ripple, inductor resistance effect, design considerations, boost converter for discontinuous current operation.11hrs

Unit – II

Principle of operation and analysis of buck-boost converter analysis, inductors current ripple and output voltage ripple, design considerations, buck-boost converter for discontinuous current operation, principle of operation and analysis of CUK converter , inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, Single Ended Primary Inductance Converter(SEPIC).10hrs

Unit – III

Derived Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous and discontinuous current mode of operation, design considerations, principle of operation and analysis of forward converter, design considerations, double ended(Two switch) forward converter, principle of operation and analysis of push-pull converter, design considerations, principle of operation and analysis of full bridge and half-bridge DC-DC converters, design considerations, current fed converters, multiple outputs. 10hrs

Unit – IV

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, series resonant inverter, series resonant DC-DC converter, parallel resonant DC-DC converter, series- parallel resonant DC-DC converter, resonant converters comparison, resonant DC link converter.10hrs

Unit – V

Control of DC-DC Converter: Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, PSpice simulation of feedback control, Type-3 error amplifier with compensation, design. **Design of inductor and transformers for SMPC** 11hrs

TEXTS / REFERENCE BOOKS:

1.Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rd Edition, Wiley India Pvt Ltd, 2010.

2.Daniel W Hart, “Power Electronics”, Tata McGraw Hill, 2011.

3.Umanand L “ Power Electronics- Essentials and Applications”, Wiley 2011

4.Christophe P. Basso, “Switch-Mode Power Supplies Spice Simulations and Practical Designs” BPB Publication, 2010.

5.Umanand L and Bhatt S R, “Design of Magnetic Components for Switched Mode Power Converters”, New Age International, New Delhi, 2001

6.H W Whittington, B W Fynn, “Switched Mode Power Supplies: Design and Construction”, 1st Edition, Universities Press

II SEMESTER

UTILIZATION OF SOLAR ENERGY

Course code:17ESE 201 Credits: 05

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students:

1. To estimate or measure solar radiation at any location.
2. To understand radiation characteristics of opaque material and partially transparent media
3. To estimate the thermal losses and efficiency of a flat plate collector and understand its applications.
4. To know about the different orientation systems and types of concentrating collectors, can determine the thermal performance of focusing collector.
5. To understand use of solar energy for different applications like cooking, desalination, space heating etc.
6. To know about different designs of green house, solar refrigeration and high temperature application
7. To know about different PV panel configurations and its characteristics
8. To know the importance of storage systems, types of thermal storage and alternate methods

UNIT-I

Solar Radiation Analysis: Solar constant, Basic earth sun angles, Beam and diffused radiations, Radiation on titled surfaces (estimation), Measurement of solar radiation, Numerical problems. (10Hrs)

UNIT-II

Heat Transfer for Solar Energy Utilization: Basic models of heat transfer, Radiation characteristics of opaque materials and partially transparent media, Heat transfer analysis for flat plate collectors, Numerical problems (10Hrs)

UNIT-III

Flat Plate Collectors: Physical principles of conversion of solar radiation into heat, Thermal Losses and efficiency of FPC, Practical considerations for flat plate collectors, Applications of FPC - Water heating and Drying. (11Hrs)

UNIT-IV

Focusing Type Collectors: Orientation and sun tracking systems, Types of concentrating collectors - Cylindrical parabolic collector, Compound parabolic collector, Thermal performance of focusing collectors, testing of solar collectors. (11Hrs)

UNIT-V

Solar Green Houses, Solar thermo mechanical power, Solar refrigeration & air conditioning and Solar High Temperature Applications.Solar cooking, Solar desalination, Solar ponds and Solar space heating Solar Industrial process heating and Solar power generation. (10Hrs)

Course Outcomes

At the end of the course, the student should be able to

1. Understand the estimation and measurement of radiation on flat and tilted surfaces
2. Understand the physical conversion of solar radiation into heat
3. Understand the working of solar flat plate collectors
4. Analyze orientation and sun tracking system and understand the working of focusing type of collectors
5. Understand the principles of solar cooking, solar desalination, solar ponds, solar space heating, solar industrial process heating and solar power generation

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**-**	**M**	**-**	**-**	**L**	**-**	**-**	**-**	**L**
CO2	**-**	**L**	**-**	**-**	**-**	**-**	**-**	**-**	**L**
CO3	**M**	**H**	**-**	**-**	**L**	**-**	**-**	**-**	**L**
CO4	**M**	**H**	**-**	**-**	**L**	**-**	**-**	**-**	**L**
CO5	**M**	**H**	**-**	**-**	**M**	**-**	**-**	**-**	**L**

L: Low M: Medium H: High

TEXTS *I* REFERENCE BOOKS:

1. John A Duffie& William A Beckman: "Solar Energy Thermal processes" – Wiley Inter science publication
2. H P Garg&*J* Prakash "Solar Energy - Fundamentals and Applications: - Wiley Inter science
3. G D Rai "Solar Energy Utilization" - Khanna publishers
4. S P Sukhatme "Solar Energy - Principles of thermal Collection & Storage" - Tata
5. McGraw Hill Publishing company ltd., New Delhi
6. ChethansinghSolanki "Solar Photovoltaics-Fudmentals, technologies and applications"- PHI II Edition -2012

ENERGY CONSERVATION AND MANAGEMENT

Course code:**17**ESE 202 Credits: 05
Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. To make the student realise the need for energy conservation and understand the concepts of energy audit, principles of financial appraisal for acceptance of projects and energy conservation methods through efficient use of steam, cogeneration, waste heat recovery, power factor improvement and choice of equipment in electrical utility and various industrial applications.
2. To train the students in the design of heating elements, calculation of energy saving from efficient use of steam, proper insulation, improved power factor, optimum illumination etc.
3. At the end of the course the student should be able to take up projects on energy audit, calculate energy losses in various systems, decide upon the best options for energy conservation in industries and electrical utilities.

UNIT-I

Introduction: General energy problem, global and national energy use patterns. Scope of energy conservation in domestic, transportation, agriculture and industrial sectors, Electrical energy sector (generation, transmission and distribution).Energy conservation possibilities in Iron and steel, Aluminium, Cement, Pulp and paper, Textile industries and Oil refineries. (06 Hrs)

Energy Conservation in Electric Utility and Industry: Energy costs and two-part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Electric lighting, types of lamps, calculation of illumination level, Energy conservation in illumination systems, Importance of Power factor in energy conservation , Power factor improvement methods. (06Hrs)

UNIT-II

Energy Management Principles and Energy Audit: Need, Organizing, Initiating and Managing an energy management program. Types of energy audits, Systematic procedure for technical audit. Energy monitoring and targeting: Instruments and their usage for auditing.(08Hrs)

UNIT-III

Economic Analysis: Cash flows, Payback period, ROI, depreciation and plant value calculations. Time value of money, Formulae relating present and future cash flows, NPV, IRR, B/C ratio, Life cycle costs. (08Hrs)

UNIT-IV

Efficient use of steam: Energy conservation in steam and condensate systems. (04 Hrs)

Cogeneration: Concepts, Types of cogeneration systems, Performance evaluation of a cogeneration system. (04 Hrs)

Waste Heat Recovery: Potential, benefits, waste heat recovery equipments. (04 Hrs)

UNIT-V

Space Heating, Ventilation, Air Conditioning (HVAC) and water heating: Transfer of heat, Space heating methods, Ventilation and air conditioning, Heat pumps, cooling loads, Electric water heating systems, energy conservation methods in the above devices. (04 Hrs)

Industrial Insulation: Insulation materials, Insulation selection, Critical thickness and Economical thickness of insulation. (04 Hrs)

Industrial Heating: Indirect resistance heating, Direct resistance heating (salt bath furnace) Heat treatment by induction heating in the electric arc furnace industry. (04 Hrs)

Course Outcomes

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1									
CO2									
CO3									
CO4									
CO5									

L: Low M: Medium H: High

TEXT/REFERENCE BOOKS

1. AICTE Continuing Education Course Material on Energy Management, 1996.
2 S.C.Tripathy: "Electric Energy Utilization and Conservation", TMG, Delhi, 1991.
3 Wayne C. Turner: "Energy Management Handbook", Wiley Interscience Publication, NY, 1982.
4 D.A.Reay: "Industrial Energy Conservation", Pergamon Press. 1980.
5 T.L Boten: "Thermal Energy Recovery", Wiley, 1980.
6 V.K.Mehta and Rohit Mehta: “Principles of Power Systems”, S.Chand& Co., 2005.
7 Bureau of Energy Efficiency, Ministry of Power, Government of India, Guide Books, 2016.

ENERGY SYSTEM MODELING AND ANALYSIS

Course code:**17**ESE 203 Credits: 05

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. Have the ability to model a given set of data by various methods.
2. Be able to carry out simulation of simple energy systems.
3. Be able to formulate a problem and carry out optimization of simple thermal system by various methods.
4. Be aware of methods available for testing the fidelity of representation

UNIT-I

Introduction: Engineering Design, Design Versus Analysis, Synthesis for Design, Selection Versus Design. Thermal Systems, Basic Characteristics, Analysis, Types and Examples

Designing a Workable System: Workable and optimum systems, Steps in arriving at a workable system, Creativity in concept selection, Workable Vs Optimum system, Designing of a food freezing plant.

Modeling of Thermal Systems: Introduction, Importance of Modeling in Design, Basic Features of Modeling. Types of Models, Analog Models, Mathematical Models, Physical Models, Numerical Models, Interaction Between Models, Other Classifications. Mathematical Modeling, General Procedure, Final Model and Validation, Physical, Modeling and Dimensional Analysis, Modeling and Similitude, Overall Physical Model.

Equation Fitting: Mathematical modeling, Polynomial representation, Functions of two variables, Exponential forms, Best fit Method of least squares (10Hrs)

UNIT-II

Modeling of Thermal Equipment: Modeling of counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power

System Simulation: Importance of Simulation , Different Classes, Flow of Information Information flow diagrams. Methods for Numerical Simulation, Steady Lumped Systems, Dynamic Simulation of Lumped Systems, Distributed Systems, Simulation of Large Systems, Numerical Simulation Versus Real System, Sequential and simultaneous calculations, Successive substitution, Newton-Raphson method, sizing of systems like fan-duct, etc. (10 Hrs)

UNIT-III

Problem Formulation for Optimization: Introduction, Optimization in Design, Final Optimized Design, Basic Concepts, Objective Function, Constraints, Operating Conditions Versus Hardware Mathematical Formulation, Optimization Methods, Calculus Methods, Search Methods, Linear and Dynamic Programming, Geometric Programming, Other Methods, Optimization of Thermal Systems Important Considerations, Different Approaches, Different Types of Thermal Systems, Examples Practical Aspects in Optimal Design Choice of Variables for Optimization, Sensitivity Analysis, Dependence on Objective Function: Trade-Offs, Multi-Objective Optimization, Part of Overall Design Strategy, Change of Concept or Model, Summary, References, Problems.

Lagrange Multipliers: Introduction to Calculus Methods, The Lagrange Multiplier Method Basic Approach, Physical Interpretation, Significance of the Multipliers. Optimization of Unconstrained Problems, Use of Gradients for Optimization, Determination of Minimum or Maximum, Conversion of Constrained to Unconstrained, Problem. Optimization of Constrained Problems, Applicability to Thermal Systems, Use of Curve FittingExamples, Inequality Constraints, Some Practical Considerations, Computational Approach

Geometric Programming: One independent variable unconstrained, Multivariable optimization, constrained optimization with zero degree of difficulty. (12 Hrs)

UNIT-IV

Dynamic Programming: Characteristic of the Dynamic programming solution, apparently constrained problem, Application of Dynamic programming to energy system problems. (08 Hrs)

UNIT-V

Linear Programming: Simplex method, Big-M method, Application of LP to thermal systems.

Search Methods : Basic Considerations, Importance of Search Methods, Types of Approaches

Application to Thermal Systems. Single-Variable Problem, Uniform Exhaustive Search, Dichotomous Search, Fibonacci Search, Golden Section and Other Search Methods, Comparison of Different Elimination Methods.Unconstrained Search with Multiple Variables, Lattice Search, Univariate Search, Steepest Ascent/Descent Method

Recent Research work on application of dynamic programming, Lagrange multiplier method, LPP, geometric programming and Fibonacci search method. (10 hrs)

Course Outcomes

CO1: Identify the suitable method of optimization

CO2: Solving simple optimization problems

CO3: Model simple problem

CO4: Understand differences between different methods of simulation

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	-	S	---	W	---	---	---	---	---
CO2	W	M	---	S	---	---	---	---	---
CO3	S	M	---	S	----	---	---	---	---
CO4	---	W	---	S	---	---	---	---	---

L: Low M: Medium H: High

TEXTS / REFERENCE BOOKS:

1. W.F.Stoecker: "Design of Thermal Systems", 3rd Ed., McGraw Hill, 1989.
2. B. K. Hodge: "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.
3. D.1. Wide: "Globally Optimal Design", Wiley- Interscience, 1978.
4. YogeshJaluria, " Design& Optimization of Thermal Systems", 2nd Edition, CRC Press, Taylor & Francis, 2008.

COMBUSTION ENGINE DESIGN PRINCIPLES

Course code:**17**ESE 211 Credits: 04
Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Prerequisites & selection of main parameters, application of principle of similitude, choice of materials for various engine components. (6 Hrs)

UNIT-II

Cylinder block, Cylinder liner, Cylinder heads, crankcase, gaskets, hold down studs (8 Hrs)
Piston, piston rings, piston pin (6 Hrs)

UNIT-III

Connecting rods, polar diagrams, flywheels, crank shaft, main bearings, crank pin, Methods to improve fatigue strength of crank shaft (14 Hrs)

UNIT-IV

Valves & valve gears, valve springs, cams (8 Hrs)

UNIT-V

Combustion chamber shapes for SI & CI Engines, lubrication systems, cooling systems, cooling fans, dynamics of piston- connecting rod- crank systems, engine balancing (I0 Hrs)

TEXTS / REFERENCE BOOKS:

I. Motor vehicle engines edited by M. Khovakh - MIR Publishers – 1984
2. I.C. Engines by LC. Lichty, McGraw Hill, 1951
3. Combustion Engine Processes by LC. Lichty, McGraw Hill, 1967
4. R.C. Engines by Taylor - Vo\. 2, MIT Press, 1985
5. High Speed IC Engines by Heldt P.M., Oxford & IBH, 1989
6. Diesel Engine Design by Purday H.F.P., Van Nostrand, 1919
7. Design of Automotive Engine by A. Ko1chin & V. Demidov - MIR Publishers 1984
8. Theory of Machine by Thomas Bevan, CBS Publishers and Distributers, 1984

ENERGY STORAGE

Course code:**17**ESE 212 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. Identify the importance of Energy storage &the modes energy can be stored, corresponding to energy density and power density.
2. Learn the applications of thermal energy storage system also specifically study basic thermal energy storage system at medium and high temperatures using sensible and latent heat,
3. Understand concept of mechanical Energy Storage such as Pumped hydro storage, Elastic energy storage, Energy storage in advanced Flywheels compressed air storageetc
4. Study the basics of Electromagnetic energy storage systems such as Superconducting Magnetic Energy Storage,Learn the concepts of Electro-chemical energy conversion and storage such as electrochemical cell, batteries, hydrogen oxygen cells etc.
5. Impart the knowledge of Supercapacitor and its basic components of supercapacitors, The disadvantages and advantages of supercapacitors over battery systems and their applications in public transport vehicles, private vehicles etc.

UNIT-I

Importance and modes of energy storage, Energy transportation methods, Electrical energy characteristic's and basic load calculations, Performance characteristics of energy storage systems, Types of load curves, energy shift, Ragone plot. Importance of energy density and power density.

(12 Hrs)

UNIT-II

Thermal energy storage at medium and high temperatures using sensible and latent heat, numerical problems

Energy storage in hydrogen – production of hydrogen by reforming & electrolysis, High temperature storage through reversible reactions **(12Hrs)**

UNIT-III

Mechanical Energy Storage: Pumped hydro storage-numerical problems, Elastic energy storage, Energy storage in Advanced Flywheels, Compressed air energy storage-numerical problems. **(08Hrs)**

UNIT-IV

Electro-chemical energy conversion and storage: Introduction to batteries, elements and operation of electrochemical cells, theoretical cell voltage and capacity, losses in cells. Battery classification, factors effecting battery performance, batteries for PV system.

Introduction to fuel cells, hydrogen oxygen cells, hydrogen air cell, hydrocarbon air cell, alkaline fuel cell, phosphoric and fuel cell with detailed analysis of the advantage and drawback of each type**.(08 Hrs)**

UNIT-V

Electromagnetic energy storage: Superconducting Magnetic Energy Storage.
Super capacitor: Basic components of supercapacitors like types of electrodes like high surface area activated carbons, metal oxide and conducting polymers, aqueous and organic electrolytes. The disadvantages and advantages of supercapacitors over battery systems and their applications in aspects of energy density, power density, price and market. **(12Hrs)**

Course Outcomes

1. Expressed Energy storage systems through Ragone plots & graphs, Differentiate energy density and power density for various Energy storage systems.
2. Identify applications of thermal energy storage system using sensible and latent heat,
3. Understand concept of mechanical Energy Storage such as Pumped hydro storage, Elastic energy storage, Energy storage in advanced Flywheels compressed air storage etc
4. Arrive at conclusion to select Electromagnetic energy storage systems such as Superconducting Magnetic Energy Storage, electrochemical cell, batteries, hydrogen oxygen cells for various applications.
5. Present special topics on Supercapacitor and its basic components of supercapacitors, The disadvantages and advantages of supercapacitors over battery systems and their applications in public transport vehicles, private vehicles etc.

Mapping of POs & COs:

	Programme Outcome								
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CO1	**S**	**M**	**W**	**---**	**---**	**M**	**---**	**---**	**M**
CO2	**M**	**M**	**---**	**---**	**---**	**M**	**---**	**---**	**S**
CO3	**---**	**---**	**S**	**S**	**W**	**M**	**---**	**---**	**M**
CO4	**---**	**----**	**---**	**W**	**M**	**M**	**---**	**S**	**M**
CO5	**---**	**S**	**----**	**---**	**S**	**M**	**---**	**M**	**M**

L: Low M: Medium H: High

TEXTS / REFERENCE BOOKS:
1. Johannes Jensen & Bent Sorensen ': "Fundamentals of Energy Storage", John Wiley & Sons, 1984
2. S.Rao and Dr.P.P.Parulekar:"'Energy Technology", Khanna Pub., 1997.
3. Collins: "Batteries Vo\. I & II'.
4. G.D.Rai: "Non-conventional Energy Sources", Khanna Publishers, 1989.
5. James Larminie: "Fuel Cell Systems Explained", John Wiley & Sons, 2005.
6. Tetsuya Osaka: "Energy Storage System for Electronics", Taylor & Francis Ltd., 2000.
7. ChethansinghSolanki "Solar Photovoltaics-Fudmentals, technologies and applications"- PHI II Edition -2012

DESIGN OF HEAT TRANSFER EQUIPMENT

Course code:**17**ESE 213 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Study of different methods used for design of heat exchangers, classification, design methodology, LMTD and NTU methods. (10 Hrs)

UNIT-II

Design of double pipe heat exchanger. (06 Hrs)

Design of shell and tube heat exchanger. (06 Hrs)

UNIT-III

Cross flow heat exchangers (06 Hrs)

UNIT-IV

Extended surfaces, fin design, longitudinal and transverse fins. (06 Hrs)

Regenerator (06 Hrs)

UNIT-V

Plate Type Heat Exchangers (06 Hrs)

Compact Heat Exchangers (06 Hrs)

TEXTS / REFERENCE BOOKS:`

1. D. G. Kern: "Design of Heat Exchangers".
2. D. G. Kern & A. D. Kraus: "Extended surface heat transfer".
3. S. Kokac: "Heat Exchangers-Thermal Hydraulic Fundamentals and Design", McGraw Hill.
4. J. P. Gupta: "Heat Exchanger Design".
5. Indian Standards, 4503-1967, UDC - 66045.1
6. Indian Standards, Boiler Act. AS ME Handbook, Section VIII B

HVDC TRANSMISSION

Course code:**17**ESE 215 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

General aspects of DC transmission and comparison with Ac transmission: Historical sketch, Limitations and Advantages of AC and DC Transmission. Comparison of AC and DC Transmission Application of DC Transmission, Description of DC Transmission System, Modern trends in HVDC Technology**. 08 hrs**

UNIT-II

Convertor circuits: Graetz bridge Circuit, Analysis of Graetz bridge neglecting overlap, choice of converter configuration. Analysis of Line Commutated Converter(LCC) with grid control and overlap less than 60 degree and greater than 60 degree, Capacitor commutated Converter, Analysis of a Voltage Source Converter. **14 hrs**

UNIT-III

Principles of DC Link Control, Converter Control Characteristics, System Control Hierarchy, Firing Angle Control, Current and Extinction Angle Control, Power control, Higher level Controllers. **06 Hrs**

Converter Faults, Protection against Over currents, Over voltages in a Converter Station, Surge Arrestors, Protection against Overvoltage, Smoothing Reactors, DC Breakers. **06 Hrs**

UNIT-IV

Reactive Power Requirements in Steady State, Sources of Reactive Power, SVC and STATCOM, Reactive Power Control during Transients **05 Hrs**

Generation of Harmonics, Design of AC Filters, Passive AC Filters, DC Filters **05 Hrs**

UNIT-V

Potential applications of MTDC Systems, Types of MTDC Systems, Control and Protection of MTDC Systems, MTDC Systems using Voltage Source Converters. **06 Hrs**

TEXT BOOKS/ REFERENCES:

1. K.R. Padiyar – HVDC Transimission – NEW AGE International Publishers – Second Edition
2. E W Kimbark, “Direct current Transimission
3. PrabhaKundur, “ Power system Stability and control” TMH, 9th reprint, 2007.

INSTRUMENTATION AND CONTROL IN ENERGY SYSTEMS

Course code:17ESE 221 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Generalized configurations and functional descriptions of measuring instruments.Measurement Errors for mechanical instruments.Materials, radiant storage. (06 Hrs)

Transducer classification. Generalized performance characteristics of instruments, Static and dynamic characteristics of transducers, Transient analysis of a control system. (06 Hrs)

UNIT-II

Temperature Measurement: Use of bi-materials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers. (04 Hrs)

Pressure Measurement: Manometers, dynamic response of manometers, Bourden tube, Elastic pressure elements, electromechanical pressure transducers, Measurement of High Pressure and low pressure.Calibration of Pressure measuring equipment. (10 Hrs)

UNIT-III

Flow Measurement: Flow measurement methods, variable head flow meters for incompressible Fluids. Rota meters, Electromagnetic flow meters, Hot wire anemometers, hot film transducers, Ultrasonic flow meters. (06 Hrs)

UNIT-IV

Air pollution and Measurement: Introduction, Gas sampling techniques, particulate sampling techniques, Sulphur dioxide measurements, Combustion Products Measurements, Opacity and odor measurements (06 Hrs)

Miscellaneous measurements: Measurement of liquid level, Measurement of Humidity moisture, measurement of O2, CO2 in flue gases, pH measurement (04 Hrs)

UNIT-V

Instruments for monitoring electrical parameters: Moving Iron/coil, Energy measurement, power factor meter. (04 Hrs)

Analog signal conditioning, Amplifiers, Instrumentation amplifier, AID and 0/ A Converters, Digital data processing and display, Data acquisition system. (06 Hrs)

TEXTS *I* REFERENCE BOOKS:

1. K. Sawhney. PuneetSawney: A course in Mechanical Measurements and Instrumentation. DhanpatRai&Co 2002
2. Bechwith. Marangoni. Lienhard: Mechanical Measurements Fifth edition. Addison Wesley 2000
3. J. P. Holman: Experimental methods for engineers Sixth edition, McGraw-Hili Inc. 1994.
4. E. 0 Doebelin: Measurement Systems Applications & Design, McGraw Hill, 1990.
5. K. Ghosh: Instrumentation and Control. McGraw-Hili Inc. 2003

NUCLEAR ENGINEERING

Course code:**17**ESE 222 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

UNIT-I

Scope of Nuclear Power- Review of Nuclear Physics- Reactor Theory (06Hrs)
Elements of Reaction Physics. Thermodynamic aspects of Nuclear Power

UNIT-II

Fission and Fusion Processes. Thermal Reactor Types: PWR, CANDU, HTGCR (10Hrs)

UNIT-III

Fast breeder: Fluid fuelled, Organic Cooled Reactor and Economics. (08Hrs)

UNIT-IV

Steady and Unsteady State- Calculation of critical Size of Homogeneous and Heterogeneous Reactors. (08Hrs)

Elementary Idea of Reactor Instrumentation and control. (08Hrs)

UNIT-V

Reactor Materials, Shielding, Thermal Aspects of Nuclear Systems. (08Hrs)
Types and processing of nuclear fuels (04Hrs)

TEXTS *I* REFERENCE BOOKS:

Richards Stephenson, Introduction to Nuclear Engineering, McGraw Hill.
Charles F.Bonilla, Nuclear Engineering, McGraw-Hill.
K.S.Ram, Basic Nuclear Engineering, Wiely Eastern.
M N EI Vakil, Nuclear power engineering, McGraw Hill
Samuel Glasstone, Nuclear reactor engineering. Chapman & Hall, Fourth Edition Om Prakash Gupta, Fundamentals of nuclear power reactors, Khanna publishers

POLLUTION CONTROL IN THERMAL POWER STATIONS

Course code:**17**ESE 223 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

1. The student should be able to know various type of pollution.
2. The student should be able to determine the pollutant concentration and plume height for the pollutant emission from a plant.
3. The student should be aware of mode of formation and control of various pollutants. The student should have the knowledge of water, noise, plastic and odor pollution and their control.
4. Students should be able to read, analysis and interpret latest research information on various types of pollution.

Unit -I

Impact of Man on the environment: Biosphere; Hydrologic cycle; Nutrient cycle, Carbon cycle, Nitrogen cycle, Sulphur cycle; Pollution of Air, water and Soil, Carbon Emissions and Global Warming, Ozone Depletion

Air Pollution : Sources & Effects: Definition and Scales of Concentration; Classification & Properties of Air Pollutants, Behaviour& Fate of Air Pollutants, Wet Precipitation, Interaction at the Earth's Surface, Chemical Reactions in the Atmosphere, Photochemical Smog; Effects of Air pollution;
Recent studies on effects of air pollution (as obtained from recent research publications. (10Hrs)

Unit -II

Meteorological Aspects of Air pollutant: Temperature Lapse Rates & Stability; Adiabatic Lapse rate, Atmospheric Stability, Inversions; Dispersion of Air Pollutants, Solutions to the Atmospheric Dispersion Equation, The Gaussian Plume Model, Estimation of Plume Rise;
Recent studies on plume models and plume rise (as obtained from recent research publications). (10 Hrs)

Unit-III

Air Pollution Sampling and Measurement: Types of Pollutant Sampling and Measurement; ~~Ambient Air Sampling,~~ Collection and analysis of Gaseous Air Pollutants
Recent studies on sampling and collection of SO2,NOx,CO, and particulate matter.(as obtained from recent research publications. (10 Hrs)

Unit-IV

Air Pollution Control Methods & Equipment: Control Methods; Source Correction Methods, Raw Material Changes, Process Changes, Equipment Modification or Replacement, Particulate Emission Control;~~,~~ Gravitational Settling Chambers, Cyclone Separators, Filters, Electrostatic Precipitators, Wet Scrubbers
Recent studies on Particulate matter control. (asobtained from recent research publications).(10Hrs)

Unit -V

Control of Specific Gaseous Pollutants: Important methods for Control of Sulphur Dioxide Emission; Nitrogen Oxide emission**;** Biological oxidation. Recent studies on control of various gaseous pollutants. (as obtained from recent research publications).
Control methods for soil, noise, plastic and odor pollution. Types of water pollution.
Recent studies on control of soil, noise, water, plastic and odor pollution. (as obtained from recent research publications). (10Hrs)

Mapping of POs & COs:

Course Outcomes	1	2	3	4	5	6	7	8	9
CO1	H	---	----	---	----	M	---	H	---
CO2	H	---	---	---	---	---	---	H	---
CO3	H	---	---	---	---	W	----	H	---
CO4	H	---	---	---	---	W	---	H	---

L: Low M: Medium H: High

TEXTS *I* REFERENCE BOOKS:

1. Henry C. Perkins, Air Pollution, McGraw Hill, 1974
2. W.L. Faith, Air Pollution Control, John Wiley
3. C.S.Rao, Environmental Pollution Control Engineering, New Age International Publishers, Revised Second Edition, 2014. Wiley Eastern Ltd
4. Recent research papers from quality journals

POWER GENERATION AND SYSTEM PLANNING

Course code:17ESE 224 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

Unit-I

Load forecasting – characteristics of loads –methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting –annual and monthly peak demand forecasting. (8 hrs)

Unit-II

System Planning : Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning (8 hrs)

Unit-III

Generation system: Reliability analysis-Reliability Concepts- Exponential Distribution mean time to failure-Series and Parallel system – Markov Process- Recursive technique- Generator System reliability analysis-Probability Models for generator unit and loads-Reliability Analysis of isolated and inter connected system – Generator system cost analysis (12hrs)

Unit-IV

Transmission system reliability analysis: Transmission system reliability model analysis – Capacity state classification- Average –Interruption rate method – LOLP method (6hrs)

Expansion planning: Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system. (8 hrs)

Unit-V

Distribution system planning overview: Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices (8 hrs)

Text Books/ Reference Books:

1. R.L. Sullivan, "*Power System Planning*", Tata McGraw Hill Publishing Company Ltd, 2012.
2. Roy Billinton& Ronald N. Allan, "*Reliability Evaluation of Power System*", Springer Publication, 1986.
3. Endreni.J., Reliability modeling in electric power system, John Wiley 1980
4. X. Wang & J.R. McDonald, "*Modern Power System Planning*", McGraw Hill Book Company,1994.
5. T. Gonen, "*Electrical Power Distribution Engineering*", McGraw Hill Book Company, 1986. Electrical Power Distribution A.S. Pabla, Tata McGraw Hill Publishing CompanyLtd.

APPLICATION OF POWER ELECTRONICS TO RENEWABLE ENERGY SYSTEMS

Course code:**17**ESE 225 Credits: 04

Hrs/Week: 4 hours Total Hours: 52

Course learning objectives

This Course will enable students to:

Unit – I

Renewable Electrical Systems: Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems. 11hrs

Unit – II

Electrical Machines For Renewable Energy Conversion: Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG. 10hrs

Unit – III

Power Converters for WECS: Three phase AC voltage controllers- AC-DC-AC converters, Grid Interactive Inverters-matrix converters. Standalone operation of fixed and variable speed wind energy conversion system, Grid connection Issues, Grid integrated PMSG and SCIG Based WECS 10hrs

Unit – IV

Power Converters for Solar Energy Systems: Block diagram of solar photo voltaic system, Principle of operation. line commutated converters (inversion-mode) - selection of inverter, array sizing Design PV powered DC fan and pump without battery- Design of Standalone System with Battery and AC or DC Load. A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter – Protection Against Islanding and Reverse Power Flow – AC Modules- Design of EMI Filters. 11hrs

Unit – V

Energy storage – Introduction, Energy storage technologies

Hybrid Renewable Energy Systems: Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT). 10hrs

Text Books/ Reference Books:

1. S. N. Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009
2. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
4. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
5. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
6. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.