SCHEME OF TEACHING
V SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1	EE51	Signals and Systems	PCC	3	1	0	4	5
2	EE52	Control Systems	PCC	3	1	0	4	5
3	EE53	Power System Engineering- I	PCC	4	0	0	4	4
4	EE54	Intellectual Property Rights	HSMC	3	0	0	3	3
5	EEExxx	Department Elective – 1	Elective	3	0	0	3	3
6	xxOExx	Open Elective-1	Elective	3	0	0	3	3
7	EEL56	Electrical Machines – II Lab	Lab	0	0	1	1	2
8	EEL57	Power Electronics Lab	Lab	0	0	1	1	2
9	EEL58	Electronic Devices & Circuits Lab	Lab	0	0	1	1	2
			Total	**19**	**2**	**3**	**24**	

Elective Code	Department Elective-1
EEE551	Introduction to Deep Learning
EEE552	Solar and Wind Energy Systems
EEE553	Advanced Industrial Automation

V SEMESTER

SIGNALS AND SYSTEMS

Subject code: EE51 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Sri. Victor George

Course content:

Unit I

Introduction: Definitions of signals and a system, Classification of signals, Basic operations on signals, Elementary signals viewed as interconnections of operations. Relation between the elementary signals, specific systems, Properties of systems

Unit II

Time – domain representations for LTI systems: Convolution Integral and Convolution sum, Impulse response representation, Properties of impulse response representation, step response.

Unit III

Block diagram representation, direct form I and direct form II. Differential and difference equation representation, Solution of differential and difference equation. Sampling theorem, quantization.

Unit IV

Concept of Fourier Series and Fourier transform. Fourier representation of discrete-time periodic signals, Properties of discrete time Fourier series (DTFS)
The Discrete-Time Fourier Transform: Representations of non-periodic signals: The discrete-time Fourier transform (DTFT), Properties of DTFT.

Unit V

Z- Transforms: Introduction, Z-transform, Properties of ROC, Properties of Z transforms, inversion of Z-transforms, Transforms analysis of LTI systems, Transfer function, Stability and causality, Unilateral Z-transform and its application to solve difference equations.

Text Books

1. Simon Haykin, Barry Van Veen, *Signals and Systems,* John Wiley & Sons, 2001. Reprint 2002.

2. Alan V Oppenheim, Alan S. Willsky, S. Hamid Nawab, *Signals and Systems,* Pearson Education Asia, 2nd edition, 1997.

Reference Books

1. Michel J Roberts, *Signals and Systems Analysis of signals through linear systems,* Tata McGraw Hill, 2003.

Course Outcomes (COs)

At the end of the course the student will be able to

1. Perform various operations on elementary signals used in systems and identify its properties.
   (PO-1) (PSO-1)
2. Represent Linear Time Invariant (LTI) system through different techniques.
   (PO-1) (PSO-1)
3. Analyze the relation between the input and output of an LTI system through its impulse response.
   (PO-1) (PSO-1)
4. Determine the various responses of an LTI system using different techniques.
   (PO-1) (PSO-1)
5. Apply various properties of transform techniques in the analysis of signals and systems.
   (PO-1) (PSO-1)

CONTROL SYSTEMS

Subject code: EE52 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Sri. Gurunayk Nayak

Course content:

UNIT -I

Modelling of Systems: The control system, mathematical models of physical systems-introduction, differential equations of physical systems, Mechanical systems, Friction, Translational systems, Rotational systems, Electrical systems, Analogous systems.
(Numerical only on finding transfer function, No numerical on analogous systems)
Block diagram and signal flow graph : To find overall transfer function.**(No numerical)**

UNIT -II

Time response analysis: Standard test signal, unit step response of first and second order system, time response specifications, time response specifications of second order systems, steady state errors and error constants.
Stability Analysis: Concepts of stability, necessary conditions for stability, Routh-Hurwitz criterion, relative stability. **(Numerical only with max. 2-Poles, 2-Zeros)**

UNIT -III

Root Locus Technique: Introduction, Root locus concepts, construction of root loci. (Numerical only with max. 2-Poles, 2-Zeros)
Frequency Domain Analysis: Frequency Domain Specifications, Correlation between time and frequency responses, Polar plot.

UNIT -IV

Stability in Frequency Domain: Nyquist stability criterion. (Numerical only with max. 2-Poles, 2-Zeros), Bode plot(Numerical only with max. 2-Poles, 2-Zeros), Determination of transfer function from Bode plot, Compensators- RC lag, RC lead, RC lag-lead networks.

UNIT -V

Controllers: Introduction to Controllers**,** Necessity of Controllers, Block diagram representation of of feedforward and feedback controller, Effects of Addition of Poles and zeros in plant transfer function (With respect to stability), Introduction to PID Control: Effect of Proportional, Integral, and Differential controller on time domain

behavior of the system, Introduction to Zeigler-Nichols Method for designing PID controller (No Numerical).

Text Books

1. J. Nagrath and M. Gopal, '*Control Systems Engineering*', New Age International (P) Ltd, 4th Edition.

Reference Books

1. K. Ogata, '*Modern Control Engineering*', Pearson Education Asia / PHI, 4th Edition.
2. Benjamin Kuo, '*Automatic Control Systems*', PHI, 7th Edition.
3. MATLAB Documentation on SIMIAM Package.

Course Outcomes (COs):

At the end of the course the student will be able to:

1. Derive the transfer function and mathematical model of variety of mechanical, electromechanical systems.
   (PO- 1, 2)(PSO-1)
2. Find the time domain specifications and time response of the system for various inputs.
   (PO- 1, 2)(PSO-1, 2)
3. Analyze the stability of the system using graphical and algebraic techniques.
   (PO- 1, 2)(PSO-1)
4. Find the frequency domain specifications and identify the need of compensation.
   (PO- 1, 2)(PSO-1)
5. Understand the need of PID control in mobile robotics.

POWER SYSTEM ENGINEERING - I

Subject Code: EE53 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Sri. Ramakrishna Murthy K / Sri. Victor George

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Course content:

Unit I

Introduction to Electrical Power Transmission and Distribution: Standard Voltages for transmission, a typical transmission and distribution system, feeders, distributors, and service mains, classification of power transmission systems, advantages of high voltages for transmission, classification of distribution systems, connection schemes - radial, ring main, requirements and design considerations for distribution system.

AC Distribution: AC distribution calculations -concentrated loads with power factor referred to receiving end voltage and power factor referred to respective load voltages, numerical problems.

Sag Calculations: Main components of overhead lines, Sag and tension for overhead lines with equal and unequal supports, **(no derivations, only concepts and problems).**

Unit-II

Transmission Line Parameters: Transmission line constants, resistance of transmission line and skin effect. Inductance of transmission line, magnetic field intensity inside and outside the conductor, inductance of single phase two wire line, inductance of three phase lines with equilateral and unsymmetrical spacing and transposition, Capacitance of transmission lines, electric field of a long straight conductor, capacitance of single phase system, capacitance of three phase symmetrically spaced and un-symmetrically spaced conductors, effect of earth on the capacitance of transmission lines. (**No derivation, concepts and problems only**)

Insulators: Properties of materials used for insulators, types of insulators, voltage distribution over a string of insulators, calculation of string efficiency, methods of improving string efficiency - expression for line to pin capacitor with static shielding, numerical problems. Introduction to composite insulators.

Unit III

Performance of power transmission lines: Classification of Transmission Lines, ABCD constants for short, medium and long transmission lines, Ferranti effect.

Underground cables: Advantages of underground cables over overhead lines, cable construction, Insulation resistance of single core sheathed cable, capacitance of single core cable, dielectric stress in single core cable, most economical size of a cable,

grading of cables - capacitance grading and inter sheath grading, capacitance of 3 core cable, numerical problems **(only concepts and problems, no derivation).**

Representation of Power System Components: Introduction, circuit models of power system components, one - line diagram, Impedance and reactance diagrams, per-unit system, change in base quantities, per-unit impedance and reactance diagrams.

Unit IV

Symmetrical Components: Resolution of unbalanced phasors, the 'a' operator, expression for phase voltage in terms of symmetrical components, expression for symmetrical components in terms of phase voltages relation between sequence components of phase and line voltages in star of equivalent star connected systems, relation between sequence components of phase and line currents in delta connected systems, symmetrical components in star-delta, transformer banks.

Sequence Impedances and Sequence Networks: Introduction, sequence impedances of a symmetrical circuit, sequence networks of power systems elements, sequences impedances and network of three-phase transformers, sequence impedance and networks of transmission lines, construction of sequence networks of a power system.

Unit V

Symmetrical and Unsymmetrical Faults: Introduction, analysis of three -phase symmetrical faults, fault calculations of a synchronous generator, single line-to-ground fault on an unloaded generator, line-to-line fault on an unloaded generator, double line-to-ground fault on an unloaded generator. Unsymmetrical Faults on Power System, single line-to-ground fault, line-to line fault, double line-to-ground fault, single line-to-ground fault on an unloaded generator through a fault impedance, series types of faults

Text Books

1. J.B Gupta, '*Transmission and Distribution of Electrical Power*', Katson Books, 10th Edition.
2. W.D.Stevenson Jr., '*Elements of Power System Analysis*', McGraw Hill, 4th Edition.
3. C.L.Wadhwa, '*Electrical Power Systems*', Wiley Eastern Ltd., 3rd Edition.

Reference Books

1. Soni, Gupta & Bhatnagar, '*A course in Electrical Power*', Dhanapat and Sons, 2001.
2. S.M.Singh, '*Electric Power Generation, Transmission and Distribution*', Prentice Hall of India Private Ltd., 2003.

Course Outcomes (COs):

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

1. Identify different components of transmission and distribution systems and calculate sag in over-head transmission lines. (PO-1) (PSO-1)
2. Compute the parameters of the transmission line and evaluate performance of the line. (PO-1) (PSO-1)
3. Determine voltage drop in AC distributors. (PO-1) (PSO-1)
4. Select the configurations of line insulators / underground cables and evaluate their performance. (PO-1) (PSO-1)
5. Analyze symmetrical faults by representing components of power system on per unit basis. (PO-1) (PSO-1)
6. Construct sequence networks to determine short-circuit currents and phase voltages for unbalanced faults. (PO-1) (PSO-1)

INTELLECTUAL PROPERTY RIGHTS

Subject Code: EE54 **Credits: 3:0:0**
Prerequisites: Nil **Contact Hours: 42**
Course Coordinator/s: Sri. Vinayak V Rao

Course content:

Unit-I

Basic concepts of Intellectual property [IP] law, Introduction, concept of property, need for a holistic approach, constitutional aspects of IP, evolution of the patent system in UK, US and India, basis for protection, invention, criteria for patentability, Nature of IP, Commercial exploitation of IP, Enforcement of rights and remedies against infringement, Intellectual property and economic development, International character of IP, New acts affecting IP, Importance and need of world intellectual property organizations [WIPO], Trade related intellectual property rights [TRIPS].

Unit-II

Patent: Principles underlaying patent law in India, object of patent law, value of patent system, advantages of patent to inventor, Patentable inventions, non-patentable inventions.

Procedure for obtaining the patent, Specification, Provisional and complete specification, construction and amendment of specification, Opposition proceedings to grant patents, register of patents and patent office.

Rights and obligations of a patentee, transfer of patent rights, government use of inventions, revocation and surrender of patents, infringements of patents, action for infringement, drafting of patent, Case studies.

Trade secrets: Introduction, Factors, Trade secrets v/s Patents

Unit-III

Copyrights: Nature, characteristics, subject matter of copyright, term, author, ownership, rights conferred by copyright, registration, regulatory authorities, assignment/licensees, infringement, remedies, International copyright, Case studies.

Unit-IV

Trademarks: Meaning, function, essentials of trademarks, Principles of registration, rights conferred by registration, Infringement and action against infringement, Case studies.

Industrial design: registration, procedure, piracy and remedies of industrial designs, Case studies.

Geographical indicators: Meaning, registration, rights, infringements, remedies, Case studies. Discussion on defence and obscure publication about IPR.

Unit-V

Cyber Law: Need and role of law in the cyber world, concept of property in cyberspace, protection, infringement and remedies for the copyrights in cyberspace, Implications on intellectual property rights, relevance of domain names in intellectual property rights, software copyrights, Information technology act 2000-siginificance, objectives and offenses, case studies

Text Books

1. P.Narayanan, "*Intellectual Property Law*", Eastern Law house, 3rd edition, 2018.
2. Dr.B.L.Wadehra, "*Intellectual Property Law Handbook*", Universal Law Publishing Co. Ltd., 5th edition , 2012.
3. Pawan Duggal "Textbook on Cyber Law", Universal law publishing house, 2nd edition.
4. Harish Chander, "Cyber Laws and IT Protection", PHI publication, 4th edition, 2012.

Reference Books

1. Dr. T Ramakrishna, "*Ownership and Enforcement of Intellectual Property Rights*", CIPRA, NSLIU -2005.
2. "*Intellectual Property Law (Bare Act with short comments)*", Universal Law Publishing Co. Ltd.. 2007.
3. "*The Trade marks Act 1999 (Bare Act with short comments)*", Universal Law Publishing Co. Ltd., 2005.
4. "*The Patents Act, 1970 (Bare Act with short comments), as amended by Patents (Amendment) Rules 2006 w.e.f. 5-5-2006*". Commercial law publishers (India) Pvt. Ltd., 2006.
5. Thomas T Gordon and Arthur S Cookfair, "*Patent Fundamentals for Scientist and Engineers*", CRC Press 1995.
6. Prabuddha Ganguli, "*Intellectual Property Rights*", TMH Publishing Co. Ltd, 2001

Course Outcomes (COs):

At the end of the course the student will be able to:

1. Access the need, criteria and legal aspects of IPR. (PO-1, 6, 8)(PSO-3)
2. Understand registration, opposition and amendments procedures in the IPR domain. (PO-1, 6, 8)(PSO-3)

3. Apply the drafting concepts for any product of electrical domain. (PO-1, 6, 8)(PSO-3)
4. Gain awareness on different infringements scenarios, remedial action and latest case studies in the IPR domain. (PO-1, 6, 8, 10)(PSO-3)
5. Familiarize with cyber law in IPR domain (PO-1, 6, 8)(PSO-3)

ELECTRICAL MACHINES – II LAB

Subject Code: EEL56 **Credit: 0: 0: 1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Dr. Chandrashekhar Badachi/ Smt. Mamatha G M

List of Experiments:

1. Open circuit and short circuit tests on a single phase transformer.
2. Load test on single phase transformer direct loading
3. Scott connection of two single phase transformers.
4. Load characteristics of a single phase induction motor.
5. Sumpner's test or back to back test on a pair of single phase transformers.
6. Equivalent circuit & Circle diagram of three phase induction motor.
7. Parallel operation and load sharing of single phase transformers.
8. Load test on three phase induction motor.
9. Separation of iron losses of 1 phase transformer
10. Speed control of induction motor
11. Experiment on induction generator.
12. Three phase transformer connections

Text Books

1. A Langsdorf, '*Theory of alternating current machines'*, TMH, 2nd Edition.
2. M. G. Say, '*performance and design of AC machines'*, CBS Publications, 2005.

Reference Books

1. J. Nagarath and Kothari, '*Electrical Machines'*, TMH, 2nd Edition.
2. Ashafaq Hussaim, '*Electric Machines'*, Dhanpat Rai & Co., 1999.

Course Outcomes (COs)

At the end of the course the students will be able to:

1. Predetermine the % efficiency, regulation of single phase transformer. (PO1, 4) (PSO-1)
2. Determine the performance of single phase and three phase induction motor. (PO1,4) (PSO-1)
3. Determine the performance of three phase induction machine (PO1,4) (PSO-1)

POWER ELECTRONICS LAB

Subject code: EEL57 **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Sri. Omsekhar Indela

List of experiments:

1. Static characteristics of Power MOSFET
2. Static characteristics of IGBT
3. Static characteristics of SCR
4. Static characteristics of TRIAC
5. RC half-wave and full-wave triggering circuit for a thyristor
6. Single phase fully controlled rectifier (R, RL Load, RL Load with FWD)
7. AC voltage controller using Triac-Diac combination
8. SCR firing circuit using synchronized UJT relaxation circuit
9. Commutation circuits for thyristor-LC circuit and Impulse commutation circuit
10. Digital firing circuit for thyristor, TRIAC
11. Voltage impulse commutated chopper
12. Study of the working of series inverter

Text Books

1. M. H. Rashid, "*Power Electronics: Circuits, Devices and Applications*", Third Edition, PHI, 2005.
2. Vedam Subrahmanyam, "*Power Electronics*", Revised Second Edition, New Age International Publishers, 2006.

Reference Books

1. G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, "*Thyristorised Power Controller*", New Age International Publishers.
2. M. D. Singh and Khanchandhani K.B, "*Power Electronics"*, TMH, 2001.

Course Outcomes (COs):

At the end of the course the student will be able to:

1. Gain knowledge about the working of power electronic switches like MOSFET, IGBT, SCR and Triac.
   (PO 4, 5) (PSO 1, 2)
2. Design, build and test firing circuits for thyristors.

(PO 3, 4) (PSO 1, 2)

3. Design, build and test commutation circuits for thyristors.
   (PO 3, 4) (PSO 1, 2)
4. Design, build and test power electronic circuits.
   (PO 4, 5) (PSO 1, 2)

ELECTRONIC DEVICES AND CIRCUITS LAB

Subject Code: EEL58 **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Sri. Ramakrishna Murthy K / Sri. Victor George

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List of Experiments:

Sl. No.	Laboratory Experiments
1.	Design and implementation of Clippers and clampers using i) Diodes ii) Op-Amp
2.	Design and implementation of full wave rectifier using i) Diodes ii) Op-Amp and also to demonstrate the concept of regulated output using voltage regulator
3.	Design and implementation of RC phase shift oscillator using i) FET/BJT ii) Op-amp
4.	Design of BJT emitter follower, Darlington emitter follower (with & without bootstrap) and determination of the gain, input & output impedance. Implementation of Voltage follower and its comparison with emitter follower
5.	Design, build and test RC coupled single stage FET/BJT amplifier and determination of the frequency response, input & output impedances
6.	Design and implementation of inverting amplifier, non - inverting amplifier and inverting summing amplifier using Op-amp
7.	Design and implementation of the following Active filters i. First order low pass filter ii. Second order low pass filter
8.	Design and implementation of the following Active filters i. First order high pass filter ii. Second order high pass filter
9.	Design and implementation of zero crossing detector, inverting and non-inverting voltage level detector using Op-Amp
10.	Design and implementation of i. Differentiator and Integrator using op-Amp ii. Monostable and Astable Multivibrator using 555 timer

11. Design and simulation of Amplifier circuits and clippers.
12. Design and simulation of clampers and oscillators

Text Books

1. Robert L Boylestad & Louis Nashelsky, *"Electronic Devices & Circuit Theory"*, 6th Edition, PHI, 2002.
2. David A Bell, "*Operational amplifiers and Linear IC's*", Prentice Hall, 2nd Edition.
3. Ramakant A Gayakwad, "*Op-Amps and Linear Integrated Circuits*", Prentice Hall, 4th Edition.
4. Robert F Couglin, Frederick F Driscoll, "*Operational Amplifiers and Linear Integrated Circuits*", Prentice Hall, 6th Edition.

Reference Books

1. Jacob Millman & Christos C Halkias, "*Integrated Electronics*", Tata McGraw-Hill, 1991.
2. Albert Malvino & David J Bates, *"Electronic Principles"*, 7th Edition, TMH, 2007.
3. Sergio Franco, "*Design with Operational Amplifiers and Analog Integrated Circuits*", TMC, 2008.
4. Roy Choudhary, "*Linear Integrated Circuits*", New Age International, 2003.
5. J. Nagarath, "*Electronic Devices & Circuits*", PHI, 2007.
6. Sudhaker Samuel, "*Electronic Circuits*", 2nd Edition, Tata McGraw Hill, 2010.

Course Outcomes (COs):

At the end of the course the student will be able to:

1. Design the biasing circuits for establishing the Q point of a transistor amplifier. (PO-1, 4) (PSO-1)
2. Design, Simulate (using PSpice), build and test clipper, clamper, rectifiers, voltage regulator, oscillators and RC coupled amplifier. (PO-1, 4) (PSO-1)
3. Design and analyze the performance of various linear circuits and non-linear circuits using Op-Amp. (PO-1, 4) (PSO-1)
4. Evaluate the performance of different active filters using Op-Amps. (PO-1, 4) (PSO-1)
5. Design and analyze the performance different multivibrators using 555 timer. (PO-1, 4) (PSO-1)

Department Elective- 1

Introduction to Deep Learning

Subject Code: EEE551 **Credits: 2:1:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Smt. Kusumika Krori Dutta

Course content:

Unit I

Introduction: Human brain, neuron models, neural nets as directed graphs, feedback, neural architectures, knowledge representation, connection to artificial intelligence.

Unit II

Learning Process: Error-correction learning, memory based learning, Hebbian learning, competitive learning, Boltzmann learning, credit assignment, learning with and without a teacher, learning tasks, memory, statistical learning theory.

Unit III

Modern practical deep neural networks: Deep feed forward networks, regularization for deep learning, optimization for training deep models, convolutional Networks.

Unit IV

Sequence Modelling: Recurrent and recursive nets, practical Methodology, applications.

Unit V

Deep Learning Research: Linear factor models, auto encoders, variation auto encoders, restricted Boltzmann machine, generative adversarial networks.

Text Books

1. Simon Haykin, '*Neural networks: A comprehensive foundation'*, Second Edition, Prentice Hall, New Delhi, 1999, ISBN-81-203-2373-4.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, '*Deep Learning*', MIT Press, 2016.

Course Outcomes (COs):

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

1. Understand the concepts of neural networks and deep learning. (PO1,2)(PSO-1)
2. Analyze various types of learning and their usage. (PO-1,2) (PSO-1)

3. Apply deep feedforward networks and convolutional to solve practical problems. (PO-2,5)(PSO-2)
4. Demonstrate recurrent and recursive nets function and implementation in practical problems solving. (PO-2,5)(PSO-2)
5. Design end-to-end deep learning architectures for practical applications. (PO-2,3,5) (PSO-1, 2)

SOLAR AND WIND ENERGY SYSTEMS

Subject code: EEE552 **Credits: 3:0:0**
Prerequisites: Nil **Contact Hours: 42**
Course Coordinator: Dr. Sridhar. S

Course content:

Unit- I

Fundamentals of Energy Science and Technology: Introduction, Energy, Economy and Social Development, Classification of Energy Sources, Importance of Non - conventional Energy Sources, Salient features of Non-conventional Energy Sources, World Energy Status, Energy Status in India.

Energy Conservation and Efficiency: Introduction, Important Terms and Definitions, Important Aspects of Energy Conservation, Global Efforts, Achievements and Future Planning, Energy Conservation/Efficiency Scenario in India, Energy Audit, Energy Conservation Opportunities.

Energy Storage: Introduction, Necessity of Energy Storage, Specifications of Energy Storage Devices.

Solar Energy-Basic Concepts: Introduction, The Sun as Source of Energy, The Earth, Sun, Earth Radiation Spectrum, Extraterrestrial and Terrestrial Radiations, Spectral Power Distribution of Solar Radiation, Depletion of Solar Radiation.

Unit- II

Solar Energy-Basic Concepts (continued): Measurement of Solar Radiation, Solar Radiation Data, Solar Time, Solar Radiation Geometry, Solar Day Length, Extraterrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface.

Solar Thermal Systems: Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating and Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers

Unit- III

Solar Photovoltaic Systems: Introduction, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell Technologies, Solar Cell, Module, and Array Construction, Maximizing the Solar PV Output and Load Matching. Maximum Power Point Tracker. Balance of System Components, Solar PV Systems, Solar PV Applications

Unit- IV

Wind Energy: Introduction, Basic Principles of Wind Energy Conversion, History of

Wind Energy, Wind Energy Scenario – World and India. The Nature of the Wind, the Power in the Wind, Forces on the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations

Wind energy systems: Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis

Unit- V

Basic Components of a Wind Energy Conversion(WEC) System: Classification of WEC systems, Advantages and Disadvantages of WECS, Types of Wind Machines (Wind Energy Collectors), Analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems, Energy Storage, Applications of Wind Energy, Environmental Aspects.

Text Books

1. G.D. Rai, '*Non-conventional Sources of Energy*', Khanna Publishers, 4th Edition
2. B.H. Khan, 'Non-conventional energy sources' , TMH, 2nd Edition

Reference Books:

1. ShobhNath Singh, '*Non-Conventional Energy Resources*', Pearson, 2015.
2. S.P. Sukhatme J.K.Nayak, '*Solar Energy – Principles of Thermal Collections and Storage*', McGraw Hill, 2008.
3. Ahmad Hemami, '*Wind Turbine Technology*', Cengage, 2012.

Course Outcomes (COs):

At the end of the course the student will be able to:

1. Discuss the importance of the role of renewable energy, the concept of energy storage and the principles of energy storage devices.(PO-1)(PSO-1)
2. Discuss the concept of solar radiation data and solar PV system fabrication, operation of solar cell, sizing and design of PV system. (PO-1)(PSO-1)
3. Describe the process of harnessing solar energy and its applications in heating and cooling. (PO-1)(PSO-1)
4. Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection. (PO-1)(PSO-1)
5. Discuss the performance of Wind-machines, energy storage, applications of Wind Energy and environmental aspects. (PO-1)(PSO-1)