Basaveshwar Engineering College (Autonomous)
[TEQIP Lead Institute, Govt. Aided Institution, AICTE Recognized, Affiliated to VTU Belgaum]
Bagalkot-587103, Karnataka, India.
Department of Electrical and Electronics Engineering

Power System Analysis and Stability

SubjectCode:UEE651C **Credits:03**
Contact Hours:03(2L - 2T - 0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Power System Representation: (4L-4T Hours)

Standard symbols of power system components, Single line diagram, Per unit system, Per unit impedance of 3 phase components, Change of base, Per unit impedance diagram, Advantages of per unit system calculations, Formation of Y- bus by inspection method-Numerical Problems

Symmetrical Three Phase Faults: (4L-4T Hours)

3 - phase short circuit at the terminals of unloaded generator, Sub transient, Transient and Steady state reactance, Transients on a transmission line, Short circuit currents and Reactance of synchronous machines on load and no load, Short circuit MVA-Numerical Problems

Unit-II

Symmetrical Components: (3L-3T Hours)

Definition of sequence components for 3-Phase unbalanced power systems, Operator "a" and its properties, Expressions for sequence components, Phase shift of symmetrical components in star delta transformer bank-Numerical Problems

Sequence Networks:(3L-3T Hours)

3- Ph power in terms of sequence components, voltage drop due to sequence currents, sequence impedance and sequence networks of power system elements (Alternator, Transformer and Transmission line), positive, negative and zero sequence networks of power system elements-Numerical Problems

Unit-III

Unsymmetrical Fault at the Terminals Unloaded Generator:(3L-3T Hours)

L-G, L-L, L-L-G fault with and without fault impedance at the terminals of unloaded generator- derivation for connection of sequence network and fault currents-Numerical Problems

Unsymmetrical Faults on Power Systems:(3L-3T Hours)

L-G, L-L, L-L-G faults on unloaded power systems, Open conductor faults in power system-Numerical Problems

Unit-IV

Stability Analysis: (3L-3T Hours)

Classification of Power System Stability, Steady Rotor dynamics, Swing equation, Power angle equation for salient and non salient pole synchronous machines-Numerical Problems

Equal Area Criterion:(3L-3T Hours)

Equal area criterion – Stability analysis for sudden change in mechanical input power, 3-ph fault on Generator terminals and on transmission line, Expression for critical clearing angle, Methods to improve stability of power system-Numerical Problems

References:

1. K. Uma Rao, "Computer Techniques and Models in Power Systems", 1st Edition, I. K. International publishing house, 2014.

2. Nagarath and Kothari, “Modern Power System Analysis”, 3rd Edition, TMH, 2009.
3. W.D. Stevenson, “Elements of Power Systems Analysis”, 4th Edition, Mc.Graw Hill Publishers, 2013.
4. HadiSaadat, “Power System Analysis”, TMH, Publishers, 4th Edition 2015.
5. V Neelakantan, "Power System Analysis & Stability”, Shiva Publishers, 2017

Course outcomes:

After completion of the course, the students shall be able to:

1. Students shall be able to recall the procedure for drawing the reactance diagrams of power system network and advantages of per unit system representation
2. Students shall be able to illustrate the significance of fault analysis, sequence components and power system stability studies
3. Students shall be able to derive mathematical expressions for fault currents and rotor angle under different disturbance conditions
4. Students shall be able to make use of per unit system and sequence components to carry out symmetrical and unsymmetrical fault analysis
5. Students shall be able to decide the stability of the power system and fault analysis methodology for different fault conditions
6. Students shall be able to construct positive, negative and zero sequence reactance diagrams and power angle curves for various fault conditions

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Department of Electrical and Electronics Engineering

Microcontrollers

SubjectCode:UEE652C **Credits:03**
Contact Hours:03(3L - 0T - 0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Ch1. Microprocessors and Microcontrollers (4h):

Basics hex numbers, Hexadecimal addition, Block diagram of Computer, bus and Types of buses, memory address, Introduction of Microprocessors and Microcontrollers 8051, Features, Block diagram, pin diagram, program model, Architecture, PSW, PC, SP, Memory

Ch2. 8051 Assembly Language Programming (2h):

Introduction to assembly language programming,

assembling and running a program, The program counter and ROM space,

data types and directives.

Ch3. Addressing Modes(4h):

Introduction, Addressing modes,

External Data Moves, Code Memory Read Only Data Moves, Indexed Addressing Mode, Programs, PUSH and POP Opcodes, programs, Data exchanges. Programs

Unit-II

Ch4. Logical and Arithmetic Operations (5h):

Introduction, Arithmetic instructions, incrementing and decrementing,

Addition, subtraction, multiplication and division, decimal arithmetic,

Byte level Logical instructions, Bit level logical instructions, Rotate and swap instructions, Programs

Ch5. Jump and Call Instructions (5h):

The jump and call program range, jump and call instructions,

machine cycle and time delays generation

Programs

Unit-III

Ch6. 8051 I/O and Timer Programming (6h)

Introduction, I/O programming, I/O Bit Manipulation Programming.

Timers, programming timers 0 and 1 in 8051 assembly.

Counter programming,

Ch7. 8051 Serial Port and Interrupt Programming (4h):

Basics of serial communication, 8051 connections to RS-232,

Serial port programming in 8051 assembly, Introduction to interrupts,

Unit-IV

Ch8. 8051 Interfacing and Applications (5h):

Interfacing 8051 to LCD, parallel ADC0809, serial ADC MAX1112, DAC, Stepper motor

Ch9. Programming in C for 8051(4h)

Introduction, Programming in C for 8051: data types, Programs on time delays, I/O programming,

References:

1. Kenneth J. Ayala, “The 8051 Microcontroller Architecture, Programming and Applications” 3rd edition, Cengage, 2007.

2. Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; "The 8051 Microcontroller and Embedded Systems using assembly and C", 2nd edition, Pearson, 2012.
3. Myke Predko, "Programming and Customizing the 8051 Microcontroller", TMH, 1999, 15th Reprint, 2008
4. Dr.Ramani Kalpathi and Ganesh Raja; "Microcontroller and its applications", 1st revised edition Sanguine Technical publishers, Bangalore-2007.
5. Raj Kamal, "Microcontrollers: Architecture, Programming, Interfacing and system Design", Pearson Education, 2011.
6. Dr.K. Uma Rao and Dr. Andhe Pallavi, "8051 Microcontroller Architecture, Programming and Applications", Sanguine Technical Publishers Bangalore, 2010.

Course outcomes:

After completion of the course, the students shall be able to:

1. List the features of microcontroller, peripherals and define addressing modes
2. Illustrate architecture of microcontroller, functions of registers & pins, addressing modes, directives, programming instructions, interrupts and peripheral devices
3. Identify the instructions/addressing modes, codes for selecting the register banks/timer registers and to make use of appropriate instructions for programs & delay calculation
4. Create, inspect &debug the assembly language instructions/program and re-correct code & assess number of bytes
5. Formulate the flowchart & assembly level /8051C programme for given application
6. Design and construct the interfacing circuit and develop programme with microcontroller 8051 for given application

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Department of Electrical and Electronics Engineering

Modern Control Theory (Elective)

Subject Code: UEE654E **Credits: 03**
Contact Hours: 03 (3L - 0T - 0P) **Assessment: CIE 50 and SEE 50**

Unit-I

01 State Variable Analysis and Design: **L- 05 Hrs**
Introduction, state space representation using physical variable, phase variable and canonical variables.

02 Derivation of transfer function from state model: **L-04 Hrs**
Diagonalization, Eigen values, Eigen vectors, Solution of state equations.

Unit-II

03 Solution State Transition Matrix: **L-05Hrs**

Solution of state equation, state transition matrix and its properties, computation using Laplace transformation, power series method, Cayley- Hamilton method, concept of controllability and observability methods.

04 Pole Placement Techniques: **L-05Hrs**
Stability improvements by state feedback, necessary and sufficient condition for arbitrary pole place placement

Unit-III

05 Design of Controllers: **L-05Hrs**
Introduction and Design of Proportional (P), Integral (I), Differential (D), PI, PD and PID..

06 Design of Compensators: **L-05Hrs**
Lead compensator, Lag compensator and Lag-lead compensator using frequency domain.

Unit-IV

07 Non-Linear Systems: **L-05 Hrs**
Introduction behavior of non linear system common physical non-linearly - saturation, friction, backlash, dead zone, relay multivariable non linearity. Phase plane method singular points stability of nonlinear system.

08 Liapunov Stability Criteria: **L-05 Hrs**
Liapunov function, direct method of Liapunov and the linear system, Hurwitz criterion and Liapunov's direct method, construction of Liapunov functions for non linear system by Krasvskii's method.

References:

1. Benjamin C. Kuo and Farid Golnaraghi, "Automatic Control Systems", VIII- edition, John Wiley and Sons, 2003.
2. Nagoor Kani, "Advanced Control Theory" 2Edition RBA Publications 2014.
3. Parvatikar K, "Modern control Theory" 1Edition, PRISM Publications, 2016.

Course outcomes:

After completion of the course, the students shall be able to:

1. Students should be able to identify state variables, controllers, and compensators for linear and non linear systems.
2. Students should be able to describe/illustrate state space, pole placement technique and different types of nonlinear systems
3. Students should be able to compute eigen values & vectors in state equation and controllability & observability.
4. Students should be able to analyze stability improvements by state feedback, state observer and Liapunov criteria.
5. Students should be able to compare and contrast multiple methods to implement a function in different domains.
6. Students should be able to design the PID controller, compensators and state regulator observer using system parameters.

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Department of Electrical and Electronics Engineering

Electrical Power Utilization and Drives

Subject Code: UEE65XE **Credits: 03**
Contact Hours: 03 (3L - 0T - 0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Electric heating: 10 Hrs

Introduction, Concept of electric heating, Advantages, Modes of heat transfer, Classification of electric heating, Requirements/ properties/Characteristic of a good heating element. Design of heating element, Resistance furnace/Oven, Temperature controlofresistancefurnace.Electricarcfurnace(i)Directarcfurnace(ii)Indirectarc furnace. Induction heating/Furnace: (i) Core type induction furnace – direct & indirect (ii) Coreless induction furnace (iii) High frequency eddy current heating, Dielectric heating.

Unit-II

Tariff : 02 Hrs

Introduction, Definition and significance, Objectives of tariff, Factors governing tariff, Features of good tariff or desirable characteristic of tariff, Types of tariff

Introduction to Electric Drives: 08 Hrs

Concept of electric drive, advantages and classification. Dynamics of motor load combination. Speed torque convention/Multi quadrant operation. Equivalent drive parameters-(i) rotational load (ii) Translational load. Components of load torque: Static torque, Viscous torque, Coulomb torque, Windage torque. Steady state stability: Criterion for steady state stability. Load equalization, Calculation of time and energy loss in transient operation.

Unit-III

DC motor and Induction Motor drives: 06 Hrs

DC motor drives: Speed Torque Characteristics of DC motor: DC shunt motor- Speed control, DC series motor- Speed control. Motoring and electric braking of DC shunt motor, Motoring and electric braking of DC series motor.

Induction Motor drives: Principle of operation, Equivalent circuit, Speed Torque Characteristics of Induction motor. Braking of Induction motor – Regenerative, Plugging, Dynamic braking.

Heating and rating of motors: 04 Hrs

Heating effects, heating and cooling curves. Loading conditions and classes of duty. Determination of power rating of electric motors for different applications.

Unit-IV

Electric Traction: 10Hrs

Introduction, Ideal traction system, advantages and Disadvantages of electric traction. Systems of track electrification, Types of railway services. Speed time curves of train movement- Creast speed, Average speed, Schedule speed. Simplified speed time curves. Mechanism of train movement- adhesive weight and co-efficient of adhesion. Tractive effort for propulsion of train. Power output from driving axles, Energy output from driving axles, Specific energy output, Energy Consumption.

References:

1. Garg G C, “Utilization of electrical power and electric drives”, Khanna Publishers, 9th edition,2012
2. S K Pillai, “A first course on electric drives”, Wiley Eastern Ltd., 2nd Edition,2006.

3. De N K, Sen P K, "Electric Drives", 15th edition, PHI,2012.
4. Wadhwa C L, "Generation, Distribution and Utilization of Electrical Power", 3rd edition, New age International(p) Ltd., New Delhi,2012.
5. Gupta J B, "Utilization of electrical power and electric traction", 10th edition, S K Kataria and sons,2012.
6. Dubey G K, " Fundamentals of electric drives", 2nd edition, Narosa publishingHouse,2010.

Course outcomes:

After completion of the course,

1. Students shall be able to **list and define** various parameters and features of electric heating, tariff, electric drives andtraction.
2. Students shall be able to **explain** various concepts and theory related to electric heating, tariff, electric drives andtraction.
3. Students shall be able to **relate/articulate** the concepts and theories related to electric heating, tariff, electric drives andtraction.
4. Students shall be able to **compare and contrast** the features of electric heating, tariff, electric drives andtraction.
5. Students shall be able to **evaluate/calculate** various parameters related to electric heating, tariff, electric drives andtraction.
6. Students shall be able to **discuss/choose/test** issues relating to electric heating, tariff, electric drives and traction.

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Department of Electrical and Electronics Engineering

VLSI DESIGN

Subject Code: UEE6XXE **Credits: 03**
Contact Hours: 03 (3L-0T-0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Introduction to MOS Technology: L-05 Hours

Introduction to integrated circuit technology, Metal oxide semiconductor and related VLSI technology, Basic MOS transistors, enhancement mode transistor action, depletion mode transistor, nMOS fabrication, CMOS fabrication, BiCMOS technology. Basic

Electrical Properties of MOS and BiCMOS Circuits: L-05 Hours

Drain to source current verses Voltage characteristics, threshold voltage, trans-conductance, nMOS inverter, determination of pull up to pull down ratio, nMOS inverter driven through one or more pass transistors, alternative forms of pull up, CMOS inverter, MOS transistor circuit model, BiCMOS inverters.

Unit-II

MOS and BiCMOS Circuit Design Process: L-10 Hours

MOS layers stick diagrams, nMOS design style, CMOS design style, designs rules and layout, and lambda based design rules. Basic Circuit Concept: sheet resistance, area capacitance calculation, delay unit, inverter delay, driving large capacitive loads, super buffers, wiring capacitance.

Unit-III

Subsystem Design and Layout: L-10 Hours

architectural issues, gate (restoring) logic, examples of structure ddesign (combinational logic)- a parity generator, Bus arbitration logic for n-line bus, multiplexers. Subsystem Design Process: General consideration, design process- 4 bit arithmetic processor.

Unit-IV

Semiconductor memories: L-10 Hours

Introduction, Dynamic random access memory, static randomaccess memory, nonvolatile memory, flash memory, Ferro electric random access memory.

References

1. Douglas A. Pucknell, Kamran Eshraghian, “Basic VLSI Design”, 3rdEdition, PHI.
2. Sung Mo Kang, Yusuf Leblebici, “CMOS Digital Integrated Circuits, Analysis and Design”, 3rd Edition, Tata McGraw Hill.
3. S. M. Sze, “VLSI Technology”, 2ndEdition, Tata McGraw Hill.

Course Outcomes

At the end of this course,

- Students shall be able to learn details of basics of MOS transistors and digital chip design process
- Students shall be able to understand MOS and BiCMOS Circuit Design Process
- Students shall be able to understand semiconductor memories.
- Students shall be able to Knowledge of stick diagram
- Students shall be able to excel in design of digital integrated circuits
- Students shall be able to understand Electrical Properties of MOS and BiCMOS

Battery Management System

Subject Code: UEE6XXE **Credits: 03**

Contact Hours: 03 (3L-0T-0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Battery-Management-System Requirements: L-09 Hours

Introduction and BMS functionality. Requirements: Sensing, High-voltage contactor control, Isolation sensing and thermal control, Protection and interface, State-of-charge estimation and Energy & power estimation.

Unit-II

Battery State Estimation: L-10 Hours

Preliminary definitions, approaches to estimate state of charge, Review of probability, Overview of vector random (stochastic) processes, Sequential-probabilistic-inference solution, The six-step process, Deriving the linear Kalman filter, Visualizing the Kalman filter, MATLAB code for the Kalman filter steps, Practical considerations, The extended Kalman filter (EKF),

Unit-III

Battery Health Estimation: L-10 Hours

Introduction, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Sensitivity of voltage to ESR and total capacity, A Kalman filter framework for estimating parameters, EKF for parameter estimation, Simultaneous state and parameter estimation, Robustness and speed, The problem with least-squares capacity estimates, Derivation of weighted ordinary least squares, Derivation of weighted total least squares, Goodness of the model fit and confidence intervals, Simplified method with proportional confidence on xi and yi.

Unit-IV

Cell Balancing: L-10 Hours

Causes (and not causes) of imbalance, Design choices when implementing balancing, Circuits for balancing (1): Passive, Circuits for balancing (2): Active, capacitive, Circuits for balancing (3): Active, inductive and dc-dc, How quickly must I balance a pack? And results of balancing simulations.

Voltage-Based Power-Limit Estimation: Problem definition, Voltage-based rate limits, using simple cell model, Voltage-based rate limits, using comprehensive cell model, Bisection search and Power-limits estimation example.

References

1. A.R. JHA, Next-Generation Batteries and Fuel Cells for Commercial, Military, and Space Applications, CRC Press, 2012.
2. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric, Springer, 2013.
3. Gregory L. Plett, Battery Management Systems, Volume 1: Battery Modeling , Artech House September 2015

Prerequisites

Students should have basic knowledge of

- Battery technologies and principle of operation

Course Outcomes

At the end of this course

1. Students should be able to identify, list and define all the terms associated with battery terminologies, Electric vehicles and different filters and methods of optimal control
2. Students should be able to explain the types of battery tests and methods employed to determine SoC and SoH
3. Students should be able to solve numerical problems on fundamental aspects of a rechargeable battery, performance parameters & specifications, battery cell voltage equalization
4. Students should be able to compare and contrast the types of battery state of charge & health estimation methods and control methods for optimal performance of battery
5. Students should be able to conduct tests, observe and draw the inference based on the test results on existing batteries.
6. Students should be able to develop innovative technologies and battery management system for energy conservation

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Department of Electrical and Electronics Engineering

Microcontrollers and IoT Laboratory

Subject Code: UEE661L **Credits:01**
Contact Hours:02(0L - 0T - 2P) **Assessment: CIE 50 and SEE 50**

Part A - Assembly Language Programming

1	Addition of two 8 bit numbers, 16 bit numbers, array of 8 bit numbers, average of an array
2	Subtarction of two 8 bit numbers, 16 bit numbers
3	BCD Addition- two digit numbers, 4 digit numbers
4	Multiplication, Division
5	Arranging an array of number in ascending/descending order
6	To find maximum/minimum number of an array
7	Block of data transfer- Internal RAM, Internal RAM to external RAM
8	To find number of positive and negative numbers in an array
9	Code Coversion-BCD to Hex, Hex to BCD
10	Counters-Binary, BCD

Part B-IOT Programming

1	Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2	To interface LED/Buzzer with Arduino Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds
3	To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4	To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5	To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
6	To interface DISPLAY with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.
7	To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth
8	To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when I'/'O' is received from smartphone using Bluetooth.
9	Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud
10	Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud
11	To install MySQL database on Raspberry Pi and perform basic SQL queries.
12	Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker
13	Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.
14	Write a program to create TCP server on Arduino Raspberry Pi and respond with humidity data to TCP client when requested.
15	Write a program to create UDP server on Arduino Raspberry Pi and respond with humidity data to UDP client when requested.

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AutoCAD lab

Subject Code: UEE662L **Credits:01**
Contact Hours:02(0L - 0T - 2P) **Assessment: CIE 50 and SEE 50**

Part A - Assembly Language Programming

1	Draw Commands- Mirror, Move, copy, offset, rotate, fillet, trim
2	Wiring layout of residential and workshop plan
3	Single Layer 24 Conductor 4 pole progressive Winding with sequence diagram
4	Double Layer 24 Conductor 4 pole DC lap Winding with sequence diagram
5	Double Layer 26 Conductor 4 pole DC lap Winding with sequence diagram
6	12 slots 24 conductors 3 phase full pitch star connected AC winding
7	Assembly of pole, core and field coil for a isometric pole, core and field coil of a DC machine
8	Assembly of single phase 500 kVA core type transformer
9	Assembly of 50 kW DC generator for a given dimension
10	Rotor of 25 kVA alternator assembly
11	Stator of 25 kVA alternator assembly
12	Rotor of 3 phase induction motor assembly

References

1. A.K. Sawhney, A Course in Electrical Machine Design, Dhanpat Rai & Co. (P) Limited (2016), ISBN-10: 8177001019, ISBN-13: 978-8177001013
2. V. N. Mittle & Arvind Mitttle, Design of Electrical Machines, standard publishers distributors
3. S. F. Devalapur, Electrical Drafting, Eastern Book Promoters

Prerequisites:

Students should have basic knowledge of engineering physics and Electrical Machines constructional and operational details

Course Outcomes:

At the end of this course

1. Draw layout of residential and workshop plan using commands
2. Write identify the commands and icons on the Auto CAD software
3. Draw the Windings, assembly of machine parts

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Department of Electrical and Electronics Engineering

Open Elective

Renewable Energy Sources

Subject Code: UEE5XXN **Credits: 03**
Contact Hours: 03 (3L-0T-0P) **Assessment: CIE 50 and SEE 50**

Unit-I

Introduction to Energy Sources: **02Hrs**

Classification of Energy Resources; Conventional Energy Resources – Availability and their limitations; Non-Conventional Energy Resources– Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources.

Solar Energy Basics: **04Hrs**

Introduction, Solar Constant, Basic Sun-Earth Angles – definitions and their representation, Solar Radiation Geometry (only theory); Measurement of Solar Radiation Data – Pyranometer and Pyrheliometer.

Solar Thermal Systems: **04Hrs**

Principle of Conversion of Solar Radiation into Heat, Solar Water Heaters (Flat Plate Collectors), Solar Cookers – Box type, Concentrating dish type; Solar driers, Solar Still.

Unit-II

Solar Electric Systems: **05Hrs**

Solar Thermal Electric Power Generation – Solar Pond and Concentrating Solar Collector (parabolic trough, parabolic dish, Central Tower Collector). Advantages and Disadvantages; Solar Photovoltaic – Solar Cell fundamentals, module, panel and array. Solar PV Systems – Street lighting, Domestic lighting and Solar Water pumping systems.

Wind Energy: **05Hrs**

Wind and its Properties, History of Wind Energy. Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of a WECS, Derivation for Power in the wind, Advantages and Disadvantages of WECS

Unit-III

Biomass Energy: **05Hrs**

Introduction, Photosynthesis process, Biomass conversion technologies; Biomass Gasification – Principle and Working of Gasifiers, Biogas - production of biogas, factors affectingbiogasgeneration,typesofbiogasplants–KVICandJanatamodel.

Geothermal Energy: **05Hrs**

Introduction, Geothermal resources (brief description); Advantages and disadvantages; Applications of Geothermal Energy

Unit-IV

Energy from Ocean: **06Hrs**

Tidal Energy – Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitation of TPP.

Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Advantages and Limitation of OTEC.

Emerging Technologies: **04Hrs**

Fuel Cell, Wave Energy. (Principle of Energy generation using block diagrams, advantages and limitations).

References:

1. Khan, B. H., Non-Conventional Energy Resources, TMH, New Delhi, 2006.
2. Rai, G. D., Non-Conventional Sources of Energy, IV- Edition, Khanna Publishers, New Delhi, 2007
3. Mukherjee, D., and Chakrabarti, S., Fundamentals of Renewable Energy Systems, New Age International Publishers,2005.
4. Tiwari,G.N.,and Ghosal,M.K.,Renewable Energy Sources: Basic Principles and Applications, Alpha Science International, Ltd., New Delhi, 2006.

Course outcomes:

After completion of the course,

1. **Lst and define** various parameters and features of solar, wind, biomass, geothermal and ocean energy conversion systems.
2. **Explain** various concepts and theory related to solar, wind, biomass, geothermal and ocean energy conversion systems
3. **Relate/articulate** the concepts and theories related to solar, wind, biomass, geothermal and ocean energy conversion systems
4. **Compare and contrast** the features of solar, wind, biomass, geothermal and ocean energy conversion systems
5. **Evaluate/calculate** various parameters related to solar, wind, biomass, geothermal and ocean energy conversion systems
6. Discuss/choose/test issues relating to solar, wind, biomass, geothermal and ocean energy conversion systems