Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for B. Tech in Electrical Engineering

(Applicable from the academic session 2018-2019)

Semester-V

Name of the course	**ELECTRIC MACHINE-II**
Course Code: PC-EE-501	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs/week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs/week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To understand the arrangement of windings of AC machines.
2.	To understand the principle of production of pulsating and revolving magnetic fields.
3.	To understand the principle of operation and characteristics of three phase Induction machines
4.	To understand the principle of operation and characteristics of single phase Induction machines
5.	To understand the principle of operation and characteristics of synchronous machine
6.	To understand the principle of operation and characteristics of special electromechanical devices.
7.	To solve problems of Induction machines, synchronous machines and special eletromechanical devices.
Pre-Requisite	
1.	Basic Electrical Engineering (ES-EE-101)
2.	Electric Circuit Theory (PC-EE-301)
3.	Electromagnetic field theory (PC-EE-303)
4.	Electric Machine-I (PC-EE-401)

Unit	Content	Hrs	Marks
1	**Fundamentals of AC machine windings:** Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single-turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis,3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding-concentrated and distributed, Sinusoidally distributed winding, winding distribution factor	5	
2	**Pulsating and revolving magnetic fields:** Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.	5	

3	**Induction Machines:** Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.	10	
	Single-phase induction motors:		
4	Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications	5	
5	**Synchronous machines:** Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.	10	
6	**Special Electromechanical devices:** Principle and construction of switched Reluctance motor, Permanent magnet machines, Brushless DC machines, Hysteresis motor, Stepper motor, Tacho generators.	5	

Text books:

1. Electrical Machines -II , P.S. Bimbhra, Khanna Book Publishing House.
2. Electrical Machinery, P.S. Bimbhra, Khanna Publishing House.
3. Electrical Machines, Nagrath & Kothary, TMH
4. Electrical Machines, P.K. Mukherjee and S. Chakravorti, Dhanpat Rai Publications.
5. Electrical Machines, Theory & Applications, M.N. Bandyopadhyay, PHI

Reference books:

1. Electric Machinery & Transformer, Bhag S. Guru and H.R. Hiziroglu, 3rd Edition, Oxford University press.
2. Electric Machinery & Transformes, Irving L. Kosow, PHI
3. Electric Machinery, A.E.Fitzgerald, Charles Kingsley,Jr. & Stephen D. Umans, 6th Edition, Tata McGraw Hill Edition.
4. Electrical Machines, R.K. Srivastava, Cengage Learning
5. Theory of Alternating Current Machinery, Alexander S Langsdorf, Tata Mc Graw Hill Edition
6. The performance and Design of Alternating Current Machines, M.G.Say, CBS publishers & distributors
7. Electric Machines, Charles A. Gross, CRC press.
8. Problems in Electrical Engineering, Parker smith, 9th Edition, CBS publishers & distributors.

Course Outcome:

After completion of this course, the learners will be able to

1. describe the arrangement of winding of AC machines.

2. explain the principle of operation of Induction machines, Synchronous machines and special machines.
3. solve numerical problems of Induction machines, Synchronous machines and Special machines.
4. estimate the parameters and efficiency of Induction machines and Synchronous machines.
5. determine the characteristics of Induction machines and Synchronous machines.
6. select appropriate methods for starting , braking and speed control of Induction machines.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**POWER SYSTEM-I**
Course Code: PC-EE-502	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs/week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs/week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To understand the basic principle of generation of Electricity from different sources
2.	To find parameters and characteristics of overhead transmission lines and cables.
3.	To find different parameters for the construction of overhead transmission line
4.	To determine the performance of transmission lines.
5.	To understand the principle tariff calculation.
6.	To solve numerical problems on the topics studied.

Pre-Requisite	
1.	Basic Electrical Engineering (ES-EE-101)
2.	Electric Circuit Theory (PC-EE-301)
3.	Electromagnetic field theory (PC-EE-303)

Unit	**Content**	**Hrs**	**Marks**

1	**Basic Concepts:** Evolution of Power System and present day Scenario. Structure of power system: Bulk power grid and Micro Grid. **Generation of Electric Power:** General layout of a typical coal fired power station, Hydro electric power station, Nuclear power station, their components and working principles, comparison of different methods of power generation. Introduction to Solar & Wind energy system. **Indian Electricity Rule-1956:** General Introduction.	10	
2	**Overhead transmission line:** Choice of frequency, Choice of voltage, Types of conductors, Inductance and Capacitance of a single phase and three phase symmetrical and unsymmetrical configurations. Bundle conductors. Transposition. Concept of GMD and GMR. Influence of earth on conductor capacitance. **Overhead line construction:** Line supports, Towers, Poles, Sag, Tension and Clearance, Effect of Wind and Ice on Sag. Dampers. **Corona:** Principle of Corona formation, Critical disruptive voltage, Visual critical corona discharge potential, Corona loss, advantages & disadvantages of Corona. Methods of reduction of Corona.	12	
3	**Insulators:** Types, Voltage distribution across a suspension insulator string, String efficiency, Arching shield & rings, Methods of improving voltage distribution across Insulator strings, Electrical tests on line Insulators.	05	
4	**Cables:** Types of cables, cable components, capacitance of single core & 3 core cables, dielectric stress, optimum cable thickness, grading, dielectric loss and loss angle.	04	
5	**Performance of lines:** Short, medium (nominal, T) and long lines and their representation. A.B.C.D constants, Voltage regulation, Ferranti effect, Power equations and line compensation, Power Circle diagrams.	06	
6	**Tariff:** Guiding principle of Tariff, different types of tariff.	03	

Text book:

1. Electrical Power System, Subir Roy, Prentice Hall
2. Power Systems, A. Ambikapathy, Khanna Publishing House
3. Power System Engineering, Nagrath & Kothery, TMH
4. Elements of power system analysis, C.L. Wodhwa, New Age International.
5. Electrical Power System, Ashfaq Hussain, CBS Publishers & Distributors

Reference books

1. Electric Power transmission & Distribution, S.Sivanagaraju, S.Satyanarayana,, Pearson Education.

2. A Text book on Power system Engineering, Soni, Gupta, Bhatnagar & Chakrabarti, Dhanpat Rai & Co.
3. Electric Power distribution system Engineering, 2nd Edition, T. Gonen, CRC Press.
4. www.powermin.nic.in/acts_notification/pdf/ier**1956**.pdf

Course Outcome:

After completion of this course, the learners will be able to

1. explain the principle of generation of Electric power from different sources
2. determine parameters of transmission lines and its performance
3. explain the principle of formation of corona and methods of its reduction
4. conduct electrical tests on insulators
5. solve numerical problems related to overhead transmission line, cable, insulators and tariff
6. analyze overhead transmission line based on short medium and long lines.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**CONTROL SYSTEM**
Course Code: PC-EE-503	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To find mathematical representation of LTI systems.

2.	To find time response of LTI systems of different orders		
3.	To find the frequency response of LTI systems of different orders		
4.	To understand stabilityof differentLTI systems.		
5.	To analyze LTIsystems with state variables.		
6.	To solve problems of mathematical modelling and stability of LTI systems		
Pre-Requisite			
1.	Basic Electrical Engineering (ES-EE-101)		
2.	Electric Circuit Theory (PC-EE-301)		
3.	Electromagnetic field theory (PC-EE-303)		
4.	Electric Machine-I (PC-EE-401)		
Unit	**Content**	**Hrs**	**Marks**
1	**Introduction to control system:** Concept of feedback and Automatic control, Effects of feedback,Objectives of control system, Definition of linear and nonlinear systems, Elementary concepts ofsensitivity and robustness. Types of control systems, Servomechanisms and regulators, examples offeedback control systems. Transfer function concept. Pole and Zeroes of a transfer function. Propertiesof Transfer function.	04	
2	**Mathematical modeling of dynamic systems:** Translational systems, Rotational systems, Mechanicalcoupling, Liquid level systems, Electrical analogy of Spring–Mass-Dashpot system. Block diagramrepresentation of control systems. Block diagram algebra. Signal flow graph. Mason's gain formula. Control system components: Potentiometer, Synchros, Resolvers, Position encoders. DC and ACtacho-generators. Actuators. Block diagram level description of feedback control systems for positioncontrol, speed control of DC motors, temperature control, liquid level control, voltage control of anAlternator.	08	
3	**Time domain analysis:** Time domain analysis of a standard second order closed loop system. Concept of undamped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. **Error Analysis:** Steady state errors in control systems due to step,	08	
	ramp and parabolic inputs. Concepts of system types and error constants.		

4	**Stability Analysis:** Root locus techniques, construction of Root Loci for simple systems. Effects ofgain on the movement of Pole and Zeros. **Frequency domain analysis of linear system:** Bode plots, Polar plots, Nichols chart, Concept ofresonance frequency of peak magnification. Nyquist criteria, measure of relative stability, phase andgain margin. Determination of margins in Bode plot. Nichols chart. M-circle and M-Contours inNichols chart.	10	
5	**Control System performance measure:** Improvement of system performance through compensation. Lead, Lag and Lead- lag compensation, PI, PD and PID control.	05	
6	**State variable Analysis:** Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.	10	

Text books:

1. Modern Control Engineering, K. Ogata, 4th Edition, Pearson Education
2. Control System Engineering, I. J. Nagrath & M. Gopal. New AgeInternational Publication.
3. Control System Engineering, D. Roy Choudhury, PHI
4. Control System, A. Ambikapathy, Khanna Publishing House
5. Automatic Control Systems, B.C. Kuo & F. Golnaraghi, 8th Edition, PHI **Reference books**

1. Control Engineering Theory & Practice, Bandyopadhyaya, PHI
2. Control systems, K.R. Varmah, Mc Graw hill
3. Control System Engineering, Norman Nise, 5th Edition, John Wiley & Sons
4. Modern Control System, R.C. Dorf & R.H. Bishop, 11th Edition, PearsonEducation.
5. Control System Design, C. Goodwin Graham, F. Graebe F. Stefan, Salgado.E. Mario, PHI
6. Modeling & Control of dynamic system, Macia&Thaler, Thompson
7. Modern Control Technology Components & Systems, 3rd edition, C.T Kilian,Cengage Learning
8. Modern Control Engineering, Y. Singh & S. Janardhanan, Cengage Learning
9. Control System Engineering, R. Anandanatarajan& R. Ramesh Babu, ,SCITECH
10. Automatic Control system, A. William, Wolovich, Oxford

Course Outcome:

After completion of this course, the learners will be able to

1. developmathematical model of mechanical, electrical, thermal, fluid system and different control system components like servomotors, synchros, potentiometer, tacho-generators etc.
2. analyse stability of LTI system using routh-hurtwitz (RH) criteria, root locus techniques in time domain and bode plot and nyquist technique in frequency domain.
3. design different control law or algorithms like proportional control, proportional plus derivative(PD) control, proportional plus integration(PI) control, and proportional plus integration plus derivative (PID) control and compensators like lag, lead, lag-lead for LTI systems.
4. apply state variable techniques for analysis of linear systems.
5. analyze the stability of linear discrete system.
6. solve numerical problems on LTI system modelling, responses, error dynamics and stability .

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**POWER ELECTRONICS**
Course Code: PC-EE-504	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**

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Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:

1.	To understand the functioning and characteristics of power switching devices.
2.	To understand the principle of operation of converters.
3.	To understand different triggering circuits and techniques of commutation of SCR
4.	To find external performance parameter of converters.
5.	To analyze methods of voltage control, improvement of power factor and reduction of harmonics of the converter
6.	To solve numerical problems of converters

Pre-Requisite

1.	Electric Circuit Theory (PC-EE-301)
2.	Analog Electronics (PC-EE-302)
3.	Electromagnetic field theory (PC-EE-303)
4.	Digital Electronics (PC-EE-402)

Unit	Content	Hrs	Marks
1	**Introduction:** Concept of power electronics, application of power electronics, uncontrolled converters,advantages and disadvantages of power electronics converters, power electronics systems,power diodes, power transistors, power MOSFETS, IGBT and GTO.	04	
2	**PNPN devices:** Thyristors, brief description of members of Thyristor family with symbol, V-Icharacteristics and applications. Two transistor model of SCR, SCR turn on methods,switching characteristics, gate characteristics, ratings, SCR protection, series and paralleloperation, gate triggering circuits, different commutation techniques of SCR.	05	
3	**Phase controlled converters:** Principle of operation of single phase and three phase half wave, half controlled, full controlled converters with R, R-L and RLE loads, effects of freewheeling diodes and source inductance on the performance of converters. External performance parameters of converters, techniques of power factor improvement, single phase and three phase dual converters	06	
	DC-DC converters:		
4	Principle of operation, control strategies, step up choppers, types of choppers circuits based on quadrant of operation, performance parameters, multiphase choppers.	05	

5	**Inverters:** Definition, classification of inverters based on nature of input source, wave shape of outputvoltage, method of commutation & connections. Principle of operation of single phase andthree phase bridge inverter with R and R-L loads, performance parameters of inverters,methods of voltage control and harmonic reduction of inverters.	10	
6	**Resonant Pulse Converters:** Introduction, Series Resonant inverter, Parallel Resonant inverter, Zero-Current Switching Resonant converters, Zero-Voltage Switching Resonant converter, Two quadrant Zero-Voltage Switching Resonant converter, Resonant DC link inverter.	05	
7	**Applications:** Speed control of AC and DC motors. HVDC transmission. Static circuit breaker, UPS,static VAR controller.	05	

Text books:

1. Power Electronics, M.H. Rashid,4th Edition, Pearson 2. Power Electronics, P.S. Bimbhra, Khanna Publishing House.
3. Power Electronics, V.R. Moorthi, Oxford.
4. Power Electronics, M.D. Singh and K.B. Khanchandani, Tata Mc Graw Hill.

Reference books

1. Modern Power Electronics & AC drives, B.K. Bose, Prentice Hall 2. Power Electronics, Mohan,Undeland&Riobbins, Wiley India
3. Element of power Electronics, Phillip T Krein, Oxford.
4. Power Electronics systems, J.P. Agarwal, Pearson Education.
5. Analysis of Thyristor power conditioned motor, S.K. Pillai, University Press.
6. Power Electronics, M.S. Jamal Asgha, PHI.
7. Power Electronics : Principles and applications, J.M. Jacob, Thomson **Course**

Outcome:

After completion of this course, the learners will be able to

1. differentiate between signal level and power level devices.
2. construct triggering and commutation circuits of SCR.
3. explain the principle of operation of AC-DC, DC-DC and DC-AC converters.
4. analysethe performance of AC-DC, DC-DC and DC-AC converters.
5. apply methods of voltage control and harmonic reduction to inverters.
6. solve numerical problems of switching devices, AC-DC, DC-DC and DC-AC converters.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**ELECTRIC MACHINE-IILABORATORY**

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Syllabus for B. Tech in Electrical Engineering

(Applicable from the academic session 2018-2019)

Course Code: PC-EE 591	**Semester: 5th**
Duration: 6 months	**Maximum marks:100**
Teaching Scheme	**Examination scheme:**
Theory: 0 hr/week	**Continuous Internal Assessment:40**
Tutorial: 0 hr/week	**External Assessment: 60**
Practical: 2 hrs/week	
Credit Points:1	

	Laboratory Experiments:
1.	Different methods of starting of a 3 phase Cage Induction Motor & their comparison [DOL, Auto transformer &Star-Delta]
2.	Study of equivalent circuit of three phase Induction motor by no load and blocked rotor test.
3.	Study of performance of wound rotor Induction motor under load.
4.	Study of performance of three phase squirrel- cage Induction motor –determination of iron-loss, friction &windage loss.
5.	Speed control of 3 phase squirrel cage induction motor by different methods & their comparison [voltagecontrol & frequency control].
6.	Speed control of 3 phase slip ring Induction motor by rotor resistance control
7.	Determination of regulation of Synchronous machine by a. Potier reactance method. b. Synchronous Impedance method.
8.	Determination of equivalent circuit parameters of a single phase Induction motor.
9.	Load test on single phase Induction motor to obtain the performance characteristics.
10.	To determine the direct axis resistance [Xd] & quadrature reactance [Xq] of a 3 phase synchronous machine byslip test.
11.	Load test on wound rotor Induction motor to obtain the performance characteristics.
12.	To make connection diagram to full pitch & fractional slot winding of 18 slot squirrel cage Induction motor for6 poles & 4 pole operation
13.	To study the performance of Induction generator
14.	Parallel operation of 3 phase Synchronous generators
15.	V-curve of Synchronous motor

Institute may develop experiments based on the theory taught in addition to experiments mentioned.

Reference book:

1. Laboratory experiments on Electrical Machines, C.K. Chanda, A. Chakrabarti, Dhanpat Rai & Co.
2. Laboratory manual for Electrical Machines, D.P. Kothari, B.S.Umre, I K International Publishing House Pvt. Ltd.

Course outcome: After completion of this course, the learners will be able to

1. identify appropriate equipment and instruments for the experiment.
2. test the instrument for application to the experiment.
3. construct circuits with appropriate instruments and safety precautions.
4. validate different characteristics of single phase Induction motor, three phase Induction motor, Induction generator and synchronous motor , methods of speed control of Induction motors and parallel operation of the 3 phase Synchronous generator.
5. work effectively in a team

Special Remarks: The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**POWER SYSTEM-I LABORATORY**
Course Code: PC-EE 592	**Semester: 5th**
Duration: 6 months	**Maximum marks:100**
Teaching Scheme	**Examination scheme:**

Maulana Abul Kalam Azad University of Technology, West Bengal

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Theory: 0 hr/week	**Continuous Internal Assessment:40**
Tutorial: 0 hr/week	**External Assessment: 60**
Practical: 2 hrs/week	
Credit Points:1	

	Laboratory Experiments:
1.	Determination of the generalized constants A.B, C, D of long transmission line and regulation of a 3-Φ transmission line model
2.	Study of distribution system by network analyzer.
3.	Measurement of earth resistance by earth tester.
4.	Determination of dielectric strength of insulating oil.
5.	Determination of breakdown strength of solid insulating material
6.	Determination of parameter of 3-Φ transmission line model by power circle diagram
7.	Study of different types of insulator.
8.	Study of active and reactive power control of alternator.
9.	Study and analysis of an electrical transmission line circuit with the help of software
10.	Determination of dielectric constant, tan delta, resistivity of transformer oil.

Institute may develop experiments based on the theory taught in addition to experiments mentioned.

Course outcome: After completion of this course, the learners will be able to

1. identify appropriate equipment and instruments for the experiment.
2. test the instrument for application to the experiment.
3. construct circuits with appropriate instruments and safety precautions.
4. validate different characteristics oftransmission line.
5. determine earth resistance, dielectric strength of insulating oil, breakdown strength of solid insulating material and dielectric constant of transformer oil.
6. analyze an electrical transmission line circuit with the help of software
7. work effectively in a team

Special Remarks: The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**CONTROL SYSTEMLABORATORY**
Course Code: PC-EE 593	**Semester: 5th**
Duration: 6 months	**Maximum marks:100**

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Teaching Scheme	**Examination scheme:**
Theory: 0 hr/week	**Continuous Internal Assessment:40**
Tutorial: 0 hr/week	**External Assessment: 60**
Practical: 2 hrs/week	
Credit Points:1	

	Laboratory Experiments:
1.	Familiarization with MAT-Lab control system tool box, MAT-Lab- simulink tool box & PSPICE
2.	Determination of Step response for first order & Second order system with unity feedback with the help of CRO &calculation of control system specification , Time constant, % peak overshoot, settling time etc. from theresponse.
3.	Simulation of Step response & Impulse response for type-0, type-1 & Type-2 system with unity feedback usingMATLAB & PSPICE.
4.	Determination of Root locus, Bode plot, Nyquist plot using MATLAB control system tool box for a givensystem &stability by determining control system specification from the plot.
5.	Determination of PI, PD and PID controller action of first order simulated process.
6.	Determination of approximate transfer functions experimentally from Bode plot.
7.	Evaluation of steady state error, setting time , percentage peak overshoot, gain margin, phase margin withaddition of Lead, Lag, Lead-lag compensator.
8.	Study of a practical position control system obtaining closed step responses for gain setting corresponding toover-damped and under-damped responses. Determination of rise time and peak time using individualizedcomponents by simulation. Determination of un-damped natural frequency and damping ratio fromexperimental data.
9.	Analysis of performance of Lead, Lag and Lead-Lag compensation circuits for a given system using simulation.
10.	Determination of Transfer Function of a given system from State Variable model and vice versa.
11.	Analysis of performance of a physical system using State variable technique by simulation.Study ofstep response and initial condition response for asingle input, two-output system in SV form by simulation.

Institute may develop experiments based on the theory taught in addition to experiments mentioned.

Course outcome: After completion of this course, the learners will be able to

1. identify appropriate equipment and instruments for the experiment.
2. test the instrument for application to the experiment.
3. construct circuits with appropriate instruments and safety precautions.
4. use MAT-Lab control system tool box, MAT-Lab- simulink tool box & PSPICE for simulation of systems.
5. determinecontrol system specifications of first and second order systems.
6. validate step response & impulse response for type-0, type-1 & Type-2 system with unity feedback using MATLAB & PSPICE.
7. work effectively in a team

Special Remarks: The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**POWER ELECTRONICSLABORATORY**
Course Code: PC-EE 594	**Semester: 5th**
Duration: 6 months	**Maximum marks:100**
Teaching Scheme	**Examination scheme:**

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Theory: 0 hr/week	**Continuous Internal Assessment:40**
Tutorial: 0 hr/week	**External Assessment: 60**
Practical: 2 hrs/week	
Credit Points:1	

	Laboratory Experiments:
1.	Study of the characteristics of an SCR.
2.	Study of the characteristics of a Triac
3.	Study of different triggering circuits of an SCR
4.	Study of firing circuits suitable for triggering SCR in a single phase full controlled bridge.
5.	Study of the operation of a single phase full controlled bridge converter with R and R-L load.
6.	Study of performance of single phase half controlled symmetrical and asymmetrical bridge converters.
7.	Study of performance of step down chopper with R and R-L load.
8.	Study of performance of single phase controlled converter with and without source inductance (simulation)
9.	Study of performance of step up and step down chopper with MOSFET, IGBT and GTO as switch (simulation)
10.	Study of performance of single phase half controlled symmetrical and asymmetrical bridge converter.(simulation)
11.	Study of performance of three phase controlled converter with R & R-L load. (simulation)
12.	Study of performance of PWM bridge inverter using MOSFET as switch with R and R-L load.
13.	Study of Zero Voltage Switching Resonant converter and Zero Current Switching Resonant Converter andto plot its output waveforms.
14.	Study the speed control of universal motor to plot speed v/s α

Institute may develop experiments based on the theory taught in addition to experiments mentioned.

Reference book:

1. Power Electronics Laboratory: Theory, Practice and Organization, O.P.Arora, Om Prakash Arora, Alpha science International.

Course outcome: After completion of this course, the learners will be able to

1. identify appropriate equipment and instruments for the experiment.
2. test the instrument for application to the experiment.
3. construct circuits with appropriate instruments and safety precautions.
4. validatecharacteristics of SCR, Triac, and performance of phase controlled converter, DC-DC converter, inverters and resonant pulse converters.
5. demonstrate the relation between the speed and firing angle of Universal motor.
6. work effectively in a team

Special Remarks:

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**DATA STRUCTURE & ALGORITHM**
Course Code: OE-EE-501A	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks

Practical: hrs./week		Attendance: 05 Marks	
Credit Points: 3		End Semester Exam: 70 Marks	
Objective:			
1.	To understand the basics of abstract data types.		
2.	To understand the principles of linear and nonlinear data structures.		
3.	To build an application using sorting and searching		
Pre-Requisite			
1.	Programing for problem solving (ES-CS 201)		
2.	Mathematics (BS-M-102)		
3.	Mathematics (BS-M-202)		
Unit	**Content**	**Hrs**	**Marks**
1	Introduction: Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade off. Searching: Linear Search and Binary Search Technique sand their complexity analysis.	10	
2	Stacks and Queues: ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation – corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.	10	
3	Linked Lists: Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, Doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms andthe complexity analysis. Trees: Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis	10	
4	Sorting and Hashing: Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing. Graph: BasicTerminologies and Representations, Graph search and traversal algorithms and complexity analysis.	10	

Text books:

1. Data Structures and Program Design In C, 2/E by Robert L. Kruse, Bruce P. Leung. PHI 2. Data Structure & Algorithms Using C, R.S. Salaria, 5th Ed., Khanna Publishing House
3. Data Structures in C, Aaron M. Tenenbaum. Pearson.
4. Data Structure, S. Lipschutz.. Mc Graw Hill.

Reference books

1. Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, MIT press
2. Expert Data Structures with C++, R.B Patel, Khanna Publishing House
3. Fundamentals of Data Structures of C, Ellis Horowitz, SartajSahni, Susan Andersonfreed, MIT press
4. Data Structures Using C, ReemaThareja. Oxford University press
5. Data Structure Using C, 2/e by A.K. Rath, A. K. Jagadev. SCITECH
6. Data Structures through C, YashwantKanetkar, BPB Publications.

Course Outcome:

After completion of this course, the learners will be able to

1. differentiate how the choices of data structure & algorithm methods enhance the performance of the program.
2. solve problems based upon different data structure & also write programs.
3. write programs based on different data structure
4. identify appropriate data structure & algorithmic methods in solving problem.
5. discuss the computational efficiency of the principal algorithms for sorting, searching, and hashing
6. comparethe benefits of dynamic and static data structures implementations.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**OBJECT ORIENTED PROGRAMMING**
Course Code: OE-EE-501B	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks

Practical: hrs./week		Attendance: 05 Marks	
Credit Points: 3		End Semester Exam: 70 Marks	
Objective:			
1.	To understand simple abstract data types		
2.	To understand features of object-oriented design such as encapsulation, polymorphism, inheritance		
3.	To understand common object-oriented design patterns		
4.	To design applications with an event-driven graphical user interface.		
Pre-Requisite			
1.	Programing for problem solving (ES-CS 201)		
Unit	**Content**	**Hrs**	**Marks**
1	Abstract data types and their specification. How to implement an ADT. Concrete state space, concrete invariant, abstraction function. Implementing operations, illustrated by the Text example.	08	
2	Features of object-oriented programming. Encapsulation, object identity, polymorphism – but not inheritance.	08	
3	Inheritance in OO design. Design patterns. Introduction and classification. The iterator pattern.	08	
4	Model-view-controller pattern. Commands as methods and as objects. Implementing OO language features. Memory management.	08	
5	Generic types and collections GUIs. Graphical programming with Scale and Swing . The software development process	08	

Text books:

1. Mastering Object-Oriented Programming Using C++, R.S. Salaria, Khanna Publishing House.
2. Object Oriented Modelling and Design,Rambaugh, James Michael, Blaha Prentice Hall India.
3. The complete reference-Java2, Patrick Naughton, Herbert Schildt, TMH
4. Core Java For Beginners, R.K. Das, VIKAS PUBLISHING
5. Java How to Program, Deitel and Deitel, 6th ED, Pearson

Reference books

1. Object Oriented System Development, Ali Bahrami, McGraw Hill. 2.
Ivor Horton's Beginning Java 2 SDK – Wrox
3. Programming With Java: A Primer, E. Balagurusamy 3rd Ed., TMH

Course Outcome:

After completion of this course, the learners will be able to

1. specify simple abstract data types.
2. recognise features of object-oriented design such as encapsulation, polymorphism, inheritance, and composition of systems based on object identity.

3. apply common object-oriented design patterns
4. specify uses of common object oriented design patterns with examples.
5. design applications with an event-driven graphical user interface.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**COMPUTER ORGANISATION**
Course Code: OE-EE-501C	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for B. Tech in Electrical Engineering

(Applicable from the academic session 2018-2019)

Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:

1.	To understand the analysis and design of various digital electronic circuits.
2.	To understand how Computer Systems work & its basic principles
3.	To understand how I/O devices are being accessed and its principles etc.

Pre-Requisite

1.	Programing for problem solving (ES-CS 201)
2.	Digital Electronics (PC-EE 402)

Unit	Content	Hrs	Marks
1	Basic organization of the stored program computer and operation sequence for execution of a program. Role of operating systems and compiler/assembler. Fetch, decode and execute cycle, Concept of operator, operand, registers and storage, Instruction format. Instruction sets and addressing modes. Commonly used number systems. Fixed and floating point representation of numbers.	08	
2	Overflow and underflow. Design of adders - ripple carry and carry look ahead principles. Design of ALU. Fixed point multiplication Booth's algorithm. Fixed point division - Restoring and nonrestoring algorithms. Floating point - IEEE 754 standard.	08	
3	Memory unit design with special emphasis onimplementation of CPU-memory interfacing. Memory organization, static and dynamic memory, memory hierarchy, associative memory. Cache memory, Virtual memory. Data path design for read/write access.	10	
4	Design of control unit - hardwired and microprogrammed control. Introduction to instruction pipelining. Introduction to RISC architectures. RISC vs CISC architectures. I/O operations - Concept of handshaking, Polled I/O, interrupt and DMA.	10	

Text books:

1. Computer System Architecture, Mano, M.M. PHI.
2. Computer Architecture & Organisation, Hayes J. P, McGraw Hill,
3. Computer Organisation & Design, Chaudhuri P. Pal, PHI,

4. Computer Organization & Architecture, Rajaraman , PHI

Reference books

1. Computer Architecture, BehroozParhami , Oxford University Press
2. Microprocessors and Microcontrollers, N. senthil Kumar, M. Saravanan, S. Jeevananthan ,OUP
3. Computer Organization & Architecture , P N BasuVikas Pub
4. Computer Organization & Architecture, B.Ram, Newage Publications
5. Computer Organisation, Hamacher, McGraw Hill, **Course Outcome:**

After completion of this course, the learners will be able to

1. explain basic structure of digital computer, stored program concept, different arithmetic and control unit operations, operating systems and compiler/assembler, memory and I/O operations.
2. differentiate between RISC vs CISC architectures, cache memory, virtual memory.
3. performfixed point multiplication and division.
4. applyrestoring and non-restoring algorithms, floating point - IEEE 754 standard.
5. design adder, memory unit and control unit, data path for read/write access.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Maulana Abul Kalam Azad University of Technology, West Bengal

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Syllabus for B. Tech in Electrical Engineering

(Applicable from the academic session 2018-2019)

Name of the course	**HIGH VOLTAGE ENGINEERING**
Course Code: PE-EE-501A	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To understand the breakdown phenomenon of solid, liquid and gases.
2.	To understand the method of generation of high voltage AC and DC.
3.	To understand measurement techniques of high voltage and current
4.	To understand the over voltage phenomenon and insulation coordination in Electric power systems
5.	To understand different methods of high voltage testing.
6.	To solve numerical problems of breakdown phenomena, generation and measurement of high voltage and currents, over voltage phenomena and high voltage testing.

Pre-Requisite	
1.	Electric Circuit Theory (PC-EE-301)
2.	Electromagnetic field theory (PC-EE-303)
3.	Electric Machine-I (PC-EE-401)
4.	Electrical and Electronics measurement (PC-EE-403)

Unit	**Content**	**Hrs**	**Marks**
1	**Breakdown phenomena:** Breakdown of Gases: Mechanism of Breakdown of gases, Charge multiplication, Secondaryemission, Townsend Theory, Streamer Theory, Paschen's Law, Determination of Minimumbreakdown voltage, Breakdown in non-uniform field, Effect of polarity on corona inceptionand break down voltage. Partial Discharge: definition and development in solid dielectric. Break Down of Solids: Intrinsic breakdown, Electromechanical break down, Thermalbreakdown, Streamer Breakdown. Breakdown of Liquid: Intrinsic Break down, Cavitation Theory, Suspended particle Theory. Breakdown in Vacuum: Non-metallic electron emission mechanism, Clump mechanism, Effect of pressure on breakdown voltage.	10	

2	**Generation of High Voltage and Currents** Generation of highDC and AC voltages: half wave rectifier circuit, Cockroft-Walton voltage multiplier circuit, Electrostatic generator, Cascaded transformers, Series resonant circuit. Generation of Impulse voltages and currents: standard impulse wave shapes, Multistage impulse generators, generation of switching surges, generation of impulse currents, tripping and control of impulse generators.	08	
	Measurement of High Voltage and Currents		
3	Sphere gap, Uniform field spark gap, Rod gap, Electrostatic voltmeter, Generating voltmeter, Impulse voltage measurements using voltage dividers, Measurement of High DC and Impulse currents. Cathode ray oscillographs for impulse voltage and current measurements.	08	
4	**Over voltage phenomenon and insulation coordination in Electric power systems:** Lightning Phenomena, Electrification of cloud, Development of Lightning Stroke, lightning induced over voltage, direct stroke, indirect stroke. Protection of Electrical Apparatus against over voltage, Lightning Arrestors, Valve Type, Metal Oxide arresters, Expulsion type. Effect of location of lightning arresters on protection of transformer. Protection of substation, Ground wires. Insulation Co-ordination, Basic Insulation level. Basic Impulse level, Switching Impulse level. Volt time characteristics of protective devices, Determination of Basic Impulse level of substation equipment.	08	
5	**High Voltage Testing:** Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators andbushings, testing of isolators and circuit breakers, testing of cables, power transformers. High voltage laboratory layout, indoor and outdoor laboratories, testingfacility requirements, safety precautions in H. V. Labs.	06	

Text books:

1. High Voltage Engineering, C.L. Wadhawa, New Age International Publishers.
2. High Voltage Engineering, M.S. Naidu & V. Kamraju, Tata MC Graw Hill publication.

Reference books

1. High-Voltage Engineering : theory and practice, Mazen Abdel-Salam; Hussein Anis; Ahdab El-Morshedy; RoshdyRadwan, New York, N.Y. : Marcel Dekker, ©2000.
2. High Voltage Engineering, E. Kuffel, W.S. Zaengl, J. Kuffel, 2nd edition, ButterworthHeinemann.

Course Outcome:

After completion of this course, the learners will be able to

1. explain breakdown phenomenon of gas, liquid and solid and vacuum 2. suggest methods for generation and measurement of high voltage and currents.
3. determine the basic insulation level of substation equipment.
4. apply methods for protection of electrical apparatus against over voltage
5. test insulators,bushings, isolators, circuit breakers, cables and power transformers.
6. solve numerical problems of breakdown phenomena, generation and measurement of high voltage and currents, over voltage phenomena and high voltage testing.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**POWER PLANT ENGINEERING**
Course Code: PE-EE-501B	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To understand methods of selection of power plant and its economic.
2.	To understand the principle of operation different types of power plants.
3.	Tounderstand methods of site selection of different power plants.
4.	To understand the cause of pollution and its remedy for power plants.
5.	To understand methods of cooling of generators and transformers.
6.	To solve numerical problems of load estimation, economics of power plants.

Pre-Requisite	
1.	Electric Circuit Theory (PC-EE-301)
2.	Electromagnetic field theory (PC-EE-303)
3.	Electric Machine-I (PC-EE-401)
4.	Electrical and Electronics measurement (PC-EE-403)

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Syllabus for B. Tech in Electrical Engineering

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Unit	Content	Hrs	Marks
1	**Introduction:** Power and energy, sources of energy, review of thermodynamic cycles related to powerplants, fuels and combustion calculations.Load estimation, load curves, various terms and factors involved in power plantcalculations. Effect of variable load on power plant operation, Selection of power plant. **Power plant economics and selection**: Effect of plant type on costs, rates, fixed elements, energy elements, customer elements andinvestor's profit; depreciation and replacement, theory of rates. Economics of plantselection, other considerations in plant selection.	08	
2	**Steam power plant:** General layout of steam power plant, Power plant boilers including critical and supercritical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systemssuch as coal handling system, pulverizers and coal burners, combustionsystem, draft, ash handling system, Dust collection system, Feed water treatment andcondenser and cooling towers and cooling ponds, Turbine auxiliary systems such asgoverning, feed heating, reheating, flange heating and gland leakage. Operation andmaintenance of steam power plant, heat balance and efficiency, Site selection of a steampower plant.	08	
	Diesel power plant:		
3	General layout, Components of Diesel power plant, Performance of diesel power plant, fuelsystem, lubrication system, air intake and admission system, supercharging system, exhaustsystem, diesel plant operation and efficiency, heat balance, Site selection of diesel powerplant, Comparative study of diesel power plant with steampower plant. **Gas turbine power plant:** Layout of gas turbine power plant, Elements of gas turbine power plants, Gas turbine fuels,cogeneration, auxiliary systems such as fuel, controls and lubrication, operation andmaintenance, Combined cycle power plants, Site selection of gas turbine power plant .	08	
4	**Nuclear power plant:** Principles of nuclear energy, Lay out of nuclear power plant, Basic components of nuclear reactions, nuclear power station, Nuclear waste disposal, Site selection of nuclear power plants. **Hydro electric station:** Hydrology, Principles of working, applications, site selection, classification and arrangements, hydro-electric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, interconnected systems. **Non Conventional Power Plants:** Introduction to non-conventional power plants (Solar, wind, geothermal, tidal)etc.	10	

5	**Electrical system:** Generators and their cooling, transformers and their cooling.Instrumentation Purpose, classification, selection and application, recorders and their use,listing of various control rooms.Pollution due to power generation and its remedy	06	

Text books:

1. Power Plant Engineering, P.K. Nag, McGraw Hill.
2. Power Plant Engineering, F.T. Morse, Affiliated East-West Press Pvt. Ltd.
3. Power Plant Technology El-Vakil, McGraw Hill.

Reference books

1. Steam & Gas Turbines & Power Plant Engineering by R.Yadav, Central Pub.House.
2. An introduction to thermal power plant engineering and operation, P.K.Das and A.K. Das, Notion press.

Course Outcome:

After completion of this course, the learners will be able to

1. explain the principle of operational of Steam, Hydroelectric, Diesel, Gas turbine, Nuclear power and non-conventional power plant.
2. identifythe cause of pollution for power generation and its remedy.
3. suggest location to set up Steam, Hydroelectric, Diesel, Gas turbine and Nuclear power plant.
4. compare Steam, Hydroelectric, Diesel, Gas turbine, Nuclear power and non-conventional power plant.
5. suggest methods of maintenance of Steam, Gas and Hydroelectric power plants
6. solve numerical problems of load estimation and economics of power plants.

Special Remarks (if any)
The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.

Name of the course	**RENEWABLE & NON CONVENTIONAL ENERGY**
Course Code: PE-EE-501C	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Mid Semester Exam: 15 Marks
Tutorial: 0hr/week	Assignment & Quiz: 10 Marks
Practical: hrs./week	Attendance: 05 Marks
Credit Points: 3	End Semester Exam: 70 Marks

Objective:	
1.	To understand the difference between Renewable and non-renewable energy sources

2.	To understand methods of conversion of solar energy and wind energy to other form of energy.		
3.	Tounderstand methods harnessing energy from Biomass, Geothermal and ocean		
4.	To understand the principle of operation of Magneto Hydrodynamic power generation:		
5.	To understand the principle and operation of fuel cell.		
6.	To solve numerical problems of Renewable and non-renewable energy sources		
Pre-Requisite			
1.	Electric Circuit Theory (PC-EE-301)		
2.	Electromagnetic field theory (PC-EE-303)		
3.	Electric Machine-I (PC-EE-401)		
4.	Electrical and Electronics measurement (PC-EE-403)		
Unit	**Content**	**Hrs**	**Marks**
1	**Introduction to Energy sources:** Renewable and non-renewable energy sources, energy consumption as a measure of Nation's development; strategy formeeting the future energy requirements Global and National scenarios, Prospects of renewable energy sources. Impact of renewable energy generation on environment, Kyoto Protocol.	03	
2	**Solar Energy:** Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solarradiation, local solar time, derived solar angles, sunrise, sunset and day length. flat plate collectors, concentratingcollectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond , solar water heaters,solar distillation, solar still, solar cooker, solar heating & cooling of buildings, photo voltaic - solar cells, different typesof PV Cells, Mono-poly Crystalline and amorphous Silicon solar cells. Design of PV array. Efficiency and cost of PVsystems & its applications. PV hybrid systems	08	
3	**Wind Energy:** Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components, varioustypes and their constructional features; design considerations of horizontal and	05	
	vertical axis wind machines: analysis ofaerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations		
4	**Energy from Biomass:** Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas	05	
5	**Geothermal Energy:** Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dryrock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.	05	

6	**Energy from Ocean:** Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle, prospects of OTEC inIndia. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages,limitation and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages anddisadvantages of wave energy.	05	
7	**Magneto Hydrodynamic power generation:** Principle of MHD power generation, MHD system, Design problems and developments, gas conductivity, materials forMHD generators and future prospects.	05	
8	**Hydrogen Energy:** Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas,hydrogen as alternative fuel for vehicles.	03	
9	**Fuel cell:** Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, applicationof fuel cells	03	

Text books:

1. Renewable energy sources and conversion technology, Bansal Keemann, Meliss, Tata Mc Graw Hill.
2. Energy Technology, O.P. Gupta, Khanna Publishing House.
3. Renewable energy resources and emerging technologies, D.P. Kothari, PHI.
4. Non-conventional Energy sources, G.D. Rai, Khanna Publishers.
5. Non Conventional Energy Resources, Chandra, Khanna Publishing House.

Reference books

1. Non-conventional Energy, Ashok V. Desai, New Age International Publishers Ltd.

Course Outcome:

After completion of this course, the learners will be able to

1. explain the principle of conversion of solar energy, wind energy , biomass, Geothermal energy, Ocean energy and Hydrogen energy to other form of energy.
2. explain the principle of operation of magneto hydrodynamic power generation:
3. useSolar energy, Wind energy , Biomass, Geothermal energy, Ocean energy, Hydrogen energy and fuel cell for different applications.
4. suggest location to set up wind mill and biogas generation plant
5. estimate conversion efficiency of fuel cell.
6. solve numerical problems relating to conversion of Solar energy, Wind energy , Biomass, Ocean energy and Hydrogen energy to heat and electric energy.

Special Remarks (if any)

The above-mentioned outcomes are not limited. Institute may redefine outcomes based their program educational objective.