JADAVPUR UNIVERSITY

Faculty of Engineering and Technology

Department of Power Engineering

Syllabus for 2nd to 4th Year of UG Power Engineering Course

2nd Year 1st Semester

Course code	**FET/BS/B/Math/T/211**
Category	Basic Science Course
Course title	**Mathematics III**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Probability and Statistics: Definition of probability; Conditional probability and independence; Bayes' theorem; Collection and Representation of Statistical data: Measures of Central Tendency &Dispersion;Correlation and Regression; Expectation and Variance; Random variables; Discrete and Continuous distribution; Poisson, Normal and Binomial distribution; Chebysheffs inequality.
Vector Algebra: Basics of vector algebra; Dot and Cross products of two vectors; Product of three or more vectors; volume of tetrahedron; Work done; Moment; Angular velocity. Applications to mechanics.
Vector Calculus: Vector functions of a scalar variable; Limit; Continuity and Derivative of vector functions; Applications to mechanics; Partial derivatives of vector function of more than one variables; Directional derivative; Gradient; Divergence and Curl; Vector Integration; Line integrals; Surface integrals and volume integrals; Greeen's theorem in the plane; Gausss Theorem; Stokes' Theorem and their application; Tangent Normal and Binormal of space curve; Serret-Frenet formulae; Normal plane, Rectifying plane and oscillating plane.
Ordinary Differential Equations: First order differential equations - exact, linear and Bernoulli's form, second order differential equations with constant coefficients, method of variation of parameters, general linear differential equations with constant coefficients, Euler s equations, system of differential equations.
Partial Differential Equations: First order PDE; Lagrange method; Second order PDE with constant coefficients and their classification to Elliptic, Parabolic and Hyperbolic type. Solution of PDE by method of separation of variables; Solution of one-dimensional wave and diffusion equation; Laplace equation of two dimensions.

Content Delivery Method
- ✓ Class room lecture (chalk and board)
- ✓ Tutorial
- ✓ Discussion

At the end of the course the students will be able to
- **CO1:** Solve problems related to probability, conditional probability, measures of central tendency, measures of dispersion, correlation and regression, discrete and continuous random variables, distribution functions, expectation and variance **(K3)**
- **CO2:** Compute Scalar and cross product of vectors in 2 and 3 dimensions and apply in problems of mechanics **(K3)**
- **CO3:** Comprehend Vector differentiation and ideas of divergence, curl, and Gradient vector fields and Green' theorem, Gauss Theorem, Stokes' theorem and their applications **(K2)**
- **CO4:** Apply Vector integration including line, surface and volume integrals **(K3)**
- **CO5:** Solve ordinary and partial differential equations of first order using classical methods **(K3)**
- **CO6:** Solve linear differential equations and their systems of second order using classical method and comprehend applications to one dimensional wave and diffusion equations and two dimensional Laplace equation. **(K3)**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1											
CO2	3	2													
CO3	3	2	1	1											
CO4	3	2	1	1											
CO5	3	2	1	1											
CO6	3	2	1	1											

Course code **PE/BS/B/T/212**
Category Basic Science Course
Course title **Chemistry of Energy Science**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Chemistry of photosynthesis, photolysis, energy transfer in mitochondria.
Fuel chemistry – types of fossil fuels, their origin and chemical structures, stoichiometric calculation, heating value. Properties of coal – proximate and ultimate analysis, ash analysis and composition, ash fusion temperature. Properties of liquid and gaseous hydrocarbon fuels.
Water chemistry for thermal power plants – DM water properties, water treatment plant, feed water and boiler water properties, chemistry-boiler interaction.
Chemistry of normal and organic solar cell production.
Chemistry of battery: Introduction to Electrochemistry and Batteries. Overview of Various Types of Batteries.
Fuel Cell chemistry: Introduction to fuel cell. Overview of various types of fuel cells and their chemistry.
Chemistry of super-capacitor and new generation insulation production.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/ Brainstorming (D7)

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

- **CO1:** Describe the chemistry of photosynthesis and energy transfer process in cells (**K2**)
- **CO2:**Classify fossil fuels, explain their properties and solve the stoichiometric calculations (**K2**)
- **CO3:**Illustrate the water treatment plant of thermal power plants and describe DM water properties (**K3**)
- **CO4:**Assess the chemistry of devices like solar cell, battery, fuel cell, super capacitor (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		1			2						3		2
CO2	2	3		2			2						2	3	2
CO3	2	1	1										2		1
CO4	3	2	2				2					1	2	3	2

Course code **PE/PC/B/T/213**
Category Professional Core
Course title **Engineering Thermodynamics**
Scheme and Credits **L–T–P: 4–0–0; Credits: 4.0;**

Syllabus

Concept of thermodynamic system, surrounding, state, property, process and cycle. Reversible and irreversible processes. Different energy forms-stored energy, energies in transit. Concepts of Heat and work. Simple problems with ideal gases.
First law of thermodynamics: Statement of the First law for closed systems. PMM I. Corollaries: Concept of internal energy and enthalpy; Analysis of different non-flow processes with perfect gases.
Properties of steam and other vapors; Steam Table and Steam Chart. Problems related to non-flow processes involving steam.
First law analysis for control volumes for steady state and unsteady states. Problems associated with ideal gas and steam.
Second law of thermodynamics: Limitations of the first law of thermodynamics. Statements of the second law of thermodynamics. Heat engine, Heat Pump and Refrigerator. Thermal efficiency. Coefficient of Performance. Carnot cycle. Corollaries of the Second law, Clausius inequality, Concept of Entropy. Second law analysis of closed and open systems, Entropy generation.
Study of power producing and power absorbing cycles: Vapor Power cycles: Performance parameters of cycles, Heat rate, Work ratio, Specific vapor consumption. Carnot vapor cycle, Rankine cycle.
Gas Power Cycles: Air Standard Cycles – Otto, Diesel, Dual, Stirling, Braytoncylces; Use of air tables for gas power cycle analysis.
Vapor compression and absorption refrigeration cycle. P-h Chart, Air Refrigeration cycle.
Mixture of ideal gas and vapor, Laws of thermodynamics for gas-vapor mixtures, Psychrometry, Thermodynamic analysis of psychrometric processes.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/ Brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Define thermodynamic systems and their properties, and describe different thermodynamic processes. **(K2)**
- **CO2:** Describe the First and Second laws of thermodynamics for closed and open systems and solve simple problems. **(K3)**
- **CO3:** Apply the laws of thermodynamics for vapor and gas power cycles and solve related problems. **(K3)**
- **CO4:** Apply the laws of thermodynamics for refrigeration cycles and air-conditioning systems and solve related problems. **(K3)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1												
CO2	2	3	2	1		1	1						1		
CO3	2	3	1	1		1	1						1		
CO4	2	3	1			1	2						2	1	

Course code **PE/PC/B/T/214**
Category Professional Core
Course title **Fluid Mechanics**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Introduction -Different types of fluid, Newton's law of viscosity, other properties including pressure. Concept of boundary layer.
Fluid Kinematics and dynamics-Different types of fluid motion, stream line, pathline and streakline, Equations for conservation of mass, momentum and energy in 1- 2- and 3-dimensions, Ideal fluid flow, Euler's equation of motion, Integration of equation of motion, Bernoulli's equation.
Viscous flow: Flow through pipes, laminar and turbulent flow through circular and non-circular conduits, Losses in pipe flow – Darcy-Weisbach equation, Hagen-Poseulli's equation, friction factor, pipe network, Pipes in series and parallel; Open channel flow – Chezy's equation.
Flow measurement– Flow measurement in pipes and open channel, Pitottube,venturimeter, orificemeter, flow nozzle, V-notch, rectangular weir andtrapezoidal weir.
Dimensional analysis and similitude-Buckingham pi-theorem, non-dimensional numbers, similitude.
Introduction to compressible flow – velocity of sound, Mach number, different types of compressible flow, compressibility correction factor, Stagnation properties.
Pump-Centrifugal pump and its characteristics, Design components of centrifugal pump, pumps in series and parallel, losses in pumps, Axial flow pumps, Stodola's slip factor. Positive displacement pumps – reciprocating pump, gear pump, axial piston pump, etc.--theirconstructional features and performance curves.
Axial flow fan, blower and compressor – their constructional features and performance curves. NPSH, Cavitation – its cause and remedies.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/ Brainstorming (D7)

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

- **CO1:** Describe the different kind fluid properties and flow properties. (**K2**)
- **CO2:** Explain fluid kinematics and dynamics including viscous flow through pipes. (**K2**)
- **CO3:** Apply knowledge of fluid mechanics for flow measurement, open channel flow and compressible flow. (**K3**)
- **CO4:** Relate the concept of dimensional analysis and similitude to fluid mechanic. (**K3**)
- **CO5:** Analyze constructional feature and performance of pump, axial flow fan, blower and compressor. (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3												1		
CO2	2	3	2	1		1							1		
CO3	1	3	2	1									2		
CO4	2	2	3	2											
CO5	3	2	1									2		2	

Course code **PE/PC/B/T/215**
Category Professional Core
Course title **Circuit Theory**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Elementary electrical network - basic definition -formulation of network equations, basicnetwork theorems, superposition theorem, Thevenin's -Norton's, maximum powertransfer, reciprocity, Milman's theorem and Telegen's theorem, elementary networktopology - graph of networks, formation of tie-set, cut-set and incidence matrix, Application of graph theory in circuit analysis, source transformation, two-port networks, y-parameters and z-parameters and their equivalent circuits, h-parameters and ABCD parameters, cascade and parallel connection of 2-port networks, relationship between 2-port parameters, frequency response of networks, Harmonics, Fourier series and their application in circuit analysis, Application of Laplace transforms for transient analysis, the time series representation of special signals, time domain analysis of transient using the initial and final value theorem, introduction to network synthesis, Foster form, basics of filter circuit design.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/ Brainstorming (D7)

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

- **CO1:** Explain basic network theorems - superposition theorem, Thevenin's-Norton's Theorem, maximum power transfer Theorem, Reciprocity Theorem, Milman'sTtheorem and Telegen'sTheoremetc and their application for network analysis. (**K2**)
- **CO2:** DescribeGraph Theory-formation of tie-set, cut-set and incidence matrix; application of Graph Theory for circuit analysis. (**K2**)
- **CO3:** Describe Two-port networks - y-parameters and z-parameters and their equivalent circuits, h-parameters and ABCD parameters, cascade and parallel connection of 2-port network with their application. (**K2**)
- **CO4:** Apply Laplace transforms for transient analysis, time domain analysis of electric circuits. (**K3**)
- **CO5:** Describe the application of Fourier series and their application in circuit analysis, principle of filter circuit design, network synthesis. (**K2**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1									1		1
CO2	3	2	1	1									1		1
CO3	3	1	2		1								1		
CO4	3	2	1	1	2								2		1
CO5	2	3	1	1	2								2		1

Course code **PE/PC/B/T/216**
Category Professional Core
Course title **Electrical Generators and Transformers**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

DC Machines – DC generators, Construction, Principle of Operation, classifications, emf and speed equations, Armature windings, Armature reaction, Commutation, Interpoles, compensating windings, Brushes, Operating characteristics, Losses, Efficiency, Testing, Swinburn Test, Hopkinson Test.
Synchronous Machines - Alternators, Construction, Principle of working, Excitation, Phasor diagrams, Synchronous reactance, Voltage Regulation, determination of regulation by different methods, Operating characteristics of Alternators, Two reaction theory, Phasor diagram of salient Pole Machines, Power angle characteristics, Parameter Estimation, Efficiency, Transient Analysis: Sudden Short Circuit, Loading & Load rejection, , Transient reactances.
Synchronizing,Synchronizing power and torque, conditions of Parallel Operation, load sharing in multi-machine systems.
Transformers - 1-ph Transformers, Construction and Types, Types of Cooling, Principle of Operation, emf Equations, Phasor diagrams, Equivalent Circuits, P.U. system, Open circuit and Short circuit tests, Voltage regulation, Losses, Efficiency, All-day efficiency, Auto Transformers, Parallel Operation of 1-ph Transformers.
Transformers - 3-ph Transformers, Construction, Connection and phasor groups, magnetic inrush phenomena in transformers, Harmonics and suppression of harmonics, Parameter estimation, Voltage regulation, Open delta and Scott connection, 3-ph and multiphase conversions, Testing of transformers, Parallel operation of 3-ph Transformers.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/ Brainstorming (D7)

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

- **CO1:** Describe the construction and characteristics of DC generator, single phase transformer, three phase transformer and synchronous generators (**K2**)
- **CO2:** Define different operational terms with respect to Transformers, DC generator and synchronous generator **(K2)**
- **CO2:** Explain the operation and control of single phase and three phase transformer (**K2**)
- **CO3:** Explain the operation and control of DC generator and synchronous generator (**K2**)
- **CO4:**Assess equivalent circuit of single phase transformer and three phase transformer (**K3**)
- **CO5:** Derive different operational equations of DC generators, synchronous generators, single phase and three phase transformer (**K4**)
- **CO6:** Calculate different operational features through numerical for of DC generator, synchronous generator, single phase and three phase transformer **(K4)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	3	2	1										2		1
CO3	2	3	2	1									1	2	1
CO4	2	3	2	1									1		
CO5	3	2	1										2		1
CO6	1	2	1	2									2	3	1

Course code **PE/PC/B/S/211**
Category Professional Core
Course title **Machine Shop**
Scheme and Credits **L–T–P: 0–0–3; Credits: 1.5;**

Syllabus

Machining operation: turning, taper turning, thread cutting, knurling, etc. Shaping, Grinding, Milling. Introduction to advanced machining processes.

Content delivery methods

- ✓ Active learning (D4)
- ✓ Demonstration (D7)

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

- **CO1:** Differentiate machine tools and their operation. **(A3, K4)**
- **CO2:** Adhere to safety and precautions for handling various machine **(S1)**
- **CO3:** Perform different machining operations on Lathe. **(S2)**
- **CO4:** Perform different machining operations on shaping machine. **(S2)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1					1	2	2		1			
CO2	1	1	1			2		1	2	2		3			1
CO3	2	2	1			2		1	3	2		2			1
CO4	2	2	1			2		1	3	2		1			1

Course code	**PE/PC/B/S/212**
Category	Professional Core
Course title	**Engineering Graphics**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5;**

Syllabus

Screw threaded forms, bolts and nuts, studs & their uses, keys, splines, etc. riveted and welded joints. Pulleys, rigid coupling & joints for rods, pipes, etc. Development of common surfaces (Cube, Prism, Cylinder, Truncated Cone, pyramid) Intersection of surfaces (Intersecting cylinders, Intersection of Cone and cylinder, Intersection of two prisms).
COMPUTER AIDED DRAFTING: Introduction: Cartesian and Polar Co-ordinate system, Absolute And Relative Co-ordinates; Basic editing Commands: Line, Point, Trace, Rectangle, Polygon, Circle, Arc, Ellipse, Polyline; Basic editing Commands: Basic Object Selection Methods, Window and Crossing Window, Erase, Move, Copy, Offset, Fillet, Chamfer, Trim,Extend, Mirror; Display Commands: Zoom, Pan, Redraw, Regenerate; Simple dimensioning and text, Simple exercises.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual Presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe different machine parts through drawing **(K1)**
- **CO2:** Construct surface Development of common surfaces and their Intersection **(K2, S5)**
- **CO3:** Apply Auto CAD software for basic editing Commands **(K3**)
- **CO4:** Apply knowledge of Auto CAD for simple applications. **(K3).**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1						1			1	1		
CO2	1	3	2						1	1		2			
CO3	2	1	2		3				1	1		2	1		
CO4	1	2	1		3				1	2		1	1		

Course code	**PE/ES/B/S/213**
Category	Engineering Science
Course title	**Mechanics Lab**
Scheme and Credits	**L–T–P: 0–0–2; Credits: 1.0;**

Syllabus

Experiments on mechanics and strength of materials, Determination of coefficient of friction, moment of inertia of flywheel, tension, torsion, bending tests; Hardness and impact test; Static and dynamic balancing test, governing apparatus, natural frequency of vibration of a beam, critical speed of a rotor, whirling of shaft, cam analysis.

Content delivery methods

- ✓ Active learning (D4)
- ✓ Demonstration (D8)

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

- **CO1:** Implement the knowledge of theory of machines through experiments **(S2)**
- **CO2:** Implement the knowledge of strength of material through experiments **(S2)**
- **CO3:** Identify possible causes of discrepancy between experimental observations and theory **(K3)**
- **CO4:** Prepare professional quality laboratory reports **(K3)**

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1			1		1	2	1		2	1	1	1
CO2	3	2	1			1		1	2	1		2	2	1	1
CO3	2	3	2					2	1	1		1			
CO4								2	1	3		1			

2nd Year 2nd Semester

Course code	**PE/HC/B/T/221**
Category	Humanities
Course title	**Engineering Economics and Costing**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Basics of demand and supply - elasticity of demand - concept and measurement. Theory of costs - short run and long run cost curves. Industrial development in India - trends - problems prospects - economic reforms and Indian industry - foreign direct investment and foreign collaboration in Indian industry. International environment - an overview of international trading environment - trends in World Trade and the problems of developing countries - International Economic Institutions - GATT, WTO, World Bank, IMF. Industrial Record Keeping - Double entry - concepts and conventions - Journal, Ledger, Trial Balance, Cash Book, Final Accounts. Nature, Scope, Objectives and Functions of cost accounting and management accounting - costs and its classifications - preparation of cost sheet - accounting for material - pricing of material issues - ABC analysis - Just-in-time - concepts of overheads - allocation and apportionment of overhead - absorption of overheads - marginal costing. Capital budgeting - methods of appraisal - average rate of return - pay back period - discounted cash flow (net present value, internal rate of return). Management - definition - functions - organization - definition and principles - other functions of management.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Interpret the basic dynamics of micro- and macro- economic forces. (**K2**)
- **CO2:** Explain national and international business (**K2**)
- **CO3:** Solve problems related to simple accounting, capital and finance. (**K3**)
- **CO4:** Develop cost sheet and budget for simple business cases.(**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1				2							1		
CO2	3		2			1		2					1		
CO3	2	3			1	1		1					1		
CO4	2	3						1							

Course code **PE/ES/B/T/222**
Category Engineering Science Course
Course title **Materials Science**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Properties of materials, defects in materials and plastic deformation, stress-stain curves and theories of failure.
Phase transformations and phase diagrams, Iron-carbon system, Heat treatment of steel
Future materials for improvement in thermal power plant efficiency: Mechanism of creep, creep test, stress rupture test, Larson- Miller parameter, advanced materials for ultra-supercritical boiler tubes and gas turbine blades.
Magnetic properties of materials, Ferro- Para- and Dia-magnetic properties.
Properties of new generation lamination materials. Materials for solar cells, materials for gas encapsulated protective devices, advanced dielectric materials.
Electronic materials. Smart materials: Application of nanomaterial for batteries, solar and fuel cells. Newer Energy Materials: Carbon nano-tubes (CNTs) and multiwall carbon nanotubes (MWCNTs) - methods of production, properties and its utility in energy devices. Materials for hydrogen storage, thermochemical energy storage, capacitive energy storage. Nanofluids for energy applications.
Advanced functional materials for enhancing phase change heat transfer – boiling and condensation.
Materials for organic and metallic superconductor production.
Material standards – Indian and other major International standards.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Inferabout atomic structure and bonding in materials, defects in materials, failure mechanism of materials **(K2)**
- **CO2:** Select material for improvement in thermal power plant efficiency and advanced materials for ultra-supercritical boiler tubes/gas turbine blades, Materials for hydrogen storage **(K3)**
- **CO3:** Describe the properties of new generation lamination materials, advanced dielectric materials, Electronic materials, smart materials **(K1)**
- **CO4:** Compare between newer energy materials like Carbon nano-tubes (CNTs), **multiwall** carbon nanotubes (MWCNTs) with other energy materials **(K4)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1									1	2	1	1
CO2	1	1	3									2	2	1	1
CO3	2	1	2				3					2			
CO4	2	2	1			3	2					1	1	1	

Course code **PE/PC/B/T/223**
Category Professional Core
Course title **Heat Transfer**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Basic concepts of Heat Transfer, thermophysical properties relevant for heat transfer: thermal conductivity, thermal diffusivity. Concept of heat transfer coefficient.
Conduction: General heat conduction equation, Steady state one-dimensional conduction, Conduction through plane walls, cylinder, sphere and composite walls, Concept of film coefficients and thermal resistance, Network problems. Critical thickness of insulation, Extended surfaces, Transient conduction in 1-D: lumped capacitance approach.
Convection: Concepts of forced, free and mixed convections in internal and external flows; concept of thermal boundary layer and nondimensional numbers in convective heat transfer. Relation between fluid friction and heat transfer. Heat transfer correlations in different geometry, flow and thermal configurations. Forced convection in external flows. Free convection over plates and other obstacles.
Heat transfer in fully developed flows through pipes and ducts. Fouling factors.
Heat exchangers: LMTD and NTU methods of computation of heat transfer in heat exchangers.
Radiation: Basic laws e.g. Planck's law, Stefan-Boltzmann law etc., intensity of radiation, Radiations properties: emissivity, absorptivity, reflectivity, transmissivity. View factor and view factor algebra. Radiation exchange between surfaces and enclosures.
Application of heat transfer in power plants and solar devices.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Describe the primary modes of heat transfer and interpret the corresponding governing physics (**K2**)
- **CO2:** Develop the governing equations of heat transfer through conduction, convection and radiation in simple representative configurations (**K3**)
- **CO3:** Apply the relevant laws and correlations for solving heat transfer problems involving one or multiple modes of heat transfer (**K3**)
- **CO4:** Calculate performance of different heat transfer devices (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	2	3	2	1									2		
CO3	2	3	1		1				1				1		
CO4	2	3	1	1									1		1

Course code **PE/PC/B/T/224**
Category Professional Core Course
Course title **Applied Solid Mechanics and Mechanisms**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Concept of stress, strain, stress-strain diagrams, tension, compression and shear, thermal stresses, general case of stress; Mohr's circle, thin-walled pressure vessels, torsion in circular shafts. Shear force and bending moment diagram, shear and bending stresses in beams, Buckling of columns, Strain energy in tension, compression, bending and torsion, Castigliaonos's theorem.
Planar mechanisms, four bar linkage, quick-return mechanism, velocity and acceleration analysis, kinematics of gears and gear trains, vibrations, balancing of rotating and reciprocating masses, gyroscopic motion, fly wheels.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Discuss thebasic conceptsofdifferent topics of strength of materials and solve related numerical problems **(K2, K3)**
- **CO2:** Describe the different mechanisms related to machine tools **(K2)**
- **CO3:** Deduce expressions for vibrations, velocity and acceleration analysis **(K4)**
- **CO4:** Solve the numerical problems on kinematics of gears and gear trains, gyroscopic motion, fly wheels **(K3)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									1	1	1	
CO2	2	3	1									2	2	1	1
CO3	2	3	2	1								2			
CO4	2	3	1	1								1	2	1	

Course code **PE/PC/B/T/225**
Category Professional Core Course
Course title **Digital and Power Electronics**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Digital Electronics: Number Systems- Binary, Hexadecimal and Decimal, 1's and 2's complement representations, binary arithmetic. Boolean Logic and logic gates, simplification using K-maps; Sequential logic and Flip Flops; Registers and Counters; Logic Family characteristics- overview of TTL,CMOS and their interfacing;555 Timers in different modes;
Power Electronics: Introduction – Power semiconductor devices-power diodes, power transistors, MOFFETs, other devices- types, steady state characteristics, switching characteristics, performance parameters, snubbercircuit.Thyristors– Types, operating characteristics, methods of turn on and turn off, di/dt, dv/dt protection, SCR, GTO, performance parameters, thyristor firing circuits, Thyristors Commutation techniques.Controlled converters – 1-phase, 3-phase, semi converters, full converters, dual converters, principle of operation, analysis with R, R-L, R-LE loads.Choppers – Types, principle of operation, analysis with different types of load, power supplies- SMPS, boost converters, buck converters, buck-boost converters.AC voltage converters – 1-phase, 3-phase, principle of operation with R, R-L loads, Cycloconverters.Inverters- Principle of operation, performance parameters, 1-phase, 3-phase, Voltage control, harmonic reduction, CSI.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Explain Number Systems-Binary, Hexadecimal and Decimal, 1's and 2's complement representations, binary arithmetic, Boolean logic and logic gates, simplification using K-maps. **(K2)**
- **CO2:** Describe Sequential logic and Flip Flops; Registers and Counters; Logic Family characteristics and their interfacing; 555 Timers in different modes. (**K2**)
- **CO3:** Describe the working principle of semiconductor devices such as, BJT, JFET, MOSFET etc. (**K2**)
- **CO4:** Illustrate the operation of Uncontrolled rectifiers: Single-phase, 3-phase bridge rectifiers, Controlled rectifiers: single-phase, 3-phase half wave, full wave bridge circuits, Dual Converters (**K3**)
- **CO5:**Illustrate the principle of operation of AC voltage controllers, Cycloconverter, DC choppers, 1-ph, 3-ph Inverters (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2		1							1	2		
CO2	3	1	2	1								1	2		
CO3	2	3	1		1							1	2		
CO4	3	2	1	1			1					1	2	1	1
CO5	3	2	1	1			1					1	1	1	2

Course code **PE/PC/B/T/226**
Category Professional Core Course
Course title **Electrical Motors and Drives**
Scheme and Credits **L–T–P: 4–0–0; Credits: 4.0;**

Syllabus

Concept of Electrical Drives.
Concepts of Inverter, Control converters, Chopper, Cyclo-converter, protective circuits for thyristor devices.
DC motors: characteristics, starting, speed control and braking
DC Motors Control - 1-ph Converter Drives, Semi-converter drives, 3-phase ConverterDrives, Chopper-fed drives, DC closed loop control.
AC motors: Induction and synchronous motors, Characteristics, starting, V curves and power factor control of synchronous motor
Schemes for Induction Motors speed control - Rotor resistance control, Chopper control, Slip power recovery Scheme, Variable frequency control, Control ofInduction Motors by PWM Inverter, Constant v/f operation, voltage and current control schemes of induction motors, Cyclo-converter driven Induction Motors,Universal field control, AC closed loop control, Harmonic suppression.
Schemes for synchronous motor drives, Self-controlled synchronous motor, unity power factor operation, vector control of synchronous motor, Cyclo-converter-fed synchronous motor drive, Permanent magnet synchronous motor drive, brushless dc motor drive, switched reluctance motor drive,
Stepper motors, Servomotors, Universal motor.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Clarify the basic concepts of electrical drives, inverters, control converters, cyclo converters, chopper and corresponding protective devices (**K2**)
- **CO2:** Describe the constructional and operational features and characteristics of DC motors, Induction motors, synchronous motors, servomotor, Universal Motor, permanent magnet synchronous motor **(K2)**
- **CO3:** Deduce the different schemes for DC motor control, speed control and braking schemes for Induction motor, schemes for synchronous motor drives, continuous and discontinuous conduction of AC/DC drives **(K4)**
- **CO4:** Evaluate through numericals the different condition of operation as regards to electrical motors and drives **(K4)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2									1	2		
CO2	3	2										1	2		
CO3		2	3	1			1		1			2	2	1	1
CO4		2	2	3	1				2			1	1	2	1

Course code	**PE/PC/B/S/221**
Category	Professional Core Course
Course title	**Fluid Mechanics Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5;**

List of the experiments to be conducted

1) Measurement of viscosity of fluid.
2) Determination of coefficient of discharge of obstruction type flow measuring devices
3) Flow measurement in open channel
4) Determination of friction factor of a pipe.
5) Verification of Reynolds numbers for laminar and turbulent flow through a conduit
6) Performance test of a reciprocating pump
7) Performance test of a centrifugal pump
8) Performance test of a gear pump
9) Performance test of pumps in series and parallel

Content delivery methods
- ✓ Active learning (D4)
- ✓ Demonstration (D8)

At the end of the course the students will be able to:
- **CO1:**Examine dynamic viscosity of a liquid and the friction factor due flow of water through a pipes **(A2, K3)**
- **CO2:**Determine water flow rate through pipes and notches.**(K4)**
- **CO3:**Characterizeperformance of different types of pumps and their combination (**A5)**
- **CO4**: Identify possible causes of discrepancy between experimental observations and theory (K3)
- **CO5**: Prepare professional quality laboratory reports (K3)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2					1	1	1		1	1		1
CO2	2	2	1		3			1	1	1		1	2	2	1
CO3	2	1	2	3	2	1	1	1	2	1		2	1	1	2
CO4	2	3	2					2	1	1		1			
CO5								2	1	3		1			

Course code	**PE/PC/B/S/222**
Category	Professional Core Course
Course title	**Electrical Machines Lab**
Scheme and Credits	**L–T–P: 0–0–2; Credits: 1.0;**

List of the experiments to be conducted

1. Saturation and External characteristics of a D.C. Generators.
2. Study of a D.C. Motor starter and speed control
3. Parallel operation of D.C. Generators and load sharing.
4. Parallel operation of two single phase transformer
5. Open circuit and short circuit test of a transformer and parameter calculation,
6. High Voltage test of transformers and Electrical Machines
7. Parameter estimation of a 3 phase alternators
8. Starting of Synchronous motors and determination of V-curves
9. No load and blocked rotor test of three phase induction motor and construction of Circle diagram.
10. Different types of starting and performance characteristics study of induction motors.

Content delivery methods

- ✓ Active Learning (D4)
- ✓ Demonstration (D8)

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

- **CO1:** Examine the operation, performance and control of D.C. machines (**A2, K3**)
- **CO2:** Analyze theoperation and performance of transformers (**K4**)
- **CO3:** Examine the operation and performance of A.C. machines(**A2, K3**)
- **CO4:** StudyHigh Voltage test of transformers and Electrical Machines. **(A2)**
- **CO5:** Identify possible causes of discrepancy between experimental observations and theory and prepare professional quality laboratory reports (K3)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1		2	2		1	2	1			1		2
CO2	3				2	2			2	1			1		2
CO3	2		3		1	2			2	1			2		1
CO4	2	3			1	2			2	1			2		1
CO5								2	1	3		1			

Course code	**PE/PC/B/S/223**
Category	Professional Core Course
Course title	**Computational Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5;**

Syllabus

Introduction to commercially available computing and physical modelling software for solutions of engineering problems (MATLAB, SIMULINK, PYTHON, ANYSYS FLUENT etc.). Formulation and analysis of problems on load flow studies, Economic load dispatch, heat transfer, fluid dynamics etc. with the help of these software.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Simulations (D6)

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

- **CO1:** Examine the principles of modeling of physical systems (**A2, K1**)
- **CO2:** Identify the features available in standard commercial software to translate the physical systems to software compatible forms (**K2**)
- **CO3:** Applysoftware simulation techniques to solve power engineering problems(**K3**)
- **CO4:** Interpret the simulation results and validate them(**A5, K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3		2	1				1			1	2	2	
CO2	1	2	1	2	3			1	2			1	1	1	1
CO3	1	2	2	2	3	1	1	1	1	2		1	2	1	2
CO4	2	2	3	2	1	1	1	1	2	2	1	1	2		1

3rd Year 1st Semester

Course code **PE/PC/B/T/311**
Category Professional Core Course
Course title **Power Transfer System**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0;**

Syllabus

Load characteristics, Supply systems, Overhead lines, Underground cables- Mechanical and Electrical aspects, selection of economic voltage, choice of suitable conductors,Transmission line parameters and sag of conductors, skin and proximity effects, bundle conductors, transposition, P.U. system and its application in power system analysis, Representation of short, medium and long lines and their performance analysis, Power transfer equations, regulation and efficiency, line voltage regulators, reactive power compensation – FACTS devices, Interconnected power systems, Power system transients and line surges, Stability considerations, Equal area criteria, Corona, primary and secondary distribution systems, Insulators, voltage grading and string efficiency, feeders and distributors, Radial and mesh systems, loading and its effect on voltage profile, Power factor improvement and its importance, distribution, Deregulation of Electricity industry, Tariff, HVAC and HVDC transmission, Power system economics.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Discuss Deregulation of Electricity industry; different parameters for load characteristics, basic structure for electrical power transfer, Overhead lines, Underground cables, insulators. **(K2)**
- **CO2:** Determineline parameters and performance analysis of overhead lines. Applications of per unit system **(K4)**
- **CO3:** Apply per unit system method for power system calculation; Illustrate the principle of voltage and reactive power control of transmission line with applications of compensating/FACTs Devices. (**K3**).
- **CO4:** Explain stability-Equal area criteria, Corona; describe the principle of operation of HVDC transmission systems and performance analysis **(K2).**
- **CO5:** Analyze power system faults (**K4**).

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1									1	2	
CO2	3	2	1										2	1	
CO3	2	3	1		1								2	1	
CO4	3	2	1	1									3	1	
CO5	2	3	1		1								1		3

Course code **PE/PC/B/T/312**
Category Professional Core Course
Course title **Thermal Power Generation**
Scheme and Credits **L–T–P: 4–0–0; Credits: 4.0;**

Syllabus

Analysis of Steam cycle - Rankine cycle, mean temperature of heat addition, effects of variation of steam condition on thermal efficiency, Reheat cycle, Regenerative cycle, Optimum degree of reheat and regeneration, supercritical pressure cycle.
Steam generator -- Classification, Layout of power plant steam generators, Fuel firing methods, Pulverized coal firing system, Coal burners and their arrangements, Oil firing in coal-fired steam generators, oil guns, Boiler furnace, Boiler pressure parts: economiser, evaporator, superheaters, reheaters, steam drum and drum internals, circulation, introduction to supercritical steam generators, steam temperature control, air preheater, introduction to emission control technologies: NOx,SOxand particulate emission control, steam generator performance.
Steam turbine - Ideal and Actual flow of compressible fluid through nozzle, critical pressure ratio, maximum rate of discharge, Nozzle efficiency & velocity coefficient of nozzles. Classification of steam turbine, Flow through simple impulse turbine blading, velocity diagram, blade efficiency, Gross stage efficiency, net stage efficiency, optimum velocity ratio. Degree of admission. Multistaging or compounding of impulse turbine, velocity compounding, pressure compounding, velocity and pressure compounding, Reheat factor, internal efficiency, state point locus etc. in relation to steam turbine. Flow through Reaction turbine, velocity diagram, Degree of reaction, blade height, stage efficiency, optimum velocity ratio, axial thrust in reaction turbine. Comparisons of impulse & reaction turbine, Losses in turbines, Principle of turbine governing.
Condensers - Requirement and Types of condenser, Surface condenser construction and functioning, air cooled condenser.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)
- ✓

At the end of the course the students will be able to:
- **CO1:** Explain the thermodynamics cycles of the thermal power generation and their variations (**K2**)
- **CO2:** Classify steam generators and illustrate the different components in them (**K4**)
- **CO3:** Classify steam turbines and analyze the flow and energy transfer in them (**K4**)
- **CO4:** Classify power plant condensers and analyze their operation and performance (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1				1						2	3	1
CO2	3	2	2	1			1						3	1	2
CO3	2	3	2	1									3	1	2
CO4	2	3	1				1						3	1	2

Course code **PE/PC/B/T/313**
Category Professional Core Course
Course title **Hydro Power Generation**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Hydro power scenario in India and world, its development and future prospect, Hydrology – hydrological cycle, precipitation, run-off and its measurement, hydrograph, unit hydrograph, flow duration and mass curve.
Site selection – Preparation of DPR, Clearance from various agencies, funding agencies, government rules and subsidies for SHP.
Classification of hydro electric power plants, pondage and storage, Operating principles of different types hydro plants like run-off river, dam toe type and canal base type, Design, construction and operation of different components of a hydro plant like dam, spillways, canals (power canal), penstocks (economical diameter, embedded and exposed type, short and long penstock), surge tank, draft tubes, etc.
Power house structure, overhead crane, auxiliary power supply, selection of prime mover, Kaplan, Bulb/tubular, cross flow and Deriaz turbine, speed and pressure regulation, Methods of governing of impulse and reaction turbine, starting and stopping of water turbines, operation of hydro turbines, machine loading and frequency control, maintenance of hydropower plants.
Need for testing of SHP, testing methodology and instruments.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:**Explain the hydro power generation and their variations (**K2**)
- **CO2:**Classify various types of hydro power generation scheme and illustrate the different components in them (**K4**)
- **CO3:**Classify hydro turbines and analyze the flow and energy transfer in them (**K4**)
- **CO4:**Explain the need for testing of hydro power plants and their methodologies (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1				1						2	3	1
CO2	3	2	2	1			1						3	1	2
CO3	2	3	2	1									3	1	2
CO4	2	3	1				1						3	1	2

Course code **PE/PC/B/T/314**
Category Professional Core Course
Course title **Non-Conventional Power Generation**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Introduction – Over view of renewable resources, global & national energy scenarios, comparison between renewable and conventional energy sources.
Solar Power Generation –overview of solar energy, definition of solar constant, extraterrestrial and terrestrial solar radiation, solar angles.
Solar Thermal conversion- different methodologies, concept of collectors, heliostat, heat transport system etc. solar chimney, Solar Pond.
Solar PV cell- basic principle of photovoltaic cell, classification of different PV cells, their merits and demerits, production methodology, concept of design of Solar Photovoltaic energy system, recent developments.
Wind Power- classification of wind, criteria for site selection, Betz limit, characteristics of wind turbines, classification of wind turbine & their concept, wind turbine operation, power generation control, different generation and excitation schemes.
Energy from biomass- biomass conversion technologies, energy conversion using municipal solid wastes, biogas production techniques from waste biomass and concept of electricity generation from biogas plant.
Tidal and wave energy; OTEC; Geothermal energy, MHD, Fuel cells.
Energy storages-Principle, prospects and applications; Stand-alone and integration to grid-different methodologies; different inverter technology; Technical regulation-overview of grid codes; Case studies; Economics of renewable energy.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to:
- CO1: Describe different types of renewable energy resources and identify their advantages & disadvantages **(K2)**
- CO2: Illustrate constructional features of different energy conversion & energy storage systems**(K3)**
- CO3: Classify and explain different direct and indirect energy conversion systems **(K2)**
- CO4: Deduce and analyze the performance characteristics of different renewable energy conversion technologies along with their control **(K4)**
- CO5: Solve problems to compute performance parameters of different renewable energy systems **(K3)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					2	2					1	2	3	
CO2	3						2				1		2	2	
CO3	3											1		2	2
CO4	2	3					2					1		2	2
CO5	2	3	2	2					1			1	2		

Course code **PE/PC/B/T/315**
Category Professional Core Course
Course title **Control System**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Introduction to feed back control - concept of a system, excitation and response of a system, Mathematical modeling of dynamic systems, Control system components –servomotors, synchros, stepper motors, tacho-generator, positions sensor, Block diagram and signal flow graph, transfer functions, continuous and discrete data system. Time domain analysis of 1st and 2nd order systems, Proportional integral and derivative control, error constants. Stability analysis: frequency domain techniques - Bode plot, Routh and Nyquistcritetion, gain and phase plot, stability margin. Root locus techniques - lag, lead and lag-lead compensation, introduction to state variable analysis, Actuators.
Introduction to discrete and sampled data system. Fundamental Concept on Integrated Control system for Power Plant Application, Identification of Analog and Binary Drives of Power Plant.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:Describe** a physical dynamic system with control system components using Mathematical Models (**K2**)
- **CO2:Develop** schematic representations of dynamic systems and transfer functions (both continuous time and secrete)(**K3**)
- **CO3:Analyze** (**K4**) the time-response of dynamic systems and their stability
- **CO4: Examine** a sampled data system (**K4**)
- **CO5: Appraise** the applicability of Control Systems in a Thermal Power Plant

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	2	3	2	1									2		
CO3	2	3	1		1				1				1		
CO4	2	3	1	1									1		1

Course code	**PE/PE/H/T/316A**
Category	Professional ElectiveHonors Course
Course title	**Manufacturing Science**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Introduction to manufacturing Processes;Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding, different welding techniques, welding consumables; characteristics of weldment; welding defects and inspection.
Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; conventional machining operations: lathe, shaping, milling, drilling, grinding, sloting etc. and machines used for them; principles of non-conventional machining processes; principles of work holding, design of jigs and fixtures.
Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.
Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Explain different primary manufacturing processes like casting, forming, welding etc. (K2)
- **CO2:** Explain different secondary manufacturing processes and their economics. (K2)
- **CO3:** Illustrate tool geometry, material and designing of jigs and fixtures (K4)
- **CO4:** Describe the basics concepts of Metrology, Inspection and CAD/CAM (K2)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			1						1	2	1	1
CO2	3	1	1		2	1						1	2	1	1
CO3	2	1	2			1	3					1			
CO4	2	2	1			3						1	1	1	

Course code	**PE/PE/H/T/316B**
Category	Professional ElectiveHonors Course
Course title	**Advanced Topics in Electrical Machines**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Generalized theory of electrical machines, linear transformations matrix model of dc,inductive& synchronous machines
Motional impedance matrix, effects of saturation, harmonics& solid iron rotor/pole shoe on the performance of synchronous machines
Stability assessment in terms of generalized machine model, Asynchronous operation ofsynchronous machines – resynchronization, self-synchronization, heating & cooling oflarge power transformers & turbine-generators, effects of surge voltage on electrical machines, Industrial testing of electrical machines - types tests & routine tests – IS specifications.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Discussion / brainstorming (D7)

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

- **CO1:** Describe generalized theory of electrical machines, linear transformation between rotating axes and pseudo-stationary axes variables, Parks Transformation (K2)
- **CO2:** Analyze the effects of saturation, harmonics and solid iron rotor/pole shoe on the performance of synchronous machines and Appraise stability and asynchronous operation of synchronous machine (K4)
- **CO3:** Examine the heating and cooling of large power transformers and effects of surge voltage on electrical machines (K4**)**
- **CO4:** Investigate type tests, routine tests and special tests of electrical machines (K4)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1												
CO2	2	3	2	1									1		
CO3	2	2	1	3		1	2						1	2	
CO4	2	3	1			1	2						2	1	

Course code	**PE/PC/B/S/311**
Category	Professional core Course
Course title	**Power System Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5**

List of the experiments to be conducted

1. Study of active and reactive power transfer
2. Measurement of ABCD parameters of a transmission line
3. Dielectric and TAN DELTA Test of transformer oil
4. Active and Reactive power measurement of alternators
5. Study of static relay and digital relay.
6. Study of overcurrent and under voltage relay
7. Study of reverse power relay
8. Study of digital differential type relay
9. Study of negative sequence relay
10. Study of static VAR compensators
11. Study of offset mho relay

Content delivery methods

- ✓ Active learning (D4)
- ✓ Discussions (D7)
- ✓ Demonstration (D8)

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

- **CO1:**Determine characteristics of active and reactive power transfer through transmission line and performance of static VAR compensator **(K4, A2)**
- **CO2:**Determine active and reactive power of alternators **(K4)**
- **CO3:** Investigate characteristics of different kind of relays (**K4**)
- **CO4:**Execute Dielectric and TAN DELTA Test of transformer oil **(S2)**
- **CO5:** Identify possible causes of discrepancy between experimental observations and theory and prepare professional quality laboratory reports **(K3)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1		1	1	1				2	1
CO2	3	1				1		1	1	1				2	1
CO3	2	3	1	1	2	2		1	1	1					2
CO4	3	2			1	1		1	1	1					1
CO5								2	1	3		1			

Course code	**PE/PC/B/S/312**
Category	Professional core Course
Course title	**Thermodynamics and Heat Transfer Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5**

Syllabus

Experiments for the performance test of reciprocating compressor, vapour compression refrigeration system, cooling tower, measurement of calorific value of solid fuel, different heat transfer experiments on conduction, forced and free convection, and radiation, performance test of heat exchanger.

List of Experiments:

1. *Performance test of Reciprocating air compressor*
2. *Performance test of Cooling tower*
3. *Performance test of Vapour Compression Refrigeration System*
4. *Determination of heat value of coal using Bomb Calorimeter*
5. *Determination of heat transfer through Pin Fin*
6. *Determination of Stefan Boltzmann constant*
7. *Determination of heat transfer in Free Convection*
8. *Performance test of heat exchanger*

Content delivery methods

- ✓ Active learning (D4)
- ✓ Discussions (D7)
- ✓ Demonstration (D8)

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

- **CO1:** Demonstrate technique to measure temperature, flow rate, heat flux and heat transfer coefficients (**K3,S3**)
- **CO2:**Determine performance of thermal devices like compressors, refrigerators and cooling towers **(K4, A5)**
- **CO3:** Examine and explain the properties of fuels relevant to power generation (**A2,K2**)
- **CO4:**Analyze performance of heat transfer devices like fins, heat exchangers, etc., through experiments (**K4, A5**)
- **CO5:** Examine and interpret the experimental results in a report and defend it (**K2, K6**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2						1	1			1	1		2
CO2	2	3	1			1	2		1				1	1	2
CO3	2	1						1	2				3		2
CO4	2	3	1			1	2		1				1	1	2
CO5	2	3	1	2				1	1	2					

Course code	**PE/PC/B/S/313**
Category	Professional core Course
Course title	**Nonconventional Power Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5**

List of Experiments:

1. Performance study of solar photovoltaic cell
2. Performance study of solar thermal collector
3. Performance study of wind turbine & power generation
4. Characterization of biomass fuel
5. Study of biomass gasification and power generation
6. Performance study of micro hydro plant
7. Fuel cell characterization
8. Performance study of pumped storage plant

Content delivery methods

- ✓ Simulation (D6)
- ✓ Discussion/Brain storming (D7)
- ✓ Demonstration (D8)

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

- **CO1**: Study the experimental setup & construct the physical circuit model of experiments on various renewable energy resources (K3, A2)
- **CO2**: Appraise the experimental objectives (K5, S4)
- **CO3**: Analyze data available from different experiments (K4)
- **CO4**: Interpret the report with error analysis and present them. (K3, A2)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2		1	1	2		2			1	2		2
CO2	2												3	1	2
CO3	2	3			1							2		2	1
CO4	2	1		3		1		1		2				2	

3rd Year 2nd Semester

Course code **PE/PC/B/T/321**
Category Professional core Course
Course title **Measurements and Transducers**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus
Characteristics of Measurement System and instruments, Errors in measurements,
Classification of measuring instruments, General features of indicating instruments- controlling, damping and balancing of moving systems; Static and dynamiccharacteristics.
Construction and principle of moving coil, moving iron, rectifier,electrostatic and induction type instruments for measuring voltage, current, power, energy, frequency and power factor, extension of instrument range, shunt multiplier.
Instrument Transformers: C.T. and P.T., Measurement of resistances, Measurement of inductance and capacitance using A.C. bridges, Potentiometers, Magnetic measurements, CRO and digital instruments.
Primary sensing elements and transducers: Mechanical spring devices, pressure sensitive devices, flow rate sensing devices,Characteristics and classification of transducers
Resistive transducers, strain gauge, Rosettes, resistance thermometers, thermistors, thermocouples, IC based temperature transducers, Capacitive transducers, Hall effect transducers, Magneto-strictive transducers, optoelectronic transducers, piezoelectric tranducers, LVDT
Measurement of vibration, displacement, discharge, pressure, temperature, pH and conductivity, rotation and strain, solar radiation parameters, wind speed
Signal conditioning and signal transmission, minimization of thermal emf
Energy Management System (EMS) and Dataacquisition

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Discussion / Brainstorming (D7)
- ✓ Demonstration (D8)
- ✓ Case studies (D9)

At the end of the course the students will be able to
- **CO1:** Describe the construction, operating principles and characteristics of instruments for measurement of electrical, mechanical parameters **(K2)**
- **CO2:** Explain the operation of different AC/DC bridges and potentiometers, instrument transformers, galvanometers, CRO **(K3)**
- **CO3:** Analyze performance of different measuring instruments**(K4)**
- **CO4:** Discuss primary and secondary sensing elements and transducers **(K2)**
- **CO5:** Examine energy management, signal conditioning and data acquisition system and illustrate their applications in power plants**(K3)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1												1
CO2	3	2	1												1
CO3		2	3	2					2				2		
CO4	3	2	1										2		1
CO5	1	2	3						2				2	2	1

Course code	**PE/PC/B/T/322**
Category	Professional core Course
Course title	**Nuclear Power Generation**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Introduction to nuclear physics, Nuclear power generation in general, Reactor fuel system, Fuel cycle, Production of reactor fuels, Fuel enrichment, Properties of fuel materials, Fuel management, Reprocessing of spent fuels etc. Non-fuel reactor materials, different materials used as moderator, Material for fuel cladding, etc. Reactor types, different power reactor systems, PWR, BWR, PHWR, Fast breeder reactors, gas cooled reactors, etc. Core vessel and coolant system of different reactors, description of reactor in India. Reactor safety, general principles of safety, Safety features, Reactor safety analysis, Design basis, Accidents, Loss of Coolant Accident etc., Reactor kinetics and control, general control features, control devices, control rods and their driving mechanisms, control in reactor operation, radiation protection, radiation hazards, different units of radiation, protection standards, biological effects, radioactive, Biological effects, radioactive waste treatment systems etc.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:Interpret** the key enabling concepts associated with Reactor Physics, Reactor Engineering and the Nuclear Fuel Cycle (**K2**)
- **CO2:Classify**the different types of reactors, their components and control(**K4**)
- **CO3:Appraise** the importance of nuclear safety and radiation hazards(**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1				1						2	2	
CO2	2	3	2	1									2	1	2
CO3	2	3	1		1	2	2		1				1		2

Course code	**PE/PE/B/T/323A**
Category	Professional Elective Course
Course title	**Thermal Power Plant Systems**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Layout of a thermal power plant. Familiarization with different systems of thermal power plant: BTG and BOP systems.
Boiler side systems: PF and liquid fuel systems; Air and flue gas systems; Electrostatic precipitators, FGD system.
Main and Reheat Steam System; Condensate and feedwater systems; Construction and functioning of condenser, deaerator and closed feed water heaters; HP - LP Bypass systems, Auxiliary Steam System, Turbine gland steam system, turbine lub oil system, turbine governing system.
Seal oil and hydrogen cooling system of generators.
DM Water system.
CW system. Cooling Towers—principle of operation and types, performance of cooling towers.
Coal and ash handling systems.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe layout of different thermal power plant including BTG and BOP systems (**K2**).
- **CO2:** Explain boiler side systems including reheat system (**K5**).
- **CO3:** Explain turbine side systems including feed-water system (**K5**).
- **CO4:** Explain DM water system, CW system including cooling tower and coal and ash handling system (**K5**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1				2	1		1				2	2	2
CO2	2	1	3	1		2	2					2	2	2	2
CO3	2	1	3	1		2	2					2	2	2	2
CO4	2	1	2	1		2	3					2	2	2	2

Course code **PE/PE/B/T/323B**
Category Professional Elective Course
Course title **Power System Analysis and Operation**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Power system stability: Steady state and transient stability, Swing equation and its numerical solution, equal area criterion for transient stability. Economic Dispatch. Inter area power transfer, Energy wheeling, Grid indiscipline and frequency regulation in deregulated environment, Unit-commitment. load-forecasting – LTLF, STLF and day-ahead load forecasting. Functions of load-dispatch centers. Automatic Load Frequency Control (ALFC) and Automatic Voltage Regulator (AVR) for conventional and non-conventional systems, load flow analysis, Gauss–Seidel method, Newton-Raphson method and Fast Decoupled method. Evacuation of power at local and distant nodes, Optimal load flow, state estimation.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to:
- **CO1:** Explain and formulate economic dispatch and unit commitment (**K2**)
- **CO2:** Describe automatic load frequency control (ALFC), automatic voltage regulator and function of load dispatch centers (**K2**)
- **CO3:** Distinguishand analyze steady state and transient stability(**K4**)
- **CO4:** Explain different methods of load flow analysis and optimal power flow problem (**K5**)
- **CO5:** Explain load forecasting and state estimation (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2								1	2	
CO2	2	2	1	3	1								2	2	
CO3	3	1	2	2	1		1						1		2
CO4	1	3	2	2	1		1				1		1	1	
CO5	1	2	1	3	1		1				1	1	1	2	

Course code	**PE/PE/B/T/323C**
Category	Professional Elective Course
Course title	**I. C. Engine and Gas Turbine**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Working principles of I.C. Engines, classification, two stroke & four stroke engines, different parts of I.C. engine and their functions, basic performance parameters of I.C.Engine. Cycle analysis, air standard cycles, fuel air cycle, actual cycle.
Air and Fuel Induction, volumetric efficiency, valve timing diagram, variable valve control, charge quality requirement in S.I.engine, Carburetion, Fuel properties for I.C.engine, Fuel injection in S.I.engine and C.I.engine, Electronic injection system, intake for two-stroke engines, supercharging and turbocharging.
Fluid motion in combustion chamber, crevice flow and blowby, ignition systems in S.I.engine, Combustion in S.I.engines, Detonation and pre-ignition, Combustion in C.I.engines, Knocking, HCCI and PCCI engines, Exhaust flow from engine. Emission from I.C.engine, Engine lubrication and cooling, testing and performance of I.C.engine.
Gas turbine classification, Analysis of open and closed gas turbine systems, Regeneration, Intercooling, reheating, gas turbine cycles for aircraft propulsion, Plant accessories and auxiliaries, performance analysis of gas turbine engines.

Content delivery methods
- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to
- **CO1:** Classify different types of I.C. engines and gas turbines and describe their working principle at the component level (**K2**)
- **CO2:** Illustrate the charge preparation, combustion and emission in I.C. engines (**K3**)
- **CO3:** Calculate the performance parameters from testing data in I.C. engines (**K4**)
- **CO4:** Illustrate the plant auxiliaries of gas turbine (**K3**)
- **CO5:** Calculate the performance parameters from testing data in Gas Turbine (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2											1		
CO2	2	3		2			1						2		2
CO3	2	2	3	1	1		2					1	1	2	1
CO4	2	3	2	2			1						2		2
CO5	2	2	3	1	1		2					1	1	2	1

Course code **PE/PE/B/T/323D**
Category Professional Elective Course
Course title **Microprocessors and Microcontrollers**
Scheme and Credits **L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Basic Concepts: Number Systems, Memory Devices, 8 bit Micro-processors (8085)- architecture, organization and interrupt systems.
16 Bit Microprocessors: 8086- Pin assignments, minimum and maximum mode, architecture, addressing modes, interrupts, instruction format, instruction set and assembly language programming, introduction to 8087 math coprocessor.422B
Micro-controllers: Difference between a Micro-processor and Micro-controller, Microcontrollers: Architecture, instruction set and assembly language programming of 8051 microcontroller, introduction to 8096/8097 microcontroller. Overview of modern low power micro-controllers.
Interfacing: Interrupt Handlers, UARTs, ADCs, Multi-plexers. Standard Micro-controller interfaces.
Modern Micro-controllers: Overview Low Power Micro-controllers and their Programming Environments.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Identify the key enabling concepts associated with organization and architecture of bus organized micro-computers e.g. 8086/8088 based systems (**K2**)
- **CO2:** Associate the understanding of basic concepts of organization and architectureforastandard bus organized micro-computers e.g. 8086/8088 based systems with memory organization(**K2**).
- **CO3:** Assess the requirements for a micro-controller and **Examine** modern micro-controllers (**K3**)
- **CO4:** Analyze the functioning of complex practical interfaces(**K4**)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	3	2	2	1									2		
CO3	2	3	1		1				1				2		
CO4	2	2	3	1	1								2		1

Course code	**PE/PE/B/T/323E**
Category	Professional Elective Course
Course title	**Fluidized Bed Boiler**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Definition of particle diameter, sphericity, etc, powder classification, pressure drop through fixed and fluidized beds, minimum fluidization velocity, elutriation and transport disengagement height, two phase theory of fluidization, bubble diameter, bubble rise velocity, etc, Bubbling fluidized boiler, merits over conventional types, features of fluidized boiler, basic design consideration, start up and operation of fluidized boilers, combustion and heat transfer in fluidized boilers, regimes of fluidization from bubbling to pneumatic transport, basic thermodynamics of circulating fluidized beds, features of circulating fluidized boilers, design aspects start up, operation, etc. merits of CFB over bubbling beds, national and international status of fluidized boilers, pressurized fluidized boilers and using in combined cycle plants.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:**Classify particles and fluidized bed boilers. (**K2**)
- **CO2:**Discuss design and operational features of different types of FBC. (**K2**)
- **CO3:**Calculatedifferent parameters related to construction and operation of FBC (**K3**)
- **CO4:**Compare different types of FBC considering their use.(**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1				1					1	2	2	1
CO2	2	3	2	1			2	1				1	2	2	1
CO3	2	2	3	1	2		2					1	2	1	2
CO4	2	2	3	1		1	2	1				1	2	2	2

Course code **PE/PE/H/T/324A**
Category Professional Elective Honors Course
Course title **Advanced Power Cycles**
Scheme and Credits **L–T–P: 4–0–0; Credits: 4.0**

Syllabus

General introduction; performance parameters of power cycles.
Properties of ideal working fluid for vapor power cycles. Practical losses in Rankine and Reheat cycles. Supercritical cycles, Organic Rankine Cycles; Practical Regenerative cycles with open and closed feed water heaters, choice of heaters, heater arrangements and optimum degree of regeneration. Supercritical pressure cycle. Heat Balance Diagram and its utility.
Thermodynamic Availability analyses of closed and open systems, 2nd law efficiency. First and Second Law analyses of practical vapor power cycles. Effects of operating parameters on steam power plant performance.
Gas turbine cycles: Ideal and actual Brayton cycles; GT cycle performance parameters, Gas turbine cycles with intercooling, reheating and regeneration.
Combined Cycles: Definition and classification, simple thermodynamic analyses of coupled cycles. Binary vapor power cycle, Gas Turbine Combined Cycle, STIG, IGCC, Cogeneration, CHP applications.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Review different vapor and gas power cycles and recognize their salient performance parameters (**K2**)
- **CO2:** Calculate the performance parameters of steam, gas and combined cycles (**K3**)
- **CO3:** Compare the performance of different advanced power plant cycles (**K4**)
- **CO4:** Interpret the concept of thermodynamic availability in analyzing thermodynamic system performances (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1		2	2		1				2	2	2
CO2	2	3	2	1			2		1				1	1	1
CO3	2	3	1		1	2	2		1				2	2	2
CO4	2	3	1	1		2	1		1			1	1	1	2

Course code	**PE/PE/H/T/324B**
Category	Professional Elective Honors Course
Course title	**Optimization Techniques**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Mathematical programming problem, conditions for optimality, Classical optimization techniques: Game theory and Nash equilibrium, Linear programming, Quadratic programming, Dynamic programming, Non linear programming, Mixed integer nonlinear programming, Metaheuristic algorithms, Generalised local and global solutions: Evolutionary computing based algorithms, Swarm Intelligence based algorithms, Physics postulates based algorithms, Multi objective optimization, pareto solutions, Concepts of convex box and convex hull, Artificial neural network and fuzzy logic.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:**Develop mathematical programming problems and construct conditions for optimality (**K3**)
- **CO2:**Analyze different classical optimization techniques (**K4**)
- **CO3:**Develop artificial neural network, evolutionary computing based algorithms and physics postulates based algorithms (**K5**)
- **CO4:** Examine swarm Intelligence based algorithms and fuzzy logic (**K4**)
- **CO5:**Formulate multi objective optimization techniques and pareto solutions (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3									1	1		
CO2	2	1	3	2	2								1	2	
CO3	2	1	2	2	3								1	2	
CO4	1	2	2	2	3									2	2
CO5	1	2	2	2	3		1							2	2

Course code	**PE/PE/H/T/324C**
Category	Professional Elective Honors Course
Course title	**Smart Grid Systems**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Smart Grid: Definition, characteristics, Traditional grid v/s smart grid, components of smart grid, Overview of the Technologies Required for Smart Grid, The Key Challenges; Renewable Energy Integration: Integration Challenges, Forecasting and Scheduling, Power Quality Problems; Stability Analysis for Smart Grid: Introduction to Stability, Voltage Stability Assessment, Voltage Stability Assessment Techniques, Voltage Stability Indexing, Angle Stability Assessment, State Estimation; Smart Grid Communications and MeasurementTechnology: Communication and Measurement, Monitoring, Communication and Networking in the Smart Grid; Network Topologies; Research Challenges,PMU, Smart Meters, and MeasurementsTechnologies, GIS and Google Mapping Tools, Multiagent Systems (MAS) Technology; Demand Response and Forecasting in Smart grid: State-of-the-Art,Electricity Demand Data, Time Series Analysis, Algorithm Description; Data Management:Power Grid Database Management, Power Grid Data Mining; Energy Storage: Applications and Advantages: Different Energy Storage Technologies-BESS, SMES, SCES, FES, TES, PHS, CAES, HES etc.Applications of Energy Storage System, Technical Benefit of ESS, Financial Benefit of ESS, Environmental Benefit of ESS, Cost of Energy Storage System, Integration of Energy Storage into the Power Network; Plug-in-Vehicle in Smart Grid; Economy of Smart Grid: Costs of Smart Grid, Economic Indicators of Smart Grid, Design Variables of Smart Grid.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe the concepts of smart grid system and differentiate its various components (**K2**)
- **CO2:** Explain the control, communication and data monitoring topologies of smart grid systems (**K5**)
- **CO3:** Analyze and Explain different socio-techno-economic aspects of smart grid systems. (**K4, K5**)
- **CO4:** Classify energy storage devices and integrate them with grid(**K2, K5**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1										2	2	3	
CO2	2	2	2	3									1	2	2
CO3	2	2	3	2	2		2					1	1	3	2
CO4	2	2	2	3	1								1	2	3

Course code	**PE/PC/B/T/325**
Category	Professional Core Course
Course title	**Energy Conservation and Sustainability**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Introduction to energy conservation, evaluation of energy conserving opportunities, approach and modern techniques, benefits, trends.
Thermal Energy Conservation Technology, Efficiency Improvements in Thermal Utilities: Boilers, Steam System, Thermic Fluid Heating Systems, Furnaces. Use of Refractories, insulation etc, Techno-Economic evaluation of conservation technologies,
Technologies and effects of Fuel Shift and mix: Oil, Gas, Coal, Bio-mass, and Renewables.
Sources of waste heat and its potential applications, Waste heat survey and measurements.
Waste Heat boilers, Latent Heat Thermal Storage (LHTS) for Energy Sustainability
Electrical Energy Conservation, Opportunities and Techniques for electrical energy conservation in Buildings and industry, Energy conservation through controls, Energy Efficient Motors, energy efficient lighting.
Green Buildings, Intelligent Buildings, Rating of Buildings, Efficient Use of Buildings,
Requirement of Energy Mix, Selection of Energy sources for load
Energy-environment interaction, ESP, FGD, SCR, etc. Continuous emission monitoring system (CEMS). Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, Heat and radioactivity disposal. Approaches to mitigate environmental emissions from energy sector, Global Protocols, Clean development mechanism.
Statutory requirements for Environment Management, Environment and Social Impact Studies, Protection of Coastal Zone and Aquatic Life, Concepts of ISO 14000 – Environmental Audit.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Explain the energy conserving opportunities with different approaches and techniques (**K2**)
- **CO2:** Analyze the thermal energy conserving technologies and waste heat recovery techniques (**K4**)
- **CO3:** Analyze the electrical energy conserving technologies in different applications (**K4**)
- **CO4:** Relate energy-environment interaction and illustrate the mitigation principles and pollution norms (**K4**)
- **CO5:** Explain the statutory requirements of energy management and the social impact (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			2		2						2	3	
CO2	2	3	1	1	2		2						2	3	2
CO3	2	3	1	1	2		2						2	3	2
CO4	2	1	2	2		2	3					2	3	2	1
CO5	1					3	2				1	2	1	1	3

Course code	**PE/PC/B/S/321**
Category	Professional Core Course
Course title	**Control and Transducer Lab**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5**

List of Experiments

1. Study of DC Position Control System
2. Study of Microprocessor based control of Stepper Motor
3. Design Compensation Circuits
4. Determination of Impulse & Step responses for systems of different orders
5. Determination of Root Locus &Nyquist Plots of different systems
6. Design of PID Controller Using Simulink/Matlab
7. Measurement of L, C, R using LCR meter
8. Measurement of active and reactive power
9. Temperature measurement using thermocouple, thermistors etc and data acquisition.
10. Measurement of magnetic flux density using Gauss-meter
11. Measurement of liquid level using ultrasonic level sensor
12. Measurement of Flow using ultrasonic flow-meter
13. Measurement of pH and electrical conductivity of water, KCl, etc
14. Signal conditioning and DAS.
15. Proximity Sensor and application for Speed Measurement
16. Vibration Monitoring of Turbine, Generator and conceptof Vibration Analysis.

Content delivery methods

- ✓ Demonstration (D8)
- ✓ Visual presentation (D2)
- ✓ Simulations (D6)

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

- **CO1:** Design Compensation Circuits and studymotor control systems (**A2, K3**)
- **CO2:**Investigate time and frequency response of 1st order and 2nd order systemand Design of PID controller using MATLAB/SIMULINK (A5, K3)
- **CO3:**Measure different electrical and non electrical quantities using transducers and characterize their behavior (K6,A5)
- **CO4:**Investigate signal conditioning and data acquisition system (DAS) (K3)
- **CO5:**Identify possible causes of discrepancy between experiments and theory and prepare appropriate laboratory reports (K3)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		2	2	3				2			1	1		2
CO2	2	1	2	1	3								1		2
CO3	2	2		3					1				1		2
CO4	2		3	1	2								1		2
CO5	2	3	2					2	1	3		1			

Course code **PE/PC/B/S/322**
Category Professional Core Course
Course title **Prime Mover Lab**
Scheme and Credits **L–T–P: 0–0–3; Credits: 1.5**

List of the experiments to be conducted

1) Developing valve timing diagram of a single cylinder diesel engine.
2) Performance test of a single cylinder diesel engine.
3) Performance test of a single cylinder VCR petrol engine
4) Performance test of a multicylinder petrol engine using Morse test method
5) Performance test of a Pelton turbine.
6) Performance test of a Francis turbine.
7) Performance test of gas turbine engine

Content delivery methods

- ✓ Demonstration (D8)
- ✓ Visual presentation (D2)
- ✓ Simulations (D6)

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

- **CO1:** Developing valve timing diagram of a single cylinder diesel engine (**A4**)
- **CO2:** Assess performance of different type of engines (**K6**)
- **CO3:** Evaluate performance of different type water turbines (**K6**)
- **CO4:** Identify possible causes of discrepancy between experiments and theory and prepare appropriate laboratory reports (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	3	1	1	1	2		1			1	1	
CO2	2	1	2	1	2	2	2	1	3	1	2	1	2	1	2
CO3	2	2	1	1	2	2	1	1	3	1	2	1	2	1	1
CO4	2	3	2					2	1	3		1			

PE/PS/B/S/323: Mini Project [0 – 0 – 4]

Students will be given projects under the supervision of faculty members either as group or individual activities.

4th Year 1st Semester

Course code	**PE/HC/B/T/411**
Category	Humanities, Social Science and Management Course
Course title	**Energy Planning, Management, Audit and Acts**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Energy Scenario, Energy – Environment interaction & Climate Change: Commercial and Non-commercial energy, Primary energy resources, Commercial energy production, Final energy consumption, Indian Energy Scenario, Sectoral energy consumption, Energy needs of growing economy, Energy intensity, Long term energy scenario, Energy pricing, Energy security, Energy strategies for future, Energy conservation and its importance.
Energy & Environment, Air pollution, Climate change, United Nations Framework on Climate Change (UNFCCC), Kyoto protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), CDM Methodology & procedure, Perform and Trade (PAT) Scheme, Renewable Energy Certificates (REC), Sustainable Development.
Energy Policy and Acts: Energy planning,Integrated Energy Policy, Energy Sectors and Related Departments, Institutes and Ministries of India , Key energy Acts & Rules – The Energy Conservation Act 2001, The Electricity Act 2003,Central Electricity Regulatory Commission,; National action plan for climate changes.
Power Sector Reforms,GridCode,GridStandards,Open access and trading in power, ABT, Penalties for grid indiscipline, Integration of renewables with grid Methodology and rules of Indian Power Exchange, Methods of bidding for conventional and non-conventional energy
Energy Management: Background and definition, Role of Bureau of Energy Efficiency (BEE), Energy Audit, Energy Managers and Energy Auditors, Energy Management technologies applied to Pumps, fans & compressors, Thermal Systems, Electrical Distribution Systems, Lighting, Motors, HVAC & Refrigeration System, Renewable energy systems etc.
Financial evaluation of energy management projects – Simple payback, ROI, NPV, IRR, Cash flow, risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOS, Role of Prosumers and Energy Business.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** AssessCDM, sustainable development, energy pricing, grid code, prosumer (**K3**)
- **CO2:** Illustrate the energy intensity, PAT, REC, Energy Conservation (**K3**)
- **CO3:** Analyze energy environment interaction, Kyoto Protocol, Energy conservation act, Grid indiscipline, Energy Efficiency, Rate of return (**K4**)
- **CO4:** Analyze long term energy scenario, Energy Audit, ABT.(**K4**)
- **CO5:**Compileand evaluate energy management projects (**K5, K6**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3						1						2	1	1
CO2	3	1											2	1	1
CO3	3	1	1												
CO4	2	2	3				1						1	1	
CO5	1	2	2								3	1		2	

Course code	**PE/PC/B/T/412**
Category	Professional Core Course
Course title	**Protection and Switchgear**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Over voltage and over current phenomenon in power system, lightening arresters and guard wire, tower footing resistance, earth wire, arc phenomena in circuit breakers, power system transients, restricting and recovering voltages, circuit breakers, material for contacts and medium, different types of circuit breakers, air, vacuum and sulfur hexafluoride circuit breakers, Isolators, protective relays– digital relays, basic philosophy, principle of over current, earth fault, directional and differential relaying, desirable quality of relaying and annunciation schemes, protection schemes of generators, transformers, transmission line, buss bars and motors, carrier pilot schemes,gas insulated substations, switchyard protection,earthingtransformers,analysis of symmetrical and asymmetrical faults in power system.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe over voltage and over current phenomenon in power system (**K2**)
- **CO2:** Analyze constructional details and principle of operation of different types of relays (**K4**)
- **CO3:** Analyze constructional details and principle of operation of different types of circuit breakers (**K4**)
- **CO4:** Describe in detail lightning arrester, surge absorbers, and protection schemes of generator, transformer, transmission line, busbar, motor (**K2**)
- **CO5:** Compute fault currents under different fault condition (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3					1		2					1		
CO2	3			2		1							1		
CO3	3			2		2							1		
CO4	3		2			2		2			1	1			2
CO5	2	3	1	2		2						1			2

Course code	**PE/PE/B/T/413A**
Category	Professional Elective Course
Course title	**Information Sensing and Control in Power Plant**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Basic Concepts: Revisiting sensors, transducers and transmitters. The basic information sensing framework- 4 to 20 mA loop, Signal Conditioning, Conversion and Quantization, Engineering Conversion, Rational and Irrational Signals. Noise. Standard Terminology and Conventions used in representation of C&I systems in a Power Plant.

Parameter Sensing: Overview of Sensors used in sensing different parameters e.g. flow, pressure, temperature, level, gas concentration,speed, vibration, power and electrical parameters used in typical thermal power plant.

Plant Control: Master Control Signal. Power Control methodologies: Boiler Following Turbine, Turbine Following Boiler, Co-ordinated Control. Modulating Control Loops and their interactions. Combustion Control, Boiler Drum Level Control, Control of Steam Temperature. Auxiliary Control Loops. Controls associated with the Turbo-Alternator.

SCADA and DCS: Basic principles of decoupling for multi-variable control systems. Distributed Control Systems – architectures and functionalities. The supervisory control requirement and SCADA-architectures, components and concepts of field-to-screen delay and response times. Annunciations and Event Sequence Recorders.

Content delivery methods

- ✓ Class room lecture (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1: Identify** the physical principles behind sensing of physical parameters, conversion of these measurements to signals electrical signals, their transmission and processing and the transformation from measured data to information related to an industrial plant.(**K2**)
- **CO2: Apply** these physical principles to measurement of physical parameters required for controlled operation of a thermal power plant.(**K3**)
- **CO3: Analyze** the requirements of a control system for a thermal power plant (**K4**)
- **CO4: Examine** interfaces between control systems and measured signals from the plant.(**K4**)
- **CO5: Organize** components of control , measurement and information sensing sub-systems for integrated data acquisition and control requirements in a thermal power plant**(K5)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	2	3	2	1									2		
CO3	2	3	1		1				1				1		
CO4	2	3	1	1	1	1	1		1				1		1
C05	2	3	3	2	2	1	1		1				1	1	1

Course code **PE/PE/B/T/413B**

Category	Professional Elective Course
Course title	**High Pressure Boiler**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

Syllabus

Types and features of High Pressure Boiler. Specification of a Power Station Boiler. Sub and Supercritical Pressure Large Boiler features, Comparison, Advantages and Disadvantages.
Economizer, Superheater, Reheater Heat Transfer and Pressure Drop calculations, Boiling heat transfer, Circulation, Natural, Forced, Assisted, Burnout and dry out of evaporator tubes, Boiler performance and problems of part load operation. Furnace Design, Heat Input.
Materials of Boiler Tubes, Drum, Header. Thickness calculation of Superheater, Drum, Headers.
Water Chemistry of High Pressure Boiler. Effect of Coal & Ash Quality on Boiler design and performance. Internal and External deposits of Boiler. Boiler Mountings. Boiler Insulation. Thermal expansion of Boiler. Boiler structure & supports.
Heat Loss and Efficiency calculations in boilers.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual Presentation (D2)
- ✓ Discussion/brainstorming (D7)
- ✓ Demonstration (D8)

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

- **CO1:** Classify high Pressure Boiler according to pressure and features and identify their relative Advantages and Disadvantages. **K2**
- **CO2:**Identify different constructional features of high pressure boilers and investigate their effects on design of boiler pressure parts. (**K4**)
- **CO3:** Examine effect of water chemistry, coal & ash quality on boiler pressure parts and calculate performance and efficiency of boiler(**K3**)
- **CO4:** Discuss boiler mountings, insulation, structure & support and their expansion. (**A2**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3													2	2
CO2	2	3	1	1		2						1			2
CO3	2	2	3	1		2	2					1		2	
CO4	3	2	2	1		2						1		2	

Course code	**PE/PE/H/T/414A**
Category	ProfessionalElective Honours Course
Course title	**Design and Analysis of Thermal Systems**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Introduction to thermal design, Mathematical Modeling of Thermal Systems, Regression Analysis and Equation Fitting, Heat transfer analysis in fins of constant and variable cross-sectional area, Multi-dimensional and Transient heat conduction analysis, Formulation of the optimization problems, Modeling of thermal equipment, e.g. Heat Exchangers, evaporators, condensers, cooling towers, furnace etc. System simulation (Successive substitution, Newton Raphson method)- examples.
Basics of second law analysis in heat and fluid flow, exergoeconomic analysis of thermal systems and their applications. Dynamic modeling of thermal systems.
Energy systems in micro and nano scales.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Apply the laws of thermodynamics, heat transfer for numerical analysis of benchmark problems (**K2**)
- **CO2:** Develop the thermal models and evaluate the performance of common thermal equipment (**K3**)
- **CO3:** Interpret the concept of exergy and economics in analyzing thermodynamic system performances (**K6**)
- **CO4:** Formulate performance optimization of thermal systems based on modeling and simulation **(K6)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1		1		1				2	1	1
CO2	2	3	2	2			2		1				2	1	1
CO3	2	2	3	2	1	2	2		1		2	1	2	2	2
CO4	2	2	3	2	2	2	1		1		1	1	1	1	2

Course code	**PE/PE/H/T/414B**
Category	ProfessionalElective Honours Course
Course title	**Electric Power Automation and Utilization**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Introduction to Distribution Automation Systems: Distribution System Topology and Structure; Distribution Automation (DA) and Control; **Distribution Automation and Control Functions:** Demand-Side Management; Voltage/VAr Control; Fault Detection (Distribution Automation Function); Reconfiguration of Distribution Systems; Power Quality;:**Distribution Management Systems:** DMS and EMS; ; SCADA (Supervisory Control and Data Acquisition); RTU (Remote Terminal Units).; Distribution Management System (DMS); Automatic Meter Reading (AMR); Cost-Benefit Analysis (CBA) in Distribution Systems; **Communication Systems for Distribution Automation Systems:** Data Communication in Power System Distribution Network; ; Types of Telecommunication Media.
Heating and welding: Advantages and methods of electric of heating, resistance ovens, induction heating, dielectric heating, the arc furnace. Electric welding, resistance and arc welding. **Electrolytic Process**: Fundamental principles, extraction, refining of metals and electroplating, Factors affecting electro deposition process.**Illumination**: Laws of illumination, lighting calculation, factory lighting, flood lighting, street lighting, different types of lamps-incandescent, fluorescent, vapour, CFL and LED. **Electric Traction**: Introduction, requirements of an ideal traction, systems of traction, speed time curve, selection of traction motors, method of speed control, energy saving by series parallel control, ac traction equipment. diesel electric equipment, trains lighting system,.**Introduction to electric and Hybrid Vehicles**: Configuration and performance of electrical vehicles, traction motor characteristics,vehicle performance and energy consumption.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:**Describe the concepts of distribution automation system, and its control, management system and communication protocols. (**A5,K2**)
- **CO2:**Analyze and classify various types of electrical heating and electrical welding. (**K4,K2**)
- **CO3:**Discuss electrolytic process and various aspects of Illumination (**K2, A5**)
- **CO4: Explain** the principles and characteristic of Electric Traction, Electric Vehicle and Hybrid Vehicle. (**K2**)
- **CO5: Solve** various problems on Electric Power Automation and Utilization **(K3, S4)**

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			1							2	2	3	
CO2	3	2	2			2							1	2	
CO3	2	2	3	2			2				1	1	1	2	1
CO4	3	2	2		1		2						1	2	
CO5	2	3	2		2						1	1	2	1	2

Course code	**PE/PE/H/T/414C**
Category	ProfessionalElective Honours Course
Course title	**Experimental Techniques and Measurements**
Scheme and Credits	**L–T–P: 4–0–0; Credits: 4.0**

Syllabus

Basic principles of experimental analysis, strain gauges and strain gauge circuits, Rosettes, photo elasticity, brittle coating methods, Moire fringe methods, holograph, etc. Flow visualization techniques, measurement of pressure, velocity, discharge, temperature in fluid flow, hot-wire anemometry, hot-film anemometry, LDA, PIV, solid transformation.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Explain the measurement techniques used in engineering (**K2**)
- **CO2:** Classify various types of instruments for measurement of various parameters like flow, pressure. temperature, etc. (**K3**)
- **CO3:** Classify the data and analyze the various measured parameters (**K4**)
- **CO4:** Explain the errors associated in the measurement (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1				1						2	3	1
CO2	3	2	2	1	2		1						3	1	2
CO3	2	3	2	1								1	3	1	2
CO4	2	3	1				1	1				1	3	1	2

Course code	
Category	
Course title	**Open Elective -I**
Scheme and Credits	**L–T–P: 3–0–0; Credits: 3.0**

The students have to take the courses offered by other departments of FET according to their choice.

Course code **PE/PS/B/S/411**
Category Project and Seminar
Course title **Project**
Scheme and Credits **L–T–P: 0-0–9; Credits: 4.5**

The project will be of one year duration (two semesters). The students will be given projects under the supervision of faculty members either as group or individual activities. An involved industry problem / numerical modeling and simulation / engineering experimental work / analysis and synthesis work may be offered to the students as project problem. The students will have to submit a report of the progress at the end of first semester and also have to defend his work in front of panel of experts.

Project CO - PO

- **CO1** Select a suitable problem relevant to power engineering with an attention to real life problems faced by the society
- **CO2** Demonstrate knowledge of contemporary issues in their chosen field of project
- **CO3** Undertake problem identification, formulation and design engineering solutions either through simulation or through practical work by considering ethical responsibility
- **CO4** Estimate and cost the human and physical resources required, and make plans to obtain the necessary resources while allocating roles with clear lines of responsibility and accountability
- **CO5** Prepare comprehensive report based on literature survey and project work done
- **CO6** Demonstrate an ability to present and defend their research work to a panel of experts

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		3				2	2		1				2	3	1
CO2	3	2					1						3	1	2
CO3		2	2	2	3			2				2	3	1	2
CO4									3		2	2	3	1	2
CO5	2				1					3		2			
CO6					1					3		2			

Course code	**PE/PS/B/S/412**
Category	Project and Seminar
Course title	**Seminar**
Scheme and Credits	**L–T–P: 0–0–3; Credits: 1.5**

Students have to present seminars on technical and other topics in the class using presentation files and also submit reports on their topics of seminars.

CO – PO

- **CO1:** Prepare comprehensive report based on literature survey/Topics related to different subjects during their course of study and beyond
- **CO2:** Identify the applicability of modern tools and technology in relevant courses of the program
- **CO3:** Deliver presentation based on the preparation
- **CO4:** Answer queries posed by the listeners
- **CO5:** Correct himself/herself to improve presentation skills

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			1				2	2		2			
CO2	1		1	1	3				1			1			
CO3										3		2			
CO4	1									3		1			
CO5									1	3		1			

4th Year 2nd Semester

Course code	**PE/PE/B/T/421A**
Category	Professional Elective Course
Course title	**Combustion**
Scheme and Credits	**L–T–P: 3-0–0; Credits: 3.0**

Syllabus

Types of fuel, Properties and uses of different fuels, Combustion Stoichiometry, Thermochemistry, Adiabatic Flame temp. Chemical Equilibrium.
Fundamentals of chemical kinetics, Coupling of chemical and Thermal Analysis for reacting systems, Conservation equations in transport processes.
Premixed flames of gaseous fuels, flammability limits, flame structure, laminar burning velocity, stabilization of premixed flame, introduction to turbulent premixed flame. Non-premixed flame of gaseous fuels, structure of laminar non-premixed flame, stabilization of laminar non-premixed flame, soot formation in non-premixed flame.
Liquid fuel atomization and types of atomizers, characteristics of fuel spray,introduction to droplet and spray combustion of liquid fuel, stages of combustion in solid fuel.
Combustion applications -- furnaces, engines and gas turbines, environmental pollution from combustion, emission norms.

Content delivery methods
- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

At the end of the course the students will be able to:
- **CO1:** Describe the concepts of stoichiometry, thermochemistry, chemical kinetics and transport processes and solve problems using these concepts (**K2**)
- **CO2:** Compare different types of gaseous fuel flames and analyze their structure and stability (**K4**)
- **CO3:**Analyze the combustion of liquid and solid fuels (**K4**)
- **CO4:** Illustrate the combustion phenomena in different applications (**K4**)
- **CO5:**Assess the environmental aspect of combustion (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1									2	2	
CO2	2	3		1	1								1	2	2
CO3	2	3		1	1								2	2	1
CO4	2	2	3	2			2					1	1	3	1
CO5	2	2					3					1	1	2	2

Course code	**PE/PE/B/T/421B**
Category	Professional Elective Course
Course title	**Design of Hybrid Energy Systems**
Scheme and Credits	**L–T–P: 3-0–0; Credits: 3.0**

Syllabus

Introduction to Hybrid renewable and micro-grid systems-concept, components, and prospects; different types of hybrid systems; solar thermal and PV –cogeneration; Grid independent and grid interactive hybrid systems- feasibility study, knowledge of energy demand, design, optimization and unit sizing, resiliency and applications; power flow, control and characterization of micro-grid systems; characteristic of grid interactive inverters; optimization and optimization based on pricing; life cycle assessment of hybrid systems; Entrepreneurship in renewable technologies; evacuation of tidal and wave power; Energy storages –importance, types and application in microgrid systems; Condition Monitoring and Fault Diagnosis and protection, relay coordination; challenges and grid code for grid connected systems.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)
- ✓ Demonstration (D8)

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

- **CO1:**Describe the concepts of renewable based hybrid and microgrid systems and characterize energy vectors. (**A5,K2**)
- **CO2:** Explain the principles of tidal and wave power and Demonstrate their application (**K2, S3**)
- **CO3:** Explain and Analyze different socio-techno-economic aspects of microgrid systems. (**K2, A5**)
- **CO4: Demonstrate** the functionality of grid interactive inverters, energy storage, relay co-ordination, and grid code. (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1					1					2	2	3	
CO2	3	2	2				1						1	2	
CO3	2	2	3	2		2	2				1	1	1	2	
CO4	3	2	2				2			1			1	2	

Course code PE/PE/B/T/421C
Category Professional Elective Course
Course title **Fluid Power and Control**
Scheme and Credits **L–T–P: 3-0–0; Credits: 3.0**

Syllabus

Properties of industrial fluids, fluid reservoir for liquids and gases, fluid power units - pumps, compressors & blowers, accumulators & intensifiers, valves - one, two & three way valves, pressure control, flow control & sequence valves, master control valves, flexible piping & fittings, seals &packing, filtration of liquids, moisture control of gases, industrial hydraulic & pneumatic circuits - pressure regulating circuits, counterbalance circuits, sequence operation circuits, speed control circuits, meter-in-meter-out circuits, regenerative circuits, circuits using accumulators & intensifiers, fluid logic & control system - principles of fluid logic & application, open loop & closed loop system, block diagram, root locus method, steady state error & stability, system performance, optimization & reliability, feedback control system, analogue technique - application to hydraulic & pneumatic system.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Explain the concept of fluid power in engineering (**K2**)
- **CO2:** Classify various types of fluid power controlling systems (**K3**)
- **CO3:**Classify the different application and its use in industries (**K4**)
- **CO4:** Explain the application of electronic and pneumatic control system and errors associated in these (**K3**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1				1						2	3	1
CO2	3	2	2	1			1						3	1	2
CO3	2	3	2	1									3	1	2
CO4	2	3	1		2		1					1	3	1	2

Course code	**PE/PE/H/T/422A**
Category	Professional Elective Honours Course
Course title	**Turbomachines**
Scheme and Credits	**L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Principles: Energy transfer between fluid and rotor, classification of turbomachines, dimensionless parameters, specific speed, applications, stage velocity triangles, work and efficiency for compressors and turbines, valves used with turbomachines.
Centrifugal Fans and Blowers: Types, stage and design parameters, flow analysis in impeller blades, volute and diffusers, losses, characteristics curves and selection, fan drives and fan noise.
Centrifugal Compressor: Construction details, types, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.
Axial Flow Fans and Blowers: Analysis of axial flow machines, Isolated and different aerofoil and cascade blade theory-CL and CD, blade nomenclature, degree of reaction, stalling. Surging in Pipelines and its effect and method of control. Performance characteristics ofAxial flow machines.Guide vanes and flow straightener for axial flow machines.
Axial Flow Compressor: Stage velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, workdone factor, simple stage design problems and performance characteristics.
Axial and Radial Flow Turbines: Stage velocity diagrams, reaction stages, losses and coefficients blade design principles, testing and performance characteristics.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe the energy transfer process in turbomachines (**K2**)
- **CO2:** Classify turbomachines and their properties (**K2**)
- **CO3:** Illustrate the flow within the turbomachines (**K4**)
- **CO4:** Explain different components for various turbomachines (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1		1			2						3		2
CO2	2	3		2			2						2	3	2
CO3	2	1	1										2		1
CO4	3	2	2				2					1	2	3	2

Course code	**PE/PE/H/T/422B**
Category	Professional Elective Honours Course
Course title	**Digital Signal Processing**
Scheme and Credits	**L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Continuous time and discrete time signals and systems; LTI systems/convolution/Difference equations, Spectral analysis: Frequency domain representation –FS/FT/DTFT/DTFT/DTFS/DFT, Decimation in Time, Decimation in Frequency FFT algorithms; Sampling and reconstruction, Quantization, Decimation and Interpolation; Z transform; Digital filters: FIR and IIR filters, Digital filter realizations and design; Finite length effects Time Frequency representations; Digital Signal Processors: Architecture, Instructions, Assembly level Programming, introduction to Code Composer Studio.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Active Learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1: Identify** the key enabling concepts behind signals, systems and their representation (**K2**)
- **CO2: Construct** different Transforms(**K3**).
- **CO3: Assess** the attributes associated with Sampling and Quantization (**K3**)
- **CO4: Analyze** the functioning of discrete filters(**K4**)
- **CO5: Formulate**deigns based on DSPs using standard programming interfaces (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										1		
CO2	3	2	1										1		
CO3	3	2	1	1									1		
CO4	2	1	1										2		1
CO5	2	2	2	2	3	1	1		1				2	1	1

Course code **PE/PE/H/T/422C**
Category Professional Elective Honours Course
Course title **Computational Fluid Dynamics**
Scheme and Credits **L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Introduction to computational fluid dynamics. Conservation equations in fluid flow and heat and mass transfer, Reynolds transport theorem. Types of partial differential equations: parabolic, elliptic and hyperbolic equations; boundary conditions – well posed and ill posed problems.
Finite difference discretization of conservation equations. Explicit and implicit methods; Stability, Convergence, Consistency and Transportiveness.
Solution of heat conduction problems using finite difference method. Concept of grid independence validation; Stream function-vorticity formulation of viscous fluid flow and its discretization; Generalized advection-diffusion formulation using the primitive variables approach using finite difference and finite volume algorithms – SOLA and SIMPLE.
Introduction to commercial CFD software. Concept of pre-processor, processor and post-processor. User-defined functions. Types of computational mesh. Interpreting CFD results.
Introduction to turbulence modeling.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Describe the use of computational fluid dynamics (CFD), the conservation equations and its properties (**K2**).
- **CO2:** Illustrate discretization techniques and their properties (**K3**).
- **CO3:** Apply knowledge CFD to solve heat conduction and fluid flow related problems (**K3**).
- **CO4:** Outline the use of commercial CFD software and turbulence modeling (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1										2	3		
CO2	2	3		2									3		
CO3	2	2	3	2											
CO4		1	2	2	3				1			2		3	

Course code	**PE/PE/H/T/422D**
Category	Professional Elective Honours Course
Course title	**Digital Control Systems**
Scheme and Credits	**L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Introductory Concepts: Discrete and Sampled Data Systems. Mathematical representation of Discrete Systems- Z transforms. Sampling and Data construction.
Modelling Discrete Systems: Mapping from S-Z plane. Pulse Transfer Function. Sampled Signal Flow Graph. Discrete State-space representation of Continuous Time Systems.
Time Response: Transient Response. Time response of first and second order discrete systems.
Stability Analysis: Jury Stability Test. Stability analysis using Bilinear Transformation. Frequency domain techniques- Nyquist Stability and Bode Plots of discrete systems. Effect of sampling time. Root Locus of discrete systems.
Discrete State Space: Controllability, Observability and Stability of Discrete State-Space Systems, Eigen Values and Schur Stability. Lyapunov Stability of Discrete Systems.
Discrete Controller Design Techniques- Direct and Indirect Methods, Choice of Sampling Time. Optimal Controller Design. Discrete PID Controllers- forms and representation, design.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:Identify** the key enabling concepts behind discrete systems and their representation using standard techniques(**K2**)
- **CO2: Construct** mathematicalmodels of discrete systems using discretization, discrete transfer function and discrete state-space representation(**K3**).
- **CO3: Assess** the stability and time response attributes of a discrete system (**K3**)
- **CO4: Analyze** the performance of discrete systems using modern techniques(**K4**)
- **CO5 Formulate** discrete controllers (**K5**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1										1		
CO2	3	2	2	1									1		
CO3	2	2	3		2				1				2		
CO4	2	2	2	1	3	1	1		1				1		1
CO5	2	2	3	2	2	1	1		1				1	1	1

Course code	**PE/PE/H/T/422E**
Category	Professional Elective Honours Course
Course title	**Advanced Topics in Fluid Mechanics**
Scheme and Credits	**L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Reviews of basic laws of fluid flow in integral and differential form, Kinematics, ideal fluid flow, Newtonian fluid flow and applications, creeping flow, transition and turbulence, modeling and dimensional analysis, Boundary layer concept and its formulation in different situations, Blasius solution and similar solutions, thermal boundary layer.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Review the basic laws for fluid flows. (**K2**)
- **CO2:** Classify different types of fluid flow and their properties (**K2**)
- **CO3:** Illustrate the flow within the boundary layer (**K4**)
- **CO4:** Examine the need for superimposition of various flows (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			2		2						2	3	
CO2	2	3	1	1	2		2						2	3	2
CO3	2	3	1	1	2		2						2	3	2
CO4	2	1	2	2		2	3					2	3	2	1

Course code	**PE/PE/H/T/422F**
Category	Professional Elective Honours Course
Course title	**Fluid Flow and Gas Dynamics**
Scheme and Credits	**L–T–P: 4-0–0; Credits: 4.0**

Syllabus

Introduction and definitions, equations of motion for 3-D flow, Navier-stokes equations, circulation and vorticity, potential flow, flow around bodies (cylinders and aerofoil), transformation of circle into aerofoil. Introduction to compressible flow, velocity of sound and Mach number, isentropic flow, flow with friction and heat transfer, Rayleigh line and Fanno line, analysis of flows with normal and oblique shock waves, supersonic flows, unsteady flows.

Content delivery methods

- ✓ Class room lecture (chalk and board) (D1)
- ✓ Visual presentation (D2)
- ✓ Discussion/brainstorming (D7)

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

- **CO1:** Review the basic laws for compressible fluid flows. (**K2**)
- **CO2:** Classify different types of compressible fluid flow and their properties (**K2**)
- **CO3:** Illustrate the compressible flow around various bodies (**K4**)
- **CO4:** Analyze internal fluid flow through various systems (**K4**)

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			2		2						2	3	
CO2	2	3	1	1	2		2						2	3	2
CO3	2	3	1	1	2		2						2	3	2
CO4	2	1	2	2		2	3					2	3	2	1

Open Elective II [3 – 0 – 0]

The students have to take the courses offered by other departments of FET according to their choice.

Course code **PE/PC/B/S/421**
Category Professional Core Course
Course title **Environmental Pollution Lab**
Scheme and Credits **L–T–P: 0-0–2; Credits: 1.0**

List of Experiments

1. Demonstration of the measurement techniques of stack gas emission using flue gas analyzer.
2. Measurement of Particulate fractions (PM10, PM2.5, NRPM & TSPM) using air samplers.
3. Chemical determination of SO_2 and NO_2 employing Spectrophotometer.
4. Measurement of Ground Level Ozone using Photometric Ozone Analyzer.
5. Measurement of Carbon Monoxide using Gas Filter Correlation CO Analyzer.
6. Measurement of NO_X (NO/ NO_2) using Chemiluminescence NO_X Analyzer.
7. Determination of Aerosol Optical Thickness (AOT) employing Hand held Sunphotometer.
8. Determination of C-H-N-S using C-H-N-S Analyzer.

Content delivery methods

- ✓ Visual presentation (D2)
- ✓ Active learning (D4)
- ✓ Demonstration (D8)

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

- **CO1:** Examine and explain the characteristic of principal parameters causing air pollution (**A2, K2**)
- **CO2:** Demonstrate the technique to measure stack gas emission, particulate fractions, SO_2 and NO_2, ground level Ozone, CO, NO_x, AOT and CHNS (**K3, S3**)
- **CO3:**Analyze and characterize the various parameters obtained in experiments (**A3, A5**)
- **CO4:** Interpret the experimental results in a report and defend it (**K6**)

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1					3	1	2				1	2	
CO2	3	2			2				1				1	3	
CO3	2	3			3		2		1			1	2	2	3
CO4	2	2	1				2		1	3			1	1	2

Course code **PE/PS/B/S/422**
Category Project and Seminar
Course title **Project**
Scheme and Credits **L–T–P: 0-0–12; Credits: 6.0**

Students will be given projects under the supervision of faculty members either as group or individual activities.

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

- **CO1** Select a suitable problem relevant to power engineering with an attention to real life problems faced by the society
- **CO2** Demonstrate knowledge of contemporary issues in their chosen field of project
- **CO3** Undertake problem identification, formulation and design engineering solutions either through simulation or through practical work by considering ethical responsibility
- **CO4** Estimate and cost the human and physical resources required, and make plans to obtain the necessary resources while allocating roles with clear lines of responsibility and accountability
- **CO5** Prepare comprehensive report based on literature survey and project work done
- **CO6** Demonstrate an ability to present and defend their research work to a panel of experts

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		3				2	2		1				2	3	1
CO2	3	2					1						3	1	2
CO3		2	2	2	3			2				2	3	1	2
CO4									3		2	2	3	1	2
CO5	2				1					3		2			
CO6					1					3		2			