Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. VII

B.Tech. (ELECTRICAL) ENGINEERING

Academic Year 2024-25

List of Courses

Electric Drives

Course Code	Course Name
PC-BTE701	Electric Drives

Course pre-requisites	Power Electronics

Course Objectives

The objectives of this course are

1. Understand fundamentals of electric drives and their control through knowledge of electrical machines and power electronics
2. Discuss basics, dynamics, selection, braking and control of AC/DC drives.
3. Discuss applications of drives in industry
4. Understand the selection of motor as per the torque-speed characteristics of load.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Apply the fundamental concept of electrical drives system.
2. Select an electrical drive for a particular application and based on mechanical characteristics of load
3. Control of DC and AC motor using conventional and solid state drives.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction: Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives	04
2	Dynamics of Electrical Drives: Fundamental torque equations, Speed torque conventions and multi quadrant operation, Equivalent values of Drive parameter, Measurement of moment of Inertia, Components of load torque, Nature and Classification of load torques, Calculation of Time and Energy-Loss in transient operation, Steady state stability, Load equalization..	08
3	Selection of Motor Power Rating: Thermal Model of motor for heating and cooling, Classes of motor rating, Determination of motor rattling.	04
4	Control of Electrical Drives: Modes of operation, Speed control drive classification, Closed loop control of drives. Speed sensing, current sensing, Phase locked loop control	04
5	DC Drives: Speed torque relations for shunt, series, and separately excited motors, Starting, Braking (Regenerative, Dynamic, and Plugging),	08

	Speed Control (Armature voltage, Field flux, Armature resistance), Methods of Voltage control (Ward Leonard scheme, Controlled rectifiers, Controlled rectifier fed DC drives (separately excited only), Single phase fully-controlled rectifier, Single phase half- controlled rectifier, three phase fully-controlled rectifier, three phase half controlled rectifier, dual converter control, Chopper control (motoring and braking of separately excited and series motor)	
6	AC Drives: Induction motor drives, Review of speed-torque relations, Review of starting 6. methods, Braking (Regenerative, Plugging, AC/DC Dynamic braking), Speed control: Stator voltage control variable frequency control from voltage Source (V/F Control),Wound rotor induction motor control, rotor resistance control, Slip power recovery scheme, State Kramer and Scherbius drive, Vector control (elementary treatment only), Introduction to Synchronous Motor variable speed drive	08
7	Special Motor Drives: Stepper motor drives, Types, Torque v/s stepping rate characteristics, Drive circuits, Introduction to Brush-less DC drives, Introduction to Switched reluctance drives. Solar and Battery Drives, Recent trends in Electric Drives.	06

Text Books
1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall..
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall.
Reference Books
1. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press.
2. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media.
3. Subrahmanyam V, Electrical Drives: Concepts and Applications TMH
4. Pillai S.K, A First course on Electrical Drives Wiley Eastern PH

Sr. No.	Examination	Module
1	T-I	1, 2
2	T-II	3,4, part of 5
3	End Sem	1 to 7

Electric Drives Laboratory

Course Code	Course Name
PC-BTE702	Electric Drives Laboratory

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Perform simulations of electrical drives 2. Perform experiments on Plugging. Braking of DC and Induction motors 3. Perform experiments to understand different types of electrical drives
Course Outcomes
Upon successful completion of the course, students should be able to 1. Simulate Electrical Drives 2. Understand braking and plugging of dc and induction motors. 3. Understand DC, induction and stepper motor drive

Course Content

Module No.	*Details*	*Hrs.*
1	Simulation of Electrical drives.	**2**
2	Simulation of starting of DC motor (soft start).	**2**
3	Dynamic braking of DC motor.	**2**
4	Plugging of DC motor/Plugging while lowering the load.	**2**
5	Regenerative braking of DC motor (by making V<Eb) for high inertia load.	**2**
6	DC or AC Dynamic braking of 3 phase induction motor.	**2**
7	Plugging of induction motor	**2**
8	Single phase full wave controlled DC motor drive.	**2**
9	Chopper Drive.	**2**
10	V/F control of Induction motor using PWM inverter	**2**
11	Measurement of moment of inertia by retardation test	**2**
12	Study of stepper motor drive	**2**

Term Work
Term work shall comprise of Practical Examination/ MCQ examination

Electrical Machine Design II

Course Code	Course Name
PE-BTE702	Electrical Machine Design II

Course pre-requisites	Electrical Machine design I

Course Objectives

The objectives of this course are

1. Discuss the design of transformers, induction motors and synchronous machines
2. Introduction to computer aided design

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the construction and performance characteristics of electrical machines.
2. Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
3. Understand the principles of electrical machine design and carry out a basic design of an ac machine.
4. Use software tools to do design calculations

Course Content

Module No.	*Details*	*Hrs.*
1	Design of Synchronous machine: Specification. Major considerations in Synchronous machine design - Output Equation – Choice of specific electrical – Choice of specific magnetic loadings. Design of Salient pole Machines: Main Dimensions. Short Circuit Ratio (SCR) – Effect of SCR on machine performance. Length of Air gap. Shape of Pole Face.	04
2	Armature Design: Choice of number of slots – Turns per phase – Conductor section. Armature Windings – Coils and their Insulation. Stator Slot Dimensions Stator Core. Elimination of Harmonics. Armature parameters – Armature Resistance – Armature Leakage Reactance. Estimation of Air gap length.	08
3	Design of Salient pole Rotor: Selection and Type of Pole – pole Height – Damper Winding – Height of Pole Shoe – Mmf for the magnetic circuit – Estimation of full load field mmf – Design of Field Winding. Determination of d & q Synchronous reactances – Short Circuit Characteristic. Estimation of Losses and Efficiency - Temperature Rise.	08
4	Design of turbo alternators: Main Dimensions. Length of Air gap – Stator Design -Rotor design	04
5	Computer Application in Electrical Machine Design: Introduction Limitations (assumptions) of traditional designs. Computer aided	08

	Design (CAD) – Analysis Method - Synthesis Method - Hybrid Method. Optimization – General Procedure for Optimization – Variables and Constraints – Problem formulation. Computer aided Design of Transformer– Basic Aspects – Flowcharts for Transformer design. Computer aided Design of Induction motor – Basic Aspects – Flowcharts for Induction motor design.	
6	Introduction to FEM based machine design.	04
7	Introduction to complex structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines.	06
Term Work		
Term work shall comprise of 1. Tutorials based on each module in the syllabus content 2. MCQ examination.		

Text Books
1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 1970. 2. S. K. Sen, "Principles of Electrical Machine Design with computer programs", Oxford and IBH Publishing, 2006.
Reference Books
1. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Design Management and Auditing of Electrical Systems

Course Code	Course Name
PC-BTE703	Design Management and Auditing of Electrical Systems

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Introduction to types of electrical projects and electrical systems, energy conservation law, basics of tendering and estimation.
2. Discussion of basic concepts of design of electrical systems like power distribution, switchgear protection and auxiliary system.
3. Learning of management and auditing procedure of electrical systems.
4. Understanding renewable-energy and green building concepts from design perspective.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Work as a team leader or a member in multidisciplinary projects in the role of electrical engineer.
2. Identify the requirement of the project and design electrical systems accordingly as per IS standards.
3. Apply energy efficient ways in design and selection of electrical components.
4. Realize role of renewable-energy and green building concepts in electrical design.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction: Types of electrical projects, Types of electrical systems, Review of components of electrical system, Different plans/drawing in electrical system design, Single line diagram in detail, Introduction to Energy Conservation Act 2001	**04**
2	Design of Power Distribution System: Different types of distribution systems and selection criteria, Electrical load: Size, LF, DF, future estimates, Substation equipment options, Design consideration in: Transformer selection, sizing and specifications. IS standards applicable in above designs. (Substation „LV" Design)	**06**
3	Design of Switchgear Protection and Auxiliary System: Selection of HT/LT switchgears, Metering, Switchboards and MCC, Protection systems, cables: selection and sizing, cable installation and management systems, Basics of selection of emergency/backup supplies. UPS, DG set, Batteries, Preliminary design of interior lighting system, IS standards applicable in above designs.	**06**
4	Tendering Process: Basics of tendering and estimation, Review of economic and	**04**

	financial analysis techniques: Time value of money, Simple payback, IRR.	
5	Monitoring and Management of Electrical Systems: Energy monitoring and Targeting: Defining monitoring and targeting, Elements of monitoring and targeting, Energy analysis techniques for energy optimization. Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses, Introduction to Energy Efficient Technologies in Electrical systems: Maximum Demand controllers, Automatic Power factor controllers, Energy Efficient motors, Soft starters, Variable speed drives, Energy Efficient Transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology. Energy Management System (EMS) and Building Management System (BMS) systems	**10**
6	Energy Audit: Definition, Energy audit-need, types of Energy audit, Energy management (audit) approach- understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments: Audit of installations comprising following with respect to their electrical energy usage: Electric Motors, HVAC systems, Fan and blower systems, Compressed air systems pump, DG sets, Lighting installations etc. Evaluation of energy conservation opportunities, Energy conservation in buildings, Economic and non-economic aspects of energy conservation in electrical systems	**08**
7	Use of Renewable and Green Building Concept: Impact of renewable energy sources in electrical system design. Concept of Green Building and its accreditation.	**04**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination.		

Text Books
Reference Books
1. Handbook of Electrical Installation Practice. , By Geoffery Stokes, Wiley Blackwell 2. Designing with light: Lighting Handbook., By Anil Valia, Lighting System 3. Energy Management Handbook. By W.C. Turner, JohnWiley and Sons

4. Handbook on Energy Audits and Management. edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI).
5. Electrical Design: Estimating and Costing, by K. B. Raina and S. K. Bhattacharya, New Age International Publishers
6. Energy Auditing Made Simple, By P. Balasubramanian, Seperation Engineers (P) Limited
7. Energy Management Principles, By C.B.Smith, Pergamon Press
8. Energy Conservation Guidebook, Dale R. Patrick, Stephen Fardo, Ray E. Richardson, Fairmont Press
9. Handbook of Energy Audits., By Albert Thumann,William J. Younger, Terry Niehus, CRC Press

Sr. No.	Examination	Module
1	T-I	1, 2, Part of 3
2	T-II	Part of 3, 4, Part of 5
3	End Sem	1 to 7

Digital Control Design

Course Code	Course Name
PE-BTE704	Digital Control Design

Course pre-requisites	Control System, Control System Design, Signals and Systems

Course Objectives

The objectives of this course are

1. Obtain discrete representation of LTI systems.
2. Analyze stability of open loop and closed loop discrete-time systems.
3. Design and analyze digital controllers.
4. Design state feedback and output feedback controllers

Course Outcomes

Upon successful completion of the course, students should be able to

1. Obtain discrete representation of LTI systems.
2. Analyze stability of open loop and closed loop discrete-time systems.
3. Design and analyze digital controllers.
4. Design state feedback and output feedback controllers.

Course Content

Module No.	*Details*	*Hrs.*
1	Discrete Representation of Continuous Systems Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modeling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent, state space system	**06**
2	Discrete System Analysis Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.	**06**
3	Stability of Discrete Time System Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design	**04**
4	State Space Approach for discrete time systems State space models of discrete systems, State space analysis. Lyapunov Stability.	**05**
5	State Space Approach for discrete time systems Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability	**05**
6	Design of Digital Control System Nyquist plot for controller design, Design of Discrete PID	**08**

	Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator	
7	Discrete output feedback control Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.	**08**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination.		

Text Books
1. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
Reference Books
1. K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995. 2. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998. 3. B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 1980.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4,5
3	End Sem	1 to 7

Restructuring and Deregulation of Power System

Course Code	Course Name
OE-BTE705	Restructuring and Deregulation of Power System

Course pre-requisites	Power system-I and power system –II

Course Objectives

The objectives of this course are

1. To differentiate between vertically integrated and deregulated power system.
2. Challenges faced in operating restructured power system with reliability, security and economic efficiency.
3. Reforms adopted by developing country like India

Course Outcomes

Upon successful completion of the course, students should be able to

1. Identify different electrical market designs.
2. Understand fundamentals of micro economics.
3. Determine the suitable pricing method for centralised and decentralised trading.
4. Understand ancillary service and congestion management requirement of restructured power system

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction of restructured power system.** • Reasons for restructuring and deregulation of power system • Entities involved • Different model of competition • Electrical market vis-à- vis market of commodities	**6**
2	**Fundamentals of micro economics** • Consumer behaviour • Supplier behaviour • Market equilibrium • Various cost of production • Long term and short-term cost • Types of markets • Markets with imperfection competition	**8**
3	**Introduction to optimization** • Linear optimisation • Convexity • Duality • KKT condition • Lagrange multiplier • Optimal dispatch of generation	**6**
4	**Optimal Power Flow and Congestion Management.** • Optimal power flow – AC and DC formulation • Spot Pricing • Decentralised trading over the transmission network.	**8**

	• Centralised trading over the transmission network.	
5	**Participating in markets for electrical energy** • Consumer's perspective • Producer's perspective	**4**
6	**System security and ancillary service** • Ancillary service needs • Obtaining ancillary service • Buying ancillary service • Selling ancillary service	**5**
7	**Reforms in Indian Power Sector** • Frame work of Indian power sector • Electricity act 2003 and amendments • Transmission system cost allocation • Power exchanges – Day ahead market, real-time market • Deviation settlement mechanism • Ongoing and future developments	**5**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books
1. Daniel Krischen and Goran Strbac, "Fundamental of Power System Economics", John Wiley and Sons Ltd ,2004. 2. Sally Hunt, "Making Competition Work in Electricity", John Wiley and Sons, Inc.,2002
Reference Books
1. Steven Stoft , "Power System Economics: Designing Markets for Electricity" , Wiley-IEEE Press, 2002.

Sr. No.	Examination	Module
1	T-I	1, part of 2
2	T-II	Part of 2,3,4
3	End Sem	1 to 7

High Voltage Engineering

Course Code	Course Name
PE-BTE706	High Voltage Engineering

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Discuss breakdown in gases, solid and liquid insulating material
2. Introduce generation and measurements of high voltages.
3. Discuss lightening and switching over voltages
4. Discuss high voltage testing

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
2. Knowledge of generation and measurement of D. C., A.C., & Impulse voltages.
3. Knowledge of tests on H. V. equipment and on insulating materials, as per the standards.
4. Knowledge of how over-voltages arise in a power system, and protection against these over-voltages

Course Content

Module No.	*Details*	*Hrs.*
1	Breakdown in Gases Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend‟s theory, Streamer mechanism, Corona discharge	**08**
2	Breakdown in liquid and solid Insulating materials Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.	**07**
3	Generation of High Voltages Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators	**07**
4	Measurements of High Voltages and Currents Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.	**07**
5	Lightning and Switching Over-voltages Charge formation in clouds, Stepped leader, Dart leader,	**07**

	Lightning Surges. Switching over voltages, Protection against over-voltages, Surge diverters, Surge modifiers.	
6	High Voltage Testing of Electrical Apparatus and High Voltage Laboratories Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.	**06**
Term Work		
Term work shall comprise of 1. . Tutorials 2. MCQ examination		

Text Books
1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013. 2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.
Reference Books
1. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993. 2. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000. 3. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011. 4. Various IS standards for HV Laboratory Techniques and Testing

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	01-06

Power Electronics Applications in Power System

Course Code	Course Name
PE-BTE707	**Power Electronics Applications in Power System**

Course pre-requisites	Power Electronics Power System

Course Objectives

The objectives of this course are

1. To study the operation of power system components that improves the power system performance.
2. Introduction of series & shunt compensation for transmission lines.
3. Discuss reactive power support & elimination of harmonics using Voltage Source Inverters.
4. To study the operation & control of HVDC transmission system.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the various methods of improving power system performance.
2. Able to analyze the existing system for performance improvement
3. Able to create the system performance improvement using advanced technology

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction: Brief discussion on Transmission line theory, use of Voltage source inverters (VSI) for reactive power support, mid-point series and shunt compensation and HVDC, Discussion on voltage profile at the point of common coupling (PCC), need for load compensation, load balancing using passive elements, Limitations of load balancing using passive elements	**06**
2	Use of VSI as a Var generator, Indirect current controlled Synchronous link converter Var Compensator (SLCVC), Various PWM techniques, Harmonic elimination and space vector PWM techniques, theory and implementation issues, Expression for active and reactive powers in terms of d-q components, stationary to rotating frame transformation	**06**
3	Shunt Compensation Introduction, methods of Var generation, Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor-thyristor controlled reactor (FC-TCR), STATCOM.	**06**
4	Series Compensation Introduction, comparison between series and shunt compensation, various equipments: GTO controlled series capacitor (GCSC), comparison of TCR and GCSC, Thyristor switched series capacitor (TSSC), Thyristor controlled series capacitor (TCSC), Static Synchronous Series compensator (SSSC), modes of operation, voltage regulator, and Phase angle	**06**

	regulator (PAR), Multi-function FACTS controller, Unified power flow controller (UPFC), control capabilities of UPFC,	
5	HVDC: Introduction, various possible HVDC configurations, unipolar and bipolar links, components of HVDC systems – converter, transformer, smoothing reactor, harmonic filter, Reactive power support.	**06**
6	HVDC Operation of 6-pulse controlled rectifier in inverting mode of operation, effect of source inductance, equivalent circuit representation of 6-pulse converter considering effect of source inductance, operation of 12-pulse converter.	**06**
7	Control of HVDC system Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier- inverter characteristics, wave blocking and by-passing, limitation of HVDC system using line commutated converters, modern HVDC systems HVDC light	**06**
Term Work		
Term work shall comprise of 1. Tutorials based on each module in the syllabus content 2. MCQ examination		

Text Books
1. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS: Concepts and technology of flexible AC transmission systems, IEEE Press 2. K. R. Padiyaar , HVDC Power transmission and system
Reference Books
1. K R Padiyaar , FACTS controllers in power transmission and distribution

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Computer Aided Power System Analysis

Course Code	Course Name
PE-BTE708	Computer Aided Power System Analysis

Course pre-requisites	PSA, PSOC, Numerical techniques, programming skills

Course Objectives

The objectives of this course are
1. To understand analysis of power systems using Computer methods.
2. To understand the advance techniques in the solution of power flow problem.
3. To understand the solution methods and techniques involved in power system analysis.
4. To understand the behavior of power system under healthy and faulty condition.

Course Outcomes

At the end of the course, students will demonstrate the ability to
1. Analyze the power system under symmetrical and unsymmetrical fault condition using Zbus
2. Appraise the use of matrix computation and optimization in the field of power system
3. Evaluate state of the complex power system by various state estimation tools.
4. Investigate the behavior of power system under different operating conditions

Course Content

Module No.	*Details*	*Hrs.*
1	**Mathematical concepts:** Sparse Matrices: Sparsity directed Optimal Ordering Schemes, Solution Algorithms – LU Factorization Numerical methods to solve non-linear equation: Gauss-Seidel, Newton Raphson method, Optimization Methods: Nonlinear constraint optimization, Lagrangian Multiplier approach, Linear programming, Least square Estimation	5
2	**AC Power Flow Analysis:** Preparing/using data files required for power flow studies such as line data, generation data, bus data. Ybus formation by Power flow solution algorithms such as Gauss Siedel, Newton Raphson, Fast Decoupled and DC power flow for multi- machine or IEEE systems. Power flow studies for distribution systems.	6
3	Analysis of Faulted Power System: Symmetrical and Asymmetrical Faults, Zbus Formulation, Short Circuit Analysis of Large Power Systems using Zbus.	5
4	**Power System stability:** Numerical solution of Swing equation using Forward Euler method, Runge-kutta 4^{th} order method, stability study of multi-machine system.	6
5	**Load Forecasting Techniques:** classification of forecasting, Introduction to time series, Linear regression, forecasting methodologies, estimation of average, trend & periodic components, time series approach, kalman filter approach, long	8

	term load forecasting for system planning. Introduction to Machine learning approach for load forecasting. Error analysis in load forecasting.	
6	**Power System State Estimation**: Introduction, Network Topology Processing, observability analysis, Linear and non-linear state estimation	6
7	**Security Analysis:** Basic Concepts, Static Security Analysis at Control Centre, Contingency Analysis, Contingency Selection.	6

Term Work

Term work shall comprise of

1. Tutorials based on each module in the syllabus content
2. MCQ examination

Text Books

1. Kothari. D.P, Nagrath I.J., "Modern Power System Analysis" ,TMH publication.
2. Prabha Kundur, "Power System stability and Control", TMH Publication.

Reference Books

1. Grainger John J., Stevenson William D., "Power system Analysis", MC Graw Hill.
2. Chakrabarti .A, Halder.S, "Power System Analysis-Operation and Control", PHI
3. Hadi Sadat, "Power System Analysis", MC Graw Hill
4. S. A. Soman, S. A. Khaparde, Shubha Pandit, "Computational Methods for Large Sparse Power System Analysis: An Object Oriented Approach", Springer
5. M. A. Pai, D. Chatterjee, "Computer Techniques in Power System Analysis", McGraw Hill Education
6. David S. Watkins, Fundamentals of Matrix Computations, 3rd Edition, Willey-Inter science, 2010

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Electric Vehicle System Design

Course Code	Course Name
PE-BTE709	Electric Vehicle System Design

Course pre-requisites	Machines I and Machines II

Course Objectives
1. To illustrate the design philosophies used in the EV domain. 2. To explore the selection of power and control architecture of EV drives 3. To study the design aspects of EV battery packs and other auxiliary systems
Course Outcomes
Upon successful completion of the course, students should be able to 1. Select and size the electric motor for a particular EV application and performance criteria 2. Select and size the battery pack to meet desired EV performance and 3. Design the EV drive system with functional safety considerations. 4. Illustrate the use of hybrid energy source for EV performance improvement 5. Illustrate the design aspects of Automotive Subsystem

Course Content

Module No.	***Details***	***Hrs.***
1	**Selection/ Sizing of EV Electric Motors** Electric Vehicle modelling, Tractive force calculations, Design considerations for 2W, 3W and 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit, Vehicle Power Demand Vehicle Performance Envelope, and Vehicle Power Envelope; Vehicle Power Demand during Driving Cycles. Design considerations for EV motors and their cooling system. Application Examples of EV /HEV motors with vehicles and motor specifications.	08
2	**Selection/ Sizing of Battery pack and other Energy Resource:** Selection of type of Battery pack for 2W, 3W and 4W EVs, Battery pack sizing, Design considerations, Range per charge, range anxiety, EV motor power requirement, Impact of road conditions, environmental conditions and traffic conditions. High-Voltage Cabling and Disconnects, Safety in Battery Design, Testing for safety. Accelerated Reliability Testing of Electric Vehicles, Battery Cycle Life versus Peak Power and Rest Period. Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis. Design considerations for Ultra-capacitor based EV, requirement of charging infra.	06

	Flywheel selection and sizing for EV/HEV applications.	
3	**Automotive Subsystem Design:** Electronic Control Unit (ECU) and its Control Features, Communications between ECUs, Control Software Development: Software-in-the-Loop (SIL) Simulation and Hardware-in-the-Loop (HIL) Simulation. Acceleration and braking control, regenerative braking; Automotive Steering Systems. Design considerations of HVAC controller	04
4	**EV System integration:** EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements.	04
5	**Design of Charging Infrastructure-1:** Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards. Installation guidelines and grid requirement for charger installations.	08
6	**Design of Charging Infrastructure-2:** Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities, regenerative braking control. Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards	06
7	**Design with Functional Safety of Automotive Electronics:** Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262. Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event. Hazard and Risk Analysis (HARA) for different situations, Testing of vehicles for compliance of safety norms	06
Term Work		
Term work shall comprise of 1. Tutorials, Case study based on IEEE papers or industrial visits 2. MCQ examination		

Text Books / Reference Books
1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines and Drives Design, Analysis and Application by K. T. Chau, IEEE Press and Wiley, 2015
3. I. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

4. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press. 2005
5. Sheldon Williamsom, Energy Management Strategies for Electric and Plug-in Hybrid Vehicles, Springer 2013
6. J. Larminie and J. Lowry, Electric Vehicle Technology Explained, Wiley, 2003
7. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018

Sr. No.	Examination	Module
1	T-I	1 and 2
2	T-II	3 and 4
3	End Sem	1 to 7

Computer Network

Course Code	Course Name
OE-BTE701	Computer Network

Course pre-requisites	Communication Engineering

Course Objectives

The objectives of this course are

1. Discuss various types of networks
2. Introduce various layers of computer network protocols

Course Outcomes

Upon successful completion of the course, students should be able to

1. Explain the process of communication in computer network
2. Simulate the computer network.
3. Illustrate the protocols of TCP/IP.

Course Content

Module No.	*Details*	*Hrs.*
1	OSI reference model and network architecture: Types of communication (simplex, half duplex, full duplex), types of connections, network topology types Types of networks: peer to peer and client server networks, network hardware- transmission technology-broadcast links and point-to-point links and scale–PAN, LAN, MAN, WAN, Interne Network software: protocol hierarchies, protocol, peers, interface, network architecture, protocol stack, Connection oriented and connectionless services, service primitives Reference model: OSI,TCP/IP	**06**
2	Physical layer: Guided Transmission Media ,Unguided Transmission Media	**03**
3	Data link layer: Services provided by Data link layer to network layer, Framing Error detection – checksum, parity CRC Error correction: hamming codes Flow control- elementary data link protocols, Sliding window protocols HDLC- high level data link control protocol	**07**
4	Medium Access Sub layer: The Channel Allocation Problem, Multiple Access Protocols Multiple access Aloha system, CSMA–CSMA/CD,CSMA/CA Controlled access – reservation system, polling, token passing Channelization–FDMA,TDMA,CDMA Traditional Etheet- frame, addressing	**07**
5	Network layer:	**08**

	IPV4 addresses – address space, notations, classful, classless addressing Need for network layer, ipv4 datagram, fragmentation Routing table: Static, Dynamic, Routing protocol: Intra domain – Distance vector RIP, link state-OSPF, inter domain – path vector BGP.	
6	Transport layer: Process to process delivery- client server paradigm, multiplexing, demultiplexing, connection less vs connection oriented service. UDP: user datagram, UDP operation: connectionless services, flow and error control, encapsulation and decapsulation, queuing. TCP: TCP services: process to process communication, stream delivery service, sending and receiving buffers, segments, full duplex communication. TCP features: sequence numbers and acknowledgement number,TCP segment, TCP connection, flow control, error control, congestion control.	**08**
7	Application layer: Remote logging: TELNET, FTP	**03**

Text Books
1. S. Tanenbaum, "Computer Networks", 4th Edition, Prentice Hall, 2012.
Reference Books
1. B. F. Ferouzan, "Data and Computer Communication", 4 th Edition, Tata McGraw Hill, 2010. 2. William Stallings, "Data and Computer Communication", 10thEdition, 2014

Sr. No.	**Examination**	**Module**
1	T-I	**1, 2, Part of 3**
2	T-II	**Part of 3, 4, Part of 5**
3	End Sem	1 to 7

Engineering Economics

Course Code	Course Name
OE-BTE702	Engineering Economics

Course pre-requisites	Basics of Project Management, statistics and mathematics, general knowledge about working of organizations

Course Objectives

The objectives of this course are

1. Learn the basic concepts of engineering economics.
2. Understand some engineering economics methods for solving problems of present worth, annual cost, rate of return, payback, break even, benefit cost ratio, etc.
3. Learn to evaluate the cost effectiveness of engineering projects on the basis of their economic viability.
4. Understand the concepts of depreciation / appreciation of assets / resources and its impact on their value.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Apply appropriate engineering economics methods for solving problems of present worth, annual cost, rate of return, payback, break even, benefit cost ratio, etc.
2. Evaluate the cost effectiveness of engineering projects on the basis of their economic viability and draw inferences for the investment decisions.
3. Calculate depreciation / appreciation of assets / resources to assess its impact on present or future value.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** • Economics: Flow in an economy, Law of Supply and Demand, • Concept of Engineering Economics: Definition, Scope, Types of Efficiency • Elements of Costs: Marginal Cost, Marginal Revenue, Sunk Cost, Opportunity Cost • Break-Even Analysis, Profit / Volume Ratio **Elementary Economic Analysis** • Basics, Material Selection for a Product, Building Material Selection • Process Planning / Process Modification	03 03
2	**Interest Formulas and Their Applications** • Introduction, Time Value of Money • Interest Formulas: Single Payment Compound Amount, Single-Payment Present Worth Amount, Equal-Payment Series Compound Amount, Equal-Payment Series Sinking Fund, Equal-Payment Series Present Worth Amount, Equal-Payment Series Capital Recovery	03

	Amount, Uniform Gradient Series Annual Equivalent Amount, Effective Interest Rate • Bases for Comparison of Alternatives	
3	**Present Worth Method of Comparison** • Basics, Revenue-dominated Cash Flow Diagram, • Cost-dominated Cash Flow Diagram **Future Worth Method** • Basics, Revenue-dominated Cash Flow Diagram • Cost-dominated Cash Flow Diagram **Annual Equivalent Method** • Basics, Revenue-dominated Cash Flow Diagram • Cost-dominated Cash Flow Diagram • Alternate Approach **Rate of Return Method.** **Advantages and disadvantages of each method.**	06
4	**Replacement and Maintenance Analysis** • Basics, Types of Maintenance, Types of Replacement, • Determination of Economic Life of an Asset • Replacement of Existing Asset with a New Asset: Capital Recovery with Return, Concept of Challenger and Defender • Simple Probabilistic Model for Items Which Fail Completely.	03
5	**Depreciation** • Methods of Depreciation: Straight Line Method of Depreciation, Declining Balance Method of Depreciation, Sum-of-the-Years-Digits Method of Depreciation, Sinking Fund Method of Depreciation, Service Output Method of Depreciation. **Evaluation of Public Alternatives**	03 02
6	**Inventory Control** • Basics, Purchase Model with Instantaneous Replenishment and without Shortages, • Manufacturing Model without Shortages • Purchase Model with Shortages (Instantaneous Supply) • Manufacturing Model with Shortages	04
7	**Make or Buy Decision** • Basics, Criteria for Make or Buy • Approaches for Make or Buy Decision: Simple Cost Analysis, Economic Analysis, Break-even Analysis **Value Engineering** • Basics, Functions, Aim, • When to Apply Value Analysis, Value Analysis vs. Value Engineering • Value Engineering Procedure, Advantages and Application Areas **Mathematical Models for Value Engineering**	02 02 01

Text Books
1. Gerald J. Thuesen, W. J. Fabrycky, "Engineering Economy", 8th Edition, Prentice Hall International Series in Industrial and Systems Engineering. 2. R. Paneerselvam, "Engineering Economics", PHI Learning Pvt. Ltd. New Delhi, 2012. 3. Leland Blank, Anthony Tarquin, "Basics of Engineering Economy, McGraw Hill Higher Education Publications, 2008.
Reference Books
1. Chan S. Park, "Contemporary Engineering Economics", 5th Edition, Pearson Publication. 2. Donald G. Newnan, Jerome P. Lavelle, Ted G. Eschenbach, "Engineering Economic Analysis", 12th Edition, Oxford University Press. 3. DeGarmo, E. Paul, Sallivan and Canada, "Engineering Economy", Collier MacMilan Ltd., USA.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Embedded System

Course Code	Course Name
OE-BTE703	Embedded System

Course pre-requisites	Computer architecture

Course Objectives

The objectives of this course are

1. Introduction to embedded system design.
2. Study of ARM processor.
3. Study of embedded programming and hardware interfacing.
4. Understand the concept of RTOS.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Define the unique characteristics of embedded systems.
2. Understand the basics of C and C++.
3. Discuss the interfacing challenges of embedded processors and peripherals.
4. Understand the concepts of Real Time Operating System

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to Embedded systems:** embedded system architecture, classifications of embedded systems, challenges and design issues in embedded systems (Design Metrics), Examples of embedded systems, fundamentals of embedded processor and microcontrollers, CISC vs. RISC, fundamentals of Von-neuman/Harvard architectures, types of microcontrollers, selection of Freelancer microcontrollers.	**06**
2	**Software Programming:** C concepts and programming- data types, advanced data types- register, constants, IO operations, operators, operator precedence and associatively, Conditional statements & loops, arrays, single and double dimensional arrays, stings and string operations. **Functions**: Parameter passing-Pass by Value, Pass by Reference; creating modular programs using functions, Recursive functions. **Structures & Unions**: declaration, accessing members of structure, difference between structure and union, User Defined Data Types, Enumerated data type. **Pointers**: pointer basics and concepts, arrays and pointer relation, passing pointers to functions, dynamic memory allocation. Files and file operations. Linked lists, stacks and queues. Pre-processor directives, command line arguments. **Basics of C++:** features of C++, data types, standard I/O, arrays and strings in C++. Classes in C++.	**08**
3	**Introduction ARM Processor:** ARM 7 instruction set, addressing modes, operating modes with ARM core, ARM7 TDMI modes,	**08**

	ADC, Timers, Interrupt structure. Byte ordering (LE, BE), Thumb mode normal mode instructions changes, Pipeline utilization with all register allocations, Floating to fixed point conversion fundamentals. System design with ARM as key processor.DSP features of ARM Core Digital Signal Controllers-DSC differences with conventional micro controllers.	
4	**Hardware Interfacing**: SCI, SPI, Timing generation and measurements. Analog interfacing and data acquisition, 7-Seg LED, LCD, Alphanumeric LCD, Graphic LCD displays, Communications and Networks - RS485 (2 and3 wire) and Modbus Protocol (Intro only) - Ethernet and TCPIP Stack (Features and Usage only) - CAN features and protocol.	**06**
5	**Real-time concepts:** real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS). Real-world issues: blocking, unpredictability, interrupts, caching, Benefits of using RTOS - Concepts of Tasks/Threads/Process - Multitasking - Task Scheduling - Task management - Inter-task communication and Synchronization: - Device Drivers - How to choose an RTOS.	**06**
6	**Fundamentals of Design and Development:** Program Modeling tools Testing and Debugging methodologies.	**04**
7	**Applications of Embedded Systems:** case studies - Industrial Automation - Medical - Robotics - Access Control Systems (Smart Cards, RFIDs, Finger Scan)	**04**

Text Books
1. Rajkamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw Hill. 2. Shibu K V , Introduction to Embedded Systems , Tata Mc Graw Hil. 3. SriramIyer and Pankaj Gupta, Embedded Realtime Systems Programming, Tata McGraw Hil.
Reference Books
1. Jonathan W. Valvano ,Thomson, Embedded Microcomputer Systems. 2. David E. Simon,Pearson Education, An Embedded Software Primer. 3. Dr. K.V.K.Prasad, Dreamtech Press, Embedded real time system.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Internet of Things

Course Code	Course Name
OE-BTE 704	Internet of Things

Course pre-requisites	Embedded System, Computer Programming

Course Objectives

The objectives of this course are

1. Students will understand the concepts of Internet of Things and can able to build IoT applications.
2. Explored to the interconnection and integration of the physical world and the cyber space.
3. They are also able to design & develop IOT Devices.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the concepts of Internet of Things.
2. Analyze basic protocols in wireless sensor network.
3. Design IoT applications in different domain and be able to analyze their performance.
4. Implement basic IoT applications on embedded platform.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to IoT:** Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs.	**06**
2	**IoT & M2M:** Machine to Machine, Difference between IoT and M2M, Software define Network.	**06**
3	**Network & Communication aspects**: Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.	**06**
4	**Resource Management:** Understanding the Elements of IOT (Sensors, Connectivity through network, Application Layer), Overview of Sensors, Gateways, Sensors Available in Market, Selecting the Right Sensor for the Right Use case, Considerations for Mounting Sensors for Right Results.	**06**
5	**Challenges in IoT**: Design challenges, Development challenges, Security challenges, Other challenges.	**06**

6	**Domain specific applications of IoT**: Home automation, Industry applications, Surveillance applications, Other IoT applications.	**06**
7	**Developing IoTs**: Introduction to Python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python.	**06**

Text Books
1. Dieter Uckelmann et.al, "Architecting the Internet of Things", Springer, 2011 2. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach" . 3. Waltenegus Dargie, Christian Poellabauer,"Fundamentals of Wireless Sensor Networks: Theory and Practice"
Reference Books
1. Ian R. Sinclair, "Sensors and Transducer", Newnes, Third Edition. 2. Charalampos Doukas , "Building Internet of Things with the Arduino", Create space, April 2002

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Project Stage I PR-BTE701

Course Code	Course Name
PR-BTE701	Project Stage-1
Course Pre-Requisites	Course pre-requisites: Recommended – all courses till semester VI

Course Objectives

Objectives of the course is:

1. Apply knowledge of principles of engineering for a developing society
2. To be able to do literature survey and be able to put it ethically towards solving an engineering problem
3. To develop an ability to empathize and formulate problem and analyze it

Course Outcomes

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

1. Identify the problem based on industrial, technical and/or socio economic need
2. Review of literature on the problem identified and Formulate objectives to achieve the desired solution.
3. Design methodology in conjunction with relevant codes, industry practices and contemporary research.
4. Apply principles of ethics and standards, skill of presentation and communication techniques.

Course Content

Module No.	*Description*	*Hrs.*
1	Student shall study the topic of project work in terms of data collection, analysis, and inferencing. There would be two or more evaluation throughout the semester by committee of Faculty members	2+6(Self study)

Value Added Courses

1. Soft Computing I (VA-BTE01)

Course Objective: Provide knowledge of MATLAB/ SCILAB.

Course Outcome: Students will be able to develop good applications using MATLAB/ SCILAB

Course content: Basic Introduction and Overview, Variables and Data types, Operation,. Control Structure, Function, Introduction to different tool boxes available, introduction to MATLAB simulink

2. Introduction to Python (VA-BTE02)

Course Objective: Provide knowledge of Python

Course Outcome: Students will be able to develop good applications using Python

Course content: Basic Introduction and Overview, Variables and Data types., Operations in Python, Control Structure, List, Tuples and Dictionary, Function, Introduction to turtle and some introduction to modules, Exception handling, Object oriented in python, Numpy, Matplotlib.

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. VIII

B.Tech. (ELECTRICAL) ENGINEERING

Academic Year: 2024-25

List of Courses

Electronic Design Laboratory

Course Code	Course Name
PC-BTE801	Electronic Design Laboratory

Course pre-requisites	Electronic circuit, Analog Electronics,

Course Objectives

The objectives of this course are

1. To introduce the fundamental principles of electronics system design.
2. To highlight the circuit design issues in the context of electronic system design.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the practical issues related to practical implementation of applications using electronic circuits.
2. Choose appropriate components, software and hardware platforms.
3. Design a Printed Circuit Board, get it made and populate/solder it with components.
4. Work as a team with other students to implement an application.

Course Content

Module No.	*Details*	*Hrs.*
1	Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits;	4+4
2	Introduction to electronic instrumentation and PC based data acquisition;	4+4
3	Electronic system design, Analog system design, Interfacing of analog and digital systems	4+4
4	Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs	4+4
5	PCB design and layout;.	4+4
6	System assembly considerations	4+4
7	Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application	4+4

Term Work

Term work shall comprise of

1. Assignments on above topics.
2. Lab assignments consist of design problems based on electronics/electrical system design.
3. Mini Project*

*Mini Project: There will be a course mini project where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Four to Five students. The group has to present the project and submit the project report

Text Books
1. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 1997. 2. H.W.Ott, "Noise Reduction Techniques in Electronic Systems", Wiley, 1989. 3. W.C. Bosshart, "Printed Circuit Boards: Design and Technology", Tata McGraw Hill,1983
Reference Books
1. A. S. Sedra and K. C. Smith, "Microelectronic circuits", Oxford University Press, 2007. 2. G.L. Ginsberg, "Printed Circuit Design", McGraw Hill, 1991.

Sr. No.	Examination	Module
1	T-I	
2	T-II	
3	End Sem	1 to 7

Power System Dynamics and Control

Course Code	Course Name
PE-BTE801	Power System Dynamics and Control

Course pre-requisites	Power System I and II

Course Objectives
The objectives of this course are 1. To study the stability considerations in power system. 2. To understand the different stability of power system and multi-machine stability concept 3. To study of voltage stability, PV, QV and PQ curves 4. To study of improving the stability of power system
Course Outcomes
Upon successful completion of the course, students should be able to 1. Describe and appreciate the stability concept in the power network. 2. Implement and relate the effects of various electrical parameter on stabilit

Course Content

Module No.	*Details*	*Hrs.*
1	Power system stability considerations – definitions-classification of stability-rotor angle and voltage stability-synchronous machine representation –classical model load modeling concepts modeling of excitation systems-modeling of prime movers	**06**
2	Synchronous machine: Higher order model representation Physical Characteristics. Rotor position dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit T Synchronous Machine-effect of field circuit dynamics-effect of excitation system-small signal stability of Multi Machine System.	**06**
3	Small signal stability – state space representation – Eigen values-modal matrices small signal stability of single machine infinite bus system	**06**
4	Transient stability-swing equation-equal area criterion-solution of swing equation-Numerical m method-critical clearing time and angle-effect of excitation system and governors	**06**
5	Multi machine stability –extended equal area criterion-transient energy function approach	**06**
6	Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – PQ curve – analysis with static	**06**

	loads – load ability limit – sensitivity analysis-continuation power flow analysis - instability mechanisms examples.	
7	Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving -high speed excitation systems- small signal stability enhancement power system stabilizers – voltage stability enhancement – reactive power control.	**06**
Term Work		
Term work shall comprise of • Tutorials • MCQ examination		

Text Books
1. Kundur, P., "Power System Stability and Control", McGraw-Hill International Editions. 2. Anderson, P.M. and Fouad, A.A., "Power System Control and Stability", John Wiley.
Reference Books
1. Van Cutsem, T. and Vournas, C., "Voltage Stability of Electric Power Systems", Springer 2. P.Sauer & M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Smart Grid

Course Code	Course Name
PE-BTE802	Smart Grid

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Discuss smart grid characteristics, opportunities and barriers 2. Introduction to smart meters, smart substations 3. Discuss micro grid, distributed energy resources, power quality management in smart grid.
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understand importance of smart grid 2. Understand various components used in smart grid 3. Understand the concepts of micro grid, distributed energy resources, power quality management in smart grid. 4. Understand communication technology and security for smart grid

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Smart Grid Evolution of Electric Grid, concept of Smart Grid, definitions, need of Smart Grid, functions of Smart Grid, opportunities and barriers of Smart Grid, difference between conventional and Smart Grid, concept of resilient and self healing Grid, present development and international policies in Smart Grid, Case studies of Smart Grid, CDM opportunities in Smart Grid.	**06**
2	Smart Grid Technologies Part I Introduction to Smart Meters, real time prizing, Smart appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicle (PHEV), Vehicle to Grid, Smart sensors, Home and building automation, Phase shifting transformers.	**06**
3	Smart Grid Technologies Part II Smart substations, substation automation, feeder automation, Geographic Information Systems (GIS), Intelligent Electronic Devices (IED) & their application in monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase measurement unit (PMU).	**06**

4	Micro grids and Distributed Energy Resources Concepts of micro grid, need and applications of micro grid, formation of micro grid, issues of interconnection, protection and control of micro grid, Plastic and organic solar cells, thin film solar cells, variable speed wind generators, fuel cells, micro turbines, captive power plants, integration of renewable energy sources.	**06**
5	Power Quality Management in Smart Grid Power quality & EMC in Smart Grid, power quality issues of grid connected renewable energy sources, power quality conditioners for Smart Grid, Web based Power Quality monitoring, Power quality Audit.	**06**
6	Information & Communication Technology for Smart Grid Advanced Metering Infrastructure (AMI), Home Area Network (HAN), 6. Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, Zigbee, GPS, Wi-Fi, Wi-Max based communication, Wireless mesh network.	**06**
7	Security for Smart Grid Basics of CLOUD computing and cyber security for Smart Grid, Broadband over Power Line (BPL), IP based protocols.	**06**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books

Reference Books

1. Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley.
2. Clark C. Gellings, The Smart Grid – Enabling Energy Efficiency and Demand Response CRC press.
3. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid – Technology and Applications, Wiley.
4. Jean Claude Sabonnadière, NouredineHadjsaid, Smart Grids, Wiley Blackwell.
5. Peter S. Fox, Penner, Smart Power – Climate Changes, the Smart Grid and the Future of Electric Utilities, Island Press, 1st Edition 8th June 2010.
6. Stuart Borlase, Smart Grids (Power Engineering) CRC Press.
7. S.Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, Institution of Engineering and Technology, 30th June 2009.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

HVDC Transmission System

Course Code	Course Name
PE-BTE803	HVDC Transmission System

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Understand the advantages of dc transmission over ac transmission.
2. Understand the operation of Line Commutated Converters and Voltage Source Converters.
3. Understand the control strategies used in HVdc transmission system.
4. Understand the improvement of power system stability using an HVdc system

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the advantages of dc transmission over ac transmission.
2. Understand the operation of Line Commutated Converters and Voltage Source Converters.
3. Understand the control strategies used in HVDC transmission system.
4. Understand the improvement of power system stability using an HVDC system.

Course Content

Module No.	*Details*	*Hrs.*
1	Transmission Technology Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVDC Systems. Components of a HVdc system. Line Commutated Converter and Voltage Source Converter based systems.	**05**
2	Analysis of Line Commutated and Voltage Source Converters Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter.	**10**

	Equations in the rotating frame. Real and Reactive power control using a VSC.	
3	Control of HVdc Converters: Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls– Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation	**10**
4	Components of HVdc systems: Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes	**08**
5	Stability Enhancement using HVdc Control Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems	**05**
6	MTdc Links Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Modern Trends in HVdcTechnology. Introduction to Modular Multi-level Converters.	**04**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books
1. K R Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011. 2. E W Kimbark, “Direct Current Transmission”, Vol.1, Wiley-Interscience, 1971.
Reference Books
1. J Arillaga, “ High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983

Sr. No.	Examination	Module
1	T-I	1, Part of 2
2	T-II	Part of 2, Part of 3
3	End Sem	1 to 6

Power Quality and FACTS

Course Code	Course Name
PE-BTE804	Power Quality and FACTS

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
2. Understand the working principles of FACTS devices and their operating characteristics.
3. Understand the basic concepts of power quality.
4. Understand the working principles of devices to improve power quality.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
2. Understand the working principles of FACTS devices and their operating characteristics.
3. Understand the basic concepts of power quality.
4. Understand the working principles of devices to improve power quality.

Course Content

Module No.	*Details*	*Hrs.*
1	Transmission Lines and Series/Shunt Reactive Power Compensation Basics of AC Transmission. Analysis of uncompensated AC transmission lines. PassiveReactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.	**04**
2	Thyristor-based Flexible AC Transmission Controllers (FACTS) Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.	**06**
3	Voltage Source Converter based (FACTS) controllers Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM andSpace Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller.	**08**

	Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.	
4	Application of FACTS Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single- machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM	**06**
5	Power Quality Problems in Distribution Systems Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc- offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.	**04**
6	DSTATCOM Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM	**08**
7	Dynamic Voltage Restorer and Unified Power Quality Conditioner Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.	**06**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books
1. J. Arrillaga, M. R. Watson, S. Chan, Power System Quality Assessment, John Wiley and Sons.
Reference Books
1. M. H. J. Bollen, Understanding Power Quality Problems, Voltage Sag and Interruptions, New York IEEE press, 2000 Series on Power Engineering. 2. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, Electrical Power System Quality, McGraw Hill Publication: 3. EnriquesAcha, Manuel Madrigal, Power System Harmonics – Computer Modeling and Analysis, John Wiley and Sons Ltd. 4. Ewald F. Fuchs, Mohammad A. S. Masoum, Power Quality in Power Systems and Electrical Machines. 5. G. J. Heydt, Electric Power Quality, Stars in Circule publications. 6. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Advanced Electric Drives

Course Code	Course Name
PE-BTE805	Advanced Electric Drives

Course pre-requisites	Electric Drives

Course Objectives

The objectives of this course are

1. Discuss the operation of power electronic converters and their control strategies.
2. Introduce vector control strategies for ac motor drives
3. Discuss the implementation of the control strategies using digital signal processors

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the operation of power electronic converters and their control strategies.
2. Understand the vector control strategies for ac motor drives
3. Understand the implementation of the control strategies using digital signal processors.

Course Content

Module No.	*Details*	*Hrs.*
1	**Power Converters for AC drives** PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter	**05**
2	**Power Converters for DC drives** Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.	**05**
3	**Induction motor drives** Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).	**08**
4	**Synchronous motor drives** Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.	**06**
5	**Permanent magnet motor drives** Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM	**06**
6	**Switched reluctance motor drives** Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque	**06**

	control of SRM	
7	**DSP based motion control** Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.	**06**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books
1. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.
Reference Books
1. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, "Analysis of Electric Machineryand Drive Systems", John Wiley & Sons, 2013. 2. H. A. Taliyat and S. G. Campbell, "DSP based Electromechanical Motion Control", CRC press, 2003. 3. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC motor Drives",CRC Press, 2009

Sr. No.	Examination	Module
1	T-I	1, 2, Part of 3
2	T-II	Part of 3, 4
3	End Sem	1 to 7

Industrial Automation

Course Code	Course Name
PE-BTE806	Industrial Automation

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Understand architecture of Industrial Automation system.
2. Overview of industrial control system.
3. Overview of elements of automation system.
4. Understand performance objectives of process automation.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand Architecture of Industrial Automation Systems.
2. Understand the process of tuning and draw P & I diagrams.
3. Understand elements of industrial automation.
4. Get knowledge of design methodology for industrial automation systems

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction Industrial Automation and Control and Architecture of Industrial Automation Systems	**05**
2	Industrial Control System: P, I, D & Tuning with reference to Process Control & Drives Control	**05**
3	Process representation: P & I Diagrams and Interpretation, block diagrams	**08**
4	Design methodology User Requirement Specifications (URS) System (Or Software) Requirement Specifications (SRS) Factory & Site Acceptance Tests (FAT & SAT) Quality Assurance System	**06**
5	Elements Industrial Automation (a) Five tier concept (Sensors to Boardroom) Field Devices (Instruments, IEDs, Lab Equipment etc, Smart & Conventional) Controllers (PLC, DCS, RTU, DDCs) SCADA/HMI & Database Elements Industrial Automation (b) Higher level applications (MIS/MES/Optimization / ERP etc) IT Infrastructure (Servers, Work Stations, Engineering Stations, Gateways, FEP, Communication Networks etc…) Protocols: 7 layer model, TCP/IP Ethernet, Modbus TCP/IP & RTU, - Profibus, IEC61850, BACNet , OPC etc	**06**
6	Performance objectives: Response times (At various levels)	**06**

	Availability Calculation for the System (MTBF & MTTR) Resolution, Linearity, Accuracy	
7	Case Study(Any one) –Electric Drives : Introduction, Energy Saving with Adjustable Speed Drives - Introduction to Production Control Systems - Introduction to CNC Machines	**06**

Term Work

Term work shall comprise of

1. Tutorials
2. PLC programs/ mini project
3. MCQ examination

*Mini project: There will be a course project where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Two to Four students and will consist of design of any one Automation application

Text Books

1. Industrial Instrumentation, Control and Automation, S. Mukhopadhyay, S. Sen and A. K. Deb, Jaico Publishing House, 2013
2. Programmable controllers: Principle and Applications, Webb J.W, PHI New Delhi
3. Industrial Electronics, Thomos E. Kissell, PHI.

Reference Books

1. Chemical Process Control, An Introduction to Theory and Practice, George Stephanopoulos, Prentice Hall India, 2012.
2. Process Control Instrumentation, Curtis . D. Jhonson, Pearson (8th edition)
3. Electric Motor Drives, Modelling, Analysis and Control, R. Krishnan, Prentice Hall India, 2002
4. Hydraulic Control Systems, Herbert E. Merritt, Wiley, 1991
5. PID Controllers: Theory, Design, and Tuning, Karl Astrom and Tore Hagglund
6. Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies.
7. Industrial Electronics and Control, S K Bhattacharya, S Chatterjee, Ttti Chandigarh.

Sr. No.	Examination	Module
1	T-I	1,2, Part of 3
2	T-II	Part of 3, 4
3	End Sem	1 to 7

Industrial Electrical Systems

Course Code	Course Name
PE-BTE807	Industrial Electrical Systems

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
2. Understand various components of industrial electrical systems.
3. Analyze and select the proper size of various electrical system components.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
2. Understand various components of industrial electrical systems.
3. Analyze and select the proper size of various electrical system components.

Course Content

Module No.	*Details*	*Hrs.*
1	Electrical System Components LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices	**08**
2	Residential and Commercial Electrical Systems Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components	**08**
3	Illumination Systems Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial	**06**

	premises, flood lighting.	
4	Industrial Electrical Systems I HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.	**08**
5	Industrial Electrical Systems II (6 Hours) DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.	**06**
6	Industrial Electrical System Automation Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.	**06**
Term Work		
Term work shall comprise of 2. Tutorials 3. MCQ examination		

Text Books
1. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008. 2. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
Reference Books
3. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997. 4. Web site for IS Standards. 5. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008.

Sr. No.	Examination	Module
1	T-I	1, Part of 2
2	T-II	Part of 2, 3, Part of 4
3	End Sem	1 to 6

Advanced techniques in Power System Protection

Course Code	Course Name
OE-BTE808	Advanced techniques in Power System Protection

Course pre-requisites	Switchgear and Protection

Course Objectives

The objectives of this course are

1. Understand the art and science of numerical relay technology.
2. Demonstrate the hardware description of relaying system.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Apply the modern protection practices.
2. Appreciate new trends in relay technologies

Course Content

Module No.	*Details*	*Hrs.*
1	**Review of Relaying Practices:** Evolution of digital relays from electromechanical relays, Review of protection philosophies for transmission lines, generators and transformers. Modeling of Current and voltage transformers	5
2	**Mathematical background to protection algorithms:** Finite difference Techniques, Interpolation formulae: Forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier series and Fourier transform	8
3	**Numerical Relay :** architecture, sampling theorem, anti-aliasing filter, Fourier Algorithm, Full cycle window algorithm for phasor estimation	5
4	**Transmission Line Protection:** Distance relay scheme for three phase line, Different relay algorithms for distance protection, Out of step blocking and tripping schemes.	8
5	**Digital differential Protection**: protection of generator, transformer, bus bar protection, Travelling wave based protection schemes.	8
6	**Adaptive Relaying:** Need for adaptive relaying, Adaptive relaying for transmission lines, transformer, Auto-reclosing.	4
7	**Wide Area Measurement Applications:** WAMS architecture, WAMS based out of step relaying, supervision of back up zones, Intelligent load shedding, Intelligent islanding.	4

Term Work

Term work shall comprise of

1. Tutorials
2. MCQ examination

Text Books
1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009 **2.** A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999
Reference Books
1. Gerhard Ziegler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006 **2.** S.R. Bhide "Digital Power System Protection" PHI

Sr. No.	Examination	Module
1	T-I	
2	T-II	
3	End Sem	1 to 7

Non linear Control System

Course Code	Course Name
PE-BTE809	Non linear Control System

Course pre-requisites	Control System

Course Objectives

The objectives of this course are
1. To introduce the nature of nonlinearities found in systems and control
2. To learn standard methods of analysis and design in nonlinear system

Course Outcomes

Upon successful completion of the course, students should be able to
1. Understand and apply concepts of linear algebra for system analysis.
2. Understand mathematical models of various nonlinear systems.
3. Analyze performance of linear and nonlinear system and design controller

Course Content

Module No.	*Details*	*Hrs.*
1	**Non-linear systems:** Introduction, behavior of non-linear system, common physical non linearity- saturation, friction, backlash, dead zone, relay, multi variable non- linearity.	04
2	**Phase Plane Analysis:** Concept of phase plane, constructing phase portrait, Phase plane analysis of linear systems, Phase plane analysis of nonlinear systems, Existence of limit cycles.	07
3	**Fundamentals of Lyapunov theory:** equilibrium points, concept of stability, linearization of nonlinear systems, Local stability, Lyapunov Equation, Lyapunov's direct method, Stability and instability theorems.	08
4	System analysis based on Lyapunov's direct method and Control Design based on Lyapunov's direct method.	06
5	**Describing Functions:** Stability analysis and limit cycles, Linear compensation methods, General describing functions of common nonlinearities, Relative stability.	05
6	**Feedback linearization:** feedback linearization and canonical form, Input-state linearization, Input- output linearization.	05
7	**Control design for nonlinear system:** Control design using linearized model, Lyapunov method of control design, control design using feedback linearization and back stepping.	07

Term Work

Term work shall comprise of
1. Tutorials
2. MCQ examination

Text Books

1. Slotine, J. E. & Weiping Li, Applied Nonlinear Control, Prentice-Hall, [1991]
2. Khalil, Hasan K., Nonlinear Systems, Macmillan Publishing, [1992]

Reference Books

1. Chi-Tsong Chen, "Linear Systems Theory and Design", Oxford University Press New York, 1999.
2. T. Kailath, "Linear Systems", Prentice-Hall, New Jersey, 1980, Science and

Business Media 2008.
3. Gilbert Strang, " Linear Algebra and its Application", Fourth Edition CENGAGE Learning
4. Ogata, K., Modern Control Engineering, Prentice-Hall, [2002]
5. Gopal, M., Modern Control System Theory, John Wiley Eastern Ltd. New Delhi, [1984]
6. Friedland, B., Control System Design, McGraw-Hill, [1986]
7. Ogata, K., State Space Analysis of Control Systems, Prentice-Hall, [1967]
8. Kuo, B. C., Automatic Control Systems, Prentice-Hall, [1987]

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Robotics

Course Code	Course Name
OE-BTE801	Robotics

Course pre-requisites	

Course Objectives

The objectives of this course are

1. This course familiarizes students with the concepts and techniques in robot manipulator control.
2. Its main objective is to make students familiar with the Kinematics and Dynamics involved.in robotic manipulator used in automation industry.
3. To study and appreciate the need of control theory to control such a complex nonlinear.

Course Outcomes

Upon successful completion of the course, students should be able TO

1. Appreciate the importance of robotic arm and its applications in automation industry.
2. Appreciate the importance of control system theory to control such a complex nonlinear robotic arm.
3. Describe the kinematic and dynamic model of robotic arm.
4. Appreciate the importance of path, task and trajectory planning

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Robotics Automation and Robots, Classification, Application, Specification, Notations.	**06**
2	Direct Kinematics Dot and Cross Products, Co-ordinate frames, Rotations, Homogeneous Co-ordinates, Link Coordinates, Arm Equation (Three axis, Four axis and Five axis robots).	**06**
3	Inverse Kinematics General properties of solutions, Tool configuration, Inverse Kinematics of Three axis, Four axis and Five axis robots.	**06**
4	Workspace Analysis Workspace analysis of four axis and Five axis robots, Work envelope, Workspace fixtures	**06**
5	Trajectory Planning Trajectory Planning, Pick and Place operations, Continuous path motion, Interpolated motion, Straight-Line motion.	**06**
6	Task Planning Task level programming, Uncertainty, Configuration space, Gross motion Planning, Grasp planning, Fine-motion Planning,	**06**

	Simulation of Planer motion, Source and goal scenes, Task planner simulation	
7	Robot Arm Dynamics Lagrange-Euler Formulation, Newton-Euler Formulation, Computational Algorithm, A two Link Manipulator Example, control Techniques applied to Robotic Arm.	**06**

Text Books
1. Robert Shilling, Fundamentals of Robotics-Analysis and Control, Prentice Hall of India. 2. Fu, Gonzales and Lee, Robotics, McGraw Hill.
Reference Books
1. J.J. Craig, Introduction to Robotics, Pearson Education. 2. Curtis D. Johnson, Process Control Instrumentation Technology, PHI publication.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Power Plant Engineering

Course Code	Course Name
OE-BTE802	Power Plant Engineering

Course pre-requisites	

Course Objectives
The objectives of this course is To provide an overview of power plants and the associated energy conversion issues
Course Outcomes
Upon successful completion of the course, students should be able to Understand the principles of operation for different power plants and their economics

Course Content

Module No.	*Details*	*Hrs.*
1	Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates	**06**
2	Subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems	**06**
3	Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) Systems	**06**
4	Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.	**06**
5	Hydroelectric power plants, classification, typical layout geothermal, biogas and fuel cell power systems	**06**
6	Energy, economic issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies	**06**
7	Energy environmental issues including waste disposal options for coal and nuclear plants.	**06**

Text Books
1. Nag P.K., Power Plant Engineering, 3rd ed., Tata McGraw Hill, 2008.
Reference Books
1. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010. 2. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, 2nd ed., McGraw Hill, 1998.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Electrical Engineering Materials

Course Code	Course Name
OE-BTE803	Electrical Engineering Materials

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Introduce electrical and magnetic properties of material 2. Discuss properties of dielectric material and semiconductors
Course Outcomes
Upon successful completion of the course, students should be able 1. Understand properties of magnetic, dielectric and semiconductor material 2. Understand usage of different electrical engineering materials

Course Content

Module No.	*Details*	*Hrs.*
1	Electrical Conduction I : Electronic and Ionic Conduction , Conductivity in Metals , Ohm‟s Law , Relaxation Time , Collision Time , Mean Free Path of an Electron , Electron Scattering	**06**
2	Electrical Conduction II: Resistivity of Metals , Effect of Temperature and Impurity on Conductivity , Joule‟s Law , High Conductivity And Resistivity Materials , Superconductivity and Applications	**06**
3	Polarization of Dielectrics : Polar and Non-Polar Dielectrics , Basic Concept of Polarization , Types of Polarization, Dielectric Constant ,Internal Field in Dielectrics , Ferroelectric ,Spontaneous Polarization, Curie-Weiss Law, Piezoelectric and Pyroelectric , Dielectric Loss , Breakdown in Dielectrics,	**06**
4	Dielectric in Alternating Field : Dielectric Properties of Insulators in Alternating Fields, Complex Dielectric Constant , Electronic Polarization , Ionic Polarization , Frequency Dependence of Electronic Polarization, Dielectric Constant of Non-Polar Solids , Dipolar Relaxation , Loss Tangent	**06**
5	Magnetic Properties of Materials: Atomic Interpretation of Diamagnetic, Paramagnetic, Anti-Ferromagnetic and Ferromagnetic Materials. Ferromagnetic Domain.	**06**
6	Alloy for Core Materials for Rotating Machines , Transformers , Permanent Magnets and Non Magnetic Steels , Nonmetallic Magnetic Materials , Thin Film Magnets , Magnetic Materials for Ferromagnetic Tape And Memory Devices	**06**
7	Semiconductor Material Technology: Method for Material Preparation, Purification and Doping, Introduction to Processes of	**06**

	Manufacturing Semiconductor Devices, Transistors, Integrated Circuits .Monolithic Diodes, Integrated Resistors and Integrated Capacitor.	

Text Books
1. Dekkar, A.J., "Electrical Engineering Materials, Reprint Edition", 2009, Prentice Hall Publications Co.
Reference Books
1. Kasap S.O., "Principle of Electronic Materials and Devices", Second Edition, Tata McGraw- Hill.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Medical Electronics

Course Code	Course Name
OE-BTE804	Medical Electronics

Course pre-requisites	Electronic circuit, Analog Circuit, Digital Electronics, Communication Engineering

Course Objectives

The objectives of this course are

1. Discuss bioelectric potentials generated in human body
2. Understand the basic principle, working and design of various automated diagnostic equipments.
3. To study various medical instrumentation systems, drug delivery systems and health management systems.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand bioelectric potentials generated in human body
2. Use modern methodologies, multi-disciplinary skill set and knowledge while working on real time projects that demand convergence of engineering, science and technology

Course Content

Module No.	*Details*	*Hrs.*
1	**Fundamentals of Medical instrumentation** Generation of Bioelectric Potentials: Basic cell physiology, Physiological systems of body, Sources of biomedical signals. Basic Medical instrumentation system: Performance requirements, intelligent systems	**06**
2	**Biophysical signal capture, processing** Recording electrodes, Electrodes for ECG, EMG, Microelectrodes Physiological Transducers: Classification, Performance characteristics and types of transducers used in medical instrumentation.	**06**
3	**Biomedical Recorders** Electrocardiograph,Vectorcardiograph,Phonocardiograph, Electroencephalograph, Electromayograph	**06**
4	**Monitoring System** Patient monitoring system: Cardiac Monitor, Central Monitors, Measurement of heart rate, temperature, respiratory rate Ambulatory monitoring system: Arrhythmia monitors, ambulatory monitoring instruments Foetal monitoring instrument	**06**
5	**Modern imaging system** Digital radiography, Magnetic Resonance imaging system, Ultasonic Imaging System	**06**
6	**Therapeutic Equipment** Cardiac Pacemakers, Cardiac Defibrillators, Ventilators	**06**
7	**Telemetry, Telemedicine** Single and multi channel telemetry systems, Implantable telemetry	**06**

	system, Essential parametes of telemedicine, telemedicine system, transmission of still and video images, Cyber medicine.	

Text Books
1. Medical Instrumentation, Application and Design by J.G. Webster, TMH.
Reference Books
1. Handbook of Biomedical Engineering by R.S. Khandpur, PHI 2. Encyclopaedia of medical devices and instrumentation - J.G. Webster Vol I, II, III, IV (John Willey)

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Image Processing

Course Code	Course Name
OE=BTE805	Image Processing

Course pre-requisites	Digital Signal Processing

Course Objectives

The objectives of this course are

1. To develop an overview of the field of image processing
2. To learn the fundamental concepts of Digital Image Processing
3. To understand basic image enhancement and segmentation techniques
4. To illustrate Image Transform calculations mathematically and develop fast transform algorithm
5. To learn Image Compression and Decompression Techniques

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand the concept of Digital Image processing.
2. Explain image enhancement and Segmentation technique
3. Understand Digital Image compression and decompression techniques
4. Perform Binary Image Processing

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction: Background, Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System	**04**
2	Digital Image Fundamentals: Elements of Visual Perception, A Simple Image Model, Sampling and Quantization, Some Basic Relationships between Pixels, Imagining Geometry. Image File Formats: BMP, TIFF and JPEG. Color Models (RGB, HSI, YUV)	**06**
3	Image Enhancement: Spatial Domain Methods, Frequency Domain Methods, Some Simple Intensity Transformations, Histogram Processing, Image Subtraction, Image Averaging, Background Smoothing Filters, Sharpening Filters, Low pass Filtering, High pass Filtering, Generation of Spatial Masks from Frequency Domain Specifications. Homomorphic Filtering	**08**
4	Image Segmentation and Representation: (i) Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based Segmentation, Split and Merge Technique, (ii) Image Representation and Description,	**06**

	Chain Code, Polygonal, Representation, Shape Number, Moments	
5	Binary Image Processing: Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling, Thinning and Thickening,	**06**
6	Image Transform: (i) Introduction to the Fourier Transform, The Discrete Fourier Transform, Some Properties of the Two-Dimensional Fourier Transform Fast Fourier Transform(FFT), (ii) Discrete Hadamard Transform(DHT), Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Discrete Wavelet Transform(DWT),	**06**
7	Image Compression: Fundamentals – Coding Redundancy, Interpixel Redundancy, Psycho visual Redundancy, Fidelity Criteria. Image Compression Models – The Source Encoder and Decoder, Lossless Compression Techniques : Run Length Coding, Arithmetic Coding, Huffman Coding, Differential PCM Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization, JPEG, MPEG-1.	**06**

Text Books
1. Rafel C. Gonzalez and Richard E. Woods, „Digital Image Processing“, Pearson Education Asia, Third Edition, 2009,
Reference Books
1. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing” Tata McGraw Hill Education Private Ltd, 2009, 2. Anil K. Jain, “Fundamentals and Digital Image Processing”, Prentice Hall of India Private Ltd, Third Edition

Sr. No.	Examination	Module
1	T-I	1, 2, Part of 3
2	T-II	Part of 3, 4, Part of 5
3	End Sem	1 to 7

Value Added Courses

1. **PLC (VA-BTE03)**

Course Objective:

1. Discuss the purpose, functions, and operations of a PLC
2. Explain basic components of the PLC and how they function

Course Outcome: Students will be able to

1. Generate and print out a ladder logic report using PLC software
2. Create a PLC project using PLC
3. Configure the I/O for a PLC project using PLC

Course content: 1. Introductions to the purpose, functions, and operations of the PLC, Identification of various components of the PLC, 2. Introduction to PLC ladder logic and basic programming concepts, Establishing communications with the PLC, 3. Definitions of conditional inputs and outputs, Electrical continuity versus logical continuity, 4. PLC timer and counter concepts and programming applications, 5. Programming applications using sequencers.

2. Soft Computing II ETAP and WAMS (VA-BTE06)

Course Objective:

1. Introduce ETAP software
2. Discuss the synchro phasor measurement techniques in a Wide Area Control through the basic building blocks of GPS satellite synchronized clocks, the architecture of the Phasor Measurement Units (PMUs), and The communications equipment.

Course Outcome: Students will be able to

1. Use ETAP as an analysis platform for the designing, simulating, operating and automation of generation and distribution of power systems.
2. Understand the synchro phasor measurement techniques in a Wide Area Control

Course content: 1. Build power systems and simulate the power, current and voltage flow, Single Line diagram creation and analysis, run and Analyze AC power circuits, 2. Run load flow analysis on one line diagram, run Short Circuit analysis.

3. Introduction to Synchro Phasor & WAMS Technologies, Synchro Phasor needs and benefits for Operations, 4. Planning and Control Vision for Synchro Phasor & Online Stability Solutions Fundamental building blocks for WAMS and Synchro Phasor Platform Architecture, 5. PMU standard and communication

Project Stage II PR-BTE801

Course Code	Course Name
PR-BTE801	Project Stage-II
Course Pre-Requisites	Course pre-requisites: Recommended – all courses till semester VII

Course Objectives

Objectives of the course is:

1. Apply knowledge of principles of engineering for a developing society
2. To be able to do literature survey and be able to put it ethically towards solving an engineering problem
3. To develop an ability to empathize and formulate problem and analyze it.

Course Outcomes

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

1. Application of basic principles, modern techniques and/or IT tools, experimental/lab data for analysis and solving of the identified problem
2. Derive logical conclusions based on technical/economic study carried out.
3. Communicate the findings through written reports, presentations and/or research publications

Course Content

Module No.	*Description*	*Hrs.*
1	Student shall study the topic of project work in terms of data collection, analysis, and inferencing. There would be two or more evaluation throughout the semester by committee of Faculty members.	2+14(Self study)