Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

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

COURSE CONTENTS

Sem. V

T. Y. B.Tech. (ELECTRICAL) ENGINEERING

Academic Year: 2020-21

List of Courses

Electromagnetic Field and Waves

Course Code	Course Name
PC-BTE501	Electromagnetic Field and Waves

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on concepts of electrostatics, electric potential, energy density and its applications.
3. To impart knowledge on concepts of magneto statics, magnetic flux density, scalar and vector magnetic potential and its applications.
4. Explain time varying electric and magnetic fields and wave theory

Course Outcomes

Upon successful completion of the course, students should be able

1. Define and understand different coordinate systems, Fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.) in different media using the fundamental laws, Electromagnetic Wave concept.
2. Apply different techniques of vector calculus to understand different concepts of electromagnetic field theory.
3. Determine the electromagnetic force exerted on charged particles, current elements, working principle of various electric and electromagnetic energy conversion devices are based on this force.
4. Design electromagnetic energy storage devices like capacitor, inductor which are frequently used in electrical systems.

Course Content

Module No.	*Details*	*Hrs.*
1	**Review of Vector Calculus** Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, Three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus differentiation, Partial differentiation, integration, vector operator del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another	**04**
2	**Static Electric Field** Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density	**10**

3	**Conductors, Dielectrics and Capacitance** Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations	**06**
4	**Static Magnetic Fields** Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar 06and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors	**06**
5	**Magnetic Forces, Materials and Inductance** Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.	**06**
6	**Time Varying Fields and Maxwell's Equations** Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Conditions.	**04**
7	**Electromagnetic Waves** Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem. Smith chart for impedance matching with open, short and match condition	**06**

Text Books

1. W.Hayt, "Engineering electromagnetic", McGraw Hill.
2. E.C.Jordan &K.G. Balmain, "Electromagnetic Waves and Radiating Systems", Prentice Hall of India.

Reference Books

1. Edminister, "Schaum's series in electromagnetic", McGraw Hill publications.
2. N.NarayanRao, "Elements of electromagnetic", PHI publication.
3. S.seely, "Introduction to electromagnetic fields", McGraw Hill.
4. David K. cheng, "Field and electromagnetic", Addison Wesley.
5. Corson and lerrain, "Electromagnetic", CBS publications

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

Control System

Course Code	Course Name
PC-BTE502	Control System

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Introduction to control problem 2. Discuss time response, frequency response and state variable analysis 3. Introduction to controllers and compensators 4. Introduction to optimum and nonlinear control
Course Outcomes
Upon successful completion of the course, students should be able 1. Understand the modeling of linear-time-invariant systems using transfer function and state-space representations. 2. Understand the concept of stability and its assessment for linear-time invariant systems. 3. Compare different controllers/compensators 4. Understand non linear systems

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to control problem Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.	**04**
2	Time Response Analysis Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time- response.	**06**
3	Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.	**04**
4	Frequency-response analysis Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.	**06**
5	Introduction to Controllers and Compensators Stability, steady-state accuracy, transient accuracy, disturbance	**10**

	rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Analog and Digital implementation of controller	
6	State variable Analysis Concepts of state variables. State space model. Diagonalization of State	**06**
7	Introduction to Optimal Control and Nonlinear Control Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.	**06**

Text Books
1. Norman Nise, "Control Systems Engineering". 2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt.Ltd
Reference Books
1. I.G. Nagrath & M. Gopal, "Control Systems Engineering", Wiley Eastern Ltd. 2. J.J. D'Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker. 3. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

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

Electrical Machines II

Course Code	Course Name
PC-BTE503	Electrical Machines II

Course pre-requisites	Electrical Machines I

Course Objectives

The objectives of this course are

1. Discuss the principle and operation of generating machine both 1-phase and 3-phase
2. Demonstrate the behavior of generating and motoring machine for different operating conditions.
3. Demonstrate the principle of fractional kilowatt machine
4. Discuss the special types of machines and applications (motors and generators)

Course Outcomes

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

1. Illustrate the fundamental concept of electrical machine in electrical power generation
2. Analyze synchronous machine performance using trigonometry, complex algebra, and phasors to find correct solutions.
3. Apply the knowledge of basic machines to understand the operation of single phase induction machines and special machines

Course Content

Module No.	*Details*	*Hrs.*
1	Three Phase Induction Machine: (i) Construction and principle of operation of squirrel cage & slipring Induction motor (i) Equivalent circuit, phasor diagram, no load and blocked rotor test, circle diagram (ii) Steady state analysis: Torque -speed characteristics, maximum torque, starting torque. Starting methods	08
2	Synchronous Machines: Construction, emf induced, winding factors, Armature reaction, Phasor diagrams of cylindrical pole synchronous generator at different power factor, Methods of voltage regulation of alternator	08
3	(i) Principle of operation of Synchronous Motor, starting methods. Power flow and maximum power of synchronous machines, (ii) Excitation & power circles, V & O curves, power angle characteristics, synchronizing power and torque, hunting, synchronous condenser	06
4	Operation on infinite bus for a change in excitation for motors and generators, Parallel operation of alternators, Load sharing	04

5	Salient pole machine: Blondel's two reaction theory, Measurement of Xd& Xq, Power flow equation.	06
6	Fractional kW machines: Construction, principle of operation. And applications of Single phase induction motor, capacitor start, capacitor run motor, Shaded pole motor.	04
7	Special purpose Machines: Construction, principle of operation and applications of Stepper motor and their types, Permanent Magnet Synchronous Motor, Brushless DC motor.	06

Text Books

1. Sen P. C., "Principles of Electric Machines & Power Electronics".
2. Bimbhra P.S, "Electrical Machinery", Khanna Publisher, VII Edition.

Reference Books

1. Nagrath and Kothari, "Electrical Machines", TMH Publicatio.
2. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publisher. Gross Charles A., "Electrical Machines", CRC Press
3. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.

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

Power System I

Course Code	Course Name
PC-BTE504	Power System I

Course pre-requisites	Electrical Network

Course Objectives

Objectives of this course are

1. Understand the basic structure, components, growth, and load curves of an electrical power system.
2. Understand the parameters, performance and characteristics of power system components.
3. Understand the behaviour of the power system under symmetrical and unsymmetrical fault condition using symmetrical components.
4. To study Neutral grounding, Earthing and safety techniques in power system.

Course Outcomes

Upon successful completion of the course, students should be able

1. Evaluate and compare the load curves of power systems.
2. Estimate the parameters of transmission line, understand its operation, role and select the model for various studies.
3. Be able to model and analyse different power system components like generators, transformers etc.
4. Evaluate fault current under symmetrical and unsymmetrical fault conditions in power system.
5. Evaluate performance of mechanical design of transmission lines and select appropriate configuration for specific voltage level.
6. Understand the safety measures of power system.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction and basic structure of Power systems** Basic structure of power system, overview of conventional and non-conventional power generation. Transmission and Distribution Systems: Single Line diagram, transmission and distribution voltage levels and topologies (meshed and radial systems). Power system scenario in India, concept of regional and National GRID. Synchronous Grids and Asynchronous (DC) interconnections. Review of AC systems: power in single phase AC circuits, complex power flow, power factor correction, balanced three-phase circuits, balanced three phase power, per phase analysis. Economics of Power System: Load curves, connected load, maximum demand, demand factor, Average load, load factor, diversity factor, Tariff.	5
2	**Overhead Transmission Lines and Cables**: Electrical and Magnetic Fields around conductors, Resistance and shunt conductance, skin effect, proximity Effect. Inductance and capacitance calculations for different configurations	

	of single phase and three phase line, phenomena of Corona. Types of underground cables (including AC and DC), cable laying methods, cable derating factors.	7
3	**Models and Performance of Transmission Line:** short, medium and long line models, voltage and current waves, surge impedance loading (SIL), lossless line, voltage, current profiles under no load, Ferranti Effect, shunt compensation. Travelling wave equations, reflection wave, refraction wave, typical cases of line termination. Bewley Lattice Diagram.	6
4	**Modelling of power system components:** power transformer: Three-phase connections and star delta phase-shifts. Single phase equivalent of three-phase transformers. Three-winding transformers, autotransformers, Synchronous Machine: equivalent circuit, operation when connected to infinite bus, power angle characteristics. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub- transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System	7
5	**Symmetrical and unsymmetrical fault analysis** Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Open conductor faults. Neutral Grounding.	11
6	**Mechanical design of Transmission systems**: Conductor configuration spacing and clearance, span lengths, sag & tension, Types of insulator, Voltage distribution over insulator string, methods to improve string efficiency.	3
7	**Earthing & Safety Techniques:** Soil resistivity, earth resistance, Tolerable limit of body currents- tolerable step and touch voltage-actual step and touch voltage, Design of earthing grid- concrete encased electrodes- and tower footing – Resistance, Measurement of earth resistance, soil resistivity-Impulse behavior of Earthing.	3

Text Books

1. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
2. Wadhawa C. L., "Electrical Power Systems", New Age International.
3. Stevenson W.D., "Elements of Power System Analysis", McGRAW-HILL International
4. Saadat Hadi, "Power System Analysis, "TMH Publication.
5. B. R. Gupta, "Power system Analysis and Design", S. Chand Publications

Reference Books

1. Prabha Kundur, "Power System Stability and Control'', TMH Publication.
2. IEEE 80 – IEEE guide for safety in substation grounding
3. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication
4. Dr. K. Rajamani, "Application Guide for Power Engineers Part 1 Earthing & Grounding of Electrical systems", Notion Press.
5. J. Lewis Blackburn, "Symmetrical Components for Power System Engineering", CRC Press.

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

Power Electronics

Course Code	Course Name
PC-BTE505	Power Electronics

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Explain controlled converters 2. Analyze current and voltage inverters and demonstrate the operation and control of inverter circuits 3. Discuss DC to DC converters 4. Discuss need and application of AC filter
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understand the behavior of semiconductor devices operated as power switches. 2. Analyze and design rectifier circuit. 3. Analyze DC/DC converter circuits. 4. Analyze DC/AC inverter circuit

Course Content

Module No.	***Details***	***Hrs.***
1	Silicon Controlled Rectifiers: Principle of operation of SCR, Static & Dynamic characteristics, Gate characteristics, pulse firing	**03**
2	Other Switching Devices: Principle of operation, characteristics, rating and applications of Triac, MOSFET, IGBT and power diodes, IGCT, GTO, SGTO. Comparison of devices on the basis of turn on, turn off time.	**06**
3	Rectifiers: Introduction to Half wave uncontrolled and controlled rectifiers with differnt load Full wave controlled rectifiers with different load (single phase and three phase) Power factor improvements in rectifiers. Effect of load and source inductances	**08**
4	AC Filters: AC filter for grid connected converter, AC inductor design and need of LCL filter, LCL filter design	**04**
5	Inverters: (i) Principle of operation, Performance parameters, Single phase bridge Inverters with RL, R-L-E and pure L load. 3 phase bridge Inverters: 180 degree conduction mode. (ii) Voltage control of single phase and three phase inverters using PWM techniques, Connection of three phase inverter to grid, concept of active and reactive power flow between inverter and grid	**08**

	(iii) Current source inverters (iv) Space vector modulation	
6	Choppers: Switching mode regulators – Buck, Boost, Buck-Boost and Cuk regulators, Bi-directional Chopper	**06**
7	AC Voltage Controllers: Principle of Phase Control, Single Phase bidirectional control with R-L load, Three phase full wave controllers, AC voltage controllers with PWM control, Applications Thermal management of power electronics devices IGBT, thyristors	**07**

Text Books
1. Mohan, Undeland and Riobbins. Power Electronics Converters, Applications and Design. Wiley student Edition. (2015) 2. Muhammad Rashid. Power Electronics, Circuits, Devices and Applications. Pearson, Third Edition. 3. Daniel Hart. Power Electronics. McGraw Hill, Indian Edition. (2011) 4. Soumitra Kumar Mandal. Power Electronics. McGraw Hill Education (2014) 5. Bimbra P.S. Power Electronics. Khanna Publishers
Reference Books/Standards
1. Mohan, Undeland and Riobbins. Power Electronics Converters, Applications and Design. Wiley student Edition. (2015) 2. IEEE-519-2014 Harmonic control standard in Electric power system

Sr. No.	Examination	Module
1	T-I	**1, 3**
2	T-II	**4,5**
3	End Sem	**01-07**

Control System Laboratory

Course Code	Course Name
PC-BTE506	Control System Laboratory

Course pre-requisites	

Course Objectives

The objectives of this course are

1. Time response, frequency response and state variable analysis
2. Introduction to controllers and compensators
3. Introduction to optimum and nonlinear control
4. Identify the applications of control system

Course Outcomes

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

1. First, second and higher order systems
2. Bode plot, Nyquist plot, solution of state equations, non linear system
3. Compensator controller and observer designs

Course Content

Module No.	*Details*	*Hrs.*
Simulation assignments to study, analyze or design		
1	First, Second and Higher order systems' performance in frequency domain	02
2	Study of second order system with different damping ratio and natural frequency of oscillations	02
3-4	Bode plot, Nyquist plot analysis	04
5-7	Analysis of different compensators	04
7-8	Study of state space model	04
8-10	Analysis of different controllers	04
11	Non linear system analysis	04

Term Work

Term work shall comprise of

1. Practical Examination/ MCQ examination
2. Each student will write a technical report on application or further research based on various concepts of control system theory. The student has to present the same.

Text Books

1. Norman Nise, "Control Systems Engineering".
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt.Ltd

Reference Books

1. I.G. Nagrath & M. Gopal, "Control Systems Engineering", Wiley Eastern Ltd.
2. J.J. D'Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker.
3. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

Electrical Machines II Laboratory

Course Code	Course Name
PC-BTE507	Electrical Machines II Laboratory

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To perform load test on three phase induction motor
2. To observe the effect of rotor resistance and supply voltage on torque speed characteristic of induction motor
3. To study and evaluation of Voltage Regulation for synchronous generator volt
4. To conduct experiment to draw V and inverted V curves for synchronous motor
5. To calculate Xd and Xq of a salient pole synchronous machine

Course Outcomes

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

1. Perform load test on three phase induction motor and understand variation in torque speed characteristics with different parameters
2. Perform experiments on synchronous machines with defined procedures and safety.
3. Understand the voltage regulation in synchronous generator and different methods to find it.
4. Analyze the V curve and inverted V-curve for synchronous motor under various load conditions.
5. Determine Xd and Xq parameters of salient pole synchronous machine.

Course Content

Module No.	*Details*	*Hrs.*
1	To perform load test on 3 Phase Induction Motor.	02
2	To study the effect of rotor resistance on torque speed characteristic of 3 Phase Induction Motor.	02
3	To study the effect of supply voltage on torque speed characteristic of 3 Phase Induction Motor.	02
4	Voltage Regulation ofsynchronous generator by EMF/MMF method	02
5	Voltage Regulation of synchronous generator by ZPF method	02
6	Voltage Regulation of synchronous generator ASA Method	02
7	Voltage regulation of synchronous generator by direct loading	02
8	Slip Test on salient pole synchronous generator	02
9	V-curves and inverted V- Curves F-curves of synchronous motor	02
10	Performance characteristics of single phase induction motor	02

Term Work

Term work shall comprise of

1. Practical Examination/ MCQ examination

Text Books
3. Sen P. C., "Principles of Electric Machines & Power Electronics". 4. Bimbhra P.S, "Electrical Machinery", Khanna Publisher, VII Edition.
Reference Books
1. Nagrath and Kothari, "Electrical Machines", TMH Publicatio. 2. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publisher. 3. Gross Charles A., "Electrical Machines", CRC Press 4. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.

Power Electronics Laboratory

Course Code	Course Name
PC-BTE508	Power Electronics Laboratory

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To simulate various converter circuits.
2. To familiarize the students by introducing MATLAB simulation and help them to Simulate and analyze different Converter

Course Outcomes

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

1. Simulate uncontrolled and controlled rectifiers on software
2. Observe and analyze various converter waveforms for different loads.
3. Apply knowledge of dual converter in DC motor applications.
4. Execute three phase bridge rectifier connections and analyze waveforms
5. Identify difference in ideal and practical power electronics circuits

Course Content

Module No.	*Details*	*Hrs.*
1	Half wave diode converter	02
2	Half wave SCR converter	02
3	Single phase Full wave fully controlled SCR converter with resistive load	02
4	Single phase Full wave fully controlled SCR converter with RL load.	02
5	3 phase full wave fully controlled SCR converter with resistive load	02
6	Separately excited DC motor speed control using Dual Converter	02
7	Single phase Inverter	02
8	Two MATLAB simulations of uncontrolled & controlled converters	02

Term Work

Term work shall comprise of

Practical Examination/ MCQ examination

Reference Books

L. Ashok Kumar, A. Kalaiarasi, Y. Uma Maheswari. Power Electronics with MATLAB, Cambridge University Press. 2018

Electromagnetic Field and Waves Laboratory

Course Code	Course Name
PC-BTE509	Electromagnetic Field and Waves Laboratory

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To understand and concept of vector addition, vector calculus, co-ordinate systems, static and time varying fields and electromagnetic waves more precisely by visualize aid.
2. To familiarize the students by introducing FEMM-4.2 simulation software and help them to Simulate and analyze different Electromagnetic circuit

Course Outcomes

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

1. Understand concepts of vector calculus and underlying theories in electrostatics, magneto statics, and time-varying electromagnetic fields using field plots generated by formulae and Finite Element Method (FEM) based computations.
2. Apply knowledge of electromagnetic fields in real time application.
3. Analysis of effect electromagnetic field in electromagnetic circuits.
4. Build and simulate core electromagnetic circuits and power apparatus using FEMM software.

Course Content

Module No.	*Details*	*Hrs.*
1	Addition & Products of two vectors.	02
2	Coordinate systems (Cartesian, Cylindrical and Spherical).	02
3	Position vector and distance vector.	02
4	Curl, Divergence and gradient of a field.	02
5	Variation of electrostatic fields.	02
6	Curl free static electric field.	02
7	Variation of electrostatic fields over multiple dielectric materials.	02
8	Electric flux density.	02
9	Force on a single current carrying conductor.	02
10	Force between two current carrying conductors.	02
11	Magnetic vector potential.	02
12	Variations of time varying field.	02

Term Work

Term work shall comprise of

Practical Examination/ MCQ examination

Text Books

1. W.Hayt, “Engineering electromagnetic”, McGraw Hill.
2. E.C.Jordan &K.G. Balmain, “Electromagnetic Waves and Radiating Systems”,

Prentice Hall of India.
Reference Books
1. Edminister, “Schaum’s series in electromagnetic”, McGraw Hill publications. 2. N.NarayanRao, “Elements of electromagnetic”, PHI publication. 3. S.seely, “Introduction to electromagnetic fields”, McGraw Hill. 4. David K. cheng, “Field and electromagnetic”, Addison Wesley. 5. Corson and lerrain, “Electromagnetic”, CBS publications

Power System I Laboratory

Course Code	Course Name
PC-BTE510	Power System I Lab

Course pre-requisites	Basic knowledge of programming, familiar with Engineering software such as MATLAB, Scilab

Course Objectives

Objectives of this course are

1. Proficiency in using Engineering software such as MATLAB/ Scilab/ETAP
2. Develop programming skill.
3. Understand the parameters, performance and characteristics of power system components.
4. Understand the behaviour of the power system under symmetrical and unsymmetrical fault condition using symmetrical components.

Course Outcomes

Upon successful completion of the course, students should be able

7. Use MATLAB/ Scilab /ETAP on power system studies.
8. Select appropriate components and model to study power system steady state performance.
9. Analyse the reactive power requirement of lines, voltage profile along the line and VAR Compensation.
10. Evaluate fault current under symmetrical and unsymmetrical fault conditions in power system.
11. Analyse economics of power system in real life such as electricity bill, various factors related to consumers.

List of Experiments

Expt. No.	***Details***	***Hours***
1	Study of complex power flow through a single-phase transmission line with ideal AC voltage sources connected at each end.	2
2	Simulation of typical power system- familiarization with generator, line and load models.	2
3	Transmission Line parameter estimation for different configuration of lines using GMD, GMR.	2
4	Study of performance of line using short, medium and long line models.	2
5	To validate Ferranti effect on an unloaded transmission line.	2
6	Study of concept of SIL loading and simple shunt compensation (capacitive as well as inductive) at receiving end of a transmission line under different loading condition.	2

7	Study of transient behaviour of synchronous machine under three phase short circuit at the terminal.	2
8	Study of three phase transformer star delta configuration.	2
9	Simulation and analysis for a symmetrical three phase fault in a power system.	2
10	Simulation and analysis of unsymmetrical fault - LL, LG and LLG in a power system.	2
11	Study of effect of neutral grounding on earth fault current in a power system.	2
12	Survey / study of electricity bill.	2
13	Study of effect of load factor, diversity factor on total loading in a power system. (Here a basic load flow can be run on ETAP to understand loading.)	2
14	Visit to a power plant or any electrical substation	1/ more days

Term work

Note: The laboratory work will consist of minimum Eight experiments from the following list and/or any other experiment based on the prescribed syllabus of power system I. The Instructor is expected to ask the students to manually verify the results wherever possible, so that students can have practice of solving examples. Also, more examples can be given for practice at home.

Resources required: Minimum 20 users License software MATLAB and/ OR ETAP/ Scilab (open source software)

Text Books

1. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
2. Wadhawa C. L., "Electrical Power Systems", New Age International.
3. Stevenson W.D., "Elements of Power System Analysis", TMH Publication.
4. Saadat Hadi, "Power System Analysis, "TMH Publication.
5. MATLAB / Scilab Manual, ETAP Manual
6. Dr. K. Rajamani & Co Authors, "Monograph of IEEMA articles of Dr. K. Rajamani", ieema journal

Reference Books

1. Prabha Kundur, "Power System Stability and Control'', TMH Publication.
2. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication
3. MATLAB/Scilab online Tutorials
4. ETAP webinars

Digital Signal Processing

Course Code	Course Name
PE-BTE501	Digital Signal Processing

Course pre-requisites	Signals and Systems

Course Objectives

The objectives of this course are

1. Introduce discrete time signals and systems
2. Frequency analysis including fast algorithms
3. Discuss digital filters and different design methods of digital filter,

Course Outcomes

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

1. Represent signals mathematically in continuous and discrete-time, and in the frequency domain.
2. Analyze discrete-time systems using z-transform.
3. Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.
4. Design digital filters for various applications.
5. Apply digital signal processing for the analysis of real-life signals

Course Content

Module No.	*Details*	*Hrs.*
1	Discrete-time signals and systems Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.	**06**
2	Z-transform z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.	**06**
3	Discrete Fourier Transform (10 hours) Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Circulation convolution, comparison between linear and circulation convolution,, Circulation convolution using DFT / IDFT, Response of LTI system (linear convolution or linear filtering) using circulation Convolution, Response of LTI system (linear convolution or linear filtering) using DFT / IDFT	**10**
4	Fast Fourier Transform Algorithms Comparison of computation complexity of direct computation of DFT and FFT., Radix-2 Decimation in Time and Decimation in Frequency algorithms, IDFT using FFT algorithms	**04**

5	FIR Filter Designing Introduction: Linear Phase FIR Filters, Frequency response of different types of linear phase FIR Filters, Locations of definite zeros of different types of FIR Filters. Designing of FIR filters using windowing technique, Gibbs Phenomenon (Hamming, Hanning, Rectangular, Bartlett, Kaiser window functions), Designing of FIR filters using frequency sampling technique, Half Band FIR Filers.	**06**
6	IIR Filter Designing Introduction, Designing of analog IIR filters using Butterworth and Chebyshev approximations, Analog to analog spectral transformations, Designing of IIR digital filters using impulse invariance and bilinear transformation methods, stability properties. Designing of IIR digital filters using matched z-transformation method, backward difference algorithm	**06**
7	Applications of Digital Signal Processing Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using, ARMA Model, Linear Mean-Square Estimation, Wiener Filter.	**04**
Term Work		
Term work shall comprise of 1. Tutorials based on above topics 2. MCQ examination.		

Text Books
1. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson
Reference Books
1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India. 2. H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education. 3. S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3.4
3	End Sem	1 to 7

Computer Architecture

Course Code	Course Name
PE-BTE502	Computer Architecture

Course pre-requisites	Microprocessor and Microcontroller

Course Objectives

The objectives of this course are

1. Introduction to computer, memory and input-output organization
2. Discuss pipelining
3. Explain different architectures

Course Outcomes

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

1. Understand the concepts of microprocessors, their principles and practices.
2. Understand various data types, integer and floating point arithmetic, CPU operation and implementation
3. Understand various architectures and microprocessors.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to computer organization Architecture and function of general computer system, CISC Vs RISC,	**02**
2	Data types, Integer Arithmetic - Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.	**06**
3	Memory organization System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks	**06**
4	Input – output Organization Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface circuits - Parallel and serial port. Features of PCI and PCI Express bus.	**08**
5	16 and 32 microprocessors 80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in 80x86	**08**

6	Pipelining Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.	**06**
7	Different Architectures VLIW Architecture, DSP Architecture, SoC architecture, Processor and programming	**06**

Term Work

Term work shall comprise of

1. Assignments on the above topics which include some numerical calculations.
2. Examination (MCQ) based on topics mentioned in latest GATE syllabus
3. Mini Project*

*Mini Project: :There will be a course project in the form of case study where the students will be able to analyze and integrate the knowledge gained during the course. The case study will be done by teams of Two to Four students.

Text Books

1. W. Stallings, "Computer organization", PHI, 1987.
2. V. Carl, G. Zvonko and S. G. Zaky, "Computer organization", McGraw Hill, 1978.
3. Y. C. Lieu and G. A. Gibson, "Microcomputer Systems: The 8086/8088 Family",Prentice Hall India, 1986

Reference Books

1. J. L. Hennessy and D. A. Patterson, "Computer Architecture A Quantitative Approach", Morgan Kauffman, 2011.
2. P. Barry and P. Crowley, "Modern Embedded Computing", Morgan Kaufmann, 2012. 6. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice Hall, 2004.
3. P. Able, "8086 Assembly Language Programming", Prentice Hall India.
4. B. Brey and C. R. Sarma, "The Intel microprocessors", Pearson Education, 2000.

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

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: 1. Basic Introduction and Overview, 2.Variables and Data types, 3.Operation,. Control Structure, 4.Function, Introduction to different tool boxes available, 5. 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: 1. Basic Introduction and Overview, 2.Variables and Data types., 3.Operations in Python, Control Structure, List, Tuples and Dictionary, 4.Function, Introduction to turtle and some introduction to modules, Exception handling, 5.Object oriented in python, Numpy, Matplotlib.

3. **Finite Element Methods for Electrical Engineering (VA-BTE05)**

   Course objective: Introduce how the finite element method can be used as a numerical tool to solve differential equations.

   Course Objective: Students will be able to solve Electrical engineering problems using finite element methods

   Course content: 1. Introduction to the mathematical description of Electrical engineering problems, 2. Revision of numerical solutions to differential and algebraic equations, Overview of the finite element method - Variational approach, 3. Ritz technique, Galerkin method, Approximation functions for one, two and three-dimensional elements, 4. Application of the FEM to Analyzing electrical circuits 5. Programming FEM in open source

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

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

COURSE CONTENTS

Sem. VI

T. Y. B.Tech. (ELECTRICAL) ENGINEERING

Academic Year: 2020-21

List of Courses

PC-BTE601 Power System II.....

PC-BTE602 Switchgear and Protection .....

PC-BTE.603 Switchgear and Protection Laboratory .....

PC-BTE.604 Electrical Simulation Laboratory.....

Pc-BTE605 Power System II Laboratory

PE-BTE601 Electrical Machine Design I.....

PE-BTE602 Control System Design .....

OE-BTE601 Project Management.....

OE-BTE602 Artificial Intelligence.....

OE-BTE603 Communication Engineering.....

OE-BTE604 VLSI circuits .....

OE-BTE605 Linear Algebra and Matrix Computation

MC-BT003 Environmental Science .....

VA-BTE03/06 Value Added.....

Power System II

Course Code	Course Name
PC-BTE601	Power System II

Course pre-requisites	Course on Power System-I, mathematics III

Course Objectives

Objectives of this course are

1. To identify the mathematical tools for solving complex engineering problems.
2. To understand the formulation of Y_{bus}.
3. To study load flow analysis using different computational methods.
4. To study the power and voltage relation of the transmission line with different receiving end conditions.
5. To study different methods of controlling and monitoring power system parameters.
6. To understand wide area measurement and monitoring of power system.

Course Outcomes

Upon successful completion of the course, students should be able

1. Build the mathematical model of the power system and will be able to reduce the size of the Y_{bus} using appropriate method.
2. To determine the line flows using different computational methods and compare the performance of different methods.
3. Analyse the power system behaviour under steady state and transient conditions.
4. To Suggest and compare suitable methods to control power system parameters.
5. Appreciate the importance of central monitoring and control of the power system to maintain stability in the system.

Course Content

Module No.	*Details*	*Hrs.*
1	**Revision of mathematical concepts:** Graphs - Incidence matrix, Gauss Elimination Kron reduction, Triangular factorization. Numerical Methods to solve set of non-linear equations - Gauss Seidel (GS) method, Newton Raphson (NR) method. Numerical integration using Forward Euler method, Runge-kutta 4th order method.	5
2	**Formation of Y_{bus}:** Branch and node admittances, an equivalent admittance network, Modification of Y_{bus}, network incidence matrix and Y_{bus}, reduction. **Load flow studies:** Power Flow problem, Gauss Seidel (GS) method, Newton Raphson (NR) method, Decoupled method and Fast Decoupled method and DC load flow. Comparison of the methods.	6
3	**Power system Stability:** Classification of stability, Dynamics of synchronous machine, power angle equation, swing equation of a synchronous machine connected to an infinite bus, Power Angle Curve, stability analysis using Equal Angle Criteria, stability analysis using	8

	numerical integration of the swing equation like Forward Euler method, Runge-kutta 4^{th} order method. Methods of improving power system stability.	
4	**Voltage and Reactive power control**: Voltage profile of the transmission line (when receiving end open circuited and line connected to voltage source at both the end). Voltage and power characteristic for (1) radial line with fixed sending end voltage (2) line connected to source at both ends. Power and stability consideration of the line. Control of the voltage: Production and absorption of the reactive power, shunt compensators, static VAR compensators (TCR, FC-TCR,TSC characteristics), Tap changing transformer, STATCOM, synchronous condensers.	8
5	**Active power control on the transmission line**: Power flow control using series capacitor, TCSC, phase shifting transformer, using embedded HVDC link.	5
6	**Control of Frequency and voltage of the generator**: Generator excitation system, Reactive capability curve, Automatic voltage regulator, speed governor system and automatic generation control. Relationship between generator rotors' speed and 'system frequency' during transients. calculation of system frequency. Droop control and power sharing between generators.	7
7	**Power system monitoring and control:** Various operating states of power system and their control. Introduction to PMU and WAMS. **Introduction to Power System Operator in India:** Responsibilities, functions.	3

Text Books

6. Kothari. D.P, Nagrath I.J., "Modern Power System Analysis", TMH publication.
7. Grainger John J., Stevenson William D., "Power system Analysis", MC Graw Hill.
8. Prabha Kundur, "Power System stability and Control", TMH Publication.
9. Hadi Sadat, "Power System Analysis", MC Graw Hill.
10. Phadke, Arun G., Thorp, James S., "Synchronized Phasor Measurements and Their Applications", Springer International Publication,2008.
11. S.S. Sastry, "Introductory methods of numerical analysis",PHI,2006.

Reference Books

6. Chakrabarti .A, Halder.S, "Power System Analysis-Operation and Control", PHI
7. Hingorani N.G., "Understanding of Facts", Wiley Publications.
8. P.Venkatesh , A.Srinivasan , "Electrical Power System ",PHI
9. O. Elgerd, "Electrical Energy System Theory", MC Graw Hill.
10. M. A. Pai, D. Chatterjee, "Computer Techniques in Power System Analysis", McGraw Hill Education

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

Switchgear and Protection

Course Code	Course Name
PC-BTE602	Switchgear and Protection

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Discuss components of a protection system and types of relays 2. Discuss equipment and system protection, digital protection 3. Discuss principles of circuit breakers and different types of circuit breakers
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understand the different components of a protection system. 2. Understand the protection schemes for different power system components. 3. Understand the basic principles of digital protection. 4. Understand principles of circuit breakers.

Course Content

Module No.	*Details*	*Hrs.*
1	**Basics of protection** Protective zones. Attributes of relays, Primary and back up protection, remote and local back up, Desirable qualities. CT and PT **Typical relays:** Electromagnetic type, static type and numerical relay	04
2	**Principle and characteristics of:** Over current Relays - Time setting, plug setting, Different characteristics like IDMT, very Inverse etc., Directional Relay, Distance Relay- Reactance, Impedance, MHO relay, Differential Relay, Earth Fault Protection **Introduction to Analogue and Digital Static Relays:** Comparison of static and electro-mechanical relays, Static Over Current Relays, Static Distance Relays	04
3	**Power Apparatus Protection:** **Protection of Transmission lines & feeders**- over current protection and relay coordination, Distance relay application, Power swings and distance relaying, Pilot protection **Protection of Transformer**-The problems and hazard in transformer, Differential relay for 3 phase transformer winding protection, Magnetizing inrush, Restricted Earth fault protection, Buchholz relay. **Protection of Generator**-The problems and hazard in generator, Differential protection for stator faults, Protection against loss of prime mover and loss of excitation, field suppression, out of step protection. **Motor Protection**- The problems and hazards in Induction	12

	motor, Protection against single phasing, Thermal over load and short circuit protection using Type 2 coordination, Under voltage protection **Synchronous motor protection**. **Bus Protection**- Different bus arrangements with breakers, Ring bus arrangement, One and a half breaker arrangement and High impedance bus differential relay	
4	**Principles of Circuit Braking:** D.C and A.C. circuit breaking, arc voltage and current waveforms in an A.C. circuit., Definition of transient recovery voltage, rate of rise of TRV, expression for TRV for different values of arc resistance, current chopping, capacitance switching, ratings and specifications of circuit breakers, making and breaking capacity	04
5	**Basics of Arc Extinction**: Ionisation of Gases, Deionization, Arc Formation in AC Circuit Breakers, Modes of Arc Extinction, Arc Interruption Theories, Arc Extinction in Oil, Vacuum, Air Blast and SF6 Gas, Arc Time Constant **Air Break Circuit Breaker**: Construction, arc control devices, Lengthening of Arc, Operating Mechanism, Series Connected Over- Load Trip Coil Arrangement **Fundamentals of:** a) Air Blast Circuit Breaker b) SF6 Circuit Breaker c) SF6 Insulated Metal Clad Switchgear – Sub Station d) MOCB i.e. Minimum Oil Circuit Beaker and Bulk Oil Circuit Breaker e) Vacuum Interrupter and Vacuum Circuit Breaker	06
6	**HRC Fuses and their Applications:** Characteristic of a Fuse, Protection of Motor, Discrimination, Equipment Incorporating Fuses, High Voltage Current Limiting Fuses, Expulsion Type High Voltage Fuse, Drop Out Fuse, Test On Fuse. Metal Enclosed Switchgear, Control Gear and Contactor: Medium Voltage Metal Enclosed Switchgear with SF6 CB and VCB	04
7	Modern Protection System, Microprocessor Based Substation Protection Control and Monitoring Application of Switch-Gear & Electrical Safety Short Circuit Testing of Circuit Breakers: Direct and Indirect testing concepts in detail. **Protection against over voltage surges:** Lightening phenomenon, over voltages due to lightning, different types of lighting arresters, Insulation Co-ordination between different devices, BIL.	08
Text Books		
1. Badri Ram, D.N. Vishwakarma. Power system protection and Switchgear. McGraw Hill Education, Second Edition 2. Y.G. Paithankar. Transmission Network Protection.Marcel Dekker, Inc		

3. Bhuvanesh Oza, Nirmal Kumar Nair, Ramesh Mehta and Vijay Makwana. Power system protection and switchgear. MacGraw Hill.
4. B. Ravindarnath, M. Chandar. Power system Protection and switchgear. New age International Limited.

Reference Books

1. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982.
2. Phadke, A.G. and J.S. Thorp, Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988

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

Switchgear and Protection Laboratory

Course Code	Course Name
PC-BTE603	Switchgear and Protection Laboratory

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To demonstrate theoretical knowledge.
2. To conduct experiment based on overcurrent protection scheme.
3. To conduct experiment based on generator protection, earth fault protection

Course Outcomes

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

1. Understand operating characteristics of electromagnetic relays, circuit breaker and other protective devices.
2. Understand various protection scheme used in power system equipments.
3. Analyze performance of electromagnetic, numerical and microprocessor based relay.
4. To develop an ability and skill to design the feasible protection systems needed for each main part of a power system

Course Content

Module No.	*Details*	*Hrs.*
1	IDMT characteristic of non-directional over voltage relay	02
2	Study of Miniature Circuit Breaker HRC fuse, MCCB: components identification and Applications	02
3	Study of Power Contactor	02
4	Air Circuit Breaker: components identification and Applications.	02
5	Simulation of 2O/C+ 1E/F protection scheme.	02
6	Numerical Relay: Study and Application	02
7	Generator protection	02
8	Differential protection using static relay	02
9	Microprocessor based distance protection	02

Term Work

Term work shall comprise of

1. Practical Examination/MCQ examination
2. Visit to any Industrial switchyard/ Receiving station / substation for which students will submit report

Text Books

1. Badri Ram, D.N. Vishwakarma. Power system protection and Switchgear. McGraw Hill Education, Second Edition
2. Y.G. Paithankar. Transmission Network Protection.Marcel Dekker, Inc
3. Bhuvanesh Oza, Nirmal Kumar Nair, Ramesh Mehta and Vijay Makwana. Power system protection and switchgear. MacGraw Hill.
4. B. Ravindarnath, M. Chandar. Power system Protection and switchgear. New age International Limited.

Reference Books
1. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982. 2. Phadke, A.G. and J.S. Thorp, Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988

Electrical Simulation Laboratory

Course Code	Course Name
PC-BTE604	Electrical Simulation Lab

Course pre-requisites	Courses in Electrical Network, Machines I, II, Power Electronics, Power system and basic knowledge of programming, familiar with Engineering software such as MATLAB or Scilab

Course Objectives

Objectives of this course are

1. To demonstrate theoretical knowledge.
2. To conduct simulations for analysis of different concepts in Electrical Engineering

Course Outcomes

Upon successful completion of the course, students should be able

1. Acquire skills of using software for Electrical Engineering studies.
2. Analyze different theories studied in electrical networks, power electronics, control system, power system and electrical machines.

List of Experiments

Expt. No.	*Details*	*Hours*
1	Study of power flow in a Star connected load and Delta connected load parallel to each other and fed from 3 phase AC source through a transmission line.	2
2	Study of vector group of a transformer.	2
3	Concept of balanced and unbalanced loads in a 3-phase system.	2
4	Simulation of Hysteresis loss in a transformer in MATLAB	2
5	Comparison of linear and non-linear inductor in MATLAB	2
6	Supercapacitor charging and discharging behavior in MATLAB	2
7	Study of Analog anti-aliasing filter in MATLAB	2
8	Study of customized synchronous Machine in MATLAB	2
9	Modeling of Frequency dependent transmission line in MATLAB	2
10	Study of Induction motor starting current with DOL starter and Star-Delta starter	2
11	Load flow study in any IEEE standard multimachine system using Load flow analyzer or ETAP.	2
12	Development of overcurrent relay using Simulink	2
13	Development differential protection of transformer using Simulink	2
14	Detection of fault location on a transmission line using voltage, current measurements.	2
15	Study of Capacitor bank switching transient	2
16	Study of inductive load switching transient	2
17	Study of relay co-ordination using ETAP	2
18	Study of Type 2 Co-ordination for an Induction motor using ETAP	2
19	Study of circuit breaker short circuit ratings adequacy using ETAP Estimation of phasors using DFT Algorithm	2
20	Study vulnerability of distance relay (VADR) using WAMS	2

	software.	
21	Transient stability analysis of a simple power system using ETAP under different contingencies.	2

Term Work
Note: The laboratory work will consist of minimum Ten experiments. Instructor can choose from the following list and/or any other experiment based on expertise of her/him and not covered in any other course of Electrical Engineering. Resources required: Minimum 20 users License software MATLAB / Scilab (open source software) / and/ or ATP (open source) / PSCAD and/ or ETAP and WAMS (5 users)
Text Books
1. MATLAB / Scilab Manual 2. ATP/PSCAD manual 3. ETAP Manual
Reference Books
1. MATLAB/Scilab online Tutorials 2. ETAP webinars

Power System II Laboratory

Course Code	Course Name
PC-BTE605	Power System II Lab

Course pre-requisites	Basic knowledge of programming, familiar with Engineering software such as MATLAB or Scilab

Course Objectives

Objectives of this course are

1. Proficiency in using Engineering software.
2. Develop programming skill.
3. To study the power and voltage relation of the transmission line with different receiving end conditions.
4. To study different methods of controlling and monitoring power system parameters.

Course Outcomes

Upon successful completion of the course, students should be able

1. Use suitable Engineering software in power system studies.
2. Develop complex algorithm to solve power system problems.
3. Analyse effect of variation of load on voltage profile & reactive power requirement of the line.
4. Suggest and compare suitable methods to control power system parameters to enhance stability.
5. Appreciate the importance of central monitoring and control of the power system to maintain stability in the system.

List of Experiments

Expt. No.	*Details*	*Hours*
1	Develop a program to calculate Y bus matrix.	2
2	Reduction of Ybus matrix using methods such as Gauss elimination/Kron's elimination /LU decomposition.	2
3	Develop a program to study load flow using Gauss Siedel method	2
4	Validation of Load flow results of Gauss Siedel method with Newton Raphson method using ETAP.	2
5	Study effect of Tap changing transformer on voltage levels in a power system.	2
6	Study of Power swing equation for a two machines system in ETAP.	2
7	Analysis of small disturbance stability of a single machine connected to infinite bus.	2
8	Develop a program to find numerical solution of power swing equation.	2
9	Study of P-V curve and P-Q curve.	2
10	Study of shunt reactive power compensation with static VAR devices, STATCOM, synchronous condenser etc.	2
11	Study of series compensation and hence the performance of the line.	2
12	Study the effect of load frequency control (LFC) on an isolated power system using SIMULINK/ETAP	2

13	Study the effect of automatic generation control (AGC) on an isolated power system using SIMULINK/ETAP	2
14	Study effect of tie line transmission limit on two area system using SIMULINK/ETAP	2
15	Study of automatic voltage regulator (AVR) using SIMULINK/ETAP	2
16	Study of configuration of Phasor Measurement Units and Wide Area Measurement System.	2
17	Study of Post fault Oscillation Monitoring using WAMS.	2

Term Work

Note: The laboratory work will consist of minimum Eight experiments from the following list and/or any other experiment based on the prescribed syllabus of power system II. The Instructor is expected to ask the students to manually verify the results wherever possible, so that students can have practice of solving examples. Also, more examples can be given for practice at home.

Resources required: Minimum 20 users License software MATLAB and/ OR ETAP/ Scilab (open source software) and WAMS (5 users)

Text Books

1. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
2. Wadhawa C. L., "Electrical Power Systems", New Age International.
3. Stevenson W.D., "Elements of Power System Analysis", McGRAW-HILL International
4. Saadat Hadi, "Power System Analysis, "TMH Publication.
5. MATLAB / Scilab Manual/ETAP Manual
6. Dr. K. Rajamani & Co Authors, "Monograph of IEEMA articles of Dr. K. Rajamani", IEEMA journal

Reference Books

1. Prabha Kundur, "Power System Stability and Control'', TMH Publication.
2. IEEE 80 – IEEE guide for safety in substation grounding
3. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication
4. MATLAB/Scilab online Tutorials
5. ETAP webinars

Electrical Machines Design I

Course Code	Course Name
PE-BTE601	Electrical Machines Design I

Course pre-requisites	Electrical Machines I and II

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

Course Content

Module No.	*Details*	*Hrs.*
1	Fundamental aspects of Electrical Machine Design: Design of machines: Design factors - Limitations in design - modern trends in Design of Electrical machines - Modern machine manufacturing techniques. Materials used in Transformers and Rotating Machines: Electrical conducting materials – High conductivity materials. Magnetic materials: Soft magnetic materials – Solid core materials – Sheet steels – Special purpose alloys. Insulating Materials: Electrical properties of insulating material – Temperature rise of insulating material – classification of insulating material - Insulating materials used in Modern Electric machines.	06
2	Thermal Design aspects of Electrical machines: Thermal state in electrical machines – Theory of Solid Body Heating – Heating – Cooling. Cooling of Rotating machines: Methods of cooling - cooling system -quantity of Cooling medium (coolant).	06
3	Design of Transformers: (Core Type Transformers). Sizing of a transformer. Design Details: Output for single & three-phase transformers – Output Equation – Volt per Turn. Optimum Designs. Design of Core – Rectangular core – Square and stepped cores – Variation of core diameter. Selection of Core area and Type of Core. Choice of flux density. Design of windings – Selection of Type winding – Position of winding relative to core. Window space factor – Window dimensions – Width of window for optimum	08

	output. Design of Yoke. Overall Dimensions. Simplified Steps for Transformer Design.	
4	Transformer Design Operating Characteristics: Resistance of Winding – Leakage reactance of winding – Regulation – No-load current. Temperature Rise of Transformers - Methods for cooling of transformers – Transformer oil as cooling medium – Temperature rise in plain walled Tanks. Design of Tank - with Tubes with Radiators.	04
5	Design of Induction Motors: Introduction - Sizing of an induction motor. Relation between Rating and Dimensions of Induction Motor – Specifications - Output Equation – Main Dimensions - Factors affecting the size of the machine – Specific electrical Loading – Specific Magnetic loading – Choice of specific electrical and magnetic loadings – Efficiency and Power Factor.	04
6	Induction motor Design Details: Calculation of Main Dimensions – Separation of D and L – Peripheral velocity – Ventilating Ducts. Design of Stator Core - Stator winding Design - Stator slot design – Stator Teeth Design – Depth of Stator Core. Determination of Air gap length. Design Rotor: Design of Squirrel cage Rotor - Rules for selecting rotor slots - Design of rotor bars and slots - design of end rings. Design of wound rotor – Number of Slots - Number of Turns – Rotor current and conductor section. Design of rotor core.	10
7	Estimation of Operating Characteristics of Induction Motor: No-load current – Short circuit current – Stator and Rotor Resistance – Leakage Reactance – Circle diagram –Starting Torque – Losses and Efficiency.	04

Term Work

Term work shall comprise of

1. Tutorials
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, Part of 2
2	T-II	Part of 2, 3
3	End Sem	1 to 7

Control System Design

Course Code	Course Name
PE-BTE602	Control System Design

Course pre-requisites	Control System

Course Objectives

The objectives of this course are

1. Discuss design specifications
2. Design of classical control system in time and frequency domain
3. Explain PID controller design and controller design in state space
4. Introduction to controllability, observability and non linearities

Course Outcomes

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

1. Understand various design specifications.
2. Design controllers/ compensators to satisfy the desired design specifications in time domain and using frequency response
3. Design controllers and observers using the state-space approach.
4. Understand phase plot analysis for non linear systems

Course Content

Module No.	*Details*	*Hrs.*
1	Design Specifications Introduction to design problem and philosophy. Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response.	**06**
2	Design of Classical Control System in the time domain Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators.	**08**
3	Design of Classical Control System in frequency domain Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.	**08**
4	Design of PID controllers Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback – Feed forward control.	**06**
5	Control System Design in state space Review of state space representation.	**02**

6	Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.	**06**
7	Nonlinearities and its effect on system performance Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis.	**06**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination.		

Text Books
1. N. Nise, "Control system Engineering", John Wiley, 2000. 2. I. J. Nagrath and M. Gopal, "Control system engineering", Wiley, 2000. 3. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
Reference Books
1. K. Ogata, "Modern Control Engineering", Prentice Hall, 2010. 2. B. C. Kuo, "Automatic Control system", Prentice Hall, 1995. 3. J. J. D'Azzo and C. H. Houpis, "Linear control system analysis anddesign (conventional and modern)", McGraw Hill, 1995. 4. R. T. Stefani and G. H. Hostetter, "Design of feedback Control Systems",Saunders College Pub, 1994.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3.4
3	End Sem	1 to 7

Project Management

Course Code	Course Name
OE-BTE601	Project Management

Course pre-requisites	Basics of Electrical Engineering, Basics of statistics and mathematics, general knowledge about working of organizations

Course Objectives

The objectives of this course are

1. Get familiarized with basics of project management, its organization and project management framework.
2. Learn five important project management process groups, namely: initiating, planning, executing, monitoring & control, closing and ten important project management knowledge areas.
3. Understand the relationship between project management process groups and knowledge areas.

Course Outcomes

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

1. Explain basics of Project Management, its organization and project management framework.
2. Perform project management process group and knowledge area mapping.
3. Solve a case study using step-by-step process of managing projects and explain why each step is necessary.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction** • Basics of project management, operations management and organizational strategy, • Project management framework, organizational structures, • Project Management Processes – Initiating, Planning, Executing, Monitoring & Control, Closing.	03
2	**Project Integration Management** • Integrated change control, Developing project management plan and project charter, • Project selection, corrective action, preventive action, defect repair, change control board, • Cost benefit analysis, Net present value, internal rate of return, payback period, present value, economic value added, • Opportunity costs, sunk costs, law of diminishing returns, working capital, depreciation. **Project Scope Management** • Scope baseline, WBS, Project scope statement, WBS dictionary, benefits and uses of WBS • Requirement documentation, requirements traceability matrix, requirements management plan	04

3	**Project Time Management** • Schedule baseline, schedule compression, Network diagram, • Precedence Diagramming Method (PDM), Three point estimating, analogous estimating, parametric estimating, • Schedule management plan, resource optimization, Critical path method, Program Evaluation Review Technique (PERT). **Project Cost Management** • Earned value measurement, Earned value monitoring, cost baseline, cost budget, Cost management plan, • Reserve analysis, contingency reserve, management reserves, cost risk, • Variable / fixed costs, direct / indirect costs, life cycle costing, value analysis, control thresholds, cost of quality, Return of Interest (RoI), and discounted cash flow. **Project Quality Management** • Seven basic quality improvement tools – control chart, Pareto diagram, Cause and effect diagram, flow chart, scatter diagram, histogram. Use of s-curve in project monitoring. • Quality assurance tools and techniques – Affinity diagram, tree diagrams, process decision program charts, matrix diagrams, prioritization matrices, network diagrams.	09
4	**Project Human Resource Management** • Role of PM, sponsor, stakeholders, functional manager, portfolio manager, program manager, • HR management plan, recognition and reward systems, team building, stages of team formation and development, team types. • Conflict Management, • Responsibility Assignment Matrix (RAM), RACI Chart, • Motivation theory, Management and Leadership styles, **Project Communication Management** • Communication models, channels, method, communication blockers.	04
5	**Project Risk Management** • Risk management plan, risk response strategies, threats, opportunities, risk register, contingency plans, fallback plans, residual risks, secondary risks, • Risk types and categories, SWOT analysis, **Project Procurement Management** • Procurement management plan, types of agreements and contract types, advantages and disadvantages of each contract type, • PM's role in procurement, procurement documents : RFP, IFB, RFQ, RFI, • Types of procurement, procurement negotiations, centralized / decentralized contracting, contract interpretation, price, profit, cost, target price, sharing ratio, ceiling price	06
6	**Project Stakeholder Management** • Stakeholder analysis, stakeholder register, stakeholder expectations, stakeholder engagement,	03

	• Power and interest grid, stakeholders engagement assessment matrix	
7	**Professional and Social Responsibility** • Project management traits in professional and social responsibility, • Code of Ethics and Professional conduct w. r. t. responsibility, respect, fairness, honesty. **Project Management Case Study / Activity**	05

Text Books
1. Rita Mulcahy, "PMP Exam Prep", Eight Edition, RMC Publications, Inc., 2013. 2. Kalpesh Ashar, "Project Management – Essentials You Always Wanted to Know", Vibrant Publishers, 2012. 3. Prasanna Chandra, "Projects: Planning, Analysis, Selection, Financing, Implementation and Review", McGraw Hill India, 2014.
Reference Books
1. Dennis Lock and Lindsay Scott, "Gower Handbook of People in Project Management", Routledge Publishers, NY, USA, 2016. 2. "A Guide to the Project Management Body of Knowledge (PMBOK Guide)", 5th Edition, Project Management Institute, USA. 3. David Cleland, "Project Management Handbook", 2nd Edition, Wiley, 1988.

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

Artificial Intelligence

Course Code	Course Name
OE-BTE602	Artificial Intelligence

Course pre-requisites	

Course Objectives
The objectives of this course are 1. Introduce to Artificial Intelligence 2. Understand problem solving methods 3. Discuss applications of AI
Course Outcomes
Upon successful completion of the course, students should be able TO 1. Develop a basic understanding of AI building blocks presented in intelligent agents 2. Choose an appropriate problem solving method and knowledge representation technique, analyze the strength and weaknesses of AI approaches to knowledge – intensive problem solving 3. Design models for reasoning with uncertainty as well as the use of unreliable information

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Artificial Intelligence (AI) History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub- areas of AI, Applications of AI, Current trends in AI	04
2	Intelligent Agents Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Age	04
3	Problem solving 1 Solving problem by Searching: Problem Solving Agent, Formulating Problems, Example Problems. Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening(DFID), Informed Search Methods: Greedy best first Search A* Search , Memory bound edheuristic Search.	07
4	Problem solving 2 Local Search Algorithms and Optimization Problems: Hill-climbing search Simulated annealing, Local beam search, Genetic algorithms. Adversarial Search: Games, Optimal strategies, The minimax algorithm, Alpha-Beta Pruning.	07
5	Knowledge based Agents, The Wumpus World, The	10

	Propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL, Forward chaining, backward Chaining, Knowledge Engineering in First-Order Logic, Unification, Resolution, Introduction to logic programming (PROLOG), Uncertain Knowledge and Reasoning: Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Inference in belief network.	
6	Planning and Learning The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning, Learning: Forms of Learning, Inductive Learning, Learning Decision Tree, Expert System: Introduction, Phases in building Expert Systems, ES Architecture, ES vs Traditional System.	06
7	Applications Natural Language Processing (NLP), Expert Systems.	04

Text Books
1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach "Second Edition" Pearson Education. 2. Saroj Kaushik "Artificial Intelligence" ,Cengage Learning.
Reference Books
1. George F Luger "Artificial Intelligence" Low Price Edition , Pearson Education., Fourth edition. 2. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Pearson Education, Third Edition. 3. Elaine Rich and Kevin Knight "Artificial Intelligence" Third Edition 4. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989. 5. Hagan, Demuth, Beale, "Neural Network Design" CENGAGE Learning, India 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

Communication Engineering

Course Code	Course Name
OE-BTE603	Communication Engineering

Course pre-requisites	Electronic circuit, Analog circuit, Digital Electronics

Course Objectives

The objectives of this course are

1. Discuss analog and digital modulation
2. Discuss importance and methods of source and channel coding
3. Explain utilization of media bandwidth

Course Outcomes

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

1. Apply different analog and digital modulation demodulation techniques
2. Understand source and channel coding
3. Select different media based on application and appreciate use of multiplexing and spreading methods

Course Content

Module No.	*Details*	*Hrs.*
1	Amplitude Modulation Systems Need for modulation, normal AM, generation and demodulation (envelope & synchronous detection), modulation index, DSBSC: generation and demodulation, Effect of phase and frequency offset on demodulation, SSB: Generation using filter and phasing method, detection. Frequency division multiplexed systems using SSB.	08
2	Angle Modulation Systems Concept of frequency and phase modulation, frequency deviation and modulation index, FM spectra, Carson‟s rule, narrowband FM, generation of Wideband FM Armstrong method, direct FM generation. Demodulation of FM-discriminatory, PLL	08
3	Sampling and Discrete time Modulations Sampling Theorem – low pass and band pass, Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM) their generation and detection-phase time division multiplying.	04
4	Digital Communication PCM, quantization noise, bandwidth, advantages over analog communication, PCM system, Differential PCM, Delta Modulation, Digital Modulation – ASK, FSK, PSK, DPSK, QAM	06
5	Information theory – Information, Entropy, Rate of information, Channel capacity, Shannon theorem, Huffman coding	06
6	Channel Coding – Linear block code, Cyclic code, Convolution code.	06

7	Utilization of Media Bandwidth Guided and unguided media – Twisted pair cable, Coaxial cable, Fiber optic, Radio waves, Microwaves, Infrared waves, Light waves, Multiplexing – FDM, TDM Spreading – DSSS, FHSS,	04

Text Books
1. Haykin S., "Communications Systems", John Wiley and Sons. 2. Taub H. and Schilling D.L., "Principles of Communication Systems", Tata McGraw Hill
Reference Books
1. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education. 2. Wozencraft J. M. and Jacobs I. M., ``Principles of Communication Engineering",John Wiley. 3. Barry J. R., Lee E. A. and Messerschmitt D. G., ``Digital Communication", Kluwer Academic Publishers.. 4. Proakis J.G., ``Digital Communications'', McGraw Hill.

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

VLSI Circuits

Course Code	Course Name
OE-BTE604	VLSI Circuits

Course pre-requisites	Digital Electronics

Course Objectives

The objectives of this course are

1. To introduce the fundamental principles of VLSI circuit design and layout techniques.
2. To highlight the circuit design issues in the context of VLSI technology.
3. To examine the basic building blocks of large-scale digital integrated circuits

Course Outcomes

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

1. Demonstrate a clear understanding of choice of technology and technology scaling.
2. Design MOS based circuits and draw layout.
3. Realize logic circuits with different design styles.
4. Demonstrate a clear understanding of system level design issues such as timing and power dissipation

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction and overview:** History, basic transistor technology, NMOS and CMOS technology. **Fabrication process and layout:** NMOS, LOCOS, CMOS, CMOS Design rules, MOSFET Scaling: Types of scaling, MOSFET capacitances.	**06**
2	**MOSFET Inverters:** **Circuit Analysis**: Static and dynamic analysis (Noise, propagation delay and power dissipation) of resistive load and CMOS inverter, comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch- up. **Logic Circuit Design**: Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter.	**06**
3	**MOS Circuit Design Styles:** **Design Styles:** Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS. **Circuit Realization:** SR Latch, JK FF, D FF.	**06**
4	**Semiconductor Memories:** ROM Array**,** SRAM (operation, design strategy, leakage currents, read/write circuits), DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-	**08**

	Output circuits).	
5	**Low Power CMOS Circuits:** Various components of power dissipation. CMOS, Limits on low power design, low power design through voltage Scaling.	**04**
6	**Hardware Description Languages for VLSI Design:** Managing concurrency and time in Hardware Description Languages, Introduction to VHDL, Basic Components in VHDL, Structural Description in VHDL, Behavioral Description in VHDL, and Introduction to Verilog.	**08**
7	**VLSI Clocking:** CMOS clocking styles, Clock generation, stabilization and distribution.	**04**

Text Books
1. Sung-Mo Kang and Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", Tata McGraw Hill. 2. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education
Reference Books
1. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective", Pearson Education. 2. Etienne Sicard and Sonia Delmas Bendhia, "Basics of CMOS Cell Design", Tata McGraw Hill. 3. Debaprasad Das, "VLSI Design", Oxford. 4. Kaushik Roy and Sharat C. Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, Student Edition.

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

Linear Algebra and Matrix Computation

Course Code	Course Name
OE-BTE605	Linear Algebra and Matrix Computation

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To make student conversant with fundamentals of Linear Algebra.
2. To impart knowledge about various concepts of matrix computation.
3. To learn the complexity in solving least square problem
4. To understand concepts of Eigen Value and Eigen vectors

Course Outcomes

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

1. To apply theoretical concepts of vector spaces to solve linear equations.
2. To analyse various properties such as rank, subspaces, norm, condition number, eigen value etc. of a given matrix.
3. To compare complexity of various matrix decomposition methods.
4. To solve least square problem with different matrix computation techniques
5. To suitably select various matrix computation tools to solve real life complex problems

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction:** Over-view of the course, applications in various engineering fields, **Vector-spaces:** Fields, definition of a vector-space, examples, subspaces, sums and intersections of subspaces, span, linear independence, bases, dimension, basis extension, coordinates, calculations of bases concerning solutions of linear equations.	4
2	**Linear maps:** Definition, examples, null/kernel space, range/image space, matrix representations of linear maps, row-rank, column-rank, rank-nullity theorem, algebra of linear maps, linear functionals	4
3	**Gaussian elimination:** Basic Gaussian elimination without pivoting, LU decomposition, Gaussian elimination with pivoting. Positive definite matrices, A brief discussion on sparsity.	6
4	**Sensitivity and round-off errors:** Vector norms, matrix norms. Condition number. Perturbation, residual, round-off errors. Error propagation in Gaussian elimination.	6
5	**Least Squares Problem:** Orthogonal matrices, rotators and reflectors. Solution of the least squares problem, the full-rank case. Gram-Schmidt process. Singular value Decomposition (SVD): Introduction, Some basic applications, least squares problem	8

6	**Eigenvalues and Eigenvectors:** The power method. Unitary similarity transform, Schur's theorem, normal matrices, spectral theorem of normal matrices. Hessenberg and tri-diagonal matrices, reduction to these forms. The QR algorithm. A brief discussion on sparsity.	8
7	**Applications:** a) Graphs, KCL and KVL b) Solving linear ODEs c) The geometry of gradient descent d) Best approximation e) Multi-agent systems.	6

Text Books
1. K. Hoffman and R. Kunze, Linear Algebra, Pearson, 2015. 2. G. Strang, Linear algebra and its applications (4th Edition).
Reference Books
1. David S. Watkins, Fundamentals of Matrix Computations, 3rd Edition, Willey-Inter science, 2010. 2. Gene H. Golub and Charles F. Van Loan, Matrix Computations, 4th Edition, The Johns Hopkins University Press, 2013.

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

Environmental Science

Course Code	Course Name
MC-BTE03	Environmental Science

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To sensitize to the ever-increasing environment problems.
2. To acquire knowledge about environmental pollution.
3. To acquire knowledge with respect to renewable energy and its positive impact on environment.
4. To be aware of the national and international concern for environment for protecting the environment.

Course Outcomes

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

1. Propose specifications to comply with norms of environment engineering
2. Describe laws and regulations pertaining to health, safety and environment
3. Apply evaluation tool such as GRIHA to help design, build, operate, and maintain a resource efficient environment management system

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to Environmental Engineering**: Biotic and Abiotic Environment, Adverse effects of environment, Types of environmental pollution - Water pollution, Air pollution, Solid waste management, Control Strategies of different environmental problems	06
2	**National Legislation for Environment**: Constitutional provisions for safeguarding the environment, The Environmental (Protection) Act, The Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, The Wild life (Protection) Act, Forest Act, Biodiversity Act	06
3	**Introduction to Ecology**: Definition, Structure and function of an ecosystem-Ecological succession-primary and secondary succession. Ecological pyramid of number, pyramid of energy and pyramid of biomass	06
4	**Introduction to Renewable Energy.** Solar, Wind, Geothermal, Ocean (Tidal), Biomass – Basics, Conservation of natural resources. Environmental and economic impact of each type of renewable energy.	06
5	**Hazard Assessment, Prevention, and Control:** Stress and Safety, Safety and Health Training, Mechanical Hazards and	06

	Machine Safeguarding, Fire Hazards and Life Safety, Ethics and Safety, Hazard Analysis/Prevention and Safety Management, Environmental Safety and ISO 14000 (Environmental Management).	
6	**Introduction to National Rating System** GRIHA (Green Rating For Integrated Habitat Assessment): An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment. Case studies of GRIHA registered buildings	06
7	**International Concerns: Conventions and Treaties**-RAMSAR Convention, CITES, Convention on Biological Diversity, Convention to Combat Desertification, Convention on Climate Chang.	06

Text Books
Reference Books
1. GRIHA Manual Volume 1 - Ministry of New and Renewable Energy, Government of India, New Delhi. 2. ISO 14001:2004(E) - Environmental management systems Requirements with guidance for use. 3. Jagdish Krishnawamy, R J Ranjit Daniels,“ Environmental Studies”, Wiley India Private Ltd. New Delhi. 4. An Indita Basak, Environmental S

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
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 communicate