



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

R23

Academic Year 2026-2027

List of Courses

PC-BTE701	Power System Operation & Control
IC- BT001	Research Methodology & Ethics
PC-BTE751	Power System Operation and Control lab.....
PE-BTE701	Advanced Electric Drives
PE-BTE702	Electrical Machine Design.....
PE-BTE703	Power Quality and FACTS
PE-BTE704	Restructuring and Deregulation of Power System
PE-BTE705	Design, Management & Audit of Electrical Systems.....
PE-BTE706	Embedded System
PE-BTE707	VLSI Circuits
PE-BTE721	Vehicular systems and control of EV drives.....
PE-BTE722	Distributed generation and Micro-grid.....
PE-BTE723	High Voltage Engineering
PE-BTE725	Digital Control Design.....
PE-BTE726	Industrial Automation.....
OE-BTE701	Image Processing.....
OE-BTE702	Linear Algebra & Matrix Computation
OE-BTE703	Engineering Economics.....
OE-BTE704	Internet of Things.....
OE-BTE705	Artificial Intelligence.....
PR-BTE001	Project.....

Course Code	Course Name	
PC-BTE701	Power System Operation & Control	
Course pre-requisites	Power system modelling and Power system Analysis	
Course Objectives		
The objectives of this course are		
1. To make student understand various equipment constraints in operation of power system. 2. To impart knowledge about modelling of controllers required in power system for power and voltage control 3. To make student realize the need of centrally monitoring of large power system with the help of advance techniques such as PMU & WAMS		
Course Outcomes		
At the end of the course, students will demonstrate the ability to		
1. Summarize the equipment & stability constraints in power system operation. 2. Evaluate, compare and suggest suitable controlling devices for real and reactive power flow in a power system. 3. Formulate & find optimal generation for given power system. 4. Recognize recent trends in centrally monitored grid system as well as distributed generators & Micro-grid.		
Course Content		
Module No.	Details	Hrs.
1	Equipment and Stability Constraints in System Operation: Generator constraints, generator capability curves, thermal limit curve & loadability curves of transmission line.	4
2	Active Power & Frequency Control: Load Frequency Control (LFC) of an isolated power system, Automatic Generation Control (AGC) in a single area system, AGC in multi-area system, Tie line bias control.	6
3	Reactive Power & Voltage control: Generation and absorption of reactive power, basics of reactive power control, Automatic Voltage Regulator (AVR), brushless AC excitation system, block diagram representation of AVR loop, Excitation system stabilizer with rate feedback & PID controller Synchronous Machine as a condenser for grid stability	6
4	Power transmission & control in the transmission line: power transmission in uncompensated transmission line , P-V curve, P-Q curve of transmission line, real Power flow control using series capacitor, TCSC, phase angle regulator (phase shifting transformer), using embedded HVDC link, methods of reactive power injection – tap changing transformer, SVC (TCR + TSC) and STATCOM for voltage control.	9
5	Optimal Dispatch of Generation: Optimal dispatch neglecting generator limits and line losses, Optimal dispatch with generator limits, Optimal dispatch with line losses.	6

6	Preventive, Emergency & Restorative Control: Operating states and control actions in a power system, Preventive control, Emergency control, system islanding, Restorative control, definition of blackout, Role of Load Dispatch Center (LDC), system monitoring, data Acquisition and controls using PMU & WAMS, System hardware configurations, SCADA & EMS functions	8
7	Modern Trends in Power System Monitoring & Control: Introduction to Smart Grid, Distributed Generation, Micro-Grid and challenges in Grid Integration, Micro-PMUs for distribution systems.	3

Text Books:

1. Saadat Hadi, "Power System Analysis, "TMH Publication.
2. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
3. Prabha Kundur, "Power System Stability and Control", TMH Publication.
4. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication

Reference Books:

1. Chakrabarti .A, Halder.S, "Power System Analysis-Operation and Control", PHI
2. Hingorani N.G., "Understanding of Facts", Wiley Publications.

E resources (if any):

Power Systems Operation and Control, Dr. A.M. Kulkarni, IIT Bombay,
<https://nptel.ac.in/courses/108101040>

IC-BT01 Research Methodology and Ethics

Course pre-requisites: General Engineering, Communication Skills

Course Objectives:

1. **Introduce** students to the fundamentals of research, including types, approaches, and the process of identifying and formulating research problems.
2. **Enable** students to design an effective research plan by understanding sampling methods, data collection techniques, and literature review strategies.
3. **Familiarize** students with essential statistical tools and techniques for data analysis, hypothesis testing, and interpretation of results.
4. **Develop** the ability to write well-structured, ethical research reports and communicate findings effectively through appropriate formats and presentations.

Course Outcomes:

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

1. **Understand** the fundamentals of research, including types, approaches, and the process of formulating a research problem.
2. **Design** a research methodology by selecting appropriate data collection methods, sampling techniques, and performing a literature survey.
3. **Analyze** research data using statistical tools such as regression, hypothesis testing, and multivariate analysis to validate outcomes.
4. **Prepare** a structured and ethical research report with proper documentation of findings, figures, references, and future scope.

Course Contents:

Module.	Details	Hrs.
01	Research – definition; types of research methods, pure and applied research. descriptive and explanatory research, qualitative and quantitative approaches,	03
02	Research procedure: Considerations in selecting the research problem Formulating the problem statement, Research design - sample size.	04
03	Literature survey- Guidelines for literature survey	03
04	Data collection methods- Interview, experimental methods, case study, questionnaire design	06
05	Regression Equation and Curve fitting, Multivariate analysis, and Hypothesis tests: z test, F test, t-test, Chi Sq test, Validity of research outcomes. Suggestions and recommendations, Identifying future scope	04
06	Writing research reports – Chapters, paragraphs, sentences, figures, tables, charts, references, etc., Presentation of experimental setup, models, result analysis and conclusion	04
07	Research and publication ethics – Common unethical practices, Plagiarism, Predatory journals and Others.	04

Text Books:

1. Kothari C R, Research Methodology, Wiley Eastern
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners

Course Code	Course Name
PC-BTE751	Power System Operation & Control Lab
Course pre-requisites	Basic knowledge of programming, familiar with Engineering software

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 will be able to			
1. Use suitable Engineering software and develop complex algorithm to solve power system problems individually or in a group. 2. Analyze effect of variation of load on voltage profile & reactive power requirement of the line. 3. Compare and suggest suitable methods to control power system parameters to enhance operation. 4. Formulate & find optimal generation for given power system with software aid.			
List of Experiments			
Expt. No.	Details	Hours	CO
1	Study of complex power flow through a single-phase transmission line with ideal AC voltage sources connected at each end.	2	1
2	To validate Ferranti effect on an unloaded transmission line.	2	1,2
3	Study effect of Tap changing transformer on voltage levels in a power system.	2	1,2,3
4	Study of P-V curve and P-Q curve.	2	1,2
5	Study of shunt reactive power compensation with static VAR devices, STATCOM, synchronous condenser etc.	2	1,2,3
6	Study of series compensation and hence the performance of the line.	2	1,2,3
7	Study the effect of load frequency control (LFC) on an isolated power system.	2	1,3
8	Study the effect of automatic generation control (AGC) on an isolated power system.	2	1,3
9	Study effect of tie line transmission limit on two area system.	2	1,3
10	Study of automatic voltage regulator (AVR) for synchronous generator	2	1,3
11	Program on optimal dispatch of generation	2	1,4

Term Work
Note: The laboratory work will consist of minimum Six experiments from the above list and/or any other experiment based on the prescribed syllabus of power system Analysis. Further, a Mini project or few more experiments (minimum 2) based on PSOC course needs to be completed. 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/Python (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”, McGRAW-HILL International
4. Saadat Hadi, “Power System Analysis”, “TMH Publication.
5. MATLAB / Scilab Manual/ETAP Manual

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

Course Code	Course Name	
PE-BTE701	Advanced Electric Drives	
Course pre-requisites	Power Electronics, Electric Drives	
Course Objectives		
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 will be able to		
1. Compare the operation of power electronic converters and their control Strategies.		
2. Demonstrate the modelling of rotating ac electrical machines		
3. Asses the scalar control and vector control strategies (field oriented control and direct torque control) for ac motor drives and use of digital signal processors in implementation		
Module No.	Details	Hrs.
1	Power Converters for AC drives Modelling of three phase inverter. Control techniques of inverter: Square wave inverter operation, Sine –triangle PWM technique, Space vector modulation, Comparison of control techniques, Selective harmonic elimination technique, Current control of VSI, Three level inverter, Different topologies, SVM for 3 level inverter	08
2	Mathematical Modelling of Induction Machines Different transformations and reference frame theory, Development of mathematical model of induction machine in different reference frame, torque equation of induction motor in different reference frame	06
3	Control of Induction Motor Drives Voltage fed inverter control-v/f control (scalar control), Analogy of DC drive for the vector control of induction motor, Different field oriented control (FOC) techniques of induction motor, Comparison of scalar and vector control, Direct torque and flux control (DTC). Comparison of field oriented control (FOC) and direct torque control (DTC).	10
4	Synchronous Motor Drives Modelling of synchronous machines, Open loop v/f control, Vector control, Direct torque control, CSI fed synchronous motor drives	04
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, Characteristics of SRM, Various topologies for SRM drives, Comparison, Closed loop speed and torque, Control of SRM	04

7	DSP Based Motion Control Use of DSPs in motion control, various DSPs available, and Realization of some basic blocks in DSP for implementation of DSP based motion control.	04
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For Self-study: Mathematical Modelling of PMSM, SRM, BLDC

Term work contains 6-8 tutorials based on syllabus.

Text Books
1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall. 2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall. 3. B.K. Bose,” Modern power electronics and ac drives”, PHI
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 5. P.C. Krause, ‘Analysis of electric machinery and drives system’, Wiley

Course Code	Course Name	
PE-BTE702	Electrical Machine Design	
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. Visualize the construction and performance characteristics of electrical machines.		
2. Asses the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines		
3. Demonstrate 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 output. Design of Yoke. Overall Dimensions. Simplified Steps for Transformer Design.	08
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
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.		

Course Code	Course Name
PE-BTE703	Power Quality and FACTS
Course pre-requisites	Power Electronics, Power system

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. Assess the various power quality issues and its reasons. 2. Analyze the control techniques for VSI for improvement of power system performance. 3. Analyze and compare the thyristor based and VSI based FACT controllers. 4. Appreciate the HVDC as alternative technology for power transmission.		
Course Content		
Module No.	Details	Hrs.
1.	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
2.	Introduction: Brief discussion on Transmission line theory, use of voltage source inverters (VSI) for reactive power support, mid-point series and shunt compensation, 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	04
3.	Use of VSI as a Var generator, Indirect current controlled Synchronous link converter Var Compensator (SLCVC), STATCOM, 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. Transformation	06
4	Thyristor-based Flexible AC Transmission Controllers: (FACTS) Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensators (SVC), Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor-thyristor controlled reactor (FC-TCR), 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.	08
5	Voltage Source Converter based (FACTS) Controllers: Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC). GTO Controlled Series Compensator. Phase Angle regulator.	10

	Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller.	
6	HVDC: Introduction, various possible HVDC configurations. Components of HVDC systems – converter, transformer, smoothing reactor, harmonic filter, Reactive power support. HVDC Operation of 6-pulse controlled converter in rectifier and inverting mode. Effect of source inductance, equivalent circuit 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.	04
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. 2. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS: Concepts and technology of flexible AC transmission systems, IEEE Press 3. K. R. Padiyaar , HVDC Power transmission and system	
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. McGranahan, 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	

Course Code	Course Name	
PE-BTE704	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 will be able to		
1. Classify various types of electricity market designs and contrast the perspectives of consumers and producers within these markets. 2. Apply the fundamental principles of microeconomics to analyse decision-making and market behavior in the power sector. 3. Compare and evaluate pricing methods used in centralized and decentralized electricity trading systems. 4. Appraise the significance and functionality of ancillary services in maintaining grid stability and reliability. 5. Ascertain the use of optimization in engineering and decision-making problems.		
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 optimization • 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	8

	- Decentralized trading over the transmission network. - Centralized 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 - Tutorials - MCQ examination		

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

Course Code	Course Name
PE-BTE705	Design, Management and Audit of Electrical Systems

Course pre-requisites		Power system and Electrical Machines
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. Identify the requirement of a project and design electrical systems using appropriate tools and industry codes. 2. Conduct energy audits and identify opportunities for energy conservation and efficiency improvement in electrical installations 3. Realize role of renewable-energy and green building concepts in electrical design & apply energy efficient ways in design and selection of electrical components. 4. Prepare Engineering drawings, technical reports and documentation related to electrical system design, management practices, and audit findings 5. Work as a team leader or a member in multidisciplinary projects in the role of electrical engineer		
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.	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 financial analysis techniques: Time value of money, Simple payback, IRR.	04
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	10

	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	
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	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. 3. Case Study		

Reference Books
- Handbook of Electrical Installation Practice. , By Geoffery Stokes, Wiley Blackwell - Designing with light: Lighting Handbook., By Anil Valia, Lighting System - Energy Management Handbook. By W.C. Turner, John Wiley and Sons - Handbook on Energy Audits and Management. edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI). - Electrical Design: Estimating and Costing, by K. B. Raina and S. K. Bhattacharya, New Age International Publishers - Energy Auditing Made Simple, By P. Balasubramanian, Separation Engineers (P) Limited - Energy Management Principles, By C. B. Smith, Pergamon Press - Energy Conservation Guidebook, Dale R. Patrick, Stephen Fardo, Ray E. Richardson, Fairmont Press - Handbook of Energy Audits., By Albert Thumann, William J. Younger, Terry Niehus, CRC Press

Self-study:

- Identify the requirement of a project and design electrical systems using appropriate tools and industry codes.
- Conduct energy audits and identify opportunities for energy conservation and efficiency improvement in electrical installations
- Realize role of renewable-energy and green building concepts in electrical design & apply energy efficient ways in design and selection of electrical components.

4. Prepare Engineering drawings, technical reports and documentation related to electrical system design, management practices, and audit findings

Work as a team leader or a member in multidisciplinary projects in the role of electrical engineer.

Course Code	Course Name	
PE-BTE706	Embedded System	
Course pre-requisites	Microprocessor and Microcontroller	
Course Objectives		
The objectives of this course are		
1. Introduction to embedded system design.		
2. Study of ARM processor.		
3. Study of ARM programming and hardware interfacing.		
4. Understand the design aspects and architectural considerations.		
Course Outcomes		
Upon successful completion of the course, students should be able to		
1. Explain the architecture, design methodology, and operational principles of embedded systems.		
2. Explain the ARM architecture including instruction set, programming model and interfacing with external peripheral.		
3. Analyze the design consideration and architectural aspects of embedded systems applications.		
Course Content		
Module No.	Details	Hrs.
1	Introduction to Embedded System: Embedded system overview, An Introduction to Embedded System Architecture, Embedded System Model, Design challenge, Processor Technology, IC Technology.	06
2	Embedded system Design and development process: System Design and Development, Life Cycle Models, The Design Process, formulating the requirement specifications, functional design, and architectural design.	06
3	Introduction to ARM Architecture: Types of computer Architectures, ISA's and ARM History. Embedded System Software and Hardware, Endianness. Processor core VS CPU core, Operational Modes. Instruction Format, ARM 3 stage Pipeline.	06
4	ARM Programmer's Model: ARM Instruction Set, Load Store Instruction, Software Interrupt Instructions, Branch Instructions, Data Processing Instructions, Coprocessor Instruction, Program Status Register Instructions, Loading Constants, Conditional Execution, Addressing Modes, Thumb Instruction Set, Data Processing Instruction, Single Register Load-Store Instruction, Multiple Register Load-Store Instruction, and Stack Instructions.	08
5	Hardware Interfacing: GPIO (General Purpose I/O) Programming and Interfacing, Seven- segment LED interfacing, Interfacing to an LCD, keyboard interfacing, UART serial port interfacing, Timer programming, Interrupt and exception programming ADC, DAC and Sensor interfacing, SPI Protocol and devices.	06
6	Testing, Simulation, and Debugging Techniques and Tools: Integration and Testing of Embedded Hardware, Testing Methods, Debugging techniques, Laboratory Tools and Target Hardware Debugging.	06
7	Applications of Embedded Systems: - Automobiles and in telecommunications	04

	- Smart Cards, Missiles and Satellites - Computer Peripherals & Computer Networking - Consumer Electronics	
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For Self-study: Case Study of one application in Industrial automation, Medical, Robotics and Access Control System.

Text Books:

1. Frank Vahid and Tony Givargis , Embedded System Design: A Unified Hardware/Software Approach, Wiley India Wiley; Student edition, 2006.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide – Design and optimizing System Software, Morgan Kaufman (Elsevier) Publisher, 2014.
3. Raj kamal, Embedded Systems- Architecture, Programming and Design, McGraw Hill Education; Third edition, 2017.

Reference Books:

1. Jonathan W. Valvano ,Thomson, Embedded Microcomputer Systems, Thomson/Brooks/Cole, 2000.
2. David E. Simon, An Embedded Software Primer, Addison Wesley, 1999.
3. Dr. K.V.K.Prasad, Dreamtech Press, Embedded real time system, Dreamtech Press; New edition, 2003.
4. Shibu K V, Introduction to Embedded Systems, McGraw Hill Education India Private Limited; Second edition, 2017.

E resources (if any):

<https://nptel.ac.in/courses/108102045>

Course Code	Course Name
PE-BTE707	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. Explain the fundamental principles and fabrication techniques of CMOS technology. 2. Analyse digital circuits and memory components, including strategies for low power consumption. 3. Explore the design and simulation using Hardware Description Languages, with a focus on clocking and timing mechanisms.		
Course Content		
<i>Module No.</i>	<i>Details</i>	<i>Hrs.</i>
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.	06
3	MOS Circuit Design Styles: Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter. Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS. 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-Output circuits).	08
5	Low Power CMOS Circuits: Various components of power dissipation. CMOS, Limits on low power design, low power design through voltage Scaling.	04
6	VLSI Clocking: CMOS clocking styles, Clock generation, stabilization and distribution.	04
7	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

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.

E resources (if any):

<https://nptel.ac.in/courses/117106092>

Course Code	Course Name
PE-BTE721	Vehicular Systems and Control of EV Drives
Course pre-requisites	Electrical Machines-I and II, Power Electronics

Course Objectives		
The objectives of this course are 1. To explore and understand various traction motors, power drives and control strategies used in EVs. 2. To get conversant with the energy sources used in EVs and their state of the art. 3. To understand the various battery charging and management systems		
Course Outcomes		
Upon successful completion of this course, the learner will be able to: 1. Assess various traction motors along with their suitability in various EV segments. 2. Criticize various power converters and their control used in EV drives 3. Illustrate different battery charging methods and protocols and the impact of large scale integration of EV charging infra in existing grid. 4. Appreciate vehicle control unit for smooth operation & human safety as per regulatory standards		
Course Content		
Module No.	Details	Hrs.
1	Introduction to Traction Motors: DC Machines- Brushed and Brushless DC motors (BLDC); AC Motors: Induction motors (IM), permanent-magnet ac synchronous motor-surface-permanent-magnet (SPM) motors and interior-permanent-magnet (IPM) motors; PM Materials; Switched Reluctance Motor (SRM); Basic construction details and working principles of each of the machine. In-Wheel Motors ,Comparison of Traction Machines; Specifications of the motors, Characteristic Curves of a Machines: Constant-Torque Mode, Constant-Power Mode; Efficiency Map; Suitability of each machine in Electric vehicle domain for 2W, 3W, 4 wheeler and large size vehicles. Real life examples; Review of advancement in EV Motors and Drives.	8
2	Power Converters for EV drive: Power Conversion –Basic Principle, review of DC-DC converters, DC-AC Converters used in EV applications; Power converter topologies for IM, BLDC, PMSM and SRM motors. Modulation schemes: Sinusoidal Pulse Width Modulation, SPWM with third harmonic injection, Space vector modulation, comparison of modulation techniques. Converter / Inverter Loss calculation, Heat-sinking: passive and active cooling.	8
3	Control of Power Converters and Motors: Induction Motor Control: Variable-Voltage Variable-Frequency Control (VVVF), Field-Oriented Control (FOC), Direct Torque Control (DTC); PM Synchronous Motor Control: Field-Oriented Control of PMSM, Flux-Weakening Control of PMSM, Position Sensor-less Control of PMSM. SRM motor control: Current chopping control (CCC), Torque-Ripple Minimization Control BLDC Motor Control: Trapezoidal back EMF BLDC motor control	8
4	Battery charging Infrastructure: AC and DC charging, CC-CV charging, Pulse charging; On-board and off-board charging; Standards and protocols for charging;	8

	Fast DC chargers, Home and Public charging infrastructure; Wireless power transfer (WPT) technologies for EVs, Move-and-charge technology. Charging Infrastructure-standardization and connectivity issues; SAE J1772, CHAdeMo, GB/T, CCS2 battery charging protocols. OCPP protocol Impact on existing power grid, G2V and V2X- Vehicle-to-home (V2H), vehicle-to-vehicle (V2V), and vehicle-to-grid (V2G) energy systems. Renewable Energy Based Charging infra.	
5	EV Drive Cycle Testing: Need for a driving cycle, different Drive Cycles: New European Driving Cycle (NEDC), The Extra-Urban Driving Cycle (EUDC), EPA, WLTP, and FTP-75, Testing of EV for range per charge for a given drive cycle.	4
6	Vehicle Control Unit and Electronic Control Unit: VCU functionality: Inverter control, battery management, charging control, vehicle functions in transmission and engine control; Advanced Driver Assistance System (ADAS); Electronic control units (ECUs): Various Section ECUs and their networking; Body and Lighting ECU (Key-less Entry, Sonar, HID, LED Lamps), Body ECU (Airbag).	4
7	Regulatory standard and engineering standards for EV. Automotive Industry Standard (AIS) for electric vehicles in India (Some of the regulations are AIS038, 039, 040, 041, 048, and 049)	2

Text/Reference Books:-

1. Fundamentals And Applications Of Lithium-Ion Batteries In Electric Drive Vehicles by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
2. Battery Management Systems for Large Lithium-Ion Battery Packs, by Davide Andrea, Artech House Publication, 2010
3. Electric Vehicle Battery Systems by Sandeep Dhameja, Newens, 2002
4. Fundamentals And Applications Of Lithium-Ion Batteries In Electric by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
5. Optimal Charging Control of Electric Vehicles in Smart Grids by Wanrong Tang and Ying Jun Zhang, Springer, 2017
6. Plug In Electric Vehicles in Smart Grids Charging Strategies Edited by Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer 2015
7. Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles edited by Ottorino Veneri, Springer, 2017
8. Solar Powered Charging Infrastructure for Electric Vehicles A Sustainable Development Edited by Larry E. Erickson, Jessica Robinson, Gary Brase, and Jackson Cutsor, CRC Press, 2017
9. Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau, IET, 2016
10. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005

Course Code	Course Name
PE-BTE722	Distributed Generation and Micro-grid
Course pre-requisites	Power System
Course Objectives	
The objectives of this course are	
1. To illustrate the concept of distributed generation.	

2. To analyse the impact of grid integration. 3. To study concept of Micro grid and its configuration		
Course Outcomes		
Upon successful completion of the course, students should be able to 1. Articulate the structure of distributed generation with non-conventional energy resources. 2. Analyze the impact of grid Integration with renewable energy sources. 3. Classify and analyze different control and protection schemes for microgrid & distributed generations. 4. Assess challenges such as islanding, load sharing, and power quality issues.		
Course Content		
<i>Module No.</i>	<i>Details</i>	<i>Hrs.</i>
1	Introduction: Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro- turbines, biomass, and tidal sources. Distributed vs Central Station Generation Sources of Energy Distributed generations: Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547, DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra- capacitors, flywheels. Captive power plants	6
2	Impact of grid integration: Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.	06
3	Basics of a micro grid: Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro grids, Power Electronics interfaces in DC & AC micro grids.	06
4	Control and operation of micro grid: Modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro grid communication infrastructure	06
5	Impact of Distributed Generation on the Power System. Power Quality Disturbances. Power quality issues in micro grids, regulatory standards, Micro grid economics	04
6	Control of DG inverters, phase locked loops, current control and DC voltage control for standalone and grid parallel operations. Protection of the converter Relaying and protection: distributed generation interconnection relaying, sensing using CTs and PTs.	06
7	DG planning cost implications of power quality, cost of energy and net present value calculations and implications on power converter design. Economics of Distributed Generation-Case Studies	08

Reference Books:

1. Technical literature-papers published in power electronics related journals and IEEE standards.

2. Ned Mohan, Tore M. Undeland, William P Robbins, “Power Electronics: Converters, Application, and Design”. Wiley, 2002.
3. Ranjan Rakesh, Kothari D.P, Singal K.C, “Renewable Energy Sources and Emerging Technologies”, 2nd Ed. Prentice Hall of India ,2011
4. Math H. Bollen, Fainan Hassan, “ Integration of Distributed Generation in the Power System”, July 2011, Wiley –IEEE Press
5. Loi Lei Lai, Tze Fun Chan, “Distributed Generation: Induction and Permanent Magnet Generators”, October 2007, Wiley-IEEE Press.
6. Roger A. Messenger, Jerry Ventre, “Photovoltaic System Engineering”, 3rd Ed, 201

Course Code	Course Name
PE-BTE723	High Voltage Engineering
Course pre-requisites	Electromagnetic fields,

Course Objectives		
The objectives of this course are 1. To develop an understanding of the fundamental concepts related to high voltage phenomena and insulating media. 2. To explore methods used for the generation and measurement of high voltages and high currents. 3. To apply high voltage engineering principles to assess system behavior and protection mechanisms. 4. To analyze high voltage testing procedures and safety practices in accordance with engineering standards.		
Course Outcomes		
Upon successful completion of the course, students should be able to 1. Explain the physical principles and processes involved in high voltage engineering applications. 2. Demonstrate the ability to utilize appropriate methods and tools for high voltage generation and measurement. 3. Apply high voltage engineering concepts to evaluate insulation systems and assess system performance under electrical stress. 4. Analyze testing methodologies, standards, and safety procedures related to high voltage equipment and laboratories.		
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, Lightning Surges. Switching over voltages, Protection against over-voltages, Surge diverters, Surge modifiers.	07
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

Course Code	Course Name	
PE-BTE725	Digital Control Design	
Course pre-requisites	Control System, Digital Signal Processing	
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 discrete-time systems.		
3. Design and analyze digital controllers.		
4. Design state feedback and output feedback controllers.		
Course Content		
<i>Module No.</i>	<i>Details</i>	<i>Hrs.</i>
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	07
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.	07
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.	06
4	State Space Approach for discrete time systems State space models of discrete systems, solution to state space equations, State space analysis. Lyapunov Stability	05
5	State Space Approach for discrete time systems Controllability 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 Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator	05

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.	07
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For Self-study:

Text Books:

1. M. Gopal, “Digital Control and State Variable Methods”, 3/e McGraw Hill Higher Education, 2010

Reference Books

1. K. Ogata, “Discrete Time Control Systems”, 2/e, PHI, 2005
2. G. F. Franklin, J. D. Powell and M. L. Workman, “Digital Control of Dynamic Systems”, 3/e, Addison-Wesley, 1998.
3. B.C. Kuo, “Digital Control System”, 2/e, Holt, Rinehart and Winston, 1987

Course Code	Course Name	
PE-BTE726	Industrial Automation	
Course pre-requisites	Control System	
Course Objectives		
The objectives of this course are		
1. Understand architecture of industrial automation systems.		
2. Overview of industrial control systems.		
3. Learn elements of automation systems.		
4. Understand performance objectives of process automation.		
Course Outcomes		
Upon successful completion of the course, students should be able to		
1. Describe architecture and levels of Industrial Automation systems..		
2. Tune PID controller and interpret Process & Instrumentation diagrams.		
3. Identify and describe the components of an automation system including controllers, HMIs, IT infrastructure and communication protocols.		
4. Explain design methodologies and performance objectives 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 controller capabilities, Practical aspects, Tuning with reference to Process Control.	05
3	Process representation: P & I Diagrams and Interpretation, Functional or Process Block diagrams.	08
4	Performance objectives: Response times (At various levels) Availability Calculation for the System (MTBF & MTTR) Resolution, Linearity, Accuracy. 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.	06
6	Elements Industrial Automation (b) Higher level applications (MIS/MES/Optimization / ERP etc) IT Infrastructure (Servers, Work Stations, Engineering Stations, Gateways, FEP, Communication Networks) Protocols: 7 layer model, TCP/IP Ethernet, Modbus TCP/IP & RTU, - Profibus, IEC61850, BACNet , OPC etc	06

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. Simulation on PID controller tuning 3. DCS and PLC programs 4. MCQ examination / mini project *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		

For Self-study: DCS Programming

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, Thomas 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. Johnson, 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, Tti Chandigarh.

E resources (if any):

<https://archive.nptel.ac.in/courses/108/105/108105088/>
<https://ial-coep.vlabs.ac.in/>

Course Code	Course Name	
OE-BTE701	Image Processing	
Course pre-requisites	Signals and Systems	
Course Objectives		
1. To learn the fundamental concepts of Digital Image Processing 2. To learn low, Medium, High level image processing		
Course Outcomes		
Students will be able to 1. Explain formation of digital image, its modeling and the types. 2. Apply spatial domain image processing algorithms for image enhancement, image segmentation, binary image processing, image compression 3. Apply frequency domain image processing algorithms for image enhancement, image segmentation.		
Course Content		
Module No.	Details	Hrs.
1	Introduction: Background, Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System.s	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, Chain Code, Polygonal, Representation, Shape Number, Moments	06
5	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), (iii)	06
6	Binary Image Processing:	06

	Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling, Thinning and Thickening,	
7	Image Compression: Fundamentals – Coding Redundancy, Inter pixel 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 image formation	06

For Self-study: Image restoration, Coding of Image Processing Algorithms.

Text Book:

1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, 4/e, Pearson Education Asia, 2018

Reference Books

1. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing”, 1/e, Tata McGraw Hill Education Private Ltd, 2009,
2. Anil K. Jain, “Fundamentals and Digital Image Processing”, 3/e, Prentice Hall of India Private Ltd

Course Code	Course Name
OE-BTE702	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. Apply theoretical concepts of vector spaces to solve linear equations. 2. Analyze various properties such as rank, subspaces, norm, condition number, eigen value etc. of a given matrix. 3. Compare complexity of various matrix decomposition methods. 4. Solve least square problem with different matrix computation techniques 5. 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:	6

	a) Graphs, KCL and KVL b) Solving linear ODEs c) The geometry of gradient descent d) Best approximation e) Multi-agent systems.	
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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.

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	03
	Elementary Economic Analysis • Basics, Material Selection for a Product, Building Material Selection • Process Planning / Process Modification	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 Amount, Uniform Gradient Series Annual Equivalent Amount, Effective Interest Rate	03

	• 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

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| <ol style="list-style-type: none">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. |
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Reference Books

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| <ol style="list-style-type: none">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, Sullivan and Canada, “Engineering Economy”, Collier MacMilan Ltd., USA. |
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Course Code	Course Name	
OE-BTE704	Internet of Things	
Course pre-requisites		
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. Students are also able to design & develop IOT Devices.		
Course Outcomes		
Upon successful completion of the course, students should be able to		
1. Explain the concepts of Internet of Things & M2M communication.		
2. Classify wireless sensor network and IoT enabling technologies.		
3. Analyze various design methodologies for developing IoT applications in different domain.		
Course Content		
Module No.	Details	Hrs.
1	Introduction to IoT: Concepts, Terminology, components, characteristics, Requirements and Applications of IoT, Physical design of IoT,Logical design of IoT- Functional blocks of IoT, Communication models & APIs.	06
2	IoT & M2M: Machine to Machine – M2M architecture, applications of M2M, Difference between IoT and M2M, Software Define Network – three layer architecture, key elements of SDN, Network Function Virtualization (NFV).	06
3	Wireless Sensor Networks: Basics of Wireless sensor networks (WSN), WSN Topologies, WSN Applications, and WSN Node, Architecture components of WSN, Cyber Physical Systems, and Architectural components of CPS.	06
4	IoT Data Sensing and Processing: Sensors, Sensor Characteristics, Sensing Types, Sensing Consideration, Actuator, Actuator Types, Actuator Characteristics, Data Formats, Processing Topologies, Device Design and Selection Considerations.	06
5	Communication Technologies – Infrastructure Protocols, Discovery Protocols, Data Protocols, Identification Protocols, Device Management and Semantic Protocols.	06
6	IoT Platform Design Methodology: Purpose and Requirements specification for IoT platform design, operational view specification, application development.	06
7	Logical Design using Python: Python Data Types and Data Structures, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operations, Classes.	06

For Self-study: Case Study - Smart Agriculture, Smart Cities, and Smart Environment.

Text Books:

1. Vijay Madiseti, Arshdeep Bahga, “Internet of Things: A Hands-On Approach”, Orient Blackswan Private Limited - New Delhi; First edition, 2015.
2. Sudip Mishra, Anandrup Mukharjee, Ajit Roy, “Introduction to IoT” Cambridge University Press; First edition, 2022.

Reference Books:

1. Dieter Uckelmann et.al, “Architecting the Internet of Things”, Springer, 2011.
2. Ian R. Sinclair, “Sensors and Transducer”, Newnes; 3rd edition, 2000.
3. Charalampos Doukas , “Building Internet of Things with the Arduino”, Create space, 2002.

E resources (if any):

https://onlinecourses.nptel.ac.in/noc22_cs96/preview

Course Code	Course Name	
OE-BTE705	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. Explain 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 Agent	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 heuristic 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	Knowledgebased Agents, The Wumpus World, Forward chaining, backward Chaining, Knowledge Engineering in First-Order Logic, Unification, Resolution, Introduction to logic programming (PROLOG).	10

	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

For Self-Study : Propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL

Term work shall include assignments and develop programs to verify different algorithms.

Text Books

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach "Fourth Edition" Pearson Education.
2. Saroj Kaushik "Artificial Intelligence" ,Cengage Learning.

Reference Books

1. George F Luger "Artificial Intelligence" Low Price Edition, Sixth edition, Pearson Education.
2. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Fourth Edition, Pearson Education.
3. Elaine Rich and Kevin Knight "Artificial Intelligence" Third Edition, Mc Graw Hill.
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

Course Code	Course Name
PR-BTE701	Project
Course pre-requisites	All courses till semester VI
Course Objectives	
1. Apply multidisciplinary engineering knowledge to identify, analyze, and propose effective solutions for real-world electrical engineering problems. 2. Design and develop electrical systems or prototypes using appropriate tools, technologies, and engineering principles. 3. Demonstrate teamwork, project management, and communication skills through collaborative execution and structured reporting of the project. 4. Understand professional, ethical, and societal responsibilities while considering sustainability and lifelong learning in engineering practices.	
Course Outcomes	
Upon successful completion of the course, students should be able to 1. Apply basic principles, modern techniques and/or IT tools, experimental/lab data for analysis and solving of the identified problem. 2. Design, simulate, and implement electrical or interdisciplinary systems using modern engineering tools and technologies. 3. Demonstrate effective teamwork, project planning, and technical communication skills through well-documented project reports, presentations, research publications and collaborative work. 4. Exhibit awareness of ethical practices, sustainability, and societal impact in the execution of engineering projects, while engaging in independent learning and continuous improvement.	



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: 2026-2027

List of Courses

PE-BTE801 Energy Storage and Vehicle Management System

PE-BTE802 Modelling and Analysis of Electrical Machine

PE-BTE803 Computer Aided Power System Analysis

PE-BTE804 Advanced Techniques in Power System Protection

PE-BTE805 Smart Grid

PE-BTE806 Non-linear control system

PE-BTE807 Robotics

OE-BTE801 Project Management

OE-BTE802 Computer Network

OE-BTE803 Lean Management

Note: Above courses will be in online mode.

Course Code	Course Name
PE-BTE801	Energy storage and Vehicle Management System
Course pre-requisites	Basics of Batteries, Basic Sensors

Course Objectives		
1. To get conversant with the energy sources used in EVs and their state of the art. 2. To understand the various battery charging and management systems		
Course Outcomes		
Upon successful completion of this course, the learner will be able to: 1. Evaluate the battery specifications using various design considerations for EVs 2. Estimate heat generation and suggest thermal management systems. 3. Integrate different subsystems for electrical vehicles and their management. 4. Illustrate the importance of actuators in modern automotive system.		
Course Content		
Module No.	Details	Hrs.
1	Energy Sources for EV: Overview of energy sources for electric vehicle: Batteries, Fuel Cell, Ultra-capacitor and flywheel energy storage; Hybridization of energy sources for electric and hybrid vehicles; Comparison of sources. Batteries: Lead-acid battery, Nickel-based batteries, Sodium based batteries, lithium batteries, Metal/air batteries	08
2	Battery parameters, Battery pack formation and testing, SoC & SoH, Estimation of SoC. Battery cell balancing, Battery management System (BMS), Thermal and safety considerations in battery pack design. Battery cell packaging, Design of battery pack and safety considerations, High voltage cabling and cut-outs, Battery pack installation. Use of Battery-UC Hybrid source, Fuel Cell (FC): FC management and Hydrogen storage in EV. Voltage and AHr/ kWhr ratings of ES for EV applications: Major design considerations	06
3	Thermal Management System: Heat Calculation in various subsystems; HVAC system: HVAC compressor drive; Liquid cooling system for Battery, Electric drive and on board charger. Design considerations for thermal management system	06
4	System Integration and Implementation: Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodologies for	06

	Optimization, Cost Function Optimization, Benefits of Energy Management.	
5	Braking Systems: Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Series Brake-Optimal Feel, Series Brake-Optimal Energy Recovery; Parallel Brake; Antilock Brake System (ABS); Fundamentals of Regenerative Braking. Steering System: In-car system networking, Steering ratio characteristic, Steering Stabilization, Over-steer, understeer, Electric-Power-Assisted Steering (EPAS); Autonomous vehicles, Principle of object detection.	06
6	Automotive sensors / actuators and networking: Radar Sensor Detectors for Vehicle Safety Systems; Airborne Ultrasonic Imaging: SONAR Based Image Generation for Autonomous Vehicles, Motor angle sensor, Steering angle sensor, acceleration pedal sensor and break pedal sensor, Tyre Pressure Monitoring Systems (TPMS); In Vehicle communication system: CAN, LIN, Ethernet, Flexray	06
7	Recent trends in energy storage in Electric Vehicles. Energy storage alternatives for EVs.	04

Text/Reference Books:-

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi, Wiley, 2018.
2. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
3. Encyclopaedia of Automotive Engineering edited by David Crolla *et al.*, Wiley, 2014
4. Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach by Amir Khajepour, Saber Fallah and Avesta Goodarzi, Wiley, 2014.
5. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Second Edition Chris Mi and M. Abul Masrur, Wiley 2018.
6. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies edited by Nicu Bizon, Lucian Dascalescu and Naser Mahdavi Tabatabaei, Nova Publishers, 2014
7. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer, 2013
8. Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies, by Bogdan Ovidiu Varga, Calin Iclodean and Florin Mariasiu, Springer, 2016.

Course Code	Course Name
PE-BTE802	Modeling and Analysis of Electrical Machines

Course pre-requisites	Electrical Machines I and II
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Course Objectives		
The objectives of this course are 1. To understand the representation electrical machines by the set of mathematical equations. 2. To realize the real behaviour of electrical machines. 3. To study the concepts of space phasors and frame transformation		
Course Outcomes		
Upon successful completion of the course, students should be able to 1. Implement the mathematical representation of electrical machines. 2. Demonstrate the reference frame theory and its application for representation of induction machine model. 3. Analyse the behaviour of induction machine from its mathematical model		
Course Content		
Module No.	Details	Hrs.
1	Magnetically Coupled Circuits: Coupled Circuit with and without Leakage Linear Magnetic System, Nonlinear Magnetic System, Computer Simulation of Coupled Circuits with and without leakage	5
2	Electromechanical Energy Conversion: Energy Relationship, Energy in Coupling Fields, Graphical Interpretation of Energy Conversion, Electromagnetic and Electrostatic Forces and Torques, Steady State and Dynamic Performance of and Electromechanical System	6
3	Machine Windings and Air Gap EMF, Winding Inductances and Voltage Equations: Synchronous Machine, Induction Machine	5
4	Reference Frame Theory: Introduction, Equations of Transformation Change of Variables, Stationary Circuit Variables, Transformed to the Arbitrary Frame, Resistive Elements, Inductive Elements, Capacitive Elements, Commonly used Reference Frame, Transformation between Reference Frames, Transformation of a Balanced Set, Balanced Steady State Phasor Relationships, Balanced Steady State Voltage Equations, Variables Observed from Several Frame of Reference	8

5	Theory of Symmetrical Induction Machines: Voltage Equations in Machine Variables, Torque Equations in Machine Variables, Equations of Transformation for Rotor Circuits, Voltage Equations in Arbitrary Reference Frame Variables	5
6	Symmetrical Induction Machines Steady State and Dynamic Characteristics:	8
	Analysis of Steady State Operation, Free Acceleration Characteristics, Free Acceleration Characteristics Viewed from Various Reference Frames, Dynamic Performance during Sudden Changes in Load Torque, Dynamic Performance during a Three Phase fault at Machine Terminals	
7	Introduction to Synchronous Machine Theory: Voltage Equations in Machine Variables, Torque Equations in Machine Variables, Stator Voltage Equations in Arbitrary Reference Frame Variables, Voltage Equations in Rotor Reference Frame Variables- Parks Equations, Torque Equation in Substitute Variables, Rotor Angle and Angle between Rotors.	5

Term Work	
Term work shall comprise of	
1. Tutorials based on each module in the syllabus content 2. MCQ examination	
Text Books	
1. R. Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", Prentice Hall of India 2015. 2. P. C. Krause, "Analysis of Electrical Machinery and Drive System," Wiley IEEE Press, Third edition, 2013	
Reference Books	
1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans, "Electric Machinery", Tata McGraw Hill, Seventh edition, 2013. 2. Ned Mohan, "Advanced electrical drives Analysis, Control and Modeling using Simulink", Wiley, 2014.	

Course Code	Course Name	
PE-BTE803	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. Apply numerical techniques, matrix computation and optimization in the field of power system 2. investigate the behavior of power system under different operating conditions with software aid. 3. analyze the power system under symmetrical and unsymmetrical fault condition using Zbus 4. evaluate state of the complex power system by various state estimation tools. 5. interpret simulation/program results to make informed decisions regarding system planning, operation, and control.		
Course Content		
Module No.	Details	Hrs.
1	Mathematical concepts: 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 matrix formation, 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	8

	average, trend & periodic components, time series approach, kalman filter approach, long 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 state estimation	6
7	Security Analysis: Basic Concepts, Static Security Analysis at Control Centre, Contingency Analysis, Contingency Selection.	6

For Self-study: Sparse Matrices: Sparsity directed Optimal Ordering Schemes, Solution Algorithms – LU Factorization

Text Books:

5. Saadat Hadi, “Power System Analysis, “TMH Publication.
6. Kothari D. P Nagrath I. J., “Modern Power System Analysis”, TMH Publications.

Reference Books:

1. A. R. Bergen and Vijay Vittal, “Power system analysis”, (2nd edition), Pearson Education Asia, 2001.
2. J. D. Glover and M. Sarma, “Power System Analysis and Design “, (3rd Edition), Brooks/ Cole Publishing, 2002

E resources (if any):

Forecasting: Principles & Practice by Rob J. Hyndman & George Athanasopoulos
<https://otexts.com/fpp3/>

Introduction to Time Series and Forecasting

<https://link.springer.com/book/10.1007/978-3-319-29854-2>

<https://www.gridlabd.org/>

<https://smartgrid.ieee.org/bulletins/may-2021/multi-agent-openss-an-open-source-and-scalable-distribution-grid-platform>

Course Code	Course Name	
PE-BTE804	Advanced Techniques in Power System Protection	
Course pre-requisites	Power system, 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 will be able to		
1. Analyze & review the operating principles and characteristics of advanced protection relays including Numerical relay.		
2. Design protection schemes for transmission lines, transformers, and synchronous generators, using advanced relaying techniques.		
3. Evaluate adaptive and wide-area protection schemes for modern power systems, including the use of synchro-phasors and PMUs.		
4. 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:	4

	WAMS architecture, WAMS based out of step relaying, supervision of back up zones, Intelligent load shedding, and Intelligent islanding.	
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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

Course Code	Course Name	
PE-BTE805	Smart Grid	
Course pre-requisites	Power System, Distributed Generation and micro-grid	
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. Explain the concept and significance of smart grid in modern power systems. 2. Identify and describe the key components and technologies used in smart grid infrastructure. 3. Analyze the operation of microgrid, integration of distributed energy resources, and approaches for power quality management. 4. Evaluate the role of communication technologies and cybersecurity in the effective functioning of smart grids.		
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 pricing, 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	06

	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.	
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	
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.	
Reference Books	
1. Jean Claude Sabonnadière, NouredineHadjsaid, “Smart Grids”, Wiley Blackwell. 2. Peter S. Fox, Penner, “Smart Power – Climate Changes, the Smart Grid and the Future of Electric Utilities”, Island Press, 1st Edition 8th June 2010. 3. Stuart Borlase, “Smart Grids (Power Engineering)” CRC Press. 4. S.Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, Institution of Engineering and Technology, 30th June 2009.	

Course Code	Course Name	
PE-BTE806	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. Analyze the behavior of nonlinear control systems and identify common physical nonlinearities.		
2. Apply phase plane analysis to study the dynamics of linear and nonlinear systems.		
3. Use Lyapunov’s direct method to assess system stability and perform control design.		
4. Apply describing function technique to evaluate the stability of nonlinear systems.		
5. Design control strategies for nonlinear systems using feedback linearization and Lyapunov-based approaches.		
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

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|---|
| <ol style="list-style-type: none">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 Learning4. 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] |
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Course Code	Course Name
PE-BTE807	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. Explain the significance of robotic arms and their applications in industrial automation.
2. Apply control system theory to understand and manage the behavior of robotic arm.
3. Describe kinematic and dynamic models of robotic arm.
4. Analyze the principles of path planning, task planning, and trajectory generation in robotic systems.

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	06

	Task level programming, Uncertainty, Configuration space, Gross motion Planning, Grasp planning, Fine-motion Planning, 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.

Course Code	Course Name	
OE-BTE801	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, - Power and interest grid, stakeholders engagement assessment matrix	03
7	Professional and Social Responsibility Project management traits in professional and social responsibility,	05

	• Code of Ethics and Professional conduct w. r. t. responsibility, respect, fairness, honesty. Project Management Case Study / Activity	
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Text Books	
2. Rita Mulcahy, “PMP Exam Prep”, Eight Edition, RMC Publications, Inc., 2013. 3. Kalpesh Ashar, “Project Management – Essentials You Always Wanted to Know”, Vibrant Publishers, 2012. 4. 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.	

Course Code		Course Name
OE-BTE802		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. Describe the layered architecture, functions, and protocols of the OSI and TCP/IP models. 2. Analyze network addressing, routing algorithms, and transport layer functionalities. 3. Apply networking principles to demonstrate the operation of application layer protocols.		
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, Internet. 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 Ethernet- frame, addressing	07
5	Network layer: 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.	08

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

Course Code		Course Name
OE-BTE803		Lean Management
Course pre-requisites		
Course Objectives		
The objectives of this course are 1 Building Customer first framework 2 Visualizing invisible work 3 Identifying and Eliminating waste 4 Deploying specific methodologies to stabilize and improve processes 5 Learning how to overcome resistance to new ways of working		
Course Outcomes		
Upon successful completion of the course, students should be able to 1 Improve observation skills, identify subtle details that others miss leading to greater productivity in professional settings 2 Identify and eliminate non value adding activities 3 Do visual mapping of workflows and identify bottlenecks and inefficiencies. 4 Implement Heijunka planning to transform erratic demand-driven production into a stable, predictable, and efficient workflow.		
Course Content		
Module No.	Details	Hrs.
1	Fundamentals of Lean thinking Introduction to Lean principles history (TPS - Toyota Production System), and the difference between mass production and Lean	05
2	Observation Skills Problem solving approach, Label writing and scrubbing, Making symbol words, System Dynamic model	06
3	Waste identification Identifying and reducing eight types of wastes.	04
4	Introduction to Visual Stream Mapping in lean manufacturing Definition and purpose, The “value stream” concept, origins: material and information flow, benefits, VSM vs process mapping	03
5	VmapQ, Vmap 1 and Vmap3 Making VMapQ, Limitations of VmapQ, Making Vmap1 , Elements of standardized work, Vmap3	12
6	Heijunka Planning and control	09

	Principles and objectives of Heijunka, Steps in Heijunka planning: PQ chart, Workload calculation, Frame and production sequence pattern, Five check points of daily management, Delay recovery management, Concept of Standardized work: Standardized Work Chart and Standardized Work Combination Table	
7	Lean Leadership Leadership Dimensions, 16 personality tests, Leader's perspective on Lean implementation.	03

Reference Books	
1The TOYOTA way: 14 management principles from world's greatest manufacturer 2nd Edition 2021 by Jeffry K. Liker 2Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System First Edition 2015 by Pascal Dennis 3 Lean Manufacturing Book- Implementation made easy First edition 2021, by M. K. Khanduja	