# SAVITRIBAI PHULE PUNE UNIVERISTY, PUNE

## Faculty of Science and Technology

### Board of Studies

## Electrical Engineering

### Syllabus

## Final Year Electrical Engineering (2019 Course) (w.e.f. 2022-2023)

# BE Electrical (2019 Course)

## SEM-I

| Course Code | Course Name | Teaching Scheme | | | | Examination Scheme | | | | | | Credit | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Th | Pr | Tu | PW | ISE | ESE | TW | PR | OR | Total | Th | Pr | Tu | PW | Total |
| 403141 | Power System Operation & Control | 3 | 2 | – | – | 30 | 70 | 25 | – | 25 | 150 | 3 | 1 | – | – | 4 |
| 403142 | Advanced Control System | 3 | 2 | – | – | 30 | 70 | – | – | 50 | 150 | 3 | 1 | – | – | 4 |
| 403143 | Elective-I | 3 | 2 | – | – | 30 | 70 | – | – | 25 | 125 | 3 | 1 | – | – | 4 |
| 403144 | Elective-II | 3 | – | 2* | – | 30 | 70 | 25 | – | – | 125 | 3 | – | 1 | – | 4 |
| 403145 | Project Stage-I | – | – | – | 4 | – | – | 50 | – | 50 | 100 | – | – | – | 2 | 2 |
| 403146 | MOOCs | – | – | – | – | – | – | 50 | – | – | 50 | – | – | – | 2 | 2 |
| 403147 | Audit Course-VII | 2# | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Total** | | **12** | **6** | **2** | **4** | **120** | **280** | **150** | **–** | **150** | **700** | **12** | **3** | **1** | **4** | **20** |

| 403143: Elective-I | 403144: Elective-II | 403147: Audit Course-VII |
|---|---|---|
| 403143A: PLC and SCADA<br>403143B: Power Quality Management<br>403143C: High Voltage Engineering<br>403143D: Robotics and Automation | 403144A : Alternate Energy System<br>403144B : Electrical & Hybrid Vehicle<br>403144C : Special-purpose Machines<br>403144D: HVDC & FACTS | 403147 A: German Language I<br>403147B: Engineering Economics I<br>403147C: Sustainability(IGBC) |

## SEM-II

| Course Code | Course Name | Teaching Scheme | | | | Examination Scheme | | | | | | Credit | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Th | Pr | Tu | PW | ISE | ESE | TW | PR | OR | Total | Th | Pr | Tu | PW | Total |
| 403148 | Switchgear and Protection | 3 | 2 | – | – | 30 | 70 | 25 | – | 50 | 175 | 3 | 1 | – | – | 4 |
| 403149 | Advanced Electrical Drives & Control | 3 | 2 | – | – | 30 | 70 | 25 | 50 | – | 175 | 3 | 1 | – | – | 4 |
| 403150 | Elective-III | 3 | – | – | – | 30 | 70 | – | – | – | 100 | 3 | – | – | – | 3 |
| 403151 | Elective-IV | 3 | – | – | – | 30 | 70 | – | – | – | 100 | 3 | – | – | – | 3 |
| 403152 | Project stage II | – | – | – | 12 | – | – | 100 | – | 50 | 150 | – | – | – | 6 | 6 |
| 403153 | Audit course VIII | 2# | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Total** | | 12 | 4 | – | 12 | 120 | 280 | 150 | 50 | 100 | 700 | 12 | 2 | – | 6 | 20 |

| 403150: Elective-III | 403151: Elective-IV | 403153: Audit Course-VIII |
|---|---|---|
| 403150 A : Digital Control System<br>403150 B : Restructuring and Deregulation<br>403 150 C: Smart Grid<br>403150 D: SensorTechnology (Open Elective) | 403151A: EHV AC Transmission<br>403151B : Illumination Engineering<br>403151C: Electromagnetic Fields<br>403151D: AI and ML (Open Elective) | 403153A: German Language II<br>403153B: Engineering Economics II<br>403153C: Green Building |

*** For the tutorial, one credit is given. # Audit Course: Conduct over and above these lectures.**

# 403141: Power System Operation and Control

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 25 |
| | | | | | Term work | 25 |

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## Course Objectives:

This course aims to:

1. Study the different types of angle, voltage and frequency stability of the power system and methods to improve the stability of the power system.
2. Impart knowledge about various advanced controllers such as FACTs controllers with its evolution, principle of operation, circuit diagram and applications.
3. Introduce frequency control in a single area and two area system.
4. Understand the formulation of unit commitment and economic load dispatch.
5. Illustrate various ways of interchange of power between interconnected utilities.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Summarize angle, voltage and frequency stability in the power system control (UN).
CO2: Illustrate various ways of interchange of power between interconnected utilities (AP).
CO3: Analyze stability and optimal load dispatch using different techniques (AN).
CO4: Select appropriate FACTS devices for stable operation of the system (EV).
CO5: Evaluate the stability of the system and suggest the methods to improve it (EV).

| | | |
|---|---|---|
| Unit 01 | **Power System Stability (Angle Control):**<br>Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and reclosure ), methods to improve steady state and transient stability, numerical based on equal area criteria. | 08 hrs |
| Unit 02 | **Reactive Power Control:**<br>The necessity of reactive power control, production and absorption of reactive power, reactive power requirements for power factor control and voltage regulation and the loading capability curve of a synchronous generator, types of FACTS controller.<br>**Series compensation:** reactor and capacitor, TCSC, SSSC.<br>**Shunt compensation:** reactor and capacitor, STATCOM, FC-TCR.<br>**Series and shunt compensation:** UPFC.<br>(FACTS devices: working principle, circuit diagram, VI characteristics, applications) | 08 hrs |
| Unit 03 | **Automatic Generation Control (Frequency Control):**<br>Introduction to the concept of AGC; complete block diagram representation of load-frequency control of an isolated power system; steady state and dynamic response; | 08 hrs |

| | | |
|---|---|---|
| | control area concept; two-area load-frequency control; Schematic and block diagram of the alternator voltage regulator scheme. | |
| Unit 04 | **Economic Load Dispatch and Unit Commitment (Cost Control):**<br>● **Part A: Economic load dispatch:** Introduction, revision of cost curve, incremental cost curve of thermal, method of Lagrange multiplier, exact coordinate equation (penalty factor), economic scheduling of thermal plant considering effect of transmission losses using Bmn coefficient.<br>(Numerical on method of Lagrange multiplier, penalty factor, Bmn coefficient)<br>● **Part B: Unit commitment:** Concept of unit commitment, constraints in unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming, Numerical on priority list and dynamic programming method. | 08 hrs |
| Unit 05 | **Energy Control:** Interchange of power between interconnected utilities (numerical), economic interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools. | 06 hrs |
| Unit 06 | **Voltage Stability:**<br>Basic concepts related to voltage stability: transmission system characteristics (PV curve), generator characteristics (QV curve), and load characteristics.<br>Voltage collapse, classification of voltage stability, static and dynamic stability, analysis techniques for dynamic voltage stability, voltage stability indexing. | 07 hrs |

## Text Books:


| | |
|---|---|
| [T1] | I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", 4th Edition, Tata McGraw Hill Publishing Co. Ltd. (Edition 2) |
| [T2] | T. J. E. Miller, "Reactive power control in electric systems," Willey. |
| [T3] | Hadi Saadat, "Power System Analysis," Tata McGraw's Hill |
| [T4] | S. Sivanagaraju, G. Sreenivasan, "Power System Operation and Control," Pearson Education India, 2009. |
| [T5] | P. S. R. Murthy, "Power System Operation and Control," Tata McGraw-Hill Publishing Co., Ltd. |
| [T6] | Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control," Prentice Hall of India. |
| [T7] | Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTs," IEEE Press. |
| [T8] | Dr. B.R. Gupta, "Power System-Analysis and Design", S. Chand Publication. |


## Reference Books:


| | |
|---|---|
| [R1] | Allen J. Wood and Bruce F. Wollenberg, "Power Generation, Operation, and Control," Wiley India Edition. |
| [R2] | R. Mohan Mathur, Rajiv K. Varma, "Thyristor based FACTS controller for electrical transmission systems", by John Wiley and Sons, Inc. |

| | |
|---|---|
| [R3] | Olle I. Elgerd, "Electrical Energy System Theory", 2nd Edition, Tata McGraw-Hill Publishing Co. Ltd. |
| [R4] | Dr. K. Uma Rao, "Power System Operation and Control," Wiley India |
| [R5] | Prabha Kundur, "Power System Stability and Control," Tata McGraw's Hill |
| [R6] | "Electrical Power System Handbook", IEEE Press |
| [R7] | James Momoh, "Smart Grid: Fundamentals of design and analysis," Wiley, IEEE Press |

Online Resources:

| | |
|---|---|
| [O1] | https://www.youtube.com/playlist?list=PL86E9AC8CFBA00ADB |
| [O2] | https://onlinecourses.nptel.ac.in/noc19_ee62/preview |
| [O3] | https://www.youtube.com/watch?v=uy9lZCdkQIM&list=PLD4ED2FAF3C155625 |
| [O4] | http://nptel.ac.in/courses/108101040/ (PSOC webcourse) |
| [O5] | https://nptel.ac.in/courses/108101004 |
| [O6] | https://onlinecourses.nptel.ac.in/noc21_ee16/preview |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1, T3, T6, T8 | R4, R5 |
| 02 | T2, T4, T7 | R2, R4 |
| 03 | T1, T3, T4, T5 | R1, R3, R4, R5 |
| 04 | T1, T3, T4 | R1, R4 |
| 05 | T1 | R1 |
| 06 | T8 | R4, R5, R7 |

**List of Experiments:**

A)The following experiments are ***compulsory***:

1. To apply equal area criteria for stability analysis under a fault condition (three-phase fault at the middle point of a parallel transmission line).
2. To study the Lagrange multiplier technique for economic load dispatch (to find the optimal loading of generators).
3. To study load frequency control using an approximate and exact model.
4. To study reactive power compensation using STATCOM.

B) From the following list, perform ***any four*** experiments.

5. To solve the Unit Commitment problem by priority list method/ dynamic programming (DP) approach
6. Plot a swing curve using the point-by-point/4th order Runge-Kutta method.

7. To apply equal area criteria for analysis stability under a sudden rise in mechanical power input.
8. To study load frequency control with proportional and integral control.
9. To study the two area of load frequency control.
10. To study reactive power compensation using simulation of TCR or TCSC.
11. To study the optimum loading of generators considering transmission losses (penalty factor).

**Guidelines for the Instructor's Manual:**

- The Instructor's Manual should contain the following things related to every experiment:
- Specify prerequisite and objective(s) of experiment
- Include a circuit diagram with specifications (for hardware experiments).
- A related theory of the experiment must be included.
- The circuit diagram of the experiment should be drawn at the beginning.
- For simulation experiments using MATLAB/EMTP, the Simulink diagram with proper details must be included in the write up. For programming, take a printout of the program and the result.
- A conclusion based on calculations, results, and graphs (if any) should be written.

**Industrial Visit:**

An industrial visit is mandatory to the Load Dispatch Center/Power Station Control Room.

**Guidelines for Students' Lab Manual:**

- Students should write the journal in their own handwriting, particularly the results, diagrams, conclusions, questions, answers, etc.
- A circuit or connection diagram or construction diagram must be drawn either manually using or using software on graph paper.
- Handwriting and figures must be neat and clean.

**Guidelines for Laboratory Conduction:**

- Do the continuous assessment. The experiments performed in a particular week must be checked in the next turn in next week.
- During assessment, the teacher should make the remark by writing the word "Complete" and not simply "C". Put the signature along with the date at the end of the experiment and in the index.

# 403142: Advanced Control System

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 50 |

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## Prerequisite:

Control System Engineering, Matrix Algebra, Z-transform, and Laplace transform.

## Course Objectives:

This course aims to:

1. Introduce concepts of modern control theory, analysis, and design.
2. Provide an overview of the digital control system and nonlinear control system.
3. Explore advanced control techniques at an introductory level.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Explain compensation networks, common nonlinearities, the concept of state, sampling and reconstruction, and concepts of advanced controls (Understanding)
CO2: Determine transfer function from state model (Applying)
CO3: Test controllability and observability properties of the system (Evaluating)
CO4: Design compensators, state feedback controls, and observers for the system (Creating)

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|---|---|---|
| Unit 01 | Compensator Design in Frequency Domain | 06 hrs |

approach to control system design, cascade compensation networks, phase-lead and phase-lag compensator designs using bode plot, physical realization of compensators.

| | | |
|---|---|---|
| Unit 02 | Nonlinear Control Systems | 07 hrs |

introduction to nonlinear systems, common nonlinearities, describing function method, describing function of an ideal relay, stability analysis with describing function, introduction to Lyapunov stability analysis (basic concepts, definitions, and stability theorem)

| | | |
|---|---|---|
| Unit 03 | Introduction to State-Space | 08 hrs |

Concept of state, state-space representation of dynamical systems in physical variable form, phase variable forms and Jordon / diagonal canonical form, conversion of the transfer function to state-space model and vice versa, state equation and its solution, state transition matrix and its properties, computation of state transition matrix by Laplace transform and Caley Hamilton method.

| | | |
|---|---|---|
| Unit 04 | State-Space Design | 08 hrs |

| | | |
|---|---|---|
| The concept of controllability and observability, Kalman's and Gilbert's tests for controllability and observability, effect of pole-zero cancellation, duality property, control system design using pole-placement using transformation matrix, direct substitution, and Ackermann's formula, State observers, design of a full-order observer. | | |
| Unit 05 | Introduction to Digital Control System | 08 hrs |
| Basic block diagram of the digital control system, sampling and reconstruction, Shannon's Sampling theorem, zero-order hold and its transfer function, First-order hold (no derivation), characteristics equation, mapping between s-plane and z-plane, stability analysis in z-plane. | | |
| Unit 06 | Advanced control system topics | 08 hrs |
| Concept of sliding mode control, equivalent control, chattering, sliding mode control based on reaching law, Introduction to adaptive control, adaptive schemes, and control problems Optimal control-linear quadratic regulator problem. | | |

## Text Books:

| | |
|---|---|
| [T1] | Norman S. Nise, *Control System Engineering*, Sixth Edition, John Wily and Sons, Inc. 2011. |
| [T2] | Richard C. Dorf, Robert H. Bishop, *Modern Control Systems*, Twelfth Edition, Pearson Education. |
| [T3] | Benjamin C. Kuo, *Digital Control System*, Second Edition, Oxford University Press, 2003. |
| [T4] | I. J. Nagarath, M. Gopal, *Control System Engineering*, Fourth Edition, New Age International (P) Limited, Publishers |
| [T5] | A. Nagoor Kani, *Advanced Control Theory*, Third Edition, CBS Publishers and Distributes, 2020. |

## Reference Books:

| | |
|---|---|
| [R1] | Katsuhiko Ogata, *Modern Control Engineering*, Fifth Edition, Prentice-Hall, 2010. |
| [R2] | M. Gopal, *Digital Control and State Variable Methods*, Tata McGraw-Hill. |
| [R3] | K. Ogata, *Discrete-Time Control System*, Second Edition, PHI Pvt. Ltd. 2006 |
| [R4] | M. Gopal, *Modern Control Systems Theory*, Second Edition, New Age International (P) Limited, Publishers |
| [R5] | Karl J. Åström, Björn Wittenmark, *Adaptive Control*, Second Edition, Dover Publications, Inc. New Yark |
| [R6] | C Edwards, Sarah K. Spurgeon, S Spurgeon, *Sliding Mode Control: Theory And Applications*, Taylor and Francis, 1998 |
| [R7] | Jean-Jacques E. Slotine, Jean-Jacques E.. Slotine, Weiping Li, *Applied Nonlinear Control*, Prentice Hall, 1991. |

## Online Resources:

| | |
|---|---|
| [O1] | https://nptel.ac.in/courses/108102043 |
| [O2] | https://nptel.ac.in/courses/108102113 |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1 | R1 |
| 02 | T4, T5 | R4 |
| 03 | T2 | R1 |
| 04 | T2 | R1 |
| 05 | T3 | R2,R3 |
| 06 | T2,T3 | R4,R5,R6 |

## List of Experiments:

[Perform any 8 experiments using any simulation software]

1. Simulation of a lead or lag compensator for a given system and comparison of compensated and uncompensated systems responses.
2. Simulation of the closed-loop system with ideal real as a nonlinearity.
3. Software program for determining a state-space model for a given transfer function and vice versa.
4. Software program for determining the state transition matrix.
5. Software program for checking the observability and controllability of a given system.
6. Simulation of state feedback control design using software.
7. Simulation of a full-order observer-based state feedback control system.
8. Effect of sampling and verification of sampling theorem by simulation.
9. Converting a continuous-time system to a discrete-time system and checking the response using the software.
10. Design of a linear quadratic regulator for a given system using simulation.

## Industrial Visit:

Industrial visit to a process industry or control and automation industry

## Guidelines for the instructor's manual:

Guidelines for the instructor’s manual are given below:

- It should have a title, learning outcomes, aim, software requirement, theory, the problem with the solution, simulation results, comparison (result table, if any), and conclusion.
- All the experiments should have at least one numerical problem, which should be solved analytically, then it should be verified by the simulation. For that matter, theory can be restricted to only definitions and concepts (no detailed explanation).
- Simulation printouts should have readable and self-explanatory block diagrams and figures.
- To develop a proper understanding of all the experiments, it is suggested to take figures with the same physical system (or numerical problem) for all the experiments.

## Guidelines for Student’s Lab Manual:

Guidelines for the students' lab manual are given below.

- Students should write the theory, the problem with a solution, and the conclusion on their own in their own handwriting.
- Students should write a program on their own and should compare analytical and simulated results.
- Students should try using different values of the parameters in the numerical problem and should observe the changes in the results.
- Hand writing must be clean and neat.

## Guidelines for Laboratory Conduction:

Guidelines for laboratory conduction are as follows:

- At the beginning, the instructor should state the learning outcomes of the experiment and should provide a problem statement to the students.
- Students should solve the problem and then simulate the experiment.
- To have variations in the numerical problem, different parameters can be set for different students.

# 403143A: PLC and SCADA

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 25 |

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## Course Objectives:

This course aims to:

1. To make the students understand the fundamentals of automation and various automation systems used in the industry, such as PLC.
2. To provide knowledge levels needed for PLC programming and operating.
3. To develop the architecture of SCADA, explaining each unit in detail.
4. To apply knowledge gained about PLCs and SCADA systems to real-life industrial applications.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Develop and explain the working of a PLC with the help of a block diagram.
CO2:Classify input and output interfacing devices with PLC.
CO3:Design PLC based application by proper selection criteria, developing GUI and ladder program.
CO4:Execute, debug, and test the programs developed for digital and analog operations.
CO5:Develop the architecture of SCADA and explain the importance of SCADA in critical infrastructure.
CO6:Describe the SCADA protocols and digital control systems, along with their architecture for automation.

| | | |
|---|---|---|
| Unit 01 | Introduction to PLC | 07 hrs |

Role of automation in Industries, benefits of automation, Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers' Association), types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces), CPU, programmers and monitors, power supplies, selection criterion, advantages and disadvantages, specifications, comparison of various PLCs manufactured by Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.

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|---|---|---|
| Unit 02 | Interfacing of PLC with I/O devices | 08 hrs |

Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices Sensors-temperature, pressure, flow, level Actuators-Electrical, pneumatic, hydraulic Encoders-Incremental, Absolute Transducers, Limit switches, proximity sensors Control Elements- Mechanical, Electrical, Fluid valves

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|---|---|---|
| Unit 03 | Programming of PLC | 08 hrs |

Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of ladder diagram Timer and counter- types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF, Tank

| | | |
|---|---|---|
| level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller. | | |
| Unit 04 | Advance function and Applications of PLC | 08 hrs |
| Analog PLC operation and PLC analog signal processing, PID principles, typical continuous process control curves, simple closed loop systems, closed loop systems using Proportional, Integral and Derivative (PID), PID modules, PID tuning, tuning methods including the "Adjust and observe" method<br>AC Motor Controls: AC Motor Starter, AC Motor Overload Protection, DC Motor Controller, Variable Speed (Variable Frequency) AC Motor Drive.<br>PLC Applications in developing systems- Tank level controller using analog signals, temperature controller using RTD, speed control of electric motor. | | |
| Unit 05 | SCADA Systems | 07 hrs |
| Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system architecture, important definitions HMI, MTU, RTU, communication means, Desirable properties of the SCADA system, advantages, disadvantages, and applications of SCADA.<br>SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS), System operating states, SCADA systems in critical infrastructure: Petroleum Refining Process, Conventional electric power generation, Water Purification System, Chemical Plant. | | |
| Unit 06 | SCADA Protocols and Distributed Control Systems | 07 hrs |
| Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, DNP3 protocol, IEC 60870-5-101 (IEC101), Control and Information Protocol (CIP), Ether 01111111111111Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus).<br>Distributed Control System: Introduction to DCS- its working & operation, Architecture , Features, Advantages & Applications of DCS, Comparison between DCS & PLC. | | |
| Text Books: | | |
| [T1] | John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi, 5th Edition | |
| [T2] | John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications", PHI Publishers. | |
| [T3] | Ronald L. Kurtz, "Securing SCADA Systems," Wiley Publishing. | |
| [T4] | Stuart A. Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised edition. | |
| [T5] | Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition. | |
| [T6] | Curtis Johnson, "Process Control Instrumentation Technology," Prentice-Hall of India. | |
| Reference Books: | | |
| [R1] | Gordan Clark, Deem Reynders, "Practical Modern SCADA Protocols," ELSEVIER | |
| [R2] | Batten G. L., "Programmable Controllers," McGraw Hill Inc., Second Edition | |

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|---|---|
| [R3] | Bennett Stuart, “Real Time Computer Control," Prentice Hall, 1988 |
| [R4] | Krishna Kant, “Computer Based Industrial Control," PHI |
| [R5] | P. K. Srivstava, “Programmable Logic Controllers with Applications," BPB Publications |
| [R6] | Distributed Computer Control systems in Industrial Automation, D Popovic & Vijay Bhatkar. |

## Online Resources:

| | |
|---|---|
| [O1] | NPTEL Course: Electrical Measurement And Electronic Instruments By Prof. Avishek Chatterjee, Dept. of Electrical Engineering, IIT Kharagpur:- Web link https: // nptel.ac.in /courses /108 /105 / 108105153/ |
| [O2] | NPTEL Course: Industrial Instrumentation By Prof. Alok Barua, IIT Kharagpur:-Web linkhttps://nptel.ac.in/courses/108/105/108105064/ |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1 | R1 |
| 02 | T1, T2, T6 | R3, R4 |
| 03 | T1, T5 | R5 |
| 04 | T1, T2, T6 | R2, R5 |
| 05 | T3, T4 | R1 |
| 06 | T3 | R1, R6 |

## List of Experiments:

Minimum 11 experiments should be conducted. 6 experiments should be on PLC and 5 experiments should be on SCADA.
a) Experiments No. ***1 to 5*** are ***compulsory.***
b) ***Any 1*** experiment should be conducted from experiment number ***6 to 9.***
c) Experiments No. ***10 to 13*** are compulsory.
d) ***Any 1*** experiment should be conducted from experiment number ***14 to 17.***

1. Interfacing of lamp and button with PLC for ON and OFF operation. Verify all logic gates.
2. Set / Reset operation: one push button for ON and other push button for OFF operation.
3. Delayed operation of lamp by using push button.
4. UP/DOWN counter with RESET instruction.
5. Combination of counter and timer for lamp ON/OFF operation.
6. DOL starter and star delta starter operation by using PLC.
7. PLC based thermal ON/OFF control.
8. Interfacing of Encoder with PLC
9. PLC based speed, position, flow, level, pressure measurement system.
10. PLC interfaced with SCADA and status read/command transfer operation.
11. Parameter reading of PLC in SCADA.
12. Alarm annunciation using SCADA.
13. Reporting and trending in the SCADA system.

14. Tank level control by using SCADA.
15. Temperature monitoring by using SCADA.
16. Speed control of Machine by using SCADA.
17. Pressure control by using SCADA.

## Guidelines for Instructor's Manual:

- Specify objective(s) of the experiment.
- Include a ladder diagram.
- Related theory of the experiment must be included.
- Include step by step procedure to perform the experiment.
- Tabular representation of results taken from the experiment/observation table must be included wherever applicable.
- Provide space to write conclusions.

## Guidelines for Student's Lab Manual:

Students are expected to write the journal in the following sequence:

- Aim –
- Ladder diagram –
- Theory –
- Conclusions
- Students are expected to draw the ladder diagrams on 1mm graph paper.
  - ➢ They should take the print out or draw SCADA HMI.
  - ➢ Students should write conclusions.
  - ➢ Students should get the assignment and lab write up checked within 1 week after performing the experiment.

## Guidelines for Laboratory Conduction:

- Give the safety instructions to students.
- Allow 4-5 students per group to perform the experiment.
- Explain theory related to the experiment to be conducted.
- Introduce PLC and SCADA in detail with specifications to students.
- Explain the ladder diagram of the experiment.
- Ladder diagram should be completed by the students.
- Perform the experiment in the presence of an instructor.
- Verify the results obtained.

# 403143B: Power Quality Management

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 25 |

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## Prerequisite:

Fundamentals of Power Systems and Power Electronics

## Course Objectives:

This course aims to:

1. Develop understanding of power quality attributes.
2. Make students describe problems associated with poor power quality.
3. Make students describe mitigation techniques for improving power quality.
4. Learn various equipment of monitoring and assessment.

## Course Outcomes:

Student will be able to

CO1: Understand power quality and attribute of power quality

CO2: Describe voltage flicker and mitigation of it

CO3: Analyze the effect of power system events on voltage sag and its characteristics.

CO4: Identify the sources of harmonics and harmonics produced

CO5: Select proper method for harmonic mitigation along with methods of power quality monitoring.

CO6: Carry out power quality monitoring using power quality analyzers.

| Unit 01 | Basics of Power Quality | 07 hrs |
|---|---|---|

Importance of power quality, terms and definitions of power quality as per IEEE std. 1159-2019 such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding, grounding and power quality, recommended grounding practices for noise and power quality control.

| Unit 02 | RMS Voltage variations, Flickers and Transient Over-Voltages | 07 hrs |
|---|---|---|

RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Ferro-resonance Various means to reduce flickers. Flicker meter and monitoring. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages.

| | | |
|---|---|---|
| Unit 03 | Voltage Sag, Swell and Interruption | 07 hrs |
| Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag, Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of type of fault, fault location and fault level on voltage sag. Phase angle jumps. Types of sags ( Type 1 to type 7). Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag limits for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Measurement of voltage sag half cycle RMS, one cycle rms methods. Representation of the results of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions. | | |
| Unit 04 | Harmonics-I | 07 hrs |
| Definition of harmonics, inter-harmonics, sub-harmonics. Causes and effects of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices and other indices for assessing impacts of harmonics. A.C. quantities under non-sinusoidal conditions. Triplen harmonics characteristics and non characteristics harmonics. Power assessment under waveform distortion conditions. Harmonic sources and harmonic generation from lighting loads, Computer and allied load including SMPS, household equipment, Office automation devices, Utility equipment like transformer, synchronous machines and FACTS devices. Industrial equipment – induction machines, AC and Dc drives, Arc Furnaces. | | |
| Unit 05 | Harmonics-II | 7 hrs |
| Harmonics resonances - series and parallel resonances. Consequences of harmonic resonance. Principles for controlling harmonics. Reducing harmonic currents in loads. K-rated transformer. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Modifying the system frequency response. Harmonic filtering, IEEE 1531 standard for key design criteria for filters. Passive filters, Notch filter, Tuned filters, Broadband filters and active filters. IEEE Standard 519-2014 for Harmonic control. | | |
| Unit 06 | Power Quality Monitoring & Assessment | 07 hrs |
| Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality instrumentation. Power quality analyser specification requirement as per EN50160 Standard. Selection of power quality equipment for cost effective power quality monitoring, Selection of power quality monitors, selection of monitoring location and period. Selection of transducers. Harmonic monitoring, Transient monitoring, event recording and flicker monitoring. Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion. | | |
| Text Books: | | |
| [T1] | R. C. Dugan, Mark F. McGranaghan, Surya Santoso, and H. Wayne Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw-Hill Publication. | |
| [T2] | C.Sankaran, “Power Quality”, CRC Press. | |
| [T3] | M. H. J. Bollen, “Understanding Power Quality Problems, Voltage Sag and Interruptions”, New York: IEEE Press, 2000, Series on Power Engineering. | |
| [T4] | Arrillaga, M. R. Watson, and S. Chan, “Power System Quality Assessment," John Wiley and Sons. | |
| Reference Books: | | |

| | |
|---|---|
| [R1] | Enriques Acha, Manuel Madrigal, “Power System Harmonics: Computer Modeling and Analysis," John Wiley and Sons Ltd. |
| [R2] | Ewald F. Fuchs, Mohammad A. S. Masoum, “Power Quality in Power Systems and Electrical Machines,” Elsevier Publication. |
| [R3] | Arrillaga, M. R. Watson, “Power System Harmonics”, John Wiley and Sons. |
| [R4] | G. J. Heydt, “Electric Power Quality”, Stars in Circle Publications. |
| [R5] | EN50160 and IEEE 1100, 1346, 519, and 1159 standards. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1,T2, T3,T4 | R1,R2,R4, R5 |
| 02 | T1,T2 | R2, R4, R5 |
| 03 | T1,T2, T3 | R2, R4, R5 |
| 04 | T1,T2 | R1, R2, R3, R4, R5 |
| 05 | T1,T2 | R1, R2, R3, R4, R5 |
| 06 | T1,T2,T5 | R1, R2, R3, R4, R5 |

## List of Experiments:

***A minimum of 9 experiments are to be performed from the following list:***
***Compulsory experiments:***

1. Study of the power quality analyzer and measurement of various power quality parameters.
2. Measurement of harmonic distortion of various non linear loads.
3. Harmonic analysis of SMPS based Equipment such as UPS /AC/DC drive.
4. Harmonic compliance of institute as per IEEE 519-2014 standard and sizing of hybrid ( Active + detuned filter).
5. Power quality audit of institute or department.

***Any 4 experiments from following list:***

1. Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.)
2. Harmonic analysis of UPS/ DC Drive/AC Drive.
3. Analysis of performance of induction motor/transformer operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter.
4. Measurement of voltage sag magnitude and duration by using digital storage oscilloscope/ power quality analyzer.
5. Design of 7% detuned Passive Filter.
6. Simulation study of transient and/or flicker measurement.
7. Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonic measurement (THD) by using professional software like MATLAB.
8. Harmonic load flow analysis by using professional software such as ETAP, PSCAD, ATP.

## Guidelines for the Instructor’s Manual:

The Instructor's Manual shall have

- Brief relevant theory.

- Equipment with specifications.
- Connection diagram/methodology.
- Format of observation table and sample results.

## Guidelines for Students' Lab Manual:

The Student's Lab Journal should contain the following related to every experiment –

- Theory related to the experiment.
- Apparatus with their detailed specifications.
- Connection diagram or circuit diagram.
- Observation table/simulation waveforms.
- Sample calculations for one or two readings.
- Result table.
- Graph and conclusions
- Few short questions related to the experiment.

## Guidelines for Laboratory Conduction:

- Read and understand the power quality analyzer manual completely.
- Make sure that connections of the power analyzer are done as per manual.
- Follow safety protocols while doing a power quality audit.

# 403143C: High Voltage Engineering

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 25 |

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## Course Objectives:

This course aims:

- To make students to know and compare the various processes of breakdown in solid, liquid and gaseous dielectric materials.
- To make students understand and apply various methods of generation and measurement of DC, AC, impulse voltage and current.
- To enable students to understand the charge formation and separation phenomena in clouds, the causes of overvoltage and lightning phenomena,
- To develop the ability among learners to execute testing on various high-voltage equipment as per standards.
- To introduce students to the design, layout, safety precautions, earthing, and shielding of HV laboratory.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Identify, describe and analyze the breakdown theories of gaseous, solid and liquid materials.
CO2: Analyze the occurrence of over voltage and to provide remedial solutions
CO3: Describe and use of various methods of generation of high AC, DC, impulse voltage and current.
CO4: Demonstrate the methods of measurement of high AC, DC, impulse voltage and current, tests on high voltage equipment and devices
CO5: Study design of high voltage laboratory with all safety measures.

| Unit 01 | Breakdown in Gas | 07hrs |
|---|---|---|

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag for and factors on which time lag depends. (Numerical on Townsend's theory and Paschen's law).

| Unit 02 | Breakdown in Liquid and Solid Dielectrics | 07 hrs |
|---|---|---|

- **Breakdown in Liquid Dielectrics:** Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory.
- **Breakdown in Solid Dielectrics:** Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, electromechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and electrochemical breakdown, Partial discharge,Composite dielectric material,

| | | |
|---|---|---|
| | Properties of composite dielectrics, breakdown in composite dielectrics. (Numerical on theories of liquid and solid dielectric materials) | |
| Unit 03 | Lightning and Switching Over Voltages | 07 hrs |
| Lightning phenomenon, Different types of lightning strokes and mechanisms of lightning strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory.<br>Causes of over voltages and its effects on power systems, Over voltage due to switching surges and methods to minimize switching surges. Statistical approach of insulation coordination. | | |
| Unit 04 | Generation of High Voltages and Current | 07 hrs |
| Generation of high ac voltages-Cascading of transformers, series and parallel resonance system, Tesla coil. Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current . | | |
| Unit 05 | Measurement of High Voltage and High Currents | 07 hrs |
| Sphere gap voltmeter, electrostatic voltmeter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider, capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, Measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency a.c using current transformer with electro-optical signal converter, Radio interference measurements. | | |
| Unit 06 | High Voltage Testing of Electrical Apparatus and EHV Laboratories | 07 hrs |
| Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters.<br>Design, planning and layout of High Voltage laboratory:-Classification and layouts, earthing and shielding of H.V. laboratories. | | |
| Text Books: | | |
| [T1] | C. L. Wadhwa, “High Voltage Engineering”, New Age International Publishers Ltd. | |
| [T2] | M. S. Naidu, V. Kamaraju, “High Voltage Engineering”, Tata McGraw Hill Publication Co. Ltd. New Delhi | |
| Reference Books: | | |
| [R1] | E. Kuffel, W. S. Zaengl, J. Kuffel, “High Voltage Engineering Fundamentals”, Newnes Publication | |
| [R2] | Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, “High Voltage Engineering", Khanna Publishers, New Delh | |
| [R3] | Ravindra Arora, Wolf Gang Mosch, “High Voltage Insulation Engineering”, New Age International | |
| [R4] | High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel | |
| [R5] | Subir Ray, “An Introduction to High voltage Engineering” PHI Pvt. Ltd. New Delhi | |

| | |
|---|---|
| [R6] | IS 731-1971:Porcelain insulator for overhead power lines with nominal voltage > 1000 Volt |
| [R7] | Bushings :IS2099-1986,specification for bushings for A.C. Voltages > 1000 Volts |
| [R8] | Pollution test :IEC 60507-1991 on external and internal insulator |
| [R9] | High voltage test techniques, general definitions and test requirements: IS 2071(part 1) 1993,IEC Pub 60-1(1989) |

## Online Resources:

| | |
|---|---|
| [O1] | https://nptel.ac.in/courses/108104048 |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1,T2 | R1,R2,R3,R6 |
| 02 | T1,T2 | R1,R2,R3,R5,R6 |
| 03 | T1,T2 | R1,R2,R3,R5,R6 |
| 04 | T1,T2 | R1,R2,R3,R4,R5,R6 |
| 05 | T1,T2 | R1,R2,R3,R4,R5,R6 |
| 06 | T1,T2 | R1,R2,R3,R7,R8,R9 |

## List of Experiments:

[Minimum eight experiments to be conducted from the given list]

1. To find the constants of the breakdown equation of transformer oil.(Analytical and graphical method)
2. Measurement of unknown high a.c. voltage using sphere gap
3. To obtain breakdown strength of composite insulation systems, and observe the effect of parameters like no. of layers, thickness of layer, effect of interfacing.
4. To find out the breakdown of air in uniform and non uniform fields and compare it.
5. To study surface flashover on corrugated porcelain/polymeric insulation systems.
6. To understand the basic principle of corona and obtain audible and visible corona inception and extinction voltage under non uniform field.
7. To perform an experiment on horn gap arrester and understand arc quenching phenomenon.
8. To observe development of tracks and trees on polymeric insulation systems.
9. Parametric analysis of Impulse current generator using virtual Laboratory.
10. To perform an experiment on rod gap arresters.
11. To Study effect of barrier on breakdown voltage of air/ transformer oil.
12. Simulation of lightning and switching impulse voltage generator using any simulation software.
13. To perform various HV insulation tests on cables as per IS.
14. Study of layout /earthing/safety of HV installation /lab in any industry by visit /virtual lab.

**Industrial Visit:** Industrial visit to high voltage equipment manufacturing industry/EHV substation/High Voltage Testing Lab.

## Guidelines for Instructor's Manual:

The Instructor's Manual should contain following related to every experiment

- Brief theory related to the experiment.
- Circuit diagram and apparatus with their detail specification as per IS code.
- Students should be encouraged to visit industries/HV laboratories/HV installations.
- Students should be encouraged to use virtual labs.
- Few short questions related to each practical.
- Assignments based on use of IS and IEC.

## Guidelines for Student's Lab Manual:

The Students lab journal should contain:

- Brief theory related to the experiment.
- Circuit diagram and apparatus with their detail specification as per IS code.
- Observations, result tables and proper inferences/ conclusions from each experiment conducted.
- Reports on visit to industries/HV laboratories/HV installations.
- Simulations and print outs of use of virtual labs.
- Few short questions and answers related to each practical.
- Assignments based on use of IS and IEC.

## Guidelines for Laboratory Conduction:

There should be continuous assessment for the TW.

- Assessment must be based on understanding of theory, attentiveness during practicals.
- Session, how efficiently the student is able to do connections and get the results.
- Timely submission of journal.

# 403143D: Robotics and Automation

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 25 |

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## Course Objectives:

This course aims to:

- To know the basic parts of a typical industrial robot system with its anatomy similar to the human body.
- To analyze mathematically the kinematic and dynamic modeling of a typical robot manipulator.
- To select an appropriate type of robot with given specifications for different industrial applications.
- To know the basics of actuators, sensors, and control of an industrial robot for different applications.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: differentiate between types of robots based on configuration, method of control, types of drives, sensors used, etc.
CO2: apply mathematical modeling of a robot for a specific application with given specifications.
CO3: analyze the robot arm dynamics for calculation of torques and forces required for different joints of robots for control of the robot arm.
C04 : apply knowledge of Robot for their various applications

| Unit 01 | Robotics fundamentals | 07 hrs |
|---|---|---|

historical development of robotics, Definitions of Industrial Robot, Types of Robots, Asimov's Laws of Robotics, robot components, Robot specifications: repeatability, spatial resolution, compliance, degree of freedom, load carrying capacity, speed of response, work volume, work envelope, reach, etc,Robot configurations, Classification of Robots: Control Method: Servo controlled and non-servo controlled, their comparative study, form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study.

| Unit 02 | Mathematical Modeling and Dyanamics of Robots | 07 hrs |
|---|---|---|

Direct Kinematics, Coordinate and vector transformations using matrices, Rotation matrix, Inverse Transformations, Composite Rotation matrix, Homogeneous Transformations, The Robotic Manipulator Joint Coordinate System, inverse, Jacobian Transformation in Robotic Manipulation. **Robot Dynamics:** Lagrange's Equation, Kinetic and potential energy Equations, and Euler-Lagrange analysis for a single prismatic joint working against gravity and a single revolute joint. equation of motion.

| Unit 03 | Forward and Inverse Kinematics | 07 hrs |
|---|---|---|

Denavit-Hartenberg (D-H) representation of kinematic chains. Rules for establishing link coordinate frames.

Forward solution of robotic manipulator for SCARA Robot and PUMA Robot. Forward 67i solution for simple robot systems. **Inverse Kinematics:** Concept of Inverse Kinematics, general properties of inverse solution such as existence and uniqueness of solution, inverse solution by direct approach, Geometric approach, inverse solution for simple SCARA Robots, numericals for simple three axis robots based on direct approach.

| Unit 04 | Robotics Sensors | 07hrs |
|---|---|---|

Transducers and sensors, Sensors in robotics, Principles and applications of the following types of sensors- Proximity Sensors, Photo Electric Sensors, Laser Scanners, Position sensors – Piezo Electric Sensor, LVDT, Resolvers. Encoders: Absolute and Incremental: - Optical, Magnetic, Capacitive, pneumatic Position Sensors Range Sensors: Range Finders, Laser Range Meters, Touch Sensors, Force and torque sensors.

Safety Sensor: Light Curtain, Laser Area Scanner, Safety Switches; Machine vision

| Unit 05 | Differential motion and control | 07 hrs |
|---|---|---|

**Manipulator Differential Motion:** Concept of linear and angular velocity, Relationship between transformation matrix and angular velocity, manipulator Jacobian, Jacobian for prismatic and revolute joint, Jacobian Inverse, Singularities.
**Control of Robot Arm:** Modeling of DC motor and load, closed loop control in position servo, the effect of friction and gravity, control of a robotic joint, position velocity and acceleration profiles for trapezoidal velocity profile.
**Control of Robot manipulator:** joint position controls (JPC), resolved motion position controls (RMPC) and resolved motion rate control (RMRC).

| Unit 06 | Various applications of Robots | 07 hrs |
|---|---|---|

Pick and place the robot, Application of Robots in Arc Welding Robots, assembly and mega-assembly Robots perform continuous arc welding, spot welding, spray painting, and assembly operations. Robots for Inspection: Robotic vision systems, image representation, object recognition and categorization, depth measurement. Other industrial applications: coating, deburring, cleaning, Die Casting, Molding, Material handling, Picking, palletizing, packaging, hospitals and patient care, F&B industry, sports and recreation, defense and surveillance industry, home automation, mining industry. A robot-based manufacturing system, robot cell design considerations and the selection of robots, Robot Economics, Functional Safety in Robotic Applications

## Text Books:


| | |
|---|---|
| [T1] | Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, and Ashish Dutta, “Industrial Robotics:Technology, Programming and Applications," Tata-McGraw-Hill Education Private Limited, New Delhi, 2012. |
| [T2] | Richard D. Klafter, Thomas A. Chemielewski, Michael Neign, “Robotic Engineering – An IntegralApproach”, Prentice Hall of India Pvt. Ltd., New Delhi. Eastern Economic Edition. |
| [T3] | Robert J. Schilling, “Fundamentals of Robotics: Analysis and Control”, Prentice Hall of India, New Delhi |


## Reference Books:


| | |
|---|---|
| [R1] | K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, “Robotics: Control Sensing, Vision, and Intelligence”, |

| | |
|---|---|
| | International Edition, McGraw-Hill Book Co. |
| [R2] | John J. Craig, “Introduction to Robotics: Mechanics and Control”, Pearson Education |
| [R3] | R. K. Mittal, I. J. Nagrath, “Robotics and Control”, Tata McGraw-Hill Publishing Company Ltd., New Delhi. |
| [R4] | Saeed b. Niku, “Introduction to Robotics: Analysis, Control, Applications”, Wiley Publication, 2011. |

## Online Resources:

| | |
|---|---|
| [O1] | NPTEL Course on “Robotics”: https://nptel.ac.in/courses/112/105/112105249/ |
| [O2] | NPTEL Course on “Introduction to Robotics”: https://nptel.ac.in/courses/107/106/107106090/ |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1,T2 | R3 |
| 02 | T1,T2,T3 | R1, R2,R3,R4 |
| 03 | T1,T2,T3 | R1,R3,R4 |
| 04 | T1,T2,T3 | R1,R3,R4 |
| 05 | T2, T3 | R1,R2, R3 |
| 06 | T2 | R1 |

## A List of Experiments:

Experiment 9 is compulsory.

List of Laboratory Experiments

1.Identify and selection of Sensors such as IR sensors, Proximity Sensor, Ultrasonic Sensor, White line sensor, Temperature Sensor, Touch sensor, Tilt Sensor, Accelerometer, Gyroscopic Sensor etc. based on given application

2. Identify and selection of Actuators and related hardware such as DC motor, Servo motor, Stepper Motor, Motor drivers based on application

3. Demonstration of various robotic configurations using industrial robot

4. Design and selection of Gripper / End effector

5. One Programming exercise on lead through programming

6. MATLAB program for simple and inverse kinematics of simple robot configuration

7. To demonstrate simple robotic system using Matlab/ MscAdam / RoboAnalyser software

8.Study of various applications of Robots

9. One Industrial visit for Industrial robotic application

## Guidelines for the Instructor’s Manual:

The Instructor's Manual should contain the following things related to every experiment:

- Specify prerequisite and objective(s) of experiment.
- A related theory of the experiment must be included.

- The circuit diagram of the experiment should be drawn at the beginning.
- For simulation experiments, the Simulink diagram with proper details must be included in the write up. For programming, take a printout of the program and the result.
- A conclusion based on calculations, results, and graphs (if any) should be written.

## Guidelines for Students' Lab Manual:

- Students should write the journal in their own handwriting, particularly the results, diagrams, conclusions, questions, answers, etc.
- A circuit or connection diagram or construction diagram must be drawn either manually using or using software on graph paper.
- Handwriting and figures must be neat and clean.

## Guidelines for Laboratory Conduction:

- Do the continuous assessment. The experiments performed in a particular week must be checked in the next turn in next week.
- During assessment, the teacher should make the remark by writing the word “Complete” and not simply “C”. Put the signature along with the date at the end of the experiment and in the index.

# 403144A: Alternate Energy System

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Tutorial | 02 | Hrs/Week/Batch | Tutorial | 01 | ESE | 70 |
| | | | | | Term work | 25 |

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## Course Objectives:

This course aims to:

1. Develop a fundamental understanding of solar thermal and photovoltaic systems.
2. Provide the knowledge of development and operation of wind energy system
3. Discuss bio-energy resource assessment.
4. Introduce different storage systems, Integration and Economics of Renewable Energy Systems.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Analyze the performance of solar thermal and photovoltaic systems.
CO2:Determine wind turbine performance.
CO3:Explain and evaluate biomass resources in an Indian context.
CO4:Illustrate the importance of storage systems.
CO5:Analyze the economics of renewable energy sources.

| Unit 01 | Solar Energy-I | 08 hrs |
|---|---|---|

Solar radiation at the earth's surface, Solar constant, Spectral distribution, Extraterrestrial Radiation, Solar Terrestrial Radiation, Solar radiation geometry, Computation of cosθ for any location having any orientation, Empirical equations for predicting the availability of solar radiation: Monthly average daily and hourly global and diffuse radiation, Beam and Diffuse radiation under cloudless skies, Solar radiation on tilted surfaces : a)Beam radiation, b)Diffuse radiation, c)Reflected radiation, d)Flux on tilted surface. Instruments for measuring solar radiation, Devices for thermal collection and storage, Thermal applications, Introduction to concentrating solar power (CSP) plants using technologies like a) Parabolic troughs b) Linear Fresnel reflector, c) Parabolic Dish, etc.

| Unit 02 | Solar Energy-II | 06 hrs |
|---|---|---|

Introduction to family of solar film technology, Single c-Si, Poly c-Si PV Cell, Module and Array, Array Design (factors influencing the electrical design of the solar array) : a) Sun Intensity, b)Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate, f) Electrical Load Matching, g) Sun Tracking, Peak Power Point Operation, Electrical characteristics of Silicon PV Cells and Modules, PV System Components, Efficiency of PV system, MPPT of solar system, PV system design for various applications( residential, commercial and industrial)

| Unit 03 | Wind Energy | 08 hrs |
|---|---|---|

Power Contained in Wind, Thermodynamics of Wind Energy, Efficiency Limit for Wind Energy

Conversion, the maximum energy obtained for a Thrust-operated converter (Efficiency limit), Design of Wind Turbine Rotor, Power-Speed Characteristics, Torque-Speed Characteristics, Wind Turbine Control Systems: a) Pitch Angle Control, b) Stall Control, c) Power Electronics Control, d) Yaw Control, Control Strategy, Wind Speed Statistics, Statistical Wind Speed Distributions, Site and Turbine Selection, Extraction of wind energy and wind turbine power. Introduction to Offshore Wind Energy System and its comparison with Wind Energy System,

| Unit 04 | Biomass Energy | 06 hrs |
|---|---|---|

Biomass Classification, Biomass Resources and their Energy Potential, Biomass Conversion Technologies: Anaerobic Digestion, Ethanol Fermentation, Biomass Gasification: Gasifiers, Fluidized Bed Gasifier, Biogas Technologies and their factor affecting Biogas Production, Biogas Plants: Floating and Fixed Dome type, designing of biogas plant, Introduction to Biodiesel**,** Power Generation from Municipal Solid Waste (MSW), Landfill Gas, Liquid Waste.

| Unit 05 | Fuel Cells and Storage Systems | 08 hrs |
|---|---|---|

A. Fuel Cells: Operating principles of Fuel Cell, Fuel and Oxidant Consumption, Fuel Cell System Characteristics, Introduction to Fuel Cell Technology and its type, application and limits.
B. Storage systems: Hydrogen storage: Hydrogen production, relevant properties, Hydrogen as an Engine Fuel, methods of Hydrogen storage. Batteries: Introduction to Batteries, Elements of Electro-Chemical Cell, Battery classification, Battery Parameters, Factors affecting battery performance. Introduction to other storage technologies: pump storage, SMES, compressed air storage.

| Unit 06 | Integration of RES | 06 hrs |
|---|---|---|

A. Integration of RES with grid, Grid codes.
B. Economics of RES: Simple, Initial rate of return, time value, Net present value, Internal rate of return, Life cycle costing, Effect of fuel Escalation, Annualized and levelized cost of energy.

## Text Books:

| | |
|---|---|
| [T1] | S.P. Sukhatme, “Solar Energy”, Tata McGraw Hill |
| [T2] | Chetan Singh Solanki, “Solar Photovoltaics-Fundamentals, Technologies and Applications”, PHI Second Edition |
| [T3] | Godfrey Boyle, “Renewable Energy”, Third edition, Oxford University Press |
| [T4] | H. P. Garg, J. Prakash, “Solar Energy-Fundamentals and Applications”, Tata McGraw hill Publishing Co. ltd., First Revised Edition. |
| [T5] | Mukund R. Patel, “Wind and Power Solar System”, CRC Press |
| [T6] | Gilbert M. Masters, “Renewable and Efficient Electrical Power Systems”, Wiley - IEEE Press, August 2004 |

## Reference Books:

| | |
|---|---|
| [R1] | D.P.Kothari, K.C.Singal, Rakesh Rajan,“Renewable Energy Sources and Emerging Technologies”, PHI Second Edition |
| [R2] | Tapan Bhattacharya, “Terrestrial Solar Photovoltaics”, Narosa Publishing House |
| [R3] | Paul Gipe, “Wind Energy Comes of Age”, John Wiley & Sons Inc. |

| | |
|---|---|
| [R4] | Donald L.Klass, “Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier, Academic Press |
| [R5] | Thomas Ackermann, “Wind Power in Power Systems”, Wiley Publications. |
| [R6] | B T.Nijaguna, “Biogas Technology”, New Age International Publishers. |
| [R7] | Tony Burton, Nick Jenkins, David Sharpe, “Wind Energy HandBook-Second Edition”, John Wiley & Sons, Ltd., Publication |

## Online Resources:

| | |
|---|---|
| [O1] | A review on non-edible oil as a potential feedstock for biodiesel: physicochemical properties and production technologies. |
| [O2] | Fabrication and Design of Solar cooker. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1, T2 | R1, R2 |
| 02 | T2, T3, T4 | R1 |
| 03 | T5 | R3, R5,R7 |
| 04 | T6 | R4, R6 |
| 05 | T3,T6 | R1 |
| 06 | T6 | R1 |

## List of Tutorial:

It is expected to take ***minimum 8 tutorials*** from the following list:

1. Report on Renewable Energy Scenario in India/ across the Globe.
2. Designing of standalone Solar PV systems for various loads( 2 numericals).
3. Report on analysis of Indian solar radiation data/ Wind data.
4. Performance analysis of concentrating solar collector/ solar cooker/ solar air heaters
1. Study of Wind Electric Generators with Grid Integration.
2. Performance of Wind generation ( 2 or 3 numericals).
3. Design of a community biogas plant for a village in India( 1 or 2 numericals).
4. Analysis of Non Edible oil as an alternate energy source.
5. Performance of storage devices( 3/4 numericals).
6. Economics of renewable energy sources(2 or 3 numericals).
7. Design of Hybrid system using HOMER demo software

## Guidelines for Assessment of Tutorial:

- Maintain Record in file or separate notebook.
- Timely submission of tutorials.
- Assessment of the report must be based on understanding, presentation and contents.

# 403144B: Electric and Hybrid Vehicle

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Tutorial | 02 | Hrs/Week/Batch | Tutorial | 01 | ESE | 70 |
| | | | | | Term work | 25 |

==========

## Course Objectives:

This course aims to:
1. To gain knowledge of Li-ion battery protection.
2. To learn HEV Subsystems and Configurations.
3. To understand Mathematical Model of Li-ion battery.
4. To familiarize with Hybridization of drivetrains.
5. To learn Star Labeling Schemes for Li-ion Packs.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Analyze the Life Cycle Assessment of Li-ion battery.
CO2 : Describe the different types of Li-ion charging methods
CO3 : Comprehend the knowledge of drivetrain hybridization.
CO4 : Evaluate EV motor sizing.
CO5 : Classify Battery Recycling methods.

| | | |
|---|---|---|
| Unit 01 | Li-ion Battery | 07 hrs |

Materials used for Li-ion battery, Nanostructured Electrode Materials for Li-Ion Batteries, Li-ion battery protection, Wireless charging of EV, Life Cycle Assessment of Li-ion battery, Solid-state Battery, Panasonic 18650 & 2170 cell,

| | | |
|---|---|---|
| Unit 02 | Battery Charging and Modelling | 07 hrs |

TSCC/CV charging and CVCC/CC charging of Li-Ion battery, BMS standards,
SoC Estimation methods (Kalman Filter, Neural Network, Fuzzy logic), Public EV charging stations, Solar Powered Charging Stations, Modeling of Lithium-ion batteries, Thermal Modeling of Li-ion battery.

| | | |
|---|---|---|
| Unit 03 | Electric Vehicle Technologies | 07 hrs |

Battery Swapping System, EV Fleet Management, Sensors for Electric Vehicles
Electric bus, Electric trucks, Fuel cell vehicles, Introduction of EV Subsystems and Configurations, Energy management strategies and its general architecture.

| | | |
|---|---|---|
| Unit 04 | Plug-In Hybrid Electric Vehicles | 07 hrs |

Hybridization of drivetrains in HEVs, Hybridization of energy sources in EVs, Power Flow control in hybrid drive train topologies, Power Management Strategies in HEV, Introduction of HEV Subsystems and Configurations, Vehicle Dynamics Fundamentals and HEV Modeling (Series Hybrid), Fuel

| | | |
|---|---|---|
| efficiency analysis. | | |
| Unit 05 | EV Components Design | 07 hrs |
| Criteria for battery selection , Forces on EV calculation, Power for EV calculation, Sizing the Power Converter, Sizing of Electric Machine for EVs and HEVs, Motor Torque Calculation, Induction motor control, PMSM motor control, Battery pack design, In vehicle networks- CAN | | |
| Unit 06 | Electric Vehicle Policies and Startups | 07 hrs |
| FAME-II Policy , Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards , Star Labeling Schemes for Li-ion Packs- BEE India, EV Tariff, EV Startup examples, Li-ion Battery Recycling Policy and Standards | | |

## Text Books:

| | |
|---|---|
| [T1] | Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau |
| [T2] | Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011 |
| [T3] | Electric and Hybrid Vehicles by Tom Denton |

## Reference Books:

| | |
|---|---|
| [R1] | Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010 |
| [R2] | James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.. |

## Online Resources:

| | |
|---|---|
| [O1] | NPTEL Course : Electric Vehicles - Part 1 by Prof. Amit |

## List of Tutorials:

Any 8 of the following

1. Introduction to battery modeling MATLAB Simulink
2. Introduction to BLDC motor control MATLAB Simulink
3. Introduction to Induction Motor control MATLAB Simulink
4. Power Converter selection in MATLAB Simulink
5. Study of EV subsidies in different states.
6. Visit to the Electric Vehicle Charging Station.
7. Study of Thermal Modeling in Ansys software
8. Study of Harmonics issues of EV charging.
9. Fuel efficiency evaluation of a series HEV in city and high-way.
10. Various strategies for improving vehicle energy/fuel efficiency regenerating braking.
11. Study of various Battery Recycling Methods.

## Guidelines for Assessment of Tutorial:

- Maintain Record in file or separate notebook.
- Timely submission of tutorials.
- Assessment of the report must be based on understanding, presentation and contents.

| 403144C: Special-Purpose Machines | | | | | | |
|---|---|---|---|---|---|---|
| **Teaching Scheme** | | | **Credits** | | **Examination Scheme** | |
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Tutorial | 02 | Hrs/Week/Batch | Tutorial | 01 | ESE | 70 |
| | | | | | Term work | 25 |

==========

## Course Objectives:

The course aims:-
1. To gain knowledge of operation and performance of synchronous reluctance motors.
2. To learn the operation and performance of stepping motors.
3. To understand operation and performance of switched reluctance motors.
4. To familiarize with operation and performance of permanent magnet brushless D.C. motors.
5. To illustrate operation and performance of permanent magnet synchronous motors.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Reproduce principal of operation of PMSM, Stepper motor, SRM, Switch reluctance and linear motors.
CO2: Develop torque - speed and performance characteristics of above motors.
CO3: Enlist application of above motors.
CO4: Demonstrate various control strategies.

| Unit 01 | **Generalized Machine Theory** | 06 hrs |
|---|---|---|

Energy in singly excited magnetic field systems, determination of magnetic force and torque from energy. Determination of magnetic force and torque from co-energy, Forces and torques in systems with permanent magnets. MMF of distributed winding, Magnetic fields production of EMFs in rotating machines.

| Unit 02 | **Permanent Magnet Synchronous and brushless D.C. Motor Drives** | 06 hrs |
|---|---|---|

Synchronous machines with PMs, machine configurations. Types of PM synchronous machines Sinusoidal and Trapezoidal. EMF and torque equations Torque - speed characteristics, Concept of electronic commutation, Comparative analysis of sinusoidal and trapezoidal motor operations. Applications.

| Unit 03 | **Control of PMSM Machine** | 06 hrs |
|---|---|---|

abc-αβ and αβ-dq transformations, significance in machine modeling, Mathematical Model of PMSM (Sinusoidal), Basics of Field Oriented Control (FOC), Control Strategies: constant torque angle, unity power factor.

| Unit 04 | **Reluctance Motor** | 06 hrs |
|---|---|---|

Principle of operation and construction of Switch Reluctance motor, Selection of poles and pole arcs, Static and dynamics Torque production, Power flow, effects of saturation, Performance, Torque speed characteristics, Synchronous Reluctance, Constructional features; axial and radial air gap motors; operating principle; reluctance torque; phasor diagram; motor characteristics Introduction to control of Reluctance Drive. Applications.

| Unit 05 | **Stepper Motor** | 06 hrs |
|---|---|---|

Construction and operation of stepper motor, hybrid, Variable Reluctance and Permanent magnet, characteristics of stepper motor, Static and dynamics characteristics, theory of torque production, figures of merit; Concepts of lead angles, micro stepping, Applications selection of motor.

| Unit 06 | **Linear Electrical Machines** | 06 hrs |
|---|---|---|

Introduction to linear electric machines. Types of linear induction motors, Constructional details of linear induction motor, Operation of linear induction motor. Performance specifications and characteristics Applications.

## Text Books:

| | |
|---|---|
| [T1] | K. Venkatratnam, 'Special Electrical Machines', University Press |
| [T2] | A.E. Fitzgerald Charles Kingsley, Stephen Umans, 'Electric Machinery', Tata McGraw Hill Publication |
| [T3] | T.J.E. Miller, 'Brushless Permanent magnet and Reluctance Motor Drives' Clarendon Press, Oxford 1989 |
| [T4] | V. V. Athani, 'Stepper Motors: Fundamentals, Applications and Design', New age International, 1997. |
| [T5] | P.S. Bhimbra, Generalized Theory Of Electrical Machines |

## Reference Books:

| | |
|---|---|
| [R1] | R Krishnan, 'Permanent Magnet Synchronous and Brushless D.C. Motor Drives' CRC Press. |
| [R2] | Ion Boldea, 'Linear Electric Machines, Drives and maglevs' CRC press. |
| [R3] | Ion Boldea S. Nasar, 'Linear Electrical Actuators and Generators', Cambridge University Press. |

## Online Resources:

| | |
|---|---|
| [O1] | NPTEL video lectures on all the special purpose machines can be observed. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T2 | R1 |

| | | |
|---|---|---|
| 02 | T1, T3 | R1 |
| 03 | T1, T5 | R1 |
| 04 | T1 | R1 |
| 05 | T1, T4 | R1 |
| 06 | T5 | R2,R3 |

List of Tutorials: Minimum eight tutorials are to be performed out of the list mentioned as below:

1. Experimental analysis of PMSM motor drive
2. Experimental analysis of BLDC (Trapezoidal Motor) Drive
3. Experimental analysis of Switched Reluctance Motor Drive.
4. Experimental analysis of Synchronous Reluctance Motor Drive
5. Experimental analysis of Stepper Motor Drive.
6. Laboratory demonstration of Linear Induction Motor.
7. Simulation for the performance analysis of PMSM/BLDC drive. (Any software can be used)
8. Simulation of Switched Reluctance Drive.
9. Software programming for abc-αβ and αβ-dq transformations

Guidelines for Assessment of Tutorial:

- Maintain Record in file or separate notebook.
- Timely submission of tutorials.
- Assessment of the report must be based on understanding, presentation and contents.
- Prepare tutorial assessment sheet which may be used for the term work marks.

# 403144D: HVDC and FACTs

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Tutorial | 02 | Hrs/Week/Batch | Tutorial | 01 | ESE | 70 |
| | | | | | Term work | 25 |

==========

## Course Objectives:

This course aims to:

1. To develop understanding of modern trends in power transmission.
2. To make students describe the operation of HVDC System and Control.
3. To make students describe applications of power electronics in the control of power transmission.
4. To understand fundamentals of FACTS Controllers.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Choose a proper FACTS controller for the specific application based on system requirements.
CO2:Analyze shunt, series, and combined controllers to explore different benefits.
CO3:Compare EHVAC and HVDC systems and to describe various types of DC links.
CO4:Describe various methods for the control of HVDC systems and to perform power flow analysis in AC/DC systems.

| | | |
|---|---|---|
| Unit 01 | HVDC -I | 07 hrs |

EHVAC versus HVDC transmission, power flow through HVDC link, Graetz circuit, equation for HVDC power flow bridge connection, control of DC voltage and power flow, effects of angle of delay and angle of advance commutation, CIA, CC and CEA control.

| | | |
|---|---|---|
| Unit 02 | HVDC – II | 07 hrs |

Twelve pulse converter operation, Harmonics in HVDC systems. HVDC system layout and placement of components, HVDC protection, grounding, multi terminal HVDC systems, configurations and types.

| | | |
|---|---|---|
| Unit 03 | VSC based HVDC System | 07 hrs |

Introduction to VSC transmission, power transfer characteristics, structure of VSC link, VSC DC system control, HVDC light technology. HVDC plus, introduction, construction, operation and applications to renewable energy sources Principles of DC Link Control in a VSC based HVDC system: Power flow and dc voltage control. Reactive Power Control / AC voltage regulation using VSC. Real and Reactive power control using a VSC.

| | | |
|---|---|---|
| Unit 04 | Fundamentals of FACTS Controllers | 08 hrs |

Basics, Challenges and needs of Power Electronic Controllers, Review of rectifiers and inverters, back to back converter, dc link converter, static Power converter structures, AC controller based structures, DC link converter topologies, converter output and harmonic control, power converter control. Reactive power

control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.

| | | |
|---|---|---|
| Unit 05 | Shunt and Series Controllers | 08 hrs |

Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators – SVC, STATCOM, SVC and STATCOM comparison. Series compensation – objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes. Comparison between STATCOM and SVC, V –I and V –Q Characteristics, Transient stability, Response Time. Comparison between TSCS and SSSC

| | | |
|---|---|---|
| Unit 06 | Unified Power Flow Controller and advanced controllers | 08 hrs |

Unified power flow controller (UPFC) – Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC), Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

## Text Books:

| | |
|---|---|
| [T1] | S Kamakshaiah and V Kamaraju, “HVDC Transmission,” TMH Publications, 2011. |
| [T2] | K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011 |
| [T3] | Hingorani ,L.Gyugyi, “Concepts and Technology of Flexible AC Transmission System”, IEEE Press, New York, 2000, ISBN –0780334588. |
| [T4] | Padiyar K.R., “FACTS Controllers for Transmission and Distribution systems”, New Age International Publishers, 1st Edition, 2007. |

## Reference Books:

| | |
|---|---|
| [R1] | Jos Arrillaga, “High Voltage Direct Current Transmission”, IET Power and Energy Series 29 |
| [R2] | Erich Uhlmann, “Power Transmission by Direct Current,” Springer International |
| [R3] | Song, Y.H. and Allan T. Johns, ‘Flexible AC Transmission Systems (FACTS)’, Institution of Electrical Engineers Press, London, 1999. |
| [R4] | Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho ‘FACTS" —Modeling and simulation in Power Networks, John Wiley & Sons, 2002. |
| [R5] | J. Arrillaga, “High Voltage Direct Current Transmission,” Peter Peregrinus Ltd., London, UK |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1, T2 | R1, R2, R5 |
| 02 | T1, T2 | R1, R2, R5 |

| | | |
|---|---|---|
| 03 | T1, T2 | R1, R2, R5 |
| 04 | T3, T4 | R3, R4 |
| 05 | T3, T4 | R3, R4 |
| 06 | T3, T4 | R3, R4 |

## List of Tutorials:

1. Study of various HVDC transmission system components and its applications.
2. Study of AC/DC side voltage and current waveforms of a six-pulse converter system under variable RL load using simulation. (Hint: input PF, THD, converter efficiency, reactive power flow, etc.).
3. Study of AC/DC side voltage and current waveforms of a twelve-pulse converter system under variable R-L load using simulation. (Hint: input PF, THD, converter efficiency, reactive power flow, etc.).
4. Study of Reactive Power Control in an HVDC Transmission system
5. Study of various types of multi-terminal HVDC transmission systems
6. Study of DC link control in VSC-based HVDC transmission systems.
7. Study of various passive filters used in LCC-based HVDC transmission systems
8. Operation of VSC for power factor correction at AC side of HVDC system using sinusoidal pulse width modulation.

## Guidelines for Assessment of Tutorial:

- Maintain Record in file or separate notebook.
- Timely submission of tutorials.
- Assessment of the report must be based on understanding, presentation and contents.

# 403145: Project Stage I

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| SEM/PW/IN | 4 | Hrs./Week | SEM/PW/IN | 2 | ORAL | 50 |
| | | | | | Term work | 50 |

==========

## Preamble:

Project is an important part of the engineering curriculum covered in the final year. It is divided into Project Stage I and Project Stage II at Semesters I and II of the Final Year. This project is a substantial piece of work that will require creative activity and original thinking. The project aims to provide students with a transitional experience from the academic world to the professional world. The objectives, outcomes, and guidelines for Project Stage I are given below.

## Course Objectives:

The objectives of this course are to:

1. Provide an opportunity to learn new software, interdisciplinary theory, concepts, technology, etc. not covered in earlier subjects.
2. Empower students to use engineering knowledge and skills learned in previous courses to deliver a product that has passed through the design, analysis, testing, and evaluation.
3. Encourage multidisciplinary project work through the integration of knowledge.
4. Allow students to develop problem-solving, analysis, synthesis, and evaluation skills.
5. Encourage teamwork.
6. Improve students' communication skills by asking them to produce both a professional report and to give an oral presentation.

## Course Outcomes:

Course outcomes can be different for the different projects undertaken by the student groups. However, in general, the course outcomes for Project Stage-I can be stated as follows.
At the end of this course, students should be able to:
CO1:Define the project problem statement and identify the scope of the project.
CO2:Search the appropriate research papers, standards and e-resources and write a literature survey.
CO3:Identify tools, techniques, methods, concepts, measuring devices, and instruments required for the project to define the methodology of the project.
CO4:Justify the selection of electrical, electronic and mechanical components for the project prototyping
CO5:Simulate or develop a system for software or hardware verification.
CO6:Write a project report with proper interpretation of results.

**Guidelines for students:**

1. Form a group of 3-4 students.
2. Select a project problem statement based on an industrial or societal issue and ideate on it.
3. Research on the project topic through existing theories, literature, technology, patents, etc.
4. Define objectives, scope, and outcomes of the project in the 1st presentation.
5. Maintain a notebook to keep records of all the meetings, discussions, notes, etc. This is to be done by the individual student.
6. Some of the parameters mentioned in the above table will be evaluated and assessed at the group

level and some at an individual level.

## Guidelines:

Term work evaluation guidelines are given below.

| Sr. No. | Activity | Deadline (Semester I) | Parameters for Evaluation |
|---|---|---|---|
| 1. | Topic Approval Presentations | Up to 3rd Week | • Problem definition clearly stated (YES/NO)<br>• Objectives clearly defined (YES/NO)<br>• The overall project idea is feasible (YES/NO) |
| 2. | Progress Review-1 Presentation | Up to 8th Week | • Problem Definition (5)<br>• Scope & Objectives (10)<br>• Literature Review (10)<br>• Methodology (10)<br>• Block Diagram / Architecture (10)<br>• Project Planning (5)<br>• **Total Marks (50)** |
| 3. | Progress Review-2 Presentation | Up to 12th Week | • Requirement Specification (10)<br>• Literature Review (revised) (5)<br>• Detailed Design (10)<br>• Experimental Setup/Simulation (10)<br>• Performance Parameters (10)<br>• Partial Conclusion (5)<br>• **Total Marks (50)** |
| 4. | Submission of Project Stage –I Report | Up to 14th Week | • Timely submission (5)<br>• Formatting and Report Writing Style (5)<br>• Abstract, Literature Survey, Conclusion (5)<br>• Refereed References (5)<br>• Grammatical correctness in the report (5)<br>• **Total Marks (25)**<br><br>**(Review 1+ Review 2) conversion to 25 marks +Report (25 marks) = 50 Marks** |

# 403146: MOOCs

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| SEM/PW/IN | – | Hrs./Week | SEM/PW/IN | 2 | ORAL | – |
| | | | | | Termwork | 50 |

==========

## Preamble:

Massive Open Online Courses (MOOCs) is essentially an asynchronous teaching learning platform. To enhance the students learning and to motivate self learning, MOOCs have been added in the BE Electrical 2019 course. It is advised to students that they have to registers MOOCs courses thorough SWAYAM-NPTEL platform.

## Course Objectives:

The objectives of this course are to:

1. Provide an opportunity to learn new software, interdisciplinary theory, concepts, technology, etc. not covered in earlier subjects.
2. Make students employable in the industry or pursue a suitable higher education program.
3. Exposure to relevant tools and technologies.
4. Enrich the learning experience by using audio video and multimedia and state of the are pedagogy.

## Course Outcomes:

At the end of this course, students should be able to:
CO1:Enables the students to directly engage and learn from the best faculty in the country in order to strengthen the fundamentals.
CO2:Explore new areas of interest in a relevant field.
CO3:Enable self learning initiative in learners..
CO4:Develop critical thinking to solve complex problems in engineering, science and humanities.
CO5:Improve communication skills by interacting with peers and course teachers.

## Guidelines:

**Guidelines for students:**

1. Students have to register on the SWAYAM portal.
2. Through the SWAYAM portal, explore the courses available by NPTEL coordinator.
3. The minimum duration of the NPTEL course to be registered by the students has to be 8/12 weeks. (as per the course offered in the semester.)
4. Students can register the courses of engineering, science, humanities, management, and multidisciplinary in the NPTEL portal.
5. Students have to submit the assignments as per schedule given by NPTEL course structure and take part in a self assessment test.
6. Students have to register for the certificate examination of NPTEL by paying the required fees.
7. Students will be awarded credits of MOOCs only when they earn the certificate of the registered course.

7. Students have to submit proof (certificate) to the department in order to get credits.

**Guidelines for institute:**

1. It is advised that the institute should register for the NPTEL local chapter.
2. Keep the track of student registration in SWAYAM-NPTEL course.
3. Check the certificate authenticity submitted by student through online portal

**Guidelines for Assessment:**

1. The NPTEL will give percentage grades in certificates out of 100.
2. The percentage obtained needs to be converted to 50 marks and submitted as term work marks to university. (if someone got 75% marks then TW calculation will be 75/2=37.5=38 (out of 50) and round up the nearest integer.)
3. External examiner appointed by the university will assess certificates and marks obtained physically at the institute.

# 403147A: German Language-I

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | – | ISE | | – |

==========

## Course Objectives:

This course aims to:

1. Get introduced to the Culture, Routine of the German Society through language.
2. Meet the needs of ever growing German industry with respect to language support.

## Course Outcomes:

At the end of this course, students:
CO1: Will have the ability of basic communication.
CO2: Will have the knowledge of German script.
CO3: Will get introduced to reading ,writing and listening skills
CO4: Will develop interest to pursue profession in Indo-German Industry.

| | | |
|---|---|---|
| Unit 01 | Introduction to the German Language-I | 06 hrs |

Introduction of German Alphabets, Spell the names, Addresses, Numbers, Telephone numbers, Ordinal Numbers, Pin code Numbers, Dates, Birthdates, Age, days of the week, Months.

| | | |
|---|---|---|
| Unit 02 | Introduction to the German Language-II | 06 hrs |

Basic Greetings, Personal Pronouns, Possessive Pronouns.

| | | |
|---|---|---|
| Unit 03 | Introduction to the German Language-III | 06 hrs |

Self-Introduction, Introducing other people, about family, friends, course mates, seasons, and seasons in Germany and in neighboring countries.

## Text Books:

| | |
|---|---|
| [T1] | Netzwerk A-1 (Deutsch als Fremdsprache) Goyal Publishers & Distributors Pvt. Ltd. |

## Reference Books:

| | |
|---|---|
| [R1] | Tipps und Uebungen A1 |

## Online Resources:

| | |
|---|---|
| [O1] | Practice Material like Listening Module, reading Texts |

# 403147B: Engineering Economics-I

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | – | ISE | | – |

==========

## Course Objectives:

This course aims to:

1. Describe basics of economics and its application in engineering.
2. Explain the concept of Time value of Money and Cash flow

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Discuss concepts related to business and its impact on enterprise.
CO2:Illustrate time value of money in economic analysis.

| | | |
|---|---|---|
| Unit 01 | Engineering Economics | 10 hrs |

Nature and scope, General concepts on micro & macro economics. The Theory of demand, Demand function, Law of demand and its exceptions, Elasticity of demand, Law of supply and elasticity of supply. Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics – Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis – V ratio, Elementary economic Analysis – Material selection for product, Design selection for a product, Process planning.

| | | |
|---|---|---|
| Unit 02 | Time Value of Money and Cash flow analysis | 10 hrs |

Time value of money: Simple and compound interest, Nominal Interest rate, Effective Interest rate, Principle of economic equivalence.
Cash Flow – Diagrams, Categories & Computation
Depreciation: Meaning Causes, Factors affecting depreciation, Methods of providing depreciation, Straight Line Method & Diminishing Balance Method

## Text Books:


| | |
|---|---|
| [T1] | Riggs, Bedworth and Randhwa, “Engineering Economics”, McGraw Hill Education India. |
| [T2] | D.M. Mithani, Principles of Economics. Himalaya Publishing House |


## Reference Books:


| | |
|---|---|
| [R1] | Sasmita Mishra, “Engineering Economics & Costing “, PHI |
| [R2] | Sullivan and Wicks, “ Engineering Economy”, Pearson |
| [R3] | R. Paneer Seelvan, “ Engineering Economics”, PHI |

# 403147C: Sustainability

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | – | ISE | | – |

==========

## Course Objectives:

This course aims to:

- Increase awareness among students about sustainability.
- Understand role of engineering and technology within sustainable development.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Understand different types of environmental pollution problem.
CO2: Suggest solutions for sustainable development.
CO3: Develop a broader perspective in thinking for sustainable practices by utilizing engineering principle and knowledge

| | | | |
|---|---|---|---|
| Unit 01 | Sustainability Introduction | | 11 hrs |

Introduction, need and concept of sustainability, social, environmental and economical sustainability concepts, sustainable development, 17 goals defined by UN, Nexus between technology and sustatinable development and its challenges, multilateral environmental agreements and protocols-CDM, Environmental legislations in India-Water Act, Air Act.
Air, water and solid waste pollution sources and impacts, Sustainable water treatment. Zero waste concept. Global environmental issues, climate change, global warming, ozon layer depletion.

| | | | |
|---|---|---|---|
| Unit 02 | Sustainable Solution | | 11 hrs |

Carbon credits and trading, carbon foot print, Green engineering, sustainable urbanization, industrialization and poverty reduction, Industrial process: Material selection, pollution preventions, industrial ecology and symbiosis, Global institutions: UNEP, IPCC, UNDP, WHO, Kyoto protocols. Certification and labelling in energy and carbon: Energy Star, Compliance and voluntary carbon credits, Green-e. Tools and techniques: ISO 14001, ISO26000, ABCD planning method.Assessment measurement: Indicators, F2B2, LCA, LCC, ROI.

## Text Books:


| | |
|---|---|
| [T1] | Allen D. T. and Shonnard D. R. “Sustainable Engineering: Concept design and case studies”, Prentice hall |
| [T2] | Environmental Impact Assessment Guidelines, Notification of Government of India 2006 |
| [T3] | Mackenthun K. M. “Basic Concept of Environmental Management”, Lewis publication London 1998 |
| [T4] | ECBC code 2007, BEE, New Delhi, BEE publication, TERI publication |

| | |
|---|---|
| [T5] | Ni Bin Chang, “Systems Analysis for sustainable engineering: Theory and Applications ”, Mc-Graw-Hill Professional |
| Reference Books: | |
| [R1] | “Sustainable Excellence Associate: Study Guide” International society of sustainability professional, https://community.sustainabilityprofessionals.org/store/viewproduct.aspx?id=13043928 |
| Online Resources: | |
| [O1] | https://www.globalgoals.org/goals/ |

# 403148: Switchgear and Protection

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Oral | 50 |
| | | | | | Termwork | 25 |

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## Course Objectives:

This course aims to:

- Acquaint about construction and working principles of different types of HVCBs.
- Elaborate the need for protective relaying and the operating principles of different types of relays.
- Explain the different types of faults in the transformer, alternator, and 3-phase induction motor and the various protective schemes related to them.
- Impart knowledge about transmission line protection schemes and the characteristics of different types of distance relays.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Understand the fundamentals of protective relaying.
CO2:Demonstrate the arc interruption and analyze the RRRV in circuit breakers
CO3:Demonstrate the construction and working principle of air brake circuit breakers, SF6 circuit breakers, and a vacuum circuit breaker.
CO4:Explain the characteristics of static and digital relays and their applications in power systems.
CO5:Apply the differential protection scheme to large transformers, alternators, and induction motors.
CO6:Apply distance protection, three stepped protection for transmission line.

| | | |
|---|---|---|
| Unit 01 | Fundamentals of protective relaying | 08hrs |

Need for protective system, nature and causes of fault, types of faults, effects of faults, evolution of protective relaying, classification of relays, zones of protection, primary and backup protection, essential qualities of protective relaying. Trip circuit of circuit breaker, zone of protection. Various basic operating principles of protection- over current, (current graded and time graded ), directional over current, differential, distance, induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numericals on TSM , PSM and operating time of relay.

| | | |
|---|---|---|
| Unit 02 | Fundamentals of arc interruption | 07 hrs |

Ionization of gasses, deionization, Electric arc formation , Current interruption in AC circuit breaker, high and low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching, Numerical on RRRV, current chopping and resistance switching.

| | | |
|---|---|---|
| Unit 03 | Circuit Breaker | 08 hrs |

Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity – symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating). Classification of high voltage circuit breakers. Working and constructional features of ACB, SF6 , VCB- advantages, disadvantages and applications. Auto reclosing, Testing of circuit breakers. Introduction to GIS , its advantages over conventional substation

| Unit 04 | Static and Digital Relaying | 06 hrs |
|---|---|---|

Overview of Static relay, block diagram, operating principle, merits and demerits of static relay. Numerical Relays :-Introduction and block diagram of numerical relay, Sampling theorem, Anti –Aliasing Filter, Block diagram of PMU and its application.

| Unit 05 | Equipment protection | 08 hrs |
|---|---|---|

I. Power Transformer Protection: Types of faults in transformer, Percentage differential protection in transformers, Restricted E/F protection, incipient faults, Buchholz relay, protection against over fluxing, protection against inrush current.

II. 3 Phase Induction Motor Protection: Abnormal conditions and causes of failures in 3 phase Induction motor, single phasing protection, Overload protection, Short circuit protection.

III. Synchronous Generator (Alternator) Protection: Various faults in Alternator, abnormal operating conditions- stator faults, longitudinal percentage differential scheme and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation, protection against loss of excitation using offset Mho relay, loss of prime mover.

| Unit 06 | Transmission line protection | 08 hrs |
|---|---|---|

Over current protection for feeder using directional and non directional over current relays, Introduction to distance protection, impedance relay, reactance relay, mho relay and Quadrilateral Relays, three stepped distance protection, Effect of arc resistance, and power swing on performance of distance relay. Realization of distance relays(impedance, reactance, and mho relay) using numerical relaying algorithm(flowchart, block diagram), Introduction to PLCC, block diagram, advantages, disadvantages, Introduction to Wide Area Measurement (WAM) system.

**Text Books:**


| | |
|---|---|
| [T1] | Badri Ram, D. N. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill Publishing Co. Ltd. |
| [T2] | Y. G. Paithankar, S. R. Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India |
| [T3] | Bhavesh Bhalja,R.P. Maheshwari, N.G. Chothani,” Protection and Switchgear”, Oxford University Press, 2011 Edition. |
| [T4] | J.B.Gupta “ Switchgear and Protection”, S.K. Kataria and Sons. |
| [T5] | Power system protection and switchgear by Oza, Nair, Mehta, Makwana |


**Reference Books:**


| | |
|---|---|
| [R1] | S. Rao, “Switchgear Protection and Power Systems”, Khanna Publications |

| | |
|---|---|
| [R2] | J Lewis Blackburn , “Protective Relaying- Principles and Applications”, Dekker Publications. |
| [R3] | A.G. Phadke, J.S. Thorp ,Computer relaying for Power System , Research Studies Press LTD, England.(John Willy and Sons Inc New York) |
| [R4] | Mason C.R., “Art and Science of Protective Relaying”, Wiley Eastern Limited. |
| [R5] | Arun Ingole, “Switchgear and Protection”, Pearson. |
| [R6] | Bhuvanesh Oza, “Power System Protection and Switchgear”, McGraw Hill Education. |

## Online Resources:

| | |
|---|---|
| [O1] | Prof. Dr S.A. Soman, IIT Mumbai, A Web course on “Digital Protection of power System” http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Protection/Course_home_L27.html |
| [O2] | NPTEL Course on power system protection. |

**Mapping:**

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1,T2,T4 | R1, R2, R6 |
| 02 | T1,T3,T4 | R1, R6 |
| 03 | T1,T4 | R1, R6 |
| 04 | T2,T3,T4 | R3, R4, R6 |
| 05 | T1 , T5 | R1 ,R5, R6 |
| 06 | T1,T4 | R1,R2, R5, R6 |

## List of Experiments:

**A) Compulsory Experiments**

1. Study of switchgear testing kit.
2. Protection of Transmission line using Impedance relay

**B) Minimum 6 Experiments to be performed from the following list:**

1. Study and testing of fuse , MCB.
2. Study and testing of contactors.
3. Study and testing of ACB.
4. Study and testing of MCCB.
5. Study and testing of thermal overload relay for Induction Motor protection.
6. Study and plot Characteristics of IDMT type Induction over current relay
7. Study and plot Characteristics of digital over current relay
8. Percentage differential protection of transformer (Merz Price Protection).
9. Protection of alternators.

## Guidelines for Instructor's Manual:

Lab manual must contain;

- Title of the experiment
- Aim
- Apparatus.
- Theory: Brief theory explaining the experiment
- Circuit / connection diagram or construction diagram must be drawn either manually using geometrical instruments or using software on A-4 size quality graph paper / plain white paper.
- Detailed constructional diagram with nomenclature:
- Procedure: Write down step by step procedure to perform the experiment.
- Specifications of Switchgear:
- Observation table:
- Graph:
- Conclusion:

## Guidelines for Student's Lab Manual:

- Students should write the journal in his own handwriting using A4 size both side ruled paper.
- Circuit / Connection diagram or construction diagram must be drawn either manually or using software. [Do not use Photocopy of standard journal] on A4 size blank/graph paper.
- Hand writing must be neat and clean.
- Journal must contain a certificate indicating the name of the institute, student, department, subject, class/ year, number of experiments completed, signature of staff, Head of the department and the Principal.
- Index must contain Sr. number, title of the experiment, page number, and the signature of staff along with date.
- Use black or blue ink pen for writing.

## Guidelines for Laboratory Conduction:

- Check whether the MCB / main switch is off.
- Make connections as per circuit diagram. Do not keep loose connections. Get it checked by the teacher / Lab Assistant.
- Perform the experiment only in the presence of a teacher or Lab Assistant.
- After completion of the experiment, switch off the MCB / main switch.
- Write the experiment in the journal and get it checked within a week.

## Industrial Visit:

Industrial visit to switchgear training center /or switchgear/relay manufacturing unit/ or 220 kV substation visit and report to be submitted.

## Assignments:

Minimum 2 assignments (at least 4 to 6 questions in each) to be submitted as a part of term-work.

# 403149: Advanced Electrical Drives and Control

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| Practical | 02 | Hrs/Week/Batch | Practical | 01 | ESE | 70 |
| | | | | | Practical | 50 |
| | | | | | Termwork | 25 |

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## Course Objectives:

This course aims to:

- Understand motor load dynamics. ·
- Study and analyze the operation of the converter fed and chopper fed dc drives. ·
- Study and understand braking methods of D.C. and Induction motor drive.
- Study vector control of induction motors. ·
- Study synchronous and BLDC motor drive. ·
- Study classes and duty of motor. ·
- Understands the modes of operation of drive in various applications.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Explain motor load dynamics and multi quadrant operation of drives.
CO2: Analyze operation of converter fed and chopper fed DC drives.
CO3: Apply different braking methods of D.C. and induction motor drive.
CO4: Elaborate vector control for induction motor and BLDC drives.
CO5: Elaborate synchronous motor, reluctance motor drive.
CO6: Differentiate between classes and duty cycles of motors and select suitable drives in various industrial applications.

| | | |
|---|---|---|
| Unit 01 | Electrical Drives | 07 hrs |

A. Definition, components of electric drive system, types of electrical drives (DC and AC), selection of drive parameters, List of Industrial Applications
B. Motor-Load dynamics, speed-torque conventions and multi-quadrant operation, equivalent values of drive parameters, load torque components, nature and classification of load, constant power operation of a drive, steady-state stability.

| | | |
|---|---|---|
| Unit 02 | DC Motor Drives: | 08 hrs |

A. Single-phase and three-phase fully controlled converter drives and performance of converter fed separately excited DC Motor for speed control operations, 12 pulse converter drives.
B. Chopper controlled drives for separately excited and series DC Motor operations. Closed-loop speed control of DC motor below and above base speed for starting, speed control and braking

| | | |
|---|---|---|
| Unit 03 | Induction Motor Drives: | 08 hrs |

Regenerative braking, dynamic braking, Plugging, Numerical based on braking and speed control, voltage source inverter (VSI) control, Steady State Analysis. Current source inverter (CSI) control-open and closed loop, Regenerative braking and multi quadrant operation of Induction motor drives, Principle of vector control, Block diagram of Vector control of induction motor, Failure modes of Drives.

| | | |
|---|---|---|
| Unit 04 | BLDC drive: | 07 hrs |

Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics, closed loop control of BLDC drive (PI controller) , vector control of BLDC drive, Applications in EV ( descriptive treatment)

| | | |
|---|---|---|
| Unit 05 | Synchronous Motor drives: | 08 hrs |

A. PMSM Drive: Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics, closed loop control of PMSM drive (PI controller) , vector control of PMSM drive.
B. Synchronous Reluctance Motor -Introduction, working of SRM , application in EV (descriptive treatment)

| | | |
|---|---|---|
| Unit 06 | Drive Application | 07 hrs |

A. Classes of motor duty, types of enclosures for motor.
B. Specific requirement and choice of drives for following applications: Machine tools , Textile mills, Steel rolling mills, Sugar mills, Traction drives, Crane and hoist drives, Solar and battery powered drives

## Text Books:

| | |
|---|---|
| [T1] | G. K. Dubey, “Fundamentals of Electric Drives”, 2nd Edition, Narosa Publishing House |
| [T2] | N. K. De, P. K. Sen, “Electric Drives”, Prentice Hall of India Eastern Economy Edition |
| [T3] | S. K. Pillai, “Analysis of Thyristor Power Conditioned Motors”, University Press |
| [T4] | G.K. Dubey, “Power Semiconductor controlled drives”, PHI publication |
| [T5] | B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education |

## Reference Books:

| | |
|---|---|
| [R1] | R. Krishnan, “Electric Motor Drives – Modeling Analysis and Control”, PHI India |
| [R2] | B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education |
| [R3] | V. Subrahmanyam, “Electric Drives: Concepts and Application”, Tata Mc-Graw Hill (An imprint of Elsevier) |
| [R4] | M.D. Singh and Khanchandani “Power Electronics”, Tata Mc-Graw Hill |
| [R5] | Austin Huges, “Electrical motor and drives: Fundamental, types and applications”, Heinemann Newnes, London |

| | |
|---|---|
| [R6] | Tyagi MATLAB for engineers oxford (Indian Edition) |
| [R7] | Malcolm Barnes, “Practical Variable Speed Drives and Power Electronics”, Elsevier Newnes Publications |

## Online Resources:

| | |
|---|---|
| [O1] | NPTEL online course on Fundamentals of Electric Drives, I.I.T. Kanpur by Dr. S.P. Das. |
| [O2] | NPTEL online course on advanced Electric Drives, I.I.T. Kanpur by Dr. S.P. Das. |
| [O3] | Allen Bradley Powerflex 700 AC Drives User manual. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1 | R3 |
| 02 | T1,T5 | R2,R4 |
| 03 | T1,T4 | R1,R5 |
| 04 | T1,T2,T5 | R1,R2 |
| 05 | T1,T3,T5 | R1,R6 |
| 06 | T1,T2 | R3,R5,R7 |

## List of Experiments:

Total 9 experiments to be conducted from the following list of practical.

A) Following 5 experiments are compulsory (Hardware based)

1. Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).
2. Speed control characteristics of single phase fully converter fed separately excited D.C. motor
3. VSI fed 3 phase Induction motor (using V/f control PWM inverter) speed control characteristics.
4. Chopper fed D.C. series/separately motor speed control characteristics.
5. Electrical braking of 3 phases Induction Motor (DC Dynamic Braking, Plugging, Regenerative Braking).

B) Any 4 experiments from following (Hardware/software)

6. Speed control characteristics of 3-ph fully converter fed separately excited D.C. motor.
7. Simulation of Induction Motor Vector Control.
8. Study of constant torque and constant power characteristic of induction motor.
9. Study of speed control of BLDC / PMSM drive.
10. Simulation of closed loop control of BLDC / PMSM drive.
11. Simulation of vector control of PMSM/BLDC motor

## Guidelines for Instructor’s Manual:

- Title and circuit diagram of power electronic controlled drives/ electrical machine circuit. ·
- Working operation and output characteristics / output waveforms of power electronic switching device /converter circuit used to control the electric motor.
- Procedure to carry out the experiment

| Guidelines for Student's Lab Manual: |
| --- |
| ● Title, aim, circuit diagram, procedure and theory of power electronic switching device or converter circuit and expected machine performance with speed torque characteristics.<br>● Equipment along with the specifications needed to carry out the experiment.<br>● Circuit diagram, observation table, calculations must be written on the left side of the journal and aim, theory related to experiment and procedure must be written on the right side.<br>● Analyze and interpret the experimental results and write the conclusions appropriately. |
| Guidelines for Laboratory Conduction: |
| ● Each group in the lab should have not more than three students. ·<br>● All the students in the group must do the connections and perform the practical under the guidance of the staff member. ·<br>● Staff member has to check the results of all the groups. |

# 403150A: Digital Control System

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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## Course Objectives:

This course aims to:

- Make students elaborate basic concepts of discrete signals and systems.
- Educate students to analyze the stability of discrete systems.
- Explain formulation of state space discrete model and design the digital controllers.
- Elaborate digitize analog controllers using various numerical methods.
- Explore application of the theory of digital control to practical problems.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Analyze digital control system and its stability.
CO2: Differentiate between various control systems
CO3: Present system in state space format.
CO4: Design observer for system.
CO5: Understand digital controllers
CO6: Elaborate applications such as digital temperature control and position control

| | | |
|---|---|---|
| Unit 01 | Discrete systems and Signals | 07 hrs |

Standard discrete test signals, Basic operations on signals. Classification of discrete systems. Detail analysis of frequency aliasing and quantization, Brief review of Sampling theorem, Ideal low pass filter. Transfer function of ZOH, Frequency domain characteristics of ZOH, First order hold, frequency domain characteristics of first order hold.

| | | |
|---|---|---|
| Unit 02 | State - Space analysis | 07 hrs |

Conversion of Pulse transfer functions to State space model and vice a versa. Solution of LTI Discrete – time state equation; State Transition Matrix (STM) and properties of STM; Computation of STM by Z-transform method, by power series expansion method, by Cayley Hamilton theorem, by Similarity transformation method, Discretization of continuous time state space equation

| | | |
|---|---|---|
| Unit 03 | Design using state space | 07 hrs |

Controllability and observability of linear time invariant discrete-data system, Tests for Controllability and observability; Principal of Duality; Effect of pole- zero cancellation; Relationship between controllability, observability and stability. Pole placement design using linear state-feedback.

| | | |
|---|---|---|
| Unit 04 | Design of State Observers | 07 hrs |

Full order state observer, reduced order state observer, State estimation and full order observer design. Ackermann's formula. Compensator design by the separation principle, State feedback with integral control, State regulator design.

| Unit 05 | State space model and digitizing analog controllers | 07 hrs |
|---|---|---|

State space model of digital systems: Transformation of state-space model to various forms (controllable, observable, diagonal and Jordan canonical forms). Numerical approximation of differential equations, Euler's forward and backward method, Trapezoidal method, Bilinear transformation with frequency warping. Numerical differentiation, Matching step and other response. Pole-zero matching

| Unit 06 | Digital control system applications | 07 hrs |
|---|---|---|

Hybrid system simulation, Computer program structure for simulation of discrete time control of continuous time plant. Digital temperature control, position control, Stepper motor control, Block diagram presentation and control algorithms.

## Text Books:

| [T1] | K. Ogata, "Discrete Time Control System", 2nd Edition, PHI Learning Pvt. Ltd. 2009 |
|---|---|
| [T2] | B. C. Kuo, "Digital Control Systems", 2nd Edition, Oxford University Press |
| [T3] | M. Gopal, "Digital Control Engineering", New Age International Publishers |
| [T4] | M. Gopal, "Digital Control and State Variable Methods", 3rd Edition The McGraw Hill Co. |

## Reference Books:

| [R1] | Load D. Landau, Gianluca Zito, 'Digital Control Systems: design, Identification and Implementation' Springer. |
|---|---|
| [R2] | Mohammed Santina, Allen Stubberud, Gene Hostetter 'Digital control System Design', Sanders College publishing |
| [R3] | K.J. Astrom, B Wittenmark 'Computer Controlled Systems: Theory and Design' Prentice-Hall Inc New Jersey, 2011 Dover. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T2, T2 | R3 |
| 02 | T2 | R3 |
| 03 | T1, T2 | R3 |
| 04 | T1,T2 | R1, R2 |
| 05 | T1,T3 | R1, R2 |
| 06 | T2,T4 | R3 |

## 403150B: Restructuring and Deregulation

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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### Course Objectives:

This course aims to:

- Give brief introductions about the various institutions and their roles in the Indian Power sector and introduce the restructured power system .
- Introduce Fundamentals of Power Sector economics.
- Educate about the process and operation of restructuring of power systems and tariff setting principles.
- Explain Power Sector Restructuring Models and to introduction concept of energy trading
- Introduce the concept of electricity markets and various operations involved in the market .
- Explain the fundamental concept of congestion, its management and transmission pricing and concept of transmission pricing.

### Course Outcomes:

At the end of this course, students will be able to:
CO1: Identify the various institutions in the Indian power sector and explain their role in the Indian power sector .
CO2: Explain the various fundamentals of power sector economics
CO3: Describe the regulatory process in India and list the steps involved in tariff determination and explain the phases of tariff determination
CO4: Describe and explain different power sector restructuring models and explain the concept of energy trading
CO5: Explain the types of electricity markets and compare the types of electricity markets .
CO6: State different transmission pricing methods and describe and compare various congestion management methods.

| Unit 01 | Power Sector in India | 07hrs |
|---|---|---|

Introduction to various institutions in the Indian Power sector such as the Ministry of Power ,MNRE, CEA, Planning Commissions, PGCIL, PFC, CERC, SERC, Load dispatch centers (National, regional and state ) and their roles. Critical issues / challenges before the Indian power sector, Need of regulation and deregulation of the power industry. Conditions favoring deregulation in the power sector. An overview of the restructured power system, Difference between integrated power system and restructured power system

| Unit 02 | Fundamentals of Power Sector Economics | 07hrs |
|---|---|---|

Introduction, Consumer behaviour, Supplier behaviour, Short-run and Long-run costs, Various costs of production, Relationship between short-run and long-run average costs, Typical cost components and cost structure of the power sector, Concept of life cycle cost, annual rate of return .Elasticity of demand and

supply curve, Market equilibrium, Consumer and supplier surplus. Perfectly competitive market. Key Indices for assessment of utility performances.(Generation, transmission and distribution).Financial tools to compare investment options.

| | | |
|---|---|---|
| Unit 03 | Power Sector Regulation | 07hrs |

Regulatory process in India, types and methods of Regulation - rate of return regulation, benchmarking or yardstick regulation, performance-based regulation. Role of regulatory commission. Considerations of socio economic aspects in regulation. Principles of Tariff setting, Phases of Tariff determination. Consumer tariff structures and considerations, different consumer categories. Comparison of different tariff structures for different load patterns. The Electricity Act 2003, The Electricity Act 2010, National Electricity policy. Recently Amended Electrical policy.

| | | |
|---|---|---|
| Unit 04 | Introduction to Power Sector Restructuring Models and Introduction to energy trading | 07hrs |

Introduction, models based on energy trading or structural models – monopoly, single buyer, wholesale competition, retail competition. Models based on contractual arrangements – pool model, bilateral dispatch, pool and bilateral trades, multilateral trades, ownership models, ISO models. Introduction to energy exchange , Day ahead market (DAM ) and Term ahead market (TAM), procedure adopted in energy exchanges and trading of Renewable energy credits and carbon credits.

| | | |
|---|---|---|
| Unit 05 | Electricity markets | 07hrs |

Rules that govern electricity markets, peculiarity of electricity as a commodity. Various electricity markets such as spot markets, forward contracts and forward markets , future contracts and future markets .Market operation – settlement process , market clearing price (MCP) , Market efficiency . Market power Electricity markets under imperfect competition Sources of market power, Effect of market power, Identifying market power, HHI Index, Entropy coefficient, Lerner index, Market power mitigation, Effects of contract for differences.

| | | |
|---|---|---|
| Unit 06 | Transmission Pricing and Congestion Management | 07hrs |

Cost components of transmission system, cost allocation of transmission system, Transmission pricing methods, physical transmission rights, Open access.
Congestion in power networks, reasons for congestion, congestion management methods . Non-market methods, Market based methods. Definition of terms - Total transfer capability (TTC), Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC). Locational marginal Pricing (LMR), Firm Transmission Right (FTR)

## Text Books:


| | |
|---|---|
| [T1] | Know Your Power: A citizen Primer on the electricity Sector, Prayas Energy Group, Pune |
| [T2] | Daniel S. Kirschen, Goran Strbac, “Power System Economics” John Wiely and Sons Publication Ltd. August 2006 |
| [T3] | Mohammad Shahidehpour, Muwaffaq Alomoush, “Restructured Electrical Power Systems: Operation Trading and Volatility” CRC Press, 06-J |


## Reference Books:


| | |
|---|---|
| [R1] | Steven Stoft, “Power System Economics: Designing Markets for Electricity”, John Wiley and Sons, 2002 |

| | |
|---|---|
| [R2] | Sally Hunt, “Making Competition Work in Electricity”, 2002, John Wiley Inc |
| [R3] | Geoffrey Rothwell, Tomas Gomez, “Electricity Economics Regulation and Deregulation” A John Wiley and Sons Publication 2003 |
| [R4] | Mohammad Shahidehpour, Hatim Yamin, Zuyi Li, “Market operations in Electric Power System” A John Wiley and Sons Publication |
| [R5] | Deregulation in Power Industry – A course under continuing Education Program, Department of Electrical Engineering , IIT Bombay |

Online Resources:

| | |
|---|---|
| [O1] | http://www.cercind.gov.in/Function.html |
| [O2] | www.cercind.gov.in/serc.html |
| [O3] | http://www.power.gov.ng/index.php/about-us/our-functions |
| [O4] | http://planningcommission.nic.in/reports/genrep/arep9920/ar9920role.htm |
| [O5] | http://www.cea.nic.in/functions.html |
| [O6] | https://nptel.ac.in/courses/108101005 |
| [O7] | https://posoco.in/ |
| [08] | https://www.iexindia.com/ |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1 | [O1]-[O6] |
| 02 | T1 | R3 |
| 03 | T1 | R1 |
| 04 | T2 | R5,[O8] |
| 05 | T2 | R5,R2,R4 |
| 06 | T3 | R1 |

# 403150C: Smart Grid

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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## Course Objectives:

This course aims to:

- Explain the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers.
- Describe the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home and Building Automation, Phase Shifting Transformers.
- Elaborate the concept of Substation Automation, Feeder Automation. Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, Phase Measurement Unit.
- Elaborate the concept of microgrid.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Apply the knowledge to differentiate between Conventional and Smart Grid
CO2: Describe importance of Supercapacitors.
CO3: Identify the need of Smart metering.
CO4: Apply the communication technology in smart grid.
CO5: Comprehend the issues of micro grid.

| | | |
|---|---|---|
| Unit 01 | Introduction to Smart Grid | 07 hrs |

Concept of Smart Grid, Need of Smart Grid, Functions of Smart Grid, Opportunities and Barriers of Smart Grid, Drivers of SG in India, Functionalities and key components of smart grid, Difference between conventional and smart grid, Smart Grid Vision and Roadmap for India, Concept of Resilient and Self-Healing Grid, Smart Grid National Policies, Smart Cities, Pilot projects in India

| | | |
|---|---|---|
| Unit 02 | Smart Grid Technologies | 07 hrs |

Intelligent Electronic Devices (IED), Phase Measurement Unit (PMU). Smart Substations, Substation and Feeder Automation, application for monitoring, protection and control, Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid (V2G), Energy Storage Technologies and applications – Battery (flow and advanced), SMES, Super Capacitors, Compressed Air Energy Storage (CAES) and its comparison.

| | | |
|---|---|---|
| Unit 03 | Smart Meters and Advanced Metering Infrastructure | 07 hrs |

Introduction to Smart Meters, Prepaid meters, Net Metering, Advanced Metering Infrastructure (AMI), Real Time Pricing, Automatic Meter Reading (AMR), Outage Management System (OMS), Smart Substation , IEC 61850, Smart Sensors, Geographic Information System (GIS), IS 16444, LowPAN RF meter

| | | |
|---|---|---|
| Unit 04 | Communication Technology for Smart Grid | 07 hrs |
| Communication Architecture of SG, Wide Area Measurement Protection and Control (WAMPAC), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN)., ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing and Cyber Security for Smart Grid, LORaWAN, NB-IoT, SigFox. | | |
| Unit 05 | Microgrids | 07 hrs |
| Concept of Microgrid, need and applications of Microgrid, Microgrid Architecture, DC Microgrid, Hybrid Microgrid, Formation of Microgrid, Issues of interconnection, protection and control of Microgrid, Integration of renewable energy sources, Smart Microgrid, Microgrid and Smart Grid Comparison, Renewable Energy based Microgrid system | | |
| Unit 06 | Power Quality issues and Challenges | 07 hrs |
| Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources , Smart Grid data analytics, Distributed Generation, Reliability Indices (CAIDI, CAIFI, MAIDI, MAIFI), Load Forecasting Methods, Smart Appliances, Home and Building Automation. | | |
| Text Books: | | |
| [T1] | Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”,CRC Press | |
| [T2] | Stuart Borlase, “Smart Grids-Infrastructure, Technology and Solutions”, CRC Press, Taylor and Francis group | |
| [T3] | Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley Publications. | |
| [T4] | Nikos Ziargyriour, “Micro grid, Architecture and Control”, IEEE Press, Wiley Publications. | |
| Reference Books: | | |
| [R1] | Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press, Taylor and Francis group | |
| Online Resources: | | |

| 403150D: Sensor Technology (Open Elective) | | | | | | |
|---|---|---|---|---|---|---|
| **Teaching Scheme** | | | **Credits** | | **Examination Scheme** | |
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

==========

## Course Objectives:

This course aims to:

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Understand the characteristics of sensors used for system monitoring and protection.
CO2: Interface the various position sensors to microcontrollers.
CO3: Demonstrate the characteristics of sensors used for light and image sensing.

| | | |
|---|---|---|
| Unit 01 | Sensor fundamentals and characteristics | 06 hrs |

Sensor Classification, Performance and Types, Error Analysis characteristics

| | | |
|---|---|---|
| Unit 02 | Optical Sources and Detectors | 06 hrs |

Electronic and Optical properties of semiconductor as sensors, LED, Semiconductor lasers, Fiber optic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs.

| | | |
|---|---|---|
| Unit 03 | Light & image sensing | 06 hrs |

Sensors and sensing AFEs for capturing a broad range of wavelengths introduction, 3D Depth Sensor, Near Infrared spectroscopy, OPT3007 Light Sensor, Optical Isolators.

| | | |
|---|---|---|
| Unit 04 | System monitoring & protection sensing | 06 hrs |

Principle of operation and application of following sensors for Real-time system protection, feedback control and high-accuracy system monitoring: LM35 Temperature Sensor, INA240 current sense amplifier, DRV5053 Hall Effect based current sensor, HDC1080 / HDC1010 / HDC2010 Humidity Sensor.

| | | |
|---|---|---|
| Unit 05 | Position Sensing | 06 hrs |

Absolute and relative position sensing solutions including: angular, presence, proximity, distance, flow, level, and velocity basics, DRV 5032 Hall Effect Sensor, mmWave Sensor, AFE5805 Ultrasonic sensor, Encoder, Resolver, Inductive position sensor, Capacitive Position Sensor, LVDT.

| | | |
|---|---|---|
| Unit 06 | Special Sensors - | 06 hrs |

GPS, Bluetooth, smart sensor - film sensor, MEMS and nano sensors, laser sensors, touch screen sensors, heading sensors - compass gyroscope inclinometer, application of sensors in drone.

## Text Books:

| | |
|---|---|
| [T1] | Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York. 2. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland. |
| [T2] | Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland. |

## Reference Books:

| | |
|---|---|
| [R1] | Gerd Keiser,”Optical Fiber Communications”, 2012, 4th edition, McGraw-Hill Science, Delhi. |
| [R2] | John G Webster, “Measurement, Instrumentation and sensor Handbook”, 2014, 2nd edition, CRC Press, Florida. |
| [R3] | Eric Udd and W.B. Spillman, “Fiber optic sensors: An introduction for engineers and scientists”, 2013, 2nd edition, Wiley, New Jersey. |
| [R4] | Bahaa E. A. Saleh and Malvin Carl Teich, “Fundamentals of photonics”, 2012, 1st edition, John Wiley, New York. |

## Online Resources:

| | |
|---|---|
| [O1] | https://www.ti.com |
| [O2] | https://www.mouser.in/ |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | [01] | [R1] |
| 02 | [02] | [R2],[R4] |
| 03 | [01],[02] | [R3] |
| 04 | [01],[02] | [01] Online |
| 05 | [01],[02] | [02] online |
| 06 | [01],[02] | [R2],[R4] |

# 403151A: EHV AC Transmission

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

==========

## Course Objectives:

This course aims to:

- Explain the need of EHV and UHV systems.
- Describe the impact of such voltage levels on the environment.
- Identify problems encountered with EHV and UHV transmissions.
- Describe methods of governance on the line conductor design, line height and phase etc.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Highlight need for EHV ac transmission.
CO2:Calculate line and ground parameters.
CO3:Enlist problems encountered in EHV transmission.
CO4:Describe the effect of electric and magnetic fields on human beings.

| | | |
|---|---|---|
| Unit 01 | EHVAC Transmission | 07 hrs |

Need for EHV transmission lines, Power handling capacity and line loss, Mechanical considerations in line performance, Vibrations. Traveling wave equations, transmission reflection attenuation and distortion of traveling waves, transmission and reflection coefficients and examples.

| | | |
|---|---|---|
| Unit 02 | Calculation of line and ground parameters | 07 hrs |

Resistance of conductors, effect of temperature on overhead conductors, temperature rise of conductors and current carrying capacity, Properties of bundled conductors, Inductance of current carrying single conductor, Inductance of EHV line configurations, Line capacitance calculations

| | | |
|---|---|---|
| Unit 03 | Voltage Gradient of Conductor | 07 hrs |

Electrostatic Field of a point charge and its properties, Field of sphere gap, Field of line charges and their properties, charge potential relations for multi-conductor lines, Maximum charge condition on three phase line.
Surface voltage gradient on conductors-single conductor, two conductors and multi-conductor bundle, Maximum surface voltage gradient, Mangoldt formula, design of cylindrical cage for corona gradients.

| | | |
|---|---|---|
| Unit 04 | Electrostatic and magnetic fields of EHV lines | 07hrs |

Electric shock and threshold currents, Effects of high electrostatic fields on humans, animals and plants, Calculation of electrostatic field of single circuit of three phase line, Profile of electrostatic field of line at ground level.
Electrostatic induction on an un-energized circuit of a double circuit line. Insulated ground wire and induced voltage in insulated ground wires. Magnetic field calculation of horizontal configuration of single circuit of

three phase lines, Effects of power frequency magnetic fields on human health.

| Unit 05 | Corona and its effects | 07 hrs |
|---|---|---|

Corona formation, corona inception voltage, visual corona voltage, critical field for corona inception and for visual corona under standard operating condition and conditions other than standard operating conditions.
Power loss due to corona, corona loss formulae, corona current waveform, charge-voltage diagram and corona loss. Audible noise operation and characteristics limits for audible noise, AN measurement and meters, microphone, weighting networks.

| Unit 06 | | 07 hrs |
|---|---|---|

A. Design of EHV line: Design of EHV lines based upon steady state limits and transient over voltages, design factors under state. Design examples: steady state limits. Line insulation design based on transient over voltages.
B. Extra high voltage cable transmission: Classification of cables, Electrical characteristics of EHV Cables, Properties of cable

insulation materials.

## Text Books:

| [T1] | Rakosh das Begamudre “Extra high voltage transmission”, New Age International publishers. |
|---|---|

## Reference Books:

| [R1] | S. Rao , “EHV AC and DC Transmission” Khanna publication. |
|---|---|

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1 | R1 |
| 02 | T1 | – |
| 03 | T1 | – |
| 04 | T1 | R1 |
| 05 | T1 | R1 |
| 06 | T1 | R1 |

# 403151B: Illumination Engineering

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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## Course Objectives:

This course aims to:

- To explain conventional and modern lamps and their accessories.
- To get detailed insight of indoor and outdoor illumination system components, control and design aspects.
- To know the requirements of energy efficient lighting.
- To introduce the modern trends in the lighting

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Define and reproduce various terms in illumination.
CO2: Identify various parameters for illumination system design.
CO3: Design indoor and outdoor lighting systems.
CO4: Enlist state of the art illumination systems.

| Unit 01 | Importance of Lighting in Human Life | 07 hrs |
|---|---|---|

Optical systems of human eye, Dependence of human activities on light, performance characteristics of human visual system, External factors of vision-visual acuity, contrast, sensitivity, time illuminance, colour, visual perception, optical radiation hazards, Good and bad effects of lighting and perfect level of illumination, Artificial lighting as substitute to natural light, Ability to control natural light, Production of light, physics of generation of light, Properties of light, Quantification and Measurement of light.

| Unit 02 | Light Sources and Electrical Control of Light Sources | 08 hrs |
|---|---|---|

**Light Sources-** Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals. Discharge Lamps: Theory of gas Discharge phenomena, lamp design considerations, characteristics of low and high pressure mercury and Sodium vapour lamps, Low Vapour Pressure discharge lamps - Mercury Vapour lamp, Fluorescent Lamp, Compact Fluorescent Lamp (CFL)
High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps, Induction lamps.
Ballast, ignitors and dimmers for different types of lamps

**Control of Light Sources**

Photometric Control of Light Sources and their Quantification: Types of Luminaries, factors to be considered for designing luminaries Types of lighting fixtures. Optical control schemes, design procedure of reflecting and refracting type of luminaries. Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lighting fixtures according to installation type, types of lighting fixtures according to photometric usages, luminaries standard (IEC-598-Part I).

| | | |
|---|---|---|
| Unit 03 | Design Considerations for illumination schemes | 07 hrs |
| Zonal cavity method for general lighting design, determination for zonal cavities and different shaped ceilings using COU (coefficient of utilization), beam angles and polar diagrams. Factors to be considered for design of indoor illumination scheme | | |
| Unit 04 | Design of lighting schemes-I | 07 hrs |
| Indoor illumination design for following installations<br>Residential (Numerical)<br>Educational institute<br>Commercial installation<br>Hospitals<br>Industrial lighting<br>Special purpose lighting schemes<br>Decorative lighting<br>Theatre lighting<br>Aquarium, swimming pool lighting | | |
| Unit 05 | Design of lighting schemes-II | 07 hrs |
| Factors to be considered for design of outdoor illumination scheme<br>Outdoor Lighting Design: Road classifications according to BIS, pole arrangement, terminology, lamp and luminaries' selection, different design procedures, beam lumen method, point by point method, isolux diagram, problems on point by point method.<br>Outdoor illumination design for following installations:<br>Road lighting (Numerical)<br>Flood lighting (Numerical)<br>Stadium and sports complex<br>Lighting for advertisement/hoardings | | |
| Unit 06 | Modern trends in illumination | 07 hrs |
| LED luminary designs<br>Intelligent LED fixtures<br>Natural light conduiting<br>Organic lighting system<br>LASERS, characteristics, features and applications, non-lighting lamps<br>Optical fiber, its construction as a light guide, features and applications | | |

## Text Books:


| | |
|---|---|
| [T1] | H. S. Mamak, "Book on Lighting", Publisher International lighting Academy. |
| [T2] | Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher -York, PA : Visions Communications |
| [T3] | M. A. Cayless, A. M. Marsden, "Lamps and Lighting", Publisher-Butterworth Heinemann (ISBN 978-0-415-50308-2) |

| | |
|---|---|
| [T4] | Designing with light: Lighting Handbook., Anil Valia; Lighting System 2002 |
| Reference Books: | |
| [R1] | "BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting", Manak Bhavan, New Delhi. |
| [R2] | D. C. Pritchard, "Lighting", 4th Edition, Longman Scientific and Technical, ISBN 0-582-23422-0. |
| [R3] | "IES Lighting Handbook", (Reference Volume 1984), Illuminating Engineering Society of North America. |
| [R4] | "IES Lighting Handbook", (Application Volume 1987), Illuminating Engineering Society of North America |
| [R5] | IESNA lighting Handbook., Illuminating Engineering Society of North America 9th edition 2000 |
| [R6] | Applied Illumination Engineering, Jack L. Lindsey FIES (Author), Scott C. Dunning PHD PECEM (Author) ,ISBN-13: 978-0824748098 ISBN-10: 0824748093, 3rd Edition. |
| [R7] | IS 3646: Part I: 1992, Code of practice for interior illumination. |
| [R8] | Organic Light Emitting Diodes (OLEDs): Materials, Devices and Applications, Alastair Buckley, University of Sheffieid, UK, ISBN: 978-0-85709-425-4 |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1, T4 | R6 |
| 02 | T3, T4 | R1, R3, R4, R8 |
| 03 | T2, T4 | R2, R3, R7 |
| 04 | T3, T4 | R2,R3, R4, R5, R7 |
| 05 | T2, T3, T4 | R3, R4, R6, R7 |
| 06 | T1, T2, T4 | R2, R3, R5, R8 |

# 403151C: Electromagnetic Fields

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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## Course Objectives:

This course aims to:

- To impart knowledge on the basics of electric and magnetic fields and their applications for utilization in the development of the theory for power transmission lines and electrical machines.
- To describe how materials affect electric and magnetic fields
- To discuss the boundary conditions
- To analyze the relation between the fields under time varying situations
- To give insight to Maxwell's equations in different form and media

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Describe time varying Maxwell's equations and their applications in electromagnetic problems
CO2: Interpret electric and magnetic field with the help of associated laws
CO3: Solve simple electrostatic and magnetic boundary conditions
CO4: Determine the relationship between time varying electric and magnetic fields and electromotive force
CO5: Solve electromagnetic problems with the help of mathematical tools.

| | | |
|---|---|---|
| Unit 01 | Introduction | 07 hrs |

Sources and effects of Electro-Magnetic Fields, Scalar and vector, Unit vector, Mathematical operations of Vector, Scalar and vector fields, Different Coordinate System, Operator Del, Physical interpretation of gradient, divergence and curl, Conversion between coordinate system, Expression for gradient, divergence and curl in three coordinate system.

| | | |
|---|---|---|
| Unit 02 | Basic Electrostatics | 07 hrs |

Coulomb's law, Electric field, Electric Field Intensity (EFI), EFI due to - point charge, line charge, surface charge and volume charge, Electric displacement, Electric flux density, Gauss's law (scalar and vector form), Applications of Gauss law, Electric field due to – point charge, infinite long straight conductor and infinite plane sheet of charge, Divergence theorem, Stoke's theorem

| | | |
|---|---|---|
| Unit 03 | Applied Electrostatics | 07 hrs |

Electric Potential, Relationship between E and V, Equipotential surfaces, Electric dipole and flux lines, Electric field due to dipole, Energy density in electrostatic field, Energy stored in terms of D and E, Convection and Conduction currents, Current and current density, Continuity equation for current, Poisson's and Laplace's equations, Capacitor and its capacitance, Parallel plate capacitor, Capacitors with multiple dielectrics, Spherical capacitor, Coaxial capacitor.

| | | |
|---|---|---|
| Unit 04 | Magnetostatics and Applications | 07 hrs |

Magnetic flux density, Magnetic field intensity (MFI), Magnetic permeability, Biot-Savart's law, Applications of Biot-Savart's law, MFI due to - infinite long straight filament, finite length element, on the axis of circular loop, Ampere's Circuital law, Field due to – infinite line current, coaxial cable, uniform current sheet density, Magnetic flux density, Scalar magnetic potential, Vector magnetic potential, Poisson's Equations for Magnetostatic field, Derivations of BiotSavart law and Ampere's law based on magnetic potential, Forces due to magnetic field, Magnetic dipole.

| Unit 05 | Boundary Conditions and Analysis | 07 hrs |
|---|---|---|

Conductors, Ohm's law employing mobility, Dielectrics, Polarization in Dielectrics, Dielectric constants and strength, Relaxation time, Boundary conditions : Dielectric-Dielectric boundary conditions, Conductor – Dielectric boundary conditions, Conductor – Free space boundary conditions, Boundary conditions for Magnetostatic fields

| Unit 06 | Time Varying Fields and Maxwell's equations | 07 hrs |
|---|---|---|

Faraday's law, Transformer and motional EMFs – stationary loop in time varying B field, moving loop in static B field and moving loop in time varying field, Displacement current, Maxwell's equations in point form and integral form, Power and Poynting theorem, Time varying potentials, Time Harmonic Field, Maxwell's equations in point form and integral form for harmonic field, Concept of uniform plane wave.

## Text Books:

| | |
|---|---|
| [T1] | W. H. Hayt and J. A. Buck, "Engineering Electromagnetics", Tata McGraw Hill. |
| [T2] | Mathew Sadiku, "Elements of Electromagnetics", Oxford University Press |

## Reference Books:

| | |
|---|---|
| [R1] | R. K. Shevgaonkar, "Electromagnetic Waves", Tata McGraw Hill. |
| [R2] | Liang Chi Shen, Jin Au Kong, Amalendu Patnaik, "Engineering Electromagnetics", CENGAGE Learning |
| [R3] | K. B. Madhu Sahu, "Electromagnetic Fields", SciTech Publication. |
| [R4] | N. N. Rao, " Elements of Engineering Electromagnetics", Pearson Education. |
| [R5] | Edminister J. A., " Electromagnetics", Tata McGraw Hill. |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T2 | R2, R3, R4 |
| 02 | T1, T2 | R1, R2, R3 |
| 03 | T1, T2 | R2, R3, R4, R5 |
| 04 | T1, T2 | R2, R3 |
| 05 | T2 | R1, R4, R5 |
| 06 | T1, T2 | R2, R3, R4 |

# 403151D: Artificial Intelligence and Machine Learning

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| Theory | 03 | Hrs/Week | Theory | 03 | ISE | 30 |
| | | | | | ESE | 70 |

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## Course Objectives:

This course aims to:

- Understand the basic concept of AI, strength and weakness of problem solving and search.
- Know about various Expert System tools and applications.
- Understand the basic concepts of machine Learning and apply different dimensionality reduction techniques.
- Optimize the different linear methods of regression and classification.
- Interpret the different supervised classification methods of support vector machine.
- Acquire the knowledge of different generative models through unsupervised learning.

## Course Outcomes:

At the end of this course, students will be able to:
CO1: Evaluate Artificial Intelligence (AI) and Machine Learning(ML) methods and describe their foundations.
CO2: Demonstrate knowledge of reasoning and knowledge representation for solving real world problems.
CO3: Illustrate the construction of learning and expert system Discuss current scope and limitations of AI and societal implications
CO4: Distinguish between different types of learning types.
CO5: Apply the different supervised, unsupervised and reinforcement learning methods.

| | | |
|---|---|---|
| Unit 01 | Introduction to AI | 07 hrs |

Definitions – Foundation and History of AI, Evolution of AI - Applications of AI, Classification of AI systems with respect to environment. Artificial Intelligence vs Machine learning, Statistical Analysis: Relationship between attributes: Covariance, Correlation Coefficient, Chi Square. Intelligent Agent: Concept of Rationality, nature of environment, structure of agents.

| | | |
|---|---|---|
| Unit 02 | Problem Solving | 07 hrs |

Heuristic Search Techniques: Generate-and-Test; Hill Climbing; Properties of A* algorithm, Bestfirst Search; Problem Reduction. Constraint Satisfaction problem: Interference in CSPs; Back tracking search for CSPs; Local Search for CSPs; structure of CSP Problem. Beyond Classical Search: Local search algorithms and optimization problem, local search in continuous spaces, searching with nondeterministic action and partial observation, online search agent and unknown environments.

| | | |
|---|---|---|
| Unit 03 | Knowledge and Reasoning | 07 hrs |

Knowledge and Reasoning: Building a Knowledge Base: Propositional logic, first order Logic, situation calculus. Theorem Proving in First Order Logic, Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. Probabilistic reasoning over time: time and uncertainty, hidden Markova models, Kalman filter, dynamic bayesian network, keeping track of many objects

| | | |
|---|---|---|
| Unit 04 | Introduction to ML and Supervised Learning | 07 hrs |
| Introduction to Machine Learning, Examples of Machine Learning Applications, Learning Types **Supervised Learning** -Learning a Class from Examples, Vapnik-Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning,Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, **Dimensions of a Supervised Machine Learning** Algorithm Dimensionality Reduction-Introduction,Subset Selection, Principal Components Analysis, Factor Analysis, Multidimensional Scaling, Linear Discriminant Analysis,Isomap, Locally Linear Embedding | | |
| Unit 05 | Linear Regression | 08 hrs |
| Introduction, Linear Regression Models and Least Squares, Subset Selection, Shrinkage Methods-Ridge Regression, Lasso Regression, Least Angle Regression, Methods Using Derived Input Directions-Principal Components Regression, Partial Least Squares, A Comparison of the Selection and Shrinkage Methods , Multiple Outcome Shrinkage and Selection, More on the Lasso and Related Path Algorithms, Logistic Regression-Fitting Logistic Regression Models, Quadratic Approximations and Inference, L1 Regularized Logistic Regression | | |
| Unit 06 | Unsupervised and reinforcement learning | 08 hrs |
| Introduction, Association Rules-Market Basket Analysis, The Apriori Algorithm, Unsupervised as Supervised Learning,Generalized Association Rules, Cluster Analysis. Proximity Matrices, Clustering Algorithms-K-mean, Gaussian Mixtures as Soft K-means Clustering. **Reinforcement Learning:** Introduction, Single state case, elements of reinforcement learning, model based learning, Temporal difference learning | | |
| Text Books: | | |
| [T1] | Russell, S. and Norvig, P. 2015. Artificial Intelligence - A Modern Approach, 3rd edition, Prentice Hall | |
| [T2] | J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition , 2016 | |
| [T3] | Introduction to Machine Learning Edition 2, by Ethem Alpaydin | |
| [T4] | The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009. | |
| [T5] | Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997 | |
| Reference Books: | | |
| [R1] | Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010 2. S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011 | |
| [R2] | Ric, E., Knight, K and Shankar, B. 2009. Artificial Intelligence, 3rd edition, Tata McGraw Hill | |
| [R3] | Luger, G.F. 2008. Artificial Intelligence -Structures and Strategies for Complex Problem Solving, 6th edition, Pearson | |
| [R4] | Alpaydin, E. 2010. Introduction to Machine Learning. 2nd edition, MIT | |

| | |
|---|---|
| [R5] | Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006. |
| [R6] | Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017. |
| [R7] | Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017. |

Online Resources:

| | |
|---|---|
| [O1] | https://nptel.ac.in/courses/106/106/106106139/ |
| [O2] | https://nptel.ac.in/courses/106/106/106106202/ |
| [O3] | https://nptel.ac.in/courses/106/106/106106198/ |
| [O4] | https://nptel.ac.in/courses/106/105/106105152/ |
| [O5] | https://nptel.ac.in/courses/106/106/106106213/ |
| [O6] | https://www.coursera.org/learn/machine-learning |

Mapping:

| Unit | Text Books | Reference Books |
|---|---|---|
| 01 | T1, T2 | R1, R2, R3 |
| 02 | T1, T2 | R1, R2, R3 |
| 03 | T1, T2 | R1, R2, R3 |
| 04 | T3, T4, T5 | R4, R5, R6, R7 |
| 05 | T3, T4, T5 | R4, R5, R6, R7 |
| 06 | T3, T4, T5 | R4, R5, R6, R7 |

# 403152: Project Stage II

| Teaching Scheme | | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|---|
| SEM/PW/IN | 12 | Hrs./Week | SEM/PW/IN | 6 | ORAL | 50 |
| | | | | | Termwork | 100 |

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## Preamble:

Project is an important part of the engineering curriculum covered in the final year. It is divided into Project Stage I and Project Stage II in Semesters I and II of the Final Year. This project is a substantial piece of work that will require creative activity and original thinking. The project aims to provide students with a transitional experience from the academic world to the professional world. The objectives, outcomes, and guidelines for Project Stage II are given below.

## Course Objectives:

The objectives of this course are to:
1. Provide an opportunity to learn new software, interdisciplinary theory, concept, technology, etc. not covered in earlier subjects
2. Empower students to use engineering knowledge and skills learned in previous courses to deliver a product that has passed through the design, analysis, testing, and evaluation
3. Encourage multidisciplinary project work through the integration of knowledge
4. Allow students to develop problem-solving, analysis, synthesis, and evaluation skills.
5. Encourage teamwork.
6. Improve students' communication skills by asking them to produce both a professional report and to give an oral presentation
7. Exposed to the project management skills and ethical practices in project

## Course Outcomes:

Course outcomes can be different for the different projects undertaken by the student groups. However, in general, the course outcomes for Project Stage-II can be stated as follows.
At the end of this course, students should be able to:
CO1: Identify tools, techniques, methods, concepts, measuring devices, and instruments required for the project to define the methodology of the project
CO2: Justify the selection of electrical, electronic and mechanical components for the project prototyping
CO3: Select the appropriate testing method for system performance evaluation
CO4: Interpret results obtained by simulation, and hardware implementation and decide on further action or write a conclusion
CO5: Write a project report and research paper on the project work

## Guidelines:

Termwork evaluation guidelines are given below.

| Sr. No. | Activity | Deadline (Semester II) | Parameters for Evaluation |
|---|---|---|---|
| 1 | Progress Review-3 Presentation | Up to 6th Week | Revised Final Design (10)<br>Tools and Techniques Used with justification (10)<br>Partial Implementation/ development (15)<br>Partial Results (15) |

| | | | |
|---|---|---|---|
| | | | **Total Marks (50)** |
| 2 | Progress Review-4 Presentation | Up to 12th Week | Implementation Status of project (10)<br>Testing and Evaluation (10)<br>Intermediate Results (15)<br>Conclusion (10)<br>Future Scope (5)<br>**Total Marks (50)** |
| 3 | Submission of Project Stage –II Report | Up to 14th Week | Timely submission (5)<br>Formatting and Report Writing Style (5)<br>Abstract, Literature Survey, Conclusion (10)<br>Grammatical correctness in the report (5)<br>Publication/participation in project exhibition (20)<br>**Total Marks (50)**<br><br>**Review 3+ Review 4+ Final Project Report = 150**<br>**Rounded to 100 Marks** |

**Guidelines to students:**

1. Continue with the same group and identify opportunities for self-learning and upgrading skills.
2. Actively participate in all the activities related to the project.
3. Document the project in the form of a hard-bound report at the end and submit it to the department.
4. Attempt to make a prototype, working model, and demonstration of the project to display during the final presentation.
5. Participate in project competitions, paper presentations, etc.
6. Maintain an institutional culture of authentic collaboration, self-motivation, peer learning, and personal responsibility.
7. Maintain a notebook to keep records of all the meetings, discussions, notes, etc. This is to be done by the individual student and submitted at the end to the supervisor or guide.
8. Some parameters, mentioned in the above table, will be evaluated and assessed at a group level and some at an individual level.

# 403153A: German Language-II

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | – | ISE | | – |

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## Course Objectives:

This course aims to:

- Get introduced to the Culture, Routine of the German Society through language.
- Meet the needs of ever growing German industry with respect to language support.

## Course Outcomes:

At the end of this course, students:
CO1: Will have the ability of advanced communication.
CO2: Will develop reading, writing and listening skills.
CO3: Will understand tenses in German Language.
CO4: Will develop interest to pursue a German language course.

| | | |
|---|---|---|
| Unit 01 | Introduction of Cases: | 06 hrs |

Introduction of Cases: Nominative, Akkusative, Dative.
Personal & Possessive Pronouns in Nominative, Akkusative, Dative.

| | | |
|---|---|---|
| Unit 02 | Prepositions:- | 06 hrs |

Prepositions:- Akkusative & Dative.

| | | |
|---|---|---|
| Unit 03 | Tenses:- | 06 hrs |

Tenses:-
Past tense of sein & haben Verbs, Perfect tense

## Text Books:

| | |
|---|---|
| [T1] | Netzwerk A-1 (Deutsch als Fremdsprache), Goyal Publishers & Distributors Pvt. Ltd. |

## Reference Books:

| | |
|---|---|
| [R1] | Tipps und Uebungen A1 |

## Online Resources:

| | |
|---|---|
| [O1] | Practice Material like online Worksheets regarding the Grammar, listening Module, reading Texts. |

# 403153B: Engineering Economics-II

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | – | ISE | | – |

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## Course Objectives:

This course aims to:

1. Describe basics methods of Engineering Economic Analysis
2. Explain inflation and its impact on business decisions.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Apply various techniques for evaluation of engineering projects.
CO2:Assess cash flow under risk with varying parameters.

| | | |
|---|---|---|
| Unit 01 | Engineering Economic Analysis | 10 hrs |

Internal Rate Of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Public Sector Economic Analysis (Benefit Cost Ratio Method).Introduction to Lifecycle Costing, Introduction to Financial and Economic Analysis.Case Study – Tata Motors

| | | |
|---|---|---|
| Unit 02 | Inflation and Risk Analysis | 10 hrs |

Concept of Inflation., Measuring Inflation, Equivalence Calculation Under Inflation, Impact of Inflation on Economic Evaluation.
Sources of Project Risks, Methods of Describing Project Risks, Sensitivity Analysis, Break Even Analysis, Scenario Analysis, Probability Concept of Economic Analysis, Decision Tree and Sequential Investment Decisions

## Text Books:

| | |
|---|---|
| [T1] | Riggs, Bedworth and Randhwa, “Engineering Economics”, McGraw Hill Education India. |
| [T2] | D.M. Mithani, Principles of Economics. Himalaya Publishing House |

## Reference Books:

| | |
|---|---|
| [R1] | Sasmita Mishra, “Engineering Economics & Costing “, PHI |
| [R2] | Sullivan and Wicks, “ Engineering Economy”, Pearson |
| [R3] | R. Paneer Seelvan, “ Engineering Economics”, PHI |
| [R4] | Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc. |

# 403153C: GREEN BUILDING

| Teaching Scheme | | | Credits | | Examination Scheme | | |
|---|---|---|---|---|---|---|---|
| Theory | 02 | Hrs/Week | Theory | -- | ISE | | -- |

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## Course Objectives:

This course aims to:

- To learn the principles of planning and orientation of buildings.
- To acquire knowledge on various aspects of green buildings.

## Course Outcomes:

At the end of this course, students will be able to:
CO1:Design green and sustainable techniques for both commercial and residential buildings.
CO2:Design water, lighting, energy efficiency plan using renewable energy sources.
CO3:Explain the principles of building planning, its bylaws and provide facilities for rainwater harvesting
CO4:Understand the concepts of green buildings

| Unit 01 | Sustainability and Building design | 06 hrs |
|---|---|---|

Sustainability, objectives of sustainable development, Sustainable aspects of habitat design, sustainable buildings, principles, approaches and characteristics, climate data, climate parameters and zones, comparative analysis of various climatic zones, site planning recommended checklist for identifying site characteristics, site development and layout. Efficient water management and waste water treatment, solid waste management.

| Unit 02 | Energy efficiency | 06 hrs |
|---|---|---|

Solar passive techniques in building design to minimize load on conventional systems i.e. heating, cooling, ventilation and lighting. Designing Energy efficient lighting and HVAC systems. Use of renewable energy systems to meet part of building load. Green building certification. Overview of various green buildings in India. Policy and regulatory mechanisms.

## Text Books:


| | |
|---|---|
| [T1] | Seven Wonders of Green Building Technology: Karen Sirvaitis, Twenty-First Century Books. |
| [T2] | Jerry Yudelson Green building Through Integrated Design. McGraw Hill, 2009. |
| [T3] | Osman Attmann Green Architecture Advanced Technologies and Materials. McGraw Hill, 2010. |
| [T4] | Fundamentals of Integrated Design for Sustainable Building By Marian Keeler, Bill Burke |


## Reference Books:

| | |
|---|---|
| [R1] | Sustainable Building Design Manual, Volume 2, TERI, New Delhi |
| [R2] | Energy Efficient Buildings in India, TERI, New Delhi |
| [R3] | Sustainable Building Design Manual, Volume 1 TERI, New Delhi |
| [R4] | Mili Majumdar, “Energy-efficient buildings in India” Tata Energy Research Institute, 2002. |
| [R5] | TERI “Sustainable Building Design Manual- Volume I & II” Tata Energy Research Institute, 2009. |
| Online Resources: | |
| [O1] | https://nptel.ac.in/courses/105102175 |
| [O2] | https://theect.org/energy-efficiency-buildings-distance-learning/ |
| [O3] | https://www.udemy.com/topic/energy-management/ |
| [O4] | https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-ce13/ |
| [O5] | https://beeindia.gov.in/content/certification |
| [O6] | https://elearning.iea.org/ |
| [O7] | https://onlinecourses.nptel.ac.in/noc20_ce08/preview |