



**Scheme of Instructions & Syllabi**  
**of**  
**Bachelor of Technology**  
**(Electrical Engineering)**

(With effective from session 2021-22)

[Revised after the inclusion of Skill and Entrepreneurship courses  
effective from the session 2022-23]

**(Dr. Sweta Agarwal)**  
**HOD EE**

**(Dr. R.K.Shukla)**  
**Dean Engineering**

**(Dr. Y.D.S Arya)**  
**Vice Chancellor**

**Invertis Institute of Engineering & Technology**  
**INVERTIS UNIVERSITY**  
Invertis Village, Bareilly-Lucknow NH-24, Bareilly  
243123, Uttar Pradesh

## STUDY AND EVALUATION SCHEME

### B.Tech. in Electrical Engineering (w.e.f. academic session 2022-2023) YEAR IV, SEMESTER VII

| Sl. No.  | Course Code | COURSE TITLE/<br>SUBJECTS      | HOURS PER WEEK |   |   | EVALUATION SCHEME |     | TOTAL | Credit |
|--|-------------|--------------------------------|----------------|---|---|-------------------|-----|-------|--------|
|  |             |                                | L              | T | P | CA                | EE  |       |        |
|  |             |                                |                |   |   |                   |     |       |        |
| <b>THEORY</b>  |             |                                |                |   |   |                   |     |       |        |
| 1.   | BPE701      | Wind and Solar Energy Systems  | 3              | 0 | 0 | 25                | 50  | 75    | 3      |
| 2.   | BPE702      | Electrical and Hybrid Vehicles | 3              | 0 | 0 | 25                | 50  | 75    | 3      |
| 3.   | BOE004      | Computer Networks              | 3              | 0 | 0 | 25                | 50  | 75    | 3      |
| 4.   | BOE009      | Power Plant Engineering        | 3              | 0 | 0 | 25                | 50  | 75    | 3      |
| 5.   | BHS701      | Entrepreneurship Development   | 3              | 0 | 0 | 25                | 50  | 75    | 3      |
| <b>PRACTICALS AND PROJECTS</b>   |             |                                |                |   |   |                   |     |       |        |
| 6.   | BEE751      | Project Stage-I                | 0              | 0 | 6 | 75                | -   | 75    | 3      |
|  |             | <b>TOTAL</b>                   | 15             | 0 | 6 | 200               | 250 | 450   | 18     |
| <b>L-Lecture, T- Tutorial , P- Practical , CA – Continuous Assessment , EE – End sem exam HS- Humanities and social sciences OE- Open elective</b> |             |                                |                |   |   |                   |     |       |        |

## STUDY AND EVALUATION SCHEME

### B.Tech in Electrical Engineering (W.e.f. academic session 2022-2023) YEAR IV, SEMESTER VIII

| Sl. No.   | Course Code | COURSE TITLE/<br>SUBJECTS       | HOURS PER WEEK |   |    | EVALUATION SCHEME |     | TOTAL | Credit |
|---|-------------|---------------------------------|----------------|---|----|-------------------|-----|-------|--------|
|   |             |                                 | L              | T | P  | CA                | EE  |       |        |
|   |             |                                 |                |   |    |                   |     |       |        |
| <b>THEORY</b>   |             |                                 |                |   |    |                   |     |       |        |
| 1.  | BPE801      | Power System Protection         | 3              | 0 | 0  | 25                | 50  | 75    | 3      |
| 2.  | BOE819      | Electrical Materials            | 3              | 0 | 0  | 25                | 50  | 75    | 3      |
| 3.  | BOE820      | Bio Instrumentation             | 3              | 0 | 0  | 25                | 50  | 75    | 3      |
| <b>PRACTICALS AND PROJECTS</b>  |             |                                 |                |   |    |                   |     |       |        |
| 5.  | BEE851      | Project Stage-II                | 0              | 0 | 16 | 50                | 150 | 200   | 8      |
| 4.  | IOT68       | Advance Artificial Intelligence | 0              | 0 | 4  | 30                | 70  | 100   | 4      |
|   |             | <b>TOTAL</b>                    | 9              | 0 | 20 | 155               | 370 | 525   | 21     |
| <b>L-Lecture, T- Tutorial , P- Practical , CA – Continuous Assessment , EE – End sem exam OE- Open elective</b> |             |                                 |                |   |    |                   |     |       |        |

### HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

| Sl. No. | Course Code | Course Title | Hrs. /Week<br>L: T: P | Credits | Preferred Semester |
|---------|-------------|--------------|-----------------------|---------|--------------------|
| 1.      | BHS701      |              | 3:0:0                 | 3       | VII                |
|         |             | Total        |                       | 9       |                    |

### PROFESSIONAL ELECTIVE COURSES [ELECTRICAL ENGINEERING]

| SL. No. | Course Code | Course Title                      | Hrs. /Week<br>L: T: P | Credits | Preferred Semester |
|---------|-------------|-----------------------------------|-----------------------|---------|--------------------|
| 1.      | BPE701      | Wind and Solar Energy Systems     | 3:0:0                 | 3       | VII onwards        |
| 2.      | BPE702      | Electrical and Hybrid Vehicles    | 3:0:0                 | 3       | VII onwards        |
| 3.      | BPE703      | HVDC Transmission Systems         | 3:0:0                 | 3       | VII onwards        |
| 4.      | BPE704      | Power Quality and FACTS           | 3:0:0                 | 3       | VII onwards        |
| 5.      | BPE705      | Power System Dynamics and Control | 3:0:0                 | 3       | VII onwards        |
| 6.      | BPE801      | Power System Protection           | 3:0:0                 | 3       | VIII               |

**OPEN ELECTIVE COURSES [ELECTRICAL ENGINEERING]**

| <b>SL. No</b> | <b>Code No.</b> | <b>Subject</b>                   | <b>Credits</b> |
|---------------|-----------------|----------------------------------|----------------|
| 01.           | BOE001          | Electronic Devices               | 3              |
| 02.           | BOE002          | Data Structures and Algorithms   | 3              |
| 03.           | BOE003          | Analog and Digital Communication | 3              |
| 04.           | BOE004          | Computer Networks                | 3              |
| 05.           | BOE005          | Embedded Systems                 | 3              |
| 06.           | BOE006          | VLSI circuits                    | 3              |
| 07.           | BOE007          | Image Processing                 | 3              |
| 08.           | BOE008          | Wavelet Transforms               | 3              |
| 09.           | BOE009          | Power Plant Engineering          | 3              |
| 10.           | BOE010          | Thermal and Fluid Engineering    | 3              |
| 11.           | BOE011          | Strength of Materials            | 3              |
| 12.           | BOE012          | Fluid Machinery                  | 3              |
| 13.           | BOE013          | Automobile Engineering           | 3              |
| 14.           | BOE819          | Electrical Materials             | 3              |
| 15.           | BOE015          | Modern Manufacturing Processes   | 3              |
| 16.           | BOE016          | Internet of Things               | 3              |
| 17.           | BOE017          | Big Data Analysis                | 3              |
| 18            | BOE819          | Electrical Materials             | 3              |
| 19            | BOE820          | Bio Instrumentation              | 3              |

**PROGRAMME EDUCATIONAL OBJECTIVES**

|             |   |
|-------------|---|
| <b>PEO1</b> | To prepare students for a professional career in Electrical Engineering.  |
| <b>PEO2</b> | To develop the capability in students to solve engineering problems, carry out higher studies and research in core areas. |
| <b>PEO3</b> | To induct professionalism, creativity, innovativeness and ethical attitude leading to better services of the society.     |
| <b>PEO4</b> | Work in a team using technical knowledge, tools and environments to achieve project objectives.                           |
| <b>PEO5</b> | Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs.                    |

**PROGRAMME OUTCOMES**

|            |  |
|------------|--|
| <b>PO1</b> | Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.  |
| <b>PO2</b> | Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.  |
| <b>PO3</b> | Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| <b>PO4</b> | Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.   |
| <b>PO5</b> | Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.   |
| <b>PO6</b> | Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.  |
| <b>PO7</b> | Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.   |
| <b>PO8</b> | Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.  |
| <b>PO9</b> | Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.                                      |

**PROGRAMME ELECTIVE COURSES**

|               |                                      |                 |                  |
|---------------|--------------------------------------|-----------------|------------------|
| <b>BPE701</b> | <b>Wind and Solar Energy Systems</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|--------------------------------------|-----------------|------------------|

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
- Understand the basic physics of wind and solar power generation.
- Understand the power electronic interfaces for wind and solar generation.
- Understand the issues related to the grid-integration of solar and wind energy systems.

**Module 1: Physics of Wind Power: (5 Hours)**

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

**Module 2: Wind generator topologies: (12 Hours)**

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

**Module 3: The Solar Resource: (3 Hours)**

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

**Module 4: Solar photovoltaic: (8 Hours)**

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.

**Module 5: Network Integration Issues: (8 Hours)**

Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

**Module 6: Solar thermal power generation: (3 Hours)**

Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

**Text / References:**

1. T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2005.
2. G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2004.
3. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage",

McGraw Hill, 1984.

4. H. Siegfried and R. Waddington, “ Grid integration of wind energy conversion systems” John Wiley and Sons Ltd., 2006.
5. G. N. Tiwari and M. K. Ghosal, “ Renewable Energy Applications” , Narosa Publications, 2004.
6. J. A. Duffie and W. A. Beckman, “ Solar Engineering of Thermal Processes”, John Wiley & Sons, 1991.

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|---------------|--|-----------------|------------------|
| <b>BPE601</b> | <b>Line-Commutated and Active PWM Rectifiers</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|--|-----------------|------------------|

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Analyse controlled rectifier circuits.
- Understand the operation of line-commutated rectifiers – 6 pulse and multi-pulse configurations.
- Understand the operation of PWM rectifiers – operation in rectification and regeneration modes and lagging, leading and unity power factor mode.

**Module 1: Diode rectifiers with passive filtering (6 Hours)**

Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.

**Module 2: Thyristor rectifiers with passive filtering (6 Hours)**

Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.

**Module 3: Multi-Pulse converter (6 Lectures)**

Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

**Module 4: Single-phase ac-dc single-switch boost converter (6 Hours)**

Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

**Module 5: Ac-dc bidirectional boost converter (6 Hours)**

Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

**Module 6: Isolated single-phase ac-dc flyback converter (10 Hours)**

Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure.

Text / References:

1. G. De, "Principles of Thyristorised Converters", Oxford & IBH Publishing Co, 1988.
2. J.G. Kassakian, M. F. Schlecht and G. C. Verghese, "Principles of Power Electronics", Addison- Wesley, 1991.
3. L. Umanand, " Power Electronics: Essentials and Applications", Wiley India, 2009.
4. N. Mohan and T. M. Undeland, " Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
5. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2001.

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|---------------|--------------------------|-----------------|------------------|
| <b>BPE602</b> | <b>Electrical Drives</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|--------------------------|-----------------|------------------|

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the characteristics of dc motors and induction motors.
- Understand the principles of speed-control of dc motors and induction motors.
- Understand the power electronic converters used for dc motor and induction motor speed control.

Module 1: DC motor characteristics (5 hours)

Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation.

Module 2: Chopper fed DC drive (5 hours)

Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting.

Module 3: Multi-quadrant DC drive (6 hours)

Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking.

Module 4: Closed-loop control of DC Drive (6 hours)

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and

design, speed controller specification and design.

**Module 5: Induction motor characteristics (6 hours)**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

**Module 6: Scalar control or constant V/f control of induction motor (6 hours)**

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

**Module 7: Control of slip ring induction motor (6 hours)**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

**Text / References:**

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2. R. Krishnan, “ Electric Motor Drives: Modeling, Analysis and Control” , Prentice Hall, 2001.
3. G. K. Dubey, “ Fundamentals of Electrical Drives”, CRC Press, 2002.
4. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

|               |                                       |                 |                  |
|---------------|---------------------------------------|-----------------|------------------|
| <b>BPE702</b> | <b>Electrical and Hybrid Vehicles</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|---------------------------------------|-----------------|------------------|

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the models to describe hybrid vehicles and their performance.
- Understand the different possible ways of energy storage.
- Understand the different strategies related to energy storage systems.

**Module 1: Introduction (10 hours)**

**Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

**Introduction to Hybrid Electric Vehicles:** History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

**Module 2:Hybrid Electric Drive-trains (10 hours)**

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

**Module 3: Electric Trains (10 hours)**

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

**Module 4: Energy Storage (10 hours)**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

**Module 5: Energy Management Strategies (9 hours)**

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

**Text / References:**

1. C. Mi, M. A. Masrur and D. W. Gao, “ Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “ Hybrid Electric Vehicles: Energy Management Strategies” , Springer,2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.

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|---------------|----------------------------------|-----------------|------------------|
| <b>BPE501</b> | <b>Electrical Machine Design</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|----------------------------------|-----------------|------------------|

Course Outcomes:

- At the end of this course, students will demonstrate the ability to
- Understand the construction and performance characteristics of electrical machines.
  - Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
  - Understand the principles of electrical machine design and carry out a basic design of an ac machine.
  - Use software tools to do design calculations.

Module 1: Introduction

Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.

Module 2: Transformers

Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers.

Module 3: Induction Motors

Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of polyphase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.

Module 4: Synchronous Machines

Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.

Module 5: Computer aided Design (CAD):

Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design. Introduction to complex structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines.

Text / References:

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

4. K. L. Narang, “ A Text Book of Electrical Engineering Drawings”, SatyaPrakashan, 1969.
5. A. Shanmugasundaram, G. Gangadharan and R. Palani, “ Electrical Machine Design Data Book” , New Age International, 1979.
6. K. M. V. Murthy, “ Computer Aided Design of Electrical Machines”, B.S. Publications, 2008.
7. Electrical machines and equipment design exercise examples using Ansoft’s Maxwell 2D machine design package.

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|---------------|--------------------------------|-----------------|------------------|
| <b>BPE801</b> | <b>Power System Protection</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|--------------------------------|-----------------|------------------|

**Course Outcomes:** At the end of this course, students will demonstrate the ability to

- Understand the different components of a protection system.
- Evaluate fault current due to different types of fault in a network.
- Understand the protection schemes for different power system components.
- Understand the basic principles of digital protection.
- Understand system protection schemes, and the use of wide-area measurements.

Module 1: Introduction and Components of a Protection System (4 hours)

Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers

Module 2: Faults and Over-Current Protection (8 hours)

Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination.

Module 3: Equipment Protection Schemes(8 hours)

Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.

Module 4: Digital Protection (8 hours)

Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues.

Module 5: Modeling and Simulation of Protection Schemes (8 hours)

CT/PT modeling and standards, Simulation of transients using Electro-Magnetic Transients (EMT) programs. Relay Testing.

Module 6: System Protection (4 hours)

Effect of Power Swings on Distance Relaying. System Protection Schemes. Under- frequency, under-voltage and df/dt relays, Out-of-step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.

Text/References

1. J. L. Blackburn, “ Protective Relaying: Principles and Applications” , Marcel Dekker, New York, 1987.
2. Y. G.Paithankar and S. R. Bhide, “ Fundamentals of power system protection” , Prentice Hall, India, 2010.
3. A. G. Phadke and J. S. Thorp, “ Computer Relaying for Power Systems”, John Wiley & Sons, 1988.
4. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications” , Springer, 2008.
5. D. Reimert, “ Protective Relaying for Power Generation Systems”, Taylor and Francis, 2006.

|               |                                  |                 |                  |
|---------------|----------------------------------|-----------------|------------------|
| <b>BPE704</b> | <b>HVdc Transmission Systems</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|----------------------------------|-----------------|------------------|

Course Outcomes:

At the end of this course, students will demonstrate the ability to

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

Module 1::dc Transmission Technology (4 hours)

Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVdc Systems. Components of a HVdc system. Line Commutated Converter and Voltage Source Converter based systems.

Module2:

Analysis of Line Commutated and Voltage Source Converters (10 hours) Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap,harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Module 3:Control of HVdc Converters: (10 hours)

Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc

Voltage Control. Reactive Power Control/AC voltage regulation.

Module 3: Components of HVdc systems: (8 hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.

Module 4: Stability Enhancement using HVdc Control (4 hours)

Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

Module 5: MTdc Links (4 hours)

Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Modern Trends in HVdc Technology. Introduction to Modular Multi-level Converters.

Text/References:

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

|               |                                |                 |                  |
|---------------|--------------------------------|-----------------|------------------|
| <b>BPE705</b> | <b>Power Quality and FACTS</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|--------------------------------|-----------------|------------------|

Course Outcomes:

At the end of this course, students will demonstrate the ability to

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

Module 1: Transmission Lines and Series/Shunt Reactive Power Compensation (4 hours)

Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.

**Module 2: Thyristor-based Flexible AC Transmission Controllers (FACTS) (6 hours)**

Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

Module 3: Voltage Source Converter based (FACTS) controllers (8 hours)

Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

Module 4: Application of FACTS (4 hours)

Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

Module 5: Power Quality Problems in Distribution Systems (4 hours)

Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

Module 6: DSTATCOM (8 hours)

Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.

**Module 6: Dynamic Voltage Restorer and Unified Power Quality Conditioner (6 hours)**

Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.

Text/References

1. N. G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
3. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.
4. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 19

Course outcomes:

At the end of the course, the student will demonstrate

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

Module 1: Breakdown in Gases (8 Hours)

Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Module 2: Breakdown in liquid and solid Insulating materials (7 Hours)

Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Module 3: Generation of High Voltages (7 Hours)

Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Module 4: Measurements of High Voltages and Currents (7 Hours)

Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.

Module 5: Lightning and Switching Over-voltages (7 Hours)

Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.

Module 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)

Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.

Text/Reference Books

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013.

2. C. L. Wadhwa, “High Voltage Engineering”, New Age International Publishers, 2007.
- D. V. Razevig (Translated by Dr. M. P. Chourasia), “ High Voltage Engineering Fundamentals”, Khanna Publishers, 1993.
3. E. Kuffel, W. S. Zaengl and J. Kuffel, “ High Voltage Engineering Fundamentals”, Newnes Publication, 2000.
4. R. Arora and W. Mosch “ High Voltage and Electrical Insulation Engineering”, John Wiley & Sons, 2011.
5. Various IS standards for HV Laboratory Techniques and Testing

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| <b>BPE604</b> | <b>Electrical Energy Conservation and Auditing</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the current energy scenario and importance of energy conservation.
- Understand the concepts of energy management.
- Understand the methods of improving energy efficiency in different electrical systems.
- Understand the concepts of different energy efficient devices.

**Module 1: Energy Scenario (6 Hours)**

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

**Module 2: Basics of Energy and its various forms (7 Hours)**

Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

**Module 3: Energy Management & Audit (6 Hours)**

Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

**Module 4: Energy Efficiency in Electrical Systems (7 Hours)**

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors,

performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

**Module 5: Energy Efficiency in Industrial Systems (8 Hours)**

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

**Module 6: Energy Efficient Technologies in Electrical Systems (8Hours)**

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

**Text/Reference Books**

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. S. C. Tripathy, “Utilization of Electrical Energy and Conservation” , McGraw Hill, 1991.

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| <b>BPE605</b> | <b>Industrial Electrical Systems</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

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

**Module 1: Electrical System Components (8 Hours)**

LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system,

Contactors, Isolators, Relays, MPCB, Electric shock and Electrical safety practices

#### Module 2: Residential and Commercial Electrical Systems (8 Hours)

Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

#### Module 3: Illumination Systems (6 Hours)

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

#### Module 4: Industrial Electrical Systems I (8 Hours)

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

#### Module 5: Industrial Electrical Systems II (6 Hours)

DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

#### **Module 6: Industrial Electrical System Automation (6 Hours)**

Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

#### Text/Reference Books

1. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
2. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997.
3. Web site for IS Standards.
4. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008.

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| <b>BPE706</b> | <b>Power System Dynamics and Control</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the problem of power system stability and its impact on the system.
- Analyse linear dynamical systems and use of numerical integration methods.
- Model different power system components for the study of stability.
- Understand the methods to improve stability.

**Module 1: Introduction to Power System Operations (3 hours)**

Introduction to power system stability. Power System Operations and Control. Stability problems in Power System. Impact on Power System Operations and control.

**Module 2 : Analysis of Linear Dynamical System and Numerical Methods (5 hours)**

Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability. Modal Analysis of Linear System. Analysis using Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff System.

**Module 3 : Modeling of Synchronous Machines and Associated Controllers (12 hours)**

Modeling of synchronous machine: Physical Characteristics. Rotor position dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit Transient Analysis of a Synchronous Machine. Synchronization of Synchronous Machine to an Infinite Bus. Modeling of Excitation and Prime Mover Systems. Physical Characteristics and Models. Excitation System Control. Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.

**Module 4 : Modeling of other Power System Components (10 hours)**

Modeling of Transmission Lines and Loads. Transmission Line Physical Characteristics. Transmission Line Modeling. Load Models - induction machine model. Frequency and Voltage Dependence of Loads. Other Subsystems – HVDC and FACTS controllers, Wind Energy Systems.

**Module 5 : Stability Analysis (11 hours)**

Angular stability analysis in Single Machine Infinite Bus System. Angular Stability in multi-machine systems – Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governordroop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon. Stability Analysis Tools: Transient Stability Programs, Small Signal Analysis Programs.

**Module 6 : Enhancing System Stability (4 hours)**

Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control. Emergency Control.

Text/Reference Books

1. K.R. Padiyar, “ Power System Dynamics, Stability and Control”, B. S. Publications, 2002.
2. P. Kundur, “Power System Stability and Control”, McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Prentice Hall, 1997.

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| <b>BPE606</b> | <b>Digital Control Systems</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Obtain discrete representation of LTI systems.
- Analyse stability of open loop and closed loop discrete-time systems.
- Design and analyse digital controllers.
- Design state feedback and output feedback controllers.

Module 1: Discrete Representation of Continuous Systems (6 hours)

Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.

Module 2: Discrete System Analysis (6 hours)

Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.

Module 3: Stability of Discrete Time System (4 hours)

Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.

Module 4: State Space Approach for discrete time systems (10 hours)

State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability.

Module 5: Design of Digital Control System(8 hours)

Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.

Module 6: Discrete output feedback control (8 hours)

Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.

Text Books :

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

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| <b>BPE607</b> | <b>Digital Signal Processing</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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Course Outcomes:

At the end of this course, students will demonstrate the ability to

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

Module 1: Discrete-time signals and systems (6 hours)

Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.

Module 2: Z-transform (6 hours)

z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.

Module 2: Discrete Fourier Transform (10 hours)

Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval’s Identity, Implementation of Discrete Time Systems.

Module 3: Design of Digital filters (12 hours)

Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band-stop and High-pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.

Module 4: Applications of Digital Signal Processing (6 hours)

Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.

Text/Reference Books:

1. S. K. Mitra, “Digital Signal Processing: A computer based approach”, McGraw Hill, 2011.
2. A.V. Oppenheim and R. W. Schafer, “Discrete Time Signal Processing”, Prentice Hall, 1989.
3. J. G. Proakis and D.G. Manolakis, “ Digital Signal Processing: Principles, Algorithms And Applications”, Prentice Hall, 1997.
4. L. R. Rabiner and B. Gold, “Theory and Application of Digital Signal Processing” , Prentice Hall, 1992.
5. J. R. Johnson, “Introduction to Digital Signal Processing”, Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, “ Digital Signal Processing” , John Wiley & Sons, 1988.

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| <b>BPE608</b> | <b>Computer Architecture</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of microprocessors, their principles and practices.
- Write efficient programs in assembly language of the 8086 family of microprocessors.
- Organize a modern computer system and be able to relate it to real examples.
- Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protected modes.
- Implement embedded applications using ATOM processor.

Module 1: Introduction to computer organization (6 hours)

Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic - Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.

Module 2: Memory organization (6 hours)

System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks.

Module 3: Input – output Organization (8 hours)

Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface circuits - Parallel and serial port. Features of PCI and PCI Express bus.

Module 4: 16 and 32 microprocessors (8 hours)

80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in 80x86

**Module 5: Pipelining(8 hours)**

Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.

**Module 6: Different Architectures (8 hours)**

VLW Architecture, DSP Architecture, SoC architecture, MIPS Processor and programming

**Text/Reference Books**

1. V. Carl, G. Zvonko and S. G. Zaky, “Computer organization”, McGraw Hill, 1978.
2. B. Brey and C. R. Sarma, “The Intel microprocessors”, Pearson Education, 2000.
3. J. L. Hennessy and D. A. Patterson, “Computer Architecture A Quantitative Approach”, Morgan Kauffman, 2011.
4. W. Stallings, “Computer organization”, PHI, 1987.
5. P. Barry and P. Crowley, “Modern Embedded Computing”, Morgan Kaufmann, 2012.
6. N. Mathivanan, “Microprocessors, PC Hardware and Interfacing”, Prentice Hall, 2004.
7. Y. C. Lieu and G. A. Gibson, “Microcomputer Systems: The 8086/8088 Family”, Prentice Hall India, 1986.
8. J. Uffenbeck, “The 8086/8088 Design, Programming, Interfacing”, Prentice Hall, 1987.
9. B. Govindarajalu, “IBM PC and Clones”, Tata McGraw Hill, 1991.
10. P. Able, “8086 Assembly Language Programming”, Prentice Hall India.

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| <b>BPE609</b> | <b>Electromagnetic waves</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Analyse transmission lines and estimate voltage and current at any point on transmission line for different load conditions.
- Provide solution to real life plane wave problems for various boundary conditions.
- Analyse the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.
- Visualize TE and TM mode patterns of field distributions in a rectangular wave-guide.
- Understand and analyse radiation by antennas.

**Module 1: Transmission Lines (6 hours)**

Introduction, Concept of distributed elements, Equations of voltage and current, Standing waves and impedance transformation, Lossless and low-loss transmission lines, Power transfer on a transmission line, Analysis of transmission line in terms of admittances, Transmission line calculations with the help of Smith chart, Applications of transmission line, Impedance matching using transmission lines.

**Module 2: Maxwell’s Equations (6 hours)**

Basic quantities of Electromagnetics, Basic laws of Electromagnetics: Gauss’s law, Ampere’s Circuital law, Faraday’s law of Electromagnetic induction. Maxwell’s equations, Surface

charge and surface current, Boundary conditions at media interface.

**Module 3: Uniform Plane Wave (7 hours)**

Homogeneous unbound medium, Wave equation for time harmonic fields, Solution of the wave equation, Uniform plane wave, Wave polarization, Wave propagation in conducting medium, Phase velocity of a wave, Power flow and Poynting vector.

**Module 4: Plane Waves at Media Interface (7 hours)**

Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction of waves at dielectric interface, Total internal reflection, Wave polarization at media interface, Brewster angle, Fields and power flow at media interface, Lossy media interface, Reflection from conducting boundary.

**Module 5: Waveguides (7 hours)**

Parallel plane waveguide: Transverse Electric (TE) mode, transverse Magnetic(TM) mode, Cut-off frequency, Phase velocity and dispersion. Transverse Electromagnetic (TEM) mode, Analysis of waveguide-general approach, Rectangular waveguides.

**Module 6: Antennas (7 hours)**

Radiation parameters of antenna, Potential functions, Solution for potential functions, Radiations from Hertz dipole, Near field, Far field, Total power radiated by a dipole, Radiation resistance and radiation pattern of Hertz dipole, Hertz dipole in receiving mode.

**Text/Reference Books**

1. R. K. Shevgaonkar, “Electromagnetic Waves”, Tata McGraw Hill, 2005.
2. D. K. Cheng, “Field and Wave Electromagnetics”, Addison-Wesley, 1989.
3. M. N.O. Sadiku, “Elements of Electromagnetics”, Oxford University Press, 2007.
4. C. A. Balanis, “Advanced Engineering Electromagnetics”, John Wiley & Sons, 2012.
5. C. A. Balanis, “Antenna Theory: Analysis and Design”, John Wiley & Sons, 2005.

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| <b>BPE610</b> | <b>Computational Electromagnetics</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the basic concepts of electromagnetics.
- Understand computational techniques for computing fields.
- Apply the techniques to simple real-life problems.

**Module 1: Introduction (6 hours)**

Conventional design methodology, Computer aided design aspects – Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics. Development of Helmholtz equation, energy transformer vectors- Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

**Module 2: Analytical Methods (6 hours)**

Analytical methods of solving field equations, method of separation of variables, Roth's method, integral methods- Green's function, method of images.

**Module 3: Finite Difference Method (FDM) (7 hours)**

Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD) method- Uniqueness and convergence.

**Module 4: Finite Element Method (FEM) (7 hours)**

Overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

**Module 5: Special Topics(7 hours)**

{Background of experimental methods-electrolytic tank, R-C network solution, Field plotting (graphical method)}, hybrid methods, coupled circuit - field computations, electromagnetic - thermal and electromagnetic - structural coupled computations, solution of equations, method of moments, Poisson's fields.

**Module 6: Applications (7 hours)**

Low frequency electrical devices, static / time-harmonic / transient problems in transformers, rotating machines, actuators. CAD packages.

**Text/Reference Books**

1. P. P. Silvester and R. L. Ferrari " Finite Element for Electrical Engineers" , Cambridge University press, 1996.
2. M. N. O. Sadiku, " Numerical Techniques in Electromagnetics", CRC press, 2001.

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| <b>BPE611</b> | <b>Control Systems Design</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Course Outcomes:** At the end of this course, students will demonstrate the ability to

- Understand various design specifications.
- Design controllers to satisfy the desired design specifications using simple controller structures (P, PI, PID, compensators).
- Design controllers using the state-space approach.

**Module 1: Design Specifications (6 hours)**

Introduction to design problem and philosophy. Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response.

**Module 2: Design of Classical Control System in the time domain (8 hours)**

Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain.

Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators.

**Module 3: Design of Classical Control System in frequency domain (8 hours)** Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.

Module 4: Design of PID controllers (6 hours)

Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback – Feed forward control.

Module 5: Control System Design in state space (8 hours)

Review of state space representation. Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.

Module 6: Nonlinearities and its effect on system performance (3 hours)

Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis.

Text and Reference Books :

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

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| <b>BPE802</b> | <b>Advanced Electric Drives</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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Course Outcomes:

At the end of this course, students will demonstrate the ability to

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

Module 1: Power Converters for AC drives (10 hours)

PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.

**Module 2: Induction motor drives (10 hours)**

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).

**Module 3: Synchronous motor drives (6 hours)**

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

**Module 4: Permanent magnet motor drives (6 hours)**

Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

**Module 5: Switched reluctance motor drives (6 hours)**

Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

**Module 6: DSP based motion control (6 hours)**

Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

**Text / References:**

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

**OPEN ELECTIVE COURSES**

|               |                           |                 |                  |
|---------------|---------------------------|-----------------|------------------|
| <b>BOE001</b> | <b>Electronic Devices</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|---------------------------|-----------------|------------------|

### **Module 1**

Introduction to Semiconductor Physics: Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams. Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; sheet resistance, design of resistors

### **Module 2**

Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode

### **Module 3**

Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model, MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor, LED, photodiode and solar cell;

### **Module 4**

Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography, etching, chemical vapor deposition, sputtering, twin-tub CMOS process.

### **Text /Reference Books:**

1. G. Streetman, and S. K. Banerjee, "Solid State Electronic Devices," 7<sup>th</sup> edition, Pearson, 2014.
2. D. Neamen, D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education
3. S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3<sup>rd</sup> edition, John Wiley & Sons, 2006.
4. C.T. Sah, "Fundamentals of solid state electronics," World Scientific Publishing Co. Inc, 1991.
5. Y. Tsvetkov and M. Colin, "Operation and Modeling of the MOS Transistor," Oxford Univ. Press, 2011.

### **Course Outcomes:**

At the end of this course students will demonstrate the ability to

1. Understand the principles of semiconductor Physics
2. Understand and utilize the mathematical models of semiconductor junctions and MOS transistors for circuits and systems.

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| <b>BOE002</b> | <b>Data Structure &amp; Algorithms</b> | <b>3L:0T: 4P</b> | <b>5 credits</b> |
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| <b>Pre-requisites</b> | <b>ESC 201</b> |
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**Objectives of the course:**

1. To impart the basic concepts of data structures and algorithms.
2. To understand concepts about searching and sorting techniques
3. To understand basic concepts about stacks, queues, lists, trees and graphs.
4. To enable them to write algorithms for solving problems with the help of fundamental data structures

Detailed contents:

**Module 1:**

**Introduction:** Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade off. **Searching:** Linear Search and Binary Search Techniques and their complexity analysis.

Module 2:

**Stacks and Queues:** ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation – corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.

Module 3:

**Linked Lists:** Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linkedrepresentation of Stack and Queue, Header nodes, Doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.

**Trees:** Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.

Module 4:

**Sorting and Hashing:** Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing.

**Graph:** Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis.

Suggested books:

1. “Fundamentals of Data Structures”, Illustrated Edition by Ellis Horowitz, Sartaj Sahni,

Computer Science Press.

Suggested reference books:

1. Algorithms, Data Structures and Problem Solving with C++”, Illustrated Edition by Mark Allen Weiss, Addison-Wesley Publishing Company
2. “How to Solve it by Computer” 2nd Impression by R. G. Dromey, Pearson Education.

Course outcomes

1. For a given algorithm student will able to analyze the algorithms to determine the time and computation complexity and justify the correctness.
2. For a given Search problem (Linear Search and Binary Search) student will able to implement it.
3. For a given problem of Stacks, Queues and linked list student will able to implement it and analyze the same to determine the time and computation complexity.
4. Student will able to write an algorithm Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort and compare their performance in term of Space and Time complexity. Student will able to implement Graph search and traversal algorithms and determine the time and computation complexity.

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| <b>BOE004</b>         | <b>Computer Networks</b>  | <b>3L:0T: 4P</b> | <b>5 Credits</b> |
| <b>Pre-requisites</b> | PCC-CS - 402 PCC-CS - 403 |                  |                  |

Objectives of the course

- To develop an understanding of modern network architectures from a design and performance perspective.
- To introduce the student to the major concepts involved in wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs).
- To provide an opportunity to do network programming
- To provide a WLAN measurement idea.

Detailed contents

**Module 1:**

Data communication Components: Representation of data and its flow Networks , Various Connection Topology, Protocols and Standards, OSI model, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division and Wave division, Concepts on spread spectrum.

**Module 2:**

Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control

protocols - Stop and Wait, Go back – N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols- Pure ALOHA, Slotted ALOHA, CSMA/CD,CDMA/CA

### **Module 3:**

Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping–ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols.

### **Module 4:**

**Transport Layer:** Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), SCTP Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.

### **Module 5:**

**Application Layer:** Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography

### **Suggested books**

1. Data Communication and Networking, 4th Edition, Behrouz A. Forouzan, McGraw- Hill.
2. Data and Computer Communication, 8th Edition, William Stallings, Pearson Prentice Hall India.

### **Suggested reference books**

1. Computer Networks, 8th Edition, Andrew S. Tanenbaum, Pearson New International Edition.
2. Internetworking with TCP/IP, Volume 1, 6th Edition Douglas Comer, Prentice Hall of India.
3. TCP/IP Illustrated, Volume 1, W. Richard Stevens, Addison-Wesley, United States of America.

### **Course Outcomes**

1. Explain the functions of the different layer of the OSI Protocol.
2. Draw the functional block diagram of wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs) describe the function of each block.
3. For a given requirement (small scale) of wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs) design it based on the market available component
4. For a given problem related TCP/IP protocol developed the network programming.
5. Configure DNS DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls using open source available software and tools.

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| <b>BOE005</b> | <b>Embedded Systems</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|-------------------------|-----------------|------------------|

The concept of embedded systems design, embedded microcontroller cores, embedded memories. Examples of embedded systems, Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, digital signal processing. Sub system interfacing, interfacing with external systems, user interfacing. Design tradeoffs due to process compatibility, thermal considerations, etc., Software aspects of embedded systems: real time programming languages and operating systems for embedded systems.

#### **Text/Reference Books:**

1. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
2. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999.
3. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
4. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
5. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", Penram Intl, 1996

#### **Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Suggest design approach using advanced controllers to real-life situations.
2. Design interfacing of the systems with other data handling / processing systems.
3. Appreciate engineering constraints like energy dissipation, data exchange speeds etc.

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| <b>BOE009</b> | <b>Power Plant Engineering</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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#### **Objectives:**

To provide an overview of power plants and the associated energy conversion issues

#### **Contents:**

Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates, subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems

Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.

Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.

Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems

Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

**Course Outcomes:**

Upon completion of the course, the students can understand the principles of operation for different power plants and their economics.

**Text Books:**

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

|               |                              |                 |                  |
|---------------|------------------------------|-----------------|------------------|
| <b>BOE011</b> | <b>Strength of Materials</b> | <b>3L:1T:0P</b> | <b>4 credits</b> |
|---------------|------------------------------|-----------------|------------------|

**Objectives:**

- To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
- To calculate the elastic deformation occurring in various simple geometries for different types of loading

**Contents :**

Deformation in solids- Hooke’s law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr’s circle. **(8)**

Beams and types transverse loading on beams- shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads. **(8)**

Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell’s reciprocal theorems.**(8)**

Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs. (8)

Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure (8)

(Total: 40 lectures + 12 tutorials)

**Course Outcomes:**

- After completing this course, the students should be able to recognise various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components
- The students will be able to evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading

**Text Books:**

1. Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi, 2001.
2. R. Subramanian, Strength of Materials, Oxford University Press, 2007.
3. Ferdinand P. Beer, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGrawHill Publishing Co. Ltd., New Delhi 2005.

|               |                               |                 |                  |
|---------------|-------------------------------|-----------------|------------------|
| <b>BOE013</b> | <b>Automobile Engineering</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
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**Objectives:**

To understand the construction and working principle of various parts of an automobile

**Contents:**

Types of automobiles, vehicle construction and layouts, chassis, frame and body, vehicle aerodynamics, IC engines- components, function and materials, variable valve timing (VVT). Engine auxiliary systems, electronic injection for SI and CI engines, unit injector system, rotary distributor type and common rail direct injection system, transistor based coil ignition & capacitive discharge ignition systems, turbo chargers (WGT, VGT), engine emission control by 3-way catalytic converter system, Emission norms (Euro & BS).

Transmission systems, clutch types & construction, gear boxes- manual and automatic gear shift mechanisms, Over drive, transfer box, flywheel, torque converter, propeller shaft, slip joints, universal joints, differential and rear axle, Hotchkiss drive and Torque tube drive.

Steering geometry and types of steering gear box, power steering, types of front axle, types of suspension systems, pneumatic and hydraulic braking systems, antilock braking system (ABS), electronic brake force distribution (EBD) and traction control.

Alternative energy sources, natural gas, LPG, biodiesel, bio-ethanol, gasohol and hydrogen fuels in automobiles, modifications needed, performance, combustion & emission characteristics of alternative fuels in SI and CI engines, Electric and Hybrid vehicles,

application of Fuel Cells

**Course Outcomes:**

Upon completion of this course, students will understand the function of each automobile component and also have a clear idea about the overall vehicle performance.

**Text books:**

1. Kirpal Singh, Automobile Engineering, 7<sup>th</sup> ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., Automobile Engineering, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., Automotive Mechanics, 2<sup>nd</sup> ed., East-West Press, 1999.
4. Heisler H., Advanced Engine Technology, SAE International Publ., USA, 1998.

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|---------------|-----------------------------|-----------------|------------------|
| <b>BOE819</b> | <b>ELECTRICAL MATERIALS</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|-----------------------------|-----------------|------------------|

**Course Outcomes:**

**After successful completion of the course students will be able**

- 1. To understand the theory of electrical conduction in conductors and semiconductors and to learn about the basic properties of magnetic materials.**
- 2. To learn about dielectric polarization and its characteristics.**
- 3. To get basic understanding about material used for solar power.**
- 4. To learn about techniques for material**

**Module 1**

**Dielectric Materials:** Static dielectric constant, Polarization, atomic interpretation of the dielectric constant of mono-atomic and poly atomic gases, internal fields in the solids and liquids, static dielectric constants of solids, ferroelectric materials and spontaneous polarization, piezo- electricity. Frequency dependence of electronics, ionic and orientation polarization, complex dielectric constant and dielectric losses.

**Module 2**

**Conductivity of Metals:** Ohm's Law and relaxation time of electrons, collision time and mean free path. Electron scattering and resistivity of metals. Heat developed in current carrying conductor, thermal conductivity of metals, superconductivity.

**Magnetic Materials:** Magnetization from microscopic view point, orbital magnetic dipole movement and angular momentum materials, diamagnetism, origin of permanent magnetic dipoles in material. Paramagnetic spin systems.

**Module 3**

**Properties of ferromagnetic materials:** Spontaneous magnetization and the curie-Weils Law. Ferromagnetic Domains and coercive force, anti- ferromagnetic and ferromagnetic materials. Magnetic materials for electrical devices, introduction to permanent magnets

**Test Books:-**

1. Electrical and Electronic Engineering Materials by SK Bhattacharya, Khanna Publishers, New Delhi.
2. Electronic Components and Materials by Grover and Jamwal, Dhanpat Rai and Co., New Delhi.
3. Electrical Engineering Materials by Sahdev, Unique International Publications.

|               |                            |                 |                  |
|---------------|----------------------------|-----------------|------------------|
| <b>BOE820</b> | <b>BIO INSTRUMENTATION</b> | <b>3L:0T:0P</b> | <b>3 credits</b> |
|---------------|----------------------------|-----------------|------------------|

Pre-requisites: Knowledge of Instrumentation and Measurement

**COURSE OUTCOMES (CO)**

AT THE END OF THE COURSE, THE STUDENT WILL BE ABLE TO:

**CO1 Understand the physiology of biomedical system**

**CO2 Measure biomedical and physiological information**

**CO3 Understand the Therapeutic and Imaging devices**

**CO4 Discuss the application of Electronics in diagnostics and therapeutic area**

**CO5 Understand the patient monitoring system**

**MODULE-1**

Basic physiological system of the body: Problems encountered in measuring living systems, bioelectric potentials, biomaterials.

Basic Transducer Principles: Active and passive transducers, Transducers for biomedical applications. Generation, propagation and distribution of bioelectric potentials (ECG, EEG and EMG). Bio-potential electrodes: Basic types (micro, skin surface and needle electrodes) biochemical transducers. (PH, blood, gas and specific ions electrodes).

**MODULE-2**

The cardiovascular system and measurements: Heart and cardiovascular system and circulation block diagram, blood pressure and measurement, characteristics of blood flow and heart sounds. Electrocardiography, ECG lead configurations, ECG recording and their types. The Nervous System The anatomy of nervous system, Neuronal communication, EPSP & IPSP Organization of the brain, Measurements from the nervous system Systemic Body & Skin Temperature Measurement: Temperature measurements Brief idea about ultrasonic measurements.

**MODULE-3**

Patient care monitoring: Elements of intensive care, Organization of the Hospital for patient-care monitoring Pace-makers-types, systems, modes and generators, Defibrillators-types. Bio telemetry & applications of telemetry in patient care. Automation of chemical tests, Instrumentation for diagnostic, X Rays, Interfacing computer with medical instrumentation and other equipments, biomedical computer applications. Shock hazards from electrical equipments.

**Text Book:**

1. T. Cromwell, F.J. Weibell & F.A. Pfeiffer, "Biomedical Instrumentation & Measurements" Prentice Hall Internations.

**Reference Books:**

1. R.S. Khanpur, "Handbook of Biomedical Instrumentation" Tata Mc Graw Hill
2. H.E. Thomas, "Handbook of Biomedical Instrumentation and Measurement" Restone Publishing Company

**BASIC SCIENCE COURSES**

|               |                        |                 |                  |
|---------------|------------------------|-----------------|------------------|
| <b>BAS301</b> | <b>MATHEMATICS III</b> | <b>3L:1T:0P</b> | <b>4 credits</b> |
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### **MODULE-I**

Function of Complex variable: Analytic function, C-R equations, Cauchy's integral theorem, Cauchy's integral formula for derivatives of analytic function, Taylor's and Laurent's series, singularities, Residue theorem, Evaluation of real integrals.

### **MODULE-II**

Statistical Techniques-I: Moments, Moment generating functions, Skewness, Kurtosis, Curve fitting, Method of least squares, Fitting of straight lines, Polynomials, Exponential curves etc., Correlation, Linear, non-linear and multiple regression analysis, Probability theory.

Statistical Techniques-II: Binomial, Poisson and Normal distributions, Sampling theory (small and large), Tests of significations: Chi-square test, t-test, Analysis of variance (one way), Application to engineering, medicine, agriculture etc.

Time series and forecasting (moving and semi-averages), Statistical quality control methods, Control charts, R, p, np, and c charts.

### **MODULE-III**

Numerical Techniques-I: Zeroes of transcendental and polynomial equation using Bisection method, Regula-falsi method and Newton-Raphson method, Rate of convergence of above methods.

Interpolation: Finite differences, difference tables, Newton's forward and backward interpolation, Lagrange's and Newton's divided difference formula for unequal intervals.

Numerical Techniques-II: Solution of system of linear equations, Gauss-Seidal method, Crout method. Numerical differentiation, Numerical integration, Trapezoidal, Simpson's one third and three-eighth rules, Solution of ordinary differential (first order, second order and simultaneous) equations by Euler's, Picard's and fourth-order Runge-Kutta methods.

### **Text Books:**

1. Jain, Iyenger & Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, New Delhi, 2003.
2. Chandrika Prasad, Advanced Mathematics for Engineers, Prasad Mudralaya, 1996.
3. E. Kreysig, Advanced Engineering Mathematics, John Wiley & Sons, 2005.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2005.
5. Devi Prasad, An introduction to Numerical Analysis, Narosa Publication house, New Delhi 2006.
6. R.K. Jain & S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publication House, 2002.

### **Reference Books:**

1. J.N. Kapur, Mathematical Statistics, S. Chand & company Ltd., 2000
2. Peter V. O’Neil, Advance Engineering Mathematics Thomson (Cengage) Learning

|               |                  |                 |                  |
|---------------|------------------|-----------------|------------------|
| <b>BSC401</b> | <b>Biology-I</b> | <b>2L:1T:0P</b> | <b>3 credits</b> |
|---------------|------------------|-----------------|------------------|

### Module 1: Introduction (2 hours)

Purpose: To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry. Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18<sup>th</sup> Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.

### Module 2: Classification (3 hours)

Purpose: To convey that classification *per se* is not what biology is all about. The underlying criterion, such as morphological, biochemical or ecological be highlighted. Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricotelic, ureotelic (e) Habitata- aquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus

### Module 3: Genetics (4 hours)

Purpose: To convey that “ Genetics is to biology what Newton’s laws are to Physical Sciences” . Mendel’s laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.

### Module 4: Biomolecules (4 hours)

Purpose: To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine. Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids.

### Module 5: Enzymes (4 Hours)

Purpose: To convey that without catalysis life would not have existed on earth.

Enzymology: How to monitor enzyme catalysed reactions. How does an enzyme catalyse reactions? Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.

#### Module 6: Information Transfer (4 hours)

Purpose: The molecular basis of coding and decoding genetic information is universal. Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

#### Module 7: Macromolecular analysis (5 hours)

Purpose: To analyse biological processes at the reductionistic level. Proteins- structure and function. Hierarchy in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

#### Module 8: Metabolism (4 hours)

Purpose: The fundamental principles of energy transactions are the same in physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of  $K_{eq}$  and its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to  $CO_2 + H_2O$  (Glycolysis and Krebs cycle) and synthesis of glucose from  $CO_2$  and  $H_2O$  (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge.

#### Module 9. Microbiology (3 hours)

Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

#### Text / References:

1. N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: A global approach”, Pearson Education Ltd, 2014.
2. E. E. Conn, P. K. Stumpf, G. Bruening and R. H. Doi, “Outlines of Biochemistry”, John Wiley and Sons, 2009.
3. D. L. Nelson and M. M. Cox, “Principles of Biochemistry”, W.H. Freeman and Company, 2012.
4. G. S. Stent and R. Calendar, “Molecular Genetics”, Freeman and company, 1978.
5. L. M. Prescott, J. P. Harley and C. A. Klein, “Microbiology”, McGraw Hill Higher Education, 2005.

#### Course Outcomes

After studying the course, the student will be able to:

- Describe how biological observations of 18<sup>th</sup> Century that lead to major discoveries.
- Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and ecological
- Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring
- Convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine
- Classify enzymes and distinguish between different mechanisms of enzyme action.
- Identify DNA as a genetic material in the molecular basis of information transfer.
- Analyse biological processes at the reductionistic level
- Apply thermodynamic principles to biological systems.
- Identify and classify microorganisms.

**ENGINEERING SCIENCE COURSES**

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|--------|-----------------------|----------|-----------|
| BEE404 | Engineering Mechanics | 3L:1T:0P | 4 credits |
|--------|-----------------------|----------|-----------|

**Course Outcomes:** At the end of this course, students will demonstrate the ability to  
 Understand the concepts of co-ordinate systems.  
 Analyse the three-dimensional motion.  
 Understand the concepts of rigid bodies.  
 Analyse the free-body diagrams of different arrangements.  
 Analyse torsional motion and bending moment.

**Module 1: Introduction to vectors and tensors and co-ordinate systems (5 hours)**  
 Introduction to vectors and tensors and coordinate systems; Vector and tensor algebra; Indicical notation; Symmetric and anti-symmetric tensors; Eigenvalues and Principal axes.

Module 2: Three-dimensional Rotation (4 hours)

Three-dimensional rotation: Euler's theorem, Axis-angle formulation and Euler angles; Coordinate transformation of vectors and tensors.

Module 3: Kinematics of Rigid Body (6 hours)

Kinematics of rigid bodies: Definition and motion of a rigid body; Rigid bodies as coordinate systems; Angular velocity of a rigid body, and its rate of change; Distinction between two- and three-dimensional rotational motion; Integration of angular velocity to find orientation; Motion relative to a rotating rigid body: Five term acceleration formula.

Module 4: Kinetics of Rigid Bodies (5 hours)

Kinetics of rigid bodies: Angular momentum about a point; Inertia tensor: Definition and computation, Principal moments and axes of inertia, Parallel and perpendicular axes theorems; Mass moment of inertia of symmetrical bodies, cylinder, sphere, cone etc., Area moment of inertia and Polar moment of inertia, Forces and moments; Newton-Euler's laws of rigid body motion.

Module 5: Free Body Diagram (1 hour)

Free body diagrams; Examples on modelling of typical supports and joints and discussion on the kinematic and kinetic constraints that they impose.

Module 6: General Motion (9 hours)

Examples and problems. General planar motions. General 3-D motions. Free precession, Gyroscopes, Rolling coin.

Module 7: Bending Moment (5 hours)

Transverse loading on beams, shear force and bending moment in beams, analysis of cantilevers, simply supported beams and overhanging beams, relationships between loading, shear force and bending moment, shear force and bending moment diagrams.

Module 8: Torsional Motion (2 hours)

Torsion of circular shafts, derivation of torsion equation, stress and deformation in circular and hollow shafts.

Module 9: Friction (3 hours)

Concept of Friction; Laws of Coulomb friction; Angle of Repose; Coefficient of friction.

Text / References:

1. J. L. Meriam and L. G. Kraige, “Engineering Mechanics: Dynamics”, Wiley, 2011.
2. M. F. Beatty, “Principles of Engineering Mechanics”, Springer Science & Business Media, 1986.

**MANDATORY COURSES**

|               |                               |                 |                  |
|---------------|-------------------------------|-----------------|------------------|
| <b>BMC001</b> | <b>ENVIRONMENTAL SCIENCES</b> | <b>3L:0T:0P</b> | <b>0 credits</b> |
|---------------|-------------------------------|-----------------|------------------|

### **MODULE 1**

Introduction to Environmental Science - Definition and scope and need for public awareness  
Ecosystems, Concept, structure and functions, restoration of damaged ecosystems  
Biodiversity – Definition, description at national and global level, threats and conservation

### **MODULE 2**

Natural Resources - Renewable and non-renewable and their equitable use for sustainability,  
Material cycles – carbon, nitrogen and sulphur cycle. Conventional and Non-conventional  
Energy Sources – fossil fuel-based, hydroelectric, wind, -nuclear and solar energy, biomass,  
biodiesel, hydrogen as an alternative fuel.

### **MODULE 3**

Transportation and industrial growth Social Issues Related to Environment–Sustainable  
development, resettlement and rehabilitation Environmental ethics.

### **MODULE 4**

Environmental Changes and Human Health Environmental Pollution–Definition, causes and  
effects, control measures for water, air, soil, noise, thermal pollution.

#### **Textbook:**

1. Environmental Studies, J Krishna wamy, RJ Ranjit Daniels, Wiley India.

#### **Reference Books:**

2. Environmental Science, Bernard J. Nebel, Richard T. Right, 9780132854467, Prentice Hall Professional 1993.
3. Environment and Ecology, RK Khandal, 978-81-265-4277-2, Wiley India.