Total Contact Hours = 26 **Total Marks = 1000** **Total Credits = 26**

Semester 5TH		Contact Hours			Max Marks		Total Marks	Credits
Subject Code	Subject Name	L	T	P	Int.	Ext.		
BELES1-501	Power Systems – I (Transmission & Distribution)	3	1	0	40	60	100	4
BELES1-502	Control Systems	3	1	0	40	60	100	4
BELES1-503	Microcontrollers & PLC	3	0	0	40	60	100	3
BELES1-504	Power Systems - I Laboratory	0	0	2	60	40	100	1
BELES1-505	Control Systems Laboratory	0	0	2	60	40	100	1
BELES1-506	Microcontrollers & PLC Laboratory	0	0	2	60	40	100	1
BELES1-507	Institutional/Industrial Training (6-Week) *	0	0	--	60	40	100	3
Departmental Elective - I (Select any One)		3	0	0	40	60	100	3
BELED1-511	Electrical Drives							
BELED1-512	Electrical Machine Design							
BELED1-513	Electromagnetic Waves							
BELED1-514	Electrical Materials							
	Open-Elective	3	0	0	40	60	100	3
BHSMC0-019	Economics for Engineers	3	0	0	40	60	100	3
Total		**18**	**2**	**6**	**480**	**520**	**1000**	**26**

***Note:** During the summer vacation after 4th semester.

POWER SYSTEMS - I

(Transmission & Distribution)

Subject Code:	L	T	P	C	Duration: 60 (Hrs.)
BELES1-501	3	1	0	4	

Course Objectives:

1. To introduce the students to the structure of power and distribution systems.
2. To introduce them to overhead transmission lines and underground cables and make them to understand their operating characteristics.
3. To make them familiar with the components and the mechanical design aspects of overhead transmission lines.

Course Outcomes:

Students will be able:

1. To choose working voltage and economic size of conductors for transmission and distribution sytems.
2. To analyse performance of transmission lines and underground cables.
3. To select and design overhead line insulators and transmission lines.

UNIT-I (15 Hours)

Basics of Power Systems: Evolution and present-day scenario of a power system, Structure of a power system, Bulk power grids and micro-grids, Introduction to electrical energy generation, Distributed energy resources.

Transmission and Distribution Systems: Line diagrams, Transmission and distribution voltage levels and topologies (meshed and radial systems), Synchronous grids (AC) and Asynchronous (DC) interconnections, Comparison of cost of conductors, Choice of working voltage for transmission and distribution, Economic size of conductors, Kelvin's law, Radial and mesh distribution networks, Voltage regulation.

UNIT-II (15 Hours)

Transmission Line Parameters: Types of conductors; Solid, Stranded, ACSR, Hollow and Bundle conductors, Electrical and magnetic fields around conductors, Line parameters of single and double circuit transmission lines, Resistance of transmission lines, Inductance of single phase two wire line, concept of geometric mean distance (G.M.D.), Inductance of three phase lines, Use of bundle conductors, Transposition of power lines, Capacitance of 1-phase and 3-phase lines, Effect of earth on capacitance of conductors.

Performance of Transmission Lines: Sinusoidal steady state representation of lines by equivalent circuits; Representation of short transmission line and medium length line by nominal T & π circuits, Representation of long length line by hyperbolic equations and equivalent T & π circuits, Power flow through transmission lines, Generalized ABCD constants, Voltage regulation and efficiency of short, medium and long lines, Ferranti effect.

UNIT-III (15 Hours)

Circle Diagram and Line Compensation: Receiving end circle diagram for long transmission lines based on ABCD constants, equivalent T circuits, power loci, Surge impedance loading, Reactive power requirement of system, Series and shunt compensation, Synchronous phase modifiers, Rating of phase modifiers.

Cables: Classification of cables based upon voltage and dielectric material, Insulation resistance and Capacitance of single core cable, Dielectric stress, Capacitance of 3 core cables, Methods of laying, Heating effect, Maximum current carrying capacity, cause of failure, Comparison with overhead transmission lines.

UNIT-IV (15 Hours)

Overhead Line Insulators: Types of insulators, String efficiency, Voltage distribution in a string of suspended insulators, Grading ring, Preventive maintenance

Electrical Design Of Transmission Line: Choice of voltage, Selection of conductor size, Choice of span, No. of circuits, Conductor configuration, Insulation design, Selection of ground wire.

Mechanical Design of Transmission Lines: Supporting structures for overhead lines, Elementary ideas about transmission line construction and erection, Stringing of conductors, Spacing, Sag and Clearance from ground, Sag-tension calculations.

Recommended Text Books / Reference Books:

1. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
2. C.L. Wadhwa, "Electric Power Systems", Second Edition, Wiley Eastern Limited, 1985.
3. Harder Edwin. I. "Fundamentals of Energy Production", John Wiley and Sons, 1982.
4. Burke James, J. "Power Distribution Engineering; Fundamentals and Applications" Marcel Dekk., 1996.
5. B.R. Gupta, "Generation of Electrical Energy", S. Chand (1998).
6. C.L. Wadhawa C.L, "A Course in Electrical Power", New Age international Pvt. Ltd
7. I. J. Nagrath and D. P. Kothari, "Power System Engineering", Tata McGraw Hill, 1995.
8. O. L. Elgerd, Electrical Energy System Theory - An introduction, Tata McGraw-Hill Publication

CONTROL SYSTEMS

Subject Code:	L	T	P	C	Duration: 60 (Hrs.)
BELES1-502	3	1	0	4	

Course Objectives:

To make the students:

1. To understand basic concepts of control systems, such as; mathematical modelling, transfer functions, signal flow graphs etc.
2. To learn basic goals of control systems in terms of transient/steady state time response behaviour and frequency response analysis.
3. To understand concept of stability and application of different analysis methods.
4. To introduce to the concept of state variable analysis.

Course Outcomes:

Students will be able:

1. To do modelling of linear-time-invariant systems using transfer function and state-space representations.
2. To do the stability assessment for linear-time invariant systems.
3. To design simple feedback controllers.

UNIT-I (15 Hours)

Introduction: Industrial control examples, Mathematical models of physical systems, Control hardware and their models, Transfer function models of linear time-invariant systems, Laplace transform.

Feedback Control: Open-Loop and closed-loop systems, Benefits of feedback, Block diagram algebra and signal flow graphs.

UNIT-II (15 Hours)

Time Response Analysis: Standard test signals, Time response of first and second order systems for standard test inputs, Application of initial and final value theorem, Design specifications for second-order systems based on the time-response, Steady state error and coefficients.

Concept of Stability: Routh-Hurwitz Criteria, Relative Stability analysis, Root-Locus technique, Construction of Root-loci.

UNIT-III (15 Hours)

Frequency Response Analysis: Relationship between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability using Nyquist criterion, Gain and Phase margin, Closed-loop frequency response.

Introduction to Controller Design: Stability, Steady-state accuracy, Transient accuracy, Disturbance rejection, Methods of controller design in frequency domain, Lead and Lag compensation, Analog and Digital implementation of controllers, Application of Proportional, Integral and Derivative Controllers.

UNIT-IV (15 Hours)

State Variable Analysis: Concepts of state variables, State space model, Diagonalization of State Matrix, Solution of state equations, Eigen values and Stability Analysis, Concept of controllability and Observability, Pole-placement by state feedback, Discrete-time systems, Difference Equations, State-space models of linear discrete-time systems, Stability of linear discrete-time systems.

Recommended Text Books / Reference Books:

1. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
2. B. C. Kuo, "Automatic Control System", Prentice Hall, 1999.
3. K. Ogata, "Modern Control Engineering", Prentice Hall, 2011.
4. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.
5. Dorf Richard C. and Bishop Robert H., Modern Control System, Addison-Wesley, Pearson, 2009.
6. B. S. Manke, Linear Control Systems, 2002

MICROCONTROLLERS AND PLC

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELES1-503	3	0	0	3	

Course Objectives:

1. To introduce to the architecture of microprocessor and microcontroller.
2. To study 8051 microcontrollers in detail.
3. To interface peripheral devices with microprocessors and microcontrollers.
4. To introduce to PLCs and their applications.

Course Outcomes:

The students will;

1. Know about the architecture, operation and instruction set of 8051 microcontroller.
2. Be able to do programming of 8051 microcontrollers.
3. Be able to Interface 8051 with peripheral devices.
4. Be able to use PLCs.

UNIT-I (11 Hours)

Fundamentals of Microprocessors: Fundamentals of microprocessor architecture, 8-bit Microprocessor and Microcontroller architecture, Difference between microprocessor and microcontroller, Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems.

The 8051 Architecture: PIN diagram of 8051, Internal block diagram, CPU, ALU, address, data and control bus, Working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory, Timing diagrams and Execution Cycles.

UNIT-II (12 Hours)

Instruction Set and Programming of 8051

Addressing modes: Introduction, Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, Bit inherent addressing, Bit direct addressing,

8051 Instruction set: Instruction timings, Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instructions.

Assembly language programs, Assemblers and compilers, Programming and debugging tools.

UNIT-III (11 Hours)

Memory and I/O Interfacing: Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O such as LED, LCD, keyboard, ADC, DAC, timers, counters, memory devices.

External Communication Interface: Synchronous and asynchronous communication, RS232, SPI, I2C, Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Microcontroller Applications: Stepper motor interfacing, DC motor interfacing, Sensor interfacing, Application of microcontrollers in Arduino.

UNIT-IV (11 Hours)

Introduction to Programmable Logic Controllers

Introduction, Operation of PLC, Difference between PLC and Hardwired system, Difference between PLC and Computer, Relay logic and ladder logic, Ladder commands and examples of PLC ladder diagram realization, PLC timers, PLC counters, Applications of PLC, PLC interfacing with HMI/SCADA system.

Recommended Text Books / Reference Books:

1) M. A. Mazidi, The 8051 Microcontroller and Embedded System, Pearson Education (2008).
2) Kenneth J Ayola, The 8051 Micro Controller- Architecture, Programming and Application, Penram International Publication
3) R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applications with the 8085”, Penram International Publishing (India) Pvt. Ltd., 2004.
4) D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991.
5) B. Ram, Fundamentals of Microprocessors and Microcomputers, Dhanpat Rai andSons.
6) Otter, Job Dan, *Programmable Logic Controller*, P.H. International, Inc, USA
7) Dunning Gary, *Introduction to PLCs*, Tata McGraw Hill
8) John B Peatman, *Design with Micro Controller*, Tata McGraw Hill
9) Udayashankara V. and Mallikarjunaswamy M.S., *8051 Microcontroller Hardware, Software and Applications*, TataMcGraw Hill Education Pvt. Ltd., (2010)

POWER SYSTEMS – I LABORATORY

Subject Code:	L	T	P	C
BELES1-504	0	0	2	1

Course Objectives:

To demonstrate the various equipment and concepts related to;

1. Transmission and distribution of power, such as cables, conductors, insulators, supporting structures etc.
2. To visit a power/substation.

Course Outcomes:

1. Students will have more detailed insight about the need of various equipment used for transmission and distribution of power.
2. They will be able to draw performance characteristics of these equipment.
3. To practically compute parameters and performance of transmission lines and feeders.

LIST OF EXPERIMENTS

1. To measure active power, reactive power and power factor of a three phase load by two-wattmeter method and power factor meter and verify through current, voltage and power measurement.
2. To compute the ABCD parameters of a transmission line.
3. To analyze the performance of short and medium length transmission lines and to determine efficiency and voltage regulation.
4. To analyze the performance of long transmission line and to determine its efficiency and voltage regulation and to demonstrate Ferranti effect.
5. To find the earth resistance using three spikes.
6. To study the radial feeder performance (i) fed at one end and (ii) fed at both ends.
7. To study and demonstrate different types of transmission and distribution conductors and models of cables.
8. To measure insulation resistance of a cable.

   OR

   To measure the capacitance of single-core and three-core cables.
9. To study and demonstrate the methods of fault location in cables.
10. To study different types of supporting structures and insulators for conductors. Also to determine the efficiency of a string of insulators.
11. Optimal capacitor placement on a system having variable reactive power and low voltage profile.
12. Design a transmission system for given power and distance.

    OR

    Design of a small distribution system.

Note: At least ten experiments should be performed in a semester.

CONTROL SYSTEMS LABORATORY

Subject Code:	L	T	P	C
BELES1-505	0	0	2	1

Course Objectives:

1. To understand the basics concepts of MATLAB software.
2. To introduce variety of control system strategies.
3. To comment about the stability of designed systems.

Course Outcomes:

1. To understand the basics of MATLAB software.
2. To understand variety of control system strategies.
3. To acquire skills to understand all types of control components.
4. Ability to analyse the stability of control systems.

LIST OF EXPERIMENTS

1. Familiarization with MATLAB and its control system toolbox. Familiarization with MATLAB Simulink toolbox.
2. Determination of step response for first order and second order system with unity feedback and their display on CRO. Calculation and verification of time constant, peak overshoot, setting time etc. from the response.
3. Simulation of step response and impulse response for type-0, type-1and type-2 systems with unity feedback using MATLAB.
4. Determination of Root Locus, Bode-Plot, Nyquist Plot using MATLAB-Control system toolbox for 2nd order system. Determination of different control system performance indices from the plots.
5. Determination of PI, PD, PID controller action of first order simulated process.
6. Experimental determination of approximate transfer function from Bode plot.
7. Evaluation of steady state error, setting time, percentage peak overshoot, gain margin, phase margin, with addition of lead compensator and by compensator in forward path transfer function for unity feedback control system.
8. Determination of control system specifications for variations of system parameters in practical position control system.
9. Design of a second order linear time invariant control system and study of system response with unit step input.

10. To study the characteristics of potentiometers and to use 2- potentiometers as an error detector in a control system.
11. To study the Synchro Transmitter-Receiver set and to use it as an error detector.
12. To study the Speed – Torque characteristics of a DC Servo Motor and explore its applications.
13. To obtain the transfer function of a D.C. motor – D.C. Generator set using Transfer Function Trainer.
14. To study the speed control of an A.C. Servo motor using a closed loop and open loop systems.
15. (i) To study the operation of a position sensor and study the conversion of position in to corresponding voltage (ii) To study a PI control action and show its usefulness for minimizing steady state error of time response.

Note: At least twelve experiments should be performed in semester.

MICROCONTROLLER AND PLC LABORATORY

Subject Code:	**L**	**T**	**P**	**C**
BELES1-506	**0**	**0**	**2**	**1**

Course Objectives:
To make the students:
1. Familiar with microprocessor and microcontroller kits.
2. To write and demonstrate assembly language programms for arithmatic and logical operations.
3. To interface peripheral devices to microcontrollers and to write programs to control their operation.
4. To demonstrate applications of PLCs.

Course Outcomes:
Students will:
1. Become familiar with the microcontrollers and PLCs.
2. Be able to write assembly language programms for various types of applications.
3. Become familiar with the use of PLCs in industry.

LIST OF EXPERIMENTS

1. Introduction to 8085 Microprocessor kit/simulator and 8051 Microcontroller kit/simulator.
2. Write a program to (i) Add (ii) Subtract (iii) Multiply and (iv) Divide, two 8-bit numbers

lying at two memory locations and display the result.

3. Write a program to check a number for being ODD or EVEN and show the result on display.

   OR

   Write a program to split a byte in two nibbles and show the two nibbles on display.
4. Write a program to arrange TEN numbers stored in memory location in ascending and descending order.
5. Write a program to
   (i) Find a factorial of a given number.
   (ii) Generate Fibonaci Series
   (i) Sum up a finite series
6. Study of interrupt structure of 8051 micro-controllers and to write a program to show the use of INT0 and INT1.
7. Write a program of flashing LED connected to port 1 of the micro-controller

   OR

   Write a program to develop rolling display.
8. Write a program to control a stepper motor in direction, speed and number of steps.
9. Write a program to control the speed of DC motor.
10. Implementation of different gates using PLC.
11. Implementation of DOL and star delta starter using PLC.
12. Implement basic logic operations, motor start and stop operation using
    (i) Timers (ii) Counters
13. Motor forward and reverse direction control using PLC.
14. Make a PLC based system (i) for rack feeder and/or (ii) for conveyor belt and/or (ii) for separating and fetching work pieces.

    OR

    Implement a PLC based traffic light control.

Note: At least Ten experiments should be performed in a semester.

ELECTRICAL DRIVES

Subject Code:	**L T P C**	**Duration: 45 (Hrs.)**
BELED1-511	**3 0 0 3**	

Course Objectives:

1. To review the characteristics of DC motors.
2. To know about the operation of DC drives and their speed control methods using power electronic converters.
3. To know about the various control stratigies of induction motors using power electronic control methods.

Course Outcomes:

Students will be able:

1. To draw the characteristics of DC motors and induction motors.

2. To control the speed of DC motors using power electronic converters.
3. To use power electronic converters for induction motor speed control.

UNIT-I (11 Hours)

DC Motor Characteristics

Review of e.m.f and torque equations of DC machine, review of torque-speed characteristics of separately excited DC motor, Change in torque-speed curve with armature voltage, Load torque-speed characteristics, Operating point, Armature voltage control for varying motor speed, Flux weakening for high speed operation.

Chopper Fed DC Drive

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.

UNIT-II (12 Hours)

Multi-Quadrant DC Drive

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.

Closed-loop Control of DC Drive

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.

UNIT-III (11 Hours)

Induction Motor Characteristics: 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.

Control of Slip Ring Induction Motor

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.

UNIT-IV (11 Hours)

Scalar Control or Constant V/f Control of Induction Motor

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.

Recommended Text Books / Reference Books:

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.

ELECTRICAL MACHINE DESIGN

Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45 (Hrs.)**
BELED1-512	**3**	**0**	**0**	**3**	

Course Objectives:

1. Understand the principles of electrical machine design.
2. To know about the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
3. To design transformers and induction motors.
4. To introduce to use of computers in design.

Course Outcomes:

Students will:

1. Know the constructional features.
2. Be able to evaluate performance characteristics of electrical machines.
3. Be able to carry out a basic design of an ac machine.
4. Be able to use software tools to do design calculations.

UNIT-I (11 Hours)

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.

UNIT-II (12 Hours)

Transformers:

Sizing of a transformer, Main dimensions, Output kVA 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.

UNIT-III (11 Hours)

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 poly-phase machines, Magnetizing current, Short circuit current, Circle diagram, Operating characteristics.

UNIT-IV (11 Hours)

Computer aided Design (CAD):

Limitations (assumptions) of traditional design, 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 **c**omplex structures of modern machines: Permanent magnet synchronous motor (PMSM), Brushless DC motor (BLDC), Switched reluctance motor (SRM) and Claw-pole machines.

Recommended Text Books / Reference Books:

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.

ELECTROMAGNETIC WAVES

Subject Code:	L T P C	Duration: 45 (Hrs.)
BELED1-513	3 0 0 3	

Course Objectives:

1. Analyse transmission lines and estimate voltage and current at any point on transmission line for different load conditions.
2. Analyse the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.
3. To analyse radiation by antennas.

Course Outcomes:

Students can:

1. Provide solution to real life plane wave problems for various boundary conditions.
2. Visualize TE and TM mode patterns of field distributions in a rectangular wave-guide.
3. Analyze wave-guides and understand radiation by antennas.

UNIT-I (15 Hours)

Transmission Lines: 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.

Maxwell's Equations: 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.

UNIT-II (15 Hours)

Uniform Plane Waves: 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.

Plane Waves at Media Interface: 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.

UNIT-III (15 Hours)

Waveguides: 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.

Antennas: 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.

Recommended Text Books / 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.

ELECTRICAL MATERIALS

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELED1-514	3	0	0	3	

Course Objectives:

1. Aware about various types of conducting materials and their applications.
2. Aware about various properties of insulating materials and their applications.
3. Aware about various types of magnetic materials and their applications.

Course Outcomes:

1. Analyze the characteristics of different types of materials viz. conductors, insulators, and magnetic materials etc.
2. Select a suitable material for manufacturing electrical equipment.

UNIT-I (15 Hours)

Conducting Materials: Classification of material into conducting, semi conducting and insulating materials, Factors affecting resistance such as alloying and temperature, Classification of conducting material as low resistivity and high resistivity materials, Low resistivity copper alloys and their practical applications, Applications of special metals, High resistivity materials and their applications, Super conductivity.

UNIT-II (15 Hours)

General Properties of Insulating Materials

Electrical Properties: Volume resistivity, Surface resistance, Dielectric loss, Dielectric strength (breakdown voltage), Dielectric constant,

Physical Properties: Hygro-scopicity, Tensile and Compressive strength, Abrasive resistance, Brittleness.

Thermal Properties: Heat resistance, Classification based on permissible temperature rise,

Effect of overloading on the life of an electrical appliance, Increase in rating with the use of insulating materials having higher thermal stability, Thermal conductivity, Electro-thermal breakdown in solid dielectrics.

Chemical Properties: Solubility, Chemical resistance, Weather-ability, Mechanical properties, Mechanical structure, Tensile structure.

Applications of Insulating Materials

Definition and classification of plastics, Thermosetting materials, Thermo-plastic materials, Natural insulating materials, Properties and their applications, Gaseous materials, Ceramics, properties and applications.

UNIT-III (15 Hours)

Magnetic Materials and Special Materials: Introduction and classification of ferromagnetic materials, Permeability, B-H curve, Magnetic saturation, Hysteresis loop (including) coercive force and residual magnetism, Concept of eddy current and Hysteresis loss, Curie temperature, Magneto-striction effect, Soft Magnetic Materials, Hard magnetic materials, Hall effect and its applications, Thermocouple, Bimetals, Leads, Soldering and Fuses material and their applications.

Recommended Text Books / Reference Books:

1) SK Bhattacharya, "Electrical and Electronic Engineering Materials"1st edition Khanna Publishers, New Delhi,2006.(Unit 1,2,3)
2) A.J. Dekker "Electrical Engineering Materials", PHI, 2006. (Unit 4,5)
3) Grover and Jamwal, "Electronic Components and Materials" DhanpatRai and Co., New Delhi.
4) Sahdev, "Electrical Engineering Materials", Unique International Publications
5) C. S. Indulkar& S. Thiruvengadam, "Electrical Engineering Materials", S. Chand & Com. Ltd, New Delhi -55
6) S.P. Seth, P.V. Gupta "A course in Electrical Engineering Materials", Dhanpat Rai& Sons.

ECONOMICS FOR ENGINEERS

Subject Code: BHSMC0-019 **L T P C** **Duration: 45 Hrs**
3 0 0 3

Course Objectives
The main aim of this course is:

1. To equip the students of management with time tested tools and techniques of managerial economics to enable them to appreciate its relevance in decision making.
2. To explore the economics of information and network industries and to equip students with an understanding of how economics affect the business strategy of companies in these industries.
3. To develop economic way of thinking in dealing with practical business problems and challenges

Course Outcomes
After completing this course, the students will be able to:

1. Able to analyze the demand and supply conditions of the market and accordingly assess the position of a company.
2. Understand the basic economic problems faced by the society and make effective decisions.
3. Design competition strategies which includes costing, pricing, product differentiation, and market environment according to the natures of products and the structures of the markets.
4. Analyze the market competitions and design strategies accordingly.

UNIT-I (12 Hrs.)

Micro Economics: Meaning, Nature, Scope and Limitations Basic concepts: Marginal and Incremental Principles, Opportunity Cost, Equilibrium Utility: Cardinal Utility Approach: Diminishing Marginal Utility; Ordinal Utility Approach, Indifference Curve, Properties, Consumer Equilibrium and Marginal Rate of Substitution.

UNIT-II (11 Hrs.)

Demand: Meaning, Determinants, Law of Demand and its Exceptions. Elasticity of Demand: Measurement, Degree of Elasticity. Price, Income and Cross Elasticity of Demand. Revenue: Total Revenue (TR), Average Revenue (AR), Marginal Revenue (MR) and their Relationship.

UNIT-III (12 Hrs.)

Production Function: Meaning, Short-Run Production Function and Law of Variable Proportions, Long Run Production and Laws of Returns. Cost of Production: Concept of Economic and Managerial Costs, Short Run and Long Run Cost Curves. Economies and Diseconomies of Scale

UNIT-IV (10 Hrs.)

Equilibrium of Firm and Industry: Perfect Competition, Monopoly and Discriminating Monopoly. Monopolistic Competition: Characteristics, Individual and Group Equilibrium, Concept of Selling Cost. Oligopoly: Characteristics, Cornet's Model, Kinked Demand Curve, Concepts of Cartel and Price Leadership. Distribution: Marginal Productivity and Modern Theory of Determination.

Recommended Books

1. D. Salvatore, 'Microeconomic Theory', Tata McGraw Hill.
2. R.H. Dholkia and A.N. Oza, 'Microeconomics for Management Students', Oxford University Press.
3. D.N. Dwivedi, 'Managerial Economics', Vikas Publishing
4. P.L. Mehta, 'Managerial Economics', Sultan Chand.

Total Credits = 21

Semester 6TH		Contact Hours			Max Marks		Total Marks	Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**		
BELES1-601	Power Systems – II (Protection)	3	0	0	40	60	100	3
BELES1-602	Electrical Measurements & Instrumentation	3	0	0	40	60	100	3
BELES1-603	Power Systems - II Laboratory	0	0	2	60	40	100	1
BELES1-604	Electrical Measurements & Instrumentation Lab	0	0	2	60	40	100	1
BELES1-605	Electrical Design & Estimation Lab	0	0	2	60	40	100	1
Departmental Electives – II	**(Select any one from the following list)**	3	0	0	40	60	100	3
BELED1-611	Industrial Electrical Systems							
BELED1-612	Non-Linear &Digital Control Systems							
BELED1-613	Computer Architecture							
BELED1-614	Computational Electromagnetics							
Departmental Electives – III	**(Select any one from the following list)**	3	0	0	40	60	100	3
BELED1-621	Wind & Solar Energy Systems							
BELED1-622	HVDC Transmission Systems							
BELED1-623	EHVAC Transmission Systems							
BELED1-624	FACTS Devices in Transmission & Distribution Networks							
XXXXX	**Open-Elective***	3	0	0	40	60	100	3
BELES1-606	Introduction to Industrial Management	3	0	0	40	60	100	3
Total		**-**	**-**	**-**	**420**	**480**	**900**	**21**

*Open Electives (OE) can also be taken from existing lists of Open Elective-I, Open Elective-II and Open Elective-III subject lists.

POWER SYSTEMS – II (Protection)					
Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45(Hrs.)**
BELES1-601	**3**	**0**	**0**	**3**	

Course Objectives:

1. To provide knowledgeaboutprinciple andcomponents of protective system.
2. To impart knowledge about basics of Substation, Isolator and Fuses.
3. To provide knowledge about operating principle, types of relays and circuit breakers.
4. To provide knowledge about protection of Feeder, Bus bar, Generator and Transformer

Course Outcomes:

Students will be able to:

1. Explain causes and effects of faults,components usedfor power system protection such as;isolators and fuses, relays, circuit breakers etc.
2. Classify types of relays and circuit breakers and explain their working principles and operation.
3. Protecttransmission lines, feeders, bus bars, generator and transformer.
4. Develop concepts about the basic principlesof static anddigitalprotection.

UNIT-I (11 Hours)

Introduction to Components of Protection System:

Need for Protective System, Nature and causes of faults, Types and effects of faults, Zones of protection, Primary and backup protection, Essential qualities of protection, Basic principle of protectionsystem, Components and classification of protective system.

Substation:

Types, Classification, Main Equipment, Layout, Bus-bar Arrangement of Substation, Functions, Operation, Types and rating of Isolators, Characteristics, Types and rating of fuses.

UNIT-II (12 Hours)

Circuit Breakers:

Need for Circuit Breakers, Circuit Breaker Ratings, Arc Initiation and their Interruption Methods,Arc Quenching Theories, Re-striking voltage, Recovery Voltage, RRRV, Oil Circuit Breaker, Minimum Oil Circuit Breaker, Air Circuit Breaker, Air Blast Circuit Breaker, Vacuum Circuit breaker and SF_6 circuit breaker.

Protective Relays: Introduction, Classification, Constructional features, and Characteristics of Electromagnetic, Induction, Over-current relays, Directional over current relay, Distance relays; Impedance relay, Reactance relay and Mho relay, Differential Relays.

Under voltage relay, Over voltage relay, Trans-lay, Under-frequency relay, Over-frequency relay, Rate of change of frequency (df/dt) relays,Reverse-power relay, Negative sequence relay.

UNIT-III (11 Hours)

Transmission Line, Feeder and Bus Bar Protection:
Over current protection by time graded system, Current graded and Time- current graded system, Protection of parallel feeder, Protection of ring mains feeder, Over current earth fault protection.

Distance Protection of transmission lines, Comparison amongdistance relays, Differential and percentage differential protection, Pilot relaying protection of feeder, Differential protection of bus bars.

Overvoltages on transmission lines such as switching overvoltages and lightning overvoltages, Protection of transmission lines against lighting, Protection of power system apparatus against surges.

UNIT-IV (11 Hours)

Transformer Protection:
Over current protection, Percentage differential protection, Incipient faults in transformers, Inter-turn fault, Protection against over fluxing.

Generator Protection:
Various faults and abnormal operating conditions, Protection against unbalanced loading, Over-speeding, Loss of excitation, Loss of prime mover.

Introduction to Advance Protection Systems:
Carrier aided protection of transmission lines, Static comparators as relays, Structure and Operation of Digital protection system, Advantages of digital techniques in power system protection.

Recommended Text Books / Reference Books:

1. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
2. Burke James, J. "Power Distribution Engineering; Fundamentals and Applications" Marcel Dekk., 1996.
3. C.L. Wadhwa, A Course in Electrical Power, New Age international Pvt. Ltd
4. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill, 2001
5. M.V. Deshpande, Switchgears and Protection, Tata McGraw Hill
6. Ashfaq Hussain, Electrical Power system, 3rd edition, CBS Publishers & Distributors Pvt. Ltd. New Delhi, 2007.
7. S. S. Rao, Switchgear Protection and Power System, Khanna Publishers, Delhi,10th Edition,1992
8. Dahiya and Attri, Substation Engineering, Khanna Publishers

ELECTRICAL MEASUREMENTS & INSTRUMENTATION

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELES1-602	3	0	0	3	

Course Objectives:

1. To make the students aware about the basics of measurements and instrumentation systems.
2. To impart knowledge about different instruments for electrical measurements.
3. To introduce to basic concepts of different types of sensors and transducers.

Course Outcomes:

Students will be able:

1. To explain the constructional features, characteristics and operation of various measurement devices and transducers.
2. To measure R, L and C using DC and AC bridges.
3. To use CRO and instrument transformers for measurement and instrumentation purposes.
4. To select transducers for different applications.

UNIT-I (12 Hours)

Measurment Systems:

Introduction, Necessity of measurements, Block diagram of measurement system, Instrument characteristics such as True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Repeatability and sensitivity, Different types of errors in measurement.

Measuring Instruments:

Principle of operation and constructional features of D'Arsonval galvanometer, Permanent magnet moving coil (PMMC), Moving Iron instruments (Repulsion and Attraction type), Electrodynamic type instruments, Measurement of current, voltage, power and power factor by using these instruments, Use of Shunts, Multipliers and Potential dividers, Energy meter, Digital Multi-meter, Clamp-on meters.

UNIT-II (11 Hours)

Measurement of Resistance: Low, Medium and High resistance measurement using Kelvin Double Bridge, Ammeter-Voltmeter method, Wheat Stone Bridge, Megohm bridge, Megger.

Measurement of Inductance and Capacitance: Maxwell Inductance, Hay's, Anderson and Schering Bridges, Measurement of frequency by Wein bridge method.

UNIT-III (11 Hours)

Oscilloscope:

Basic principle and construction of Analog CRO, Sweep modes, Applications in measurement of voltage, frequency (Lissajous pattern), Introduction to Dual Trace Oscilloscope, Digital Storage Oscilloscope, Sampling oscilloscope, Comparison between analog and digital oscilloscope.

Instrument Transformers:

Theory and construction of current and potential transformers, Ratio and phase angle errors and their minimization, Characteristics of current transformers(CT) and potential transformers(PT) and their Testing.

UNIT-IV (11 Hours)

Transducers:

Transducer, Difference between sensor and transducer, Transducer characteristics, Classifications and Types, Basic requirements of Transducer/Sensors, Displacement Transducers: LVDT, RVDT and Piezoelectric, Resistance Thermometer, Thermistors, Thermocouples, Strain Gauge, Applications of Transducers.

Recommended Text Books / Reference Books:

1. Helfrick A.D. and Cooper W.D., "Modern *Electronic Instrumentation and MeasurementTechniques"*, PHI, 1990.
2. A.K. Sawhney, Puneet Sawhney, "A course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai & Sons, 2011.
3. Jones and Chin, 'Electronic Instruments and Measurement', 2010.
4. J. Toppin, 'Theory of Errors', Wessely Publishing, 2000.
5. Bell David A., *Electronics Instrumentation and Measurements,* Prentice Hall,India
6. Golding Edward William and Widdis Frederick Charles, *Electrical Measurements andMeasuring instruments,* WheelersIndia
7. Murthy D. V. S., Transducers and Instrumentation, Prentice-Hall,India

POWER SYSTEMS – II LABORATORY

Subject Code:	L	T	P	C
BELES1-603	0	0	2	1

Course Objectives:

1. Understand operation of relays and circuit breakers.
2. To demonstrate the characteristics of different types of relays.

Course Outcomes:

Students will be able:

1. To demonstrate operation of relays and circuit breakers.
2. To analyze various protection schemes in power system.
3. To plot characteristics of various types of relays, circuit breakers and fuses.

LIST OF EXPERIMENTS

1. To study the characteristics of over current protection.
2. To study the characteristics of earth fault protection.
3. To draw the operating characteristics of fuse (HRC or open type) and bimetal mini circuit breakers.
4. To study air circuit breakers, oil circuit breakers, vacuum circuit breakers and SF_6 circuit breakers and demonstrate at least two of them.
5. To study over current static relay.
6. To study the performance of under voltage relay and over voltage relay.
7. To study the characteristics of Distance (Impedance, Reactance and Mho) Relay.
8. To demonstrate the operation of Buchholz's relay.
9. To find the breakdown strength of transformer oil.
10. To study the different types of faults on transmission line demonstrationpanel/model.
11. Short circuit analysis and calculations of circuit breaker ratings for a power system network.

    OR

    Design of protection system for a substation.
12. To obtain relay co-ordination on a power system.
13. Visit to a power generation station/substation.

Note: At least ten experiments should be performed in a semester.

ELECTRICAL MEASUREMENTS & INSTRUMENTATION LAB

Subject Code:	L	T	P	C
BELES1-604	0	0	2	1

Course Objectives:

1. To demonstrate the constructional features of measuring instruments.
2. To demonstrate the applications of measuring instruments.
3. To draw the characteristics and use of various types of transducers.

Course Outcomes:

Students will be able:

1. To apply the basic measurement techniques and use measuring instruments.
2. To measure various electrical quantities using various types of meters.
3. To practically use current and potential transformers, CRO and DSO.

List of Experiments

1. To demonstrate the constructional features of various types of indicating measuring instruments, such as PMMC type, Moving iron type, Electrodynamo type etc.
2. Current Measurement using Clamp-on meter and Hall Sensor.
3. To measure high value of DC current and voltage using shunt and Multiplier.
4. To measure the active power in 3-phase balanced and unbalanced load by two wattmeter method and observe the effect of power factor variation on wattmeter reading.
5. To study and calibrate Energy Meter.
6. To measurement of low resistance using Wheat stone bridge and Kelvin's double bridge.
7. Measurement of High resistance and Insulation resistance using Megger.
8. Measurement of self-inductance by using any bridge technique such as Anderson's bridge as well as LCR meter.
9. Measurement of capacitance by using any bridge technique such as Schering bridge as well as LCR meter.
10. Measurement of frequency using Wein's Bridge.

    OR

    Determination of frequency and phase angle using CRO.
11. Use a DSO to capture transients like a step change in R-L-C circuit.

    OR

    Download one-cycle data of a periodic waveform from a DSO anduse values to compute the RMS value.
12. To study the connections and use of a potential transformer (PT) and to find out ratio error.
13. To study the connections and use of a current transformer (CT) and to find out ratio error.
14. Measurement of displacement usingLVDT and RVDT.
15. Study the characteristics of (i) Resistance TemperatureDetector(RTD) and (ii) Thermistor and measurement of temperature using them.
16. Study the characteristics of a strain gauge sensor and its application in a measuring unit.

Note: At least 12 experiments must be performed in a semester.

ELECTRICAL DESIGN & ESTIMATION LAB

Subject Code:	L	T	P	C
BELES1-605	0	0	2	1

Course Objectives:

1. To know about the layout of wiring circuits of electrical installations of a residential building or/and an educational institute or/and anindustry.
2. To enable the students to prepare the schedule of materials with specifications and estimates for different types of electrical installations.
3. To know about wiring arrangements of motor control circuits and to do an energy audit of a smallutility.

Course Outcomes:

Students will be able:

1. To estimate the cost of various types of electrical installations.
2. To identify design goals and analyze possible approaches to meet given specifications with realistic engineering constraints.
3. To use modern engineering software tools.
4. To work amicably as a member of an engineering design team.

List of Experiments

1. To study the Indian Electricity Act.
2. To estimate the cost of overhead serviceconnection and an underground serviceconnection.
3. To estimate (i) the load and cost of any five electricalappliances and (ii)their cost of repair and maintenance.
4. To carry out the schematic wiring diagram of a residential building/educationalinstitute/industry.
5. To study design parameters of electrical panelboards.
6. To draw wiring diagrams of motor control circuits for the starting of induction and synchronousmotors.
7. To study and design the earthing requirements for different types of installations and also to estimate the cost of earthing.
8. To carry out an electrical energy audit of a laboratory/office/workshop**.**
9. Protection of buildings and allied structures against lightning.
10. To design and estimate the cost of illumination of a Residential building/laboratory/drawing hall.
11. Lighting design: Different entities of illuminating systems; Exterior lighting- flood, street,

aviation and transport lighting.

OR

Lighting design for displays and signaling- neon signs, LED-LCD displays beacons and lighting for surveillance.

12. Introduction to and hands on working experience on any available programming and/or simulation platform(s), such as:
    (i) C/C++, FORTRAN, MATLAB, SIMULINK etc.
    (ii) ETAP (analytical engineering software)
    (iii) Different types of Electrical design softwares (CAD) for drawing of Electrical diagrams, schematics, control circuit diagrams etc.

Note: At least ten experiments should be performed in the semester.

Recommended Text Books / Reference Books:

1. Raina K.B. and Bhattacharya S.K., "Electrical Design, Estimating and Costing", Tata McGraw Hill, NewDelhi.
2. Gupta J.B., "A course in Electrical Installation, Estimating and Costing", SK Kataria and Sons, N.Delhi
3. Sharma B.R. and Rai H.M., "Electrical Estimating and Costing".
4. Uppal S.L., "Electrical Wiring, Estimating and Costing".
5. Singh Surjeet, "Estimating and Costing",DhanpatRai and Co., New Delhi

INDUSTRIAL ELECTRICAL SYSTEMS					
Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45 (Hrs.)**
BELED1-611	**3**	**0**	**0**	**3**	

Course Objectives:

To make the students:

1. Familiar withthe electrical wiring systems for residential, commercial and industrial consumers.
2. To learn about various components of industrial electricalsystems.
3. To introduce to industrial automation.

Course Outcomes:

Students will be able:

1. To represent the electrical wiring systems for residential, commercial and industrial consumers with standard symbols and drawings,SLD.
2. To explain various components of industrial electricalsystems.
3. To analyze and select the proper size of various electrical systemcomponents.

UNIT-I (11 Hours)

Electrical System Components: LT system wiring components, Selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components; Fuse, MCB, MCCB, ELCB, Inverse current characteristics, Symbols, Single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and electrical safety practices.

UNIT-II (12 Hours)

Residential and Commercial Electrical Systems: Types of residential and commercial wiring systems, General rules and guidelines for installation, Load calculation and sizing of wire, Rating of main switch, distribution board and protection devices, Earthing system calculations, Requirements of commercial installation, Deciding lighting scheme and number of lamps, Earthing of commercial installation, Selection and sizing of components.

Illumination Systems: Understanding various terms regarding Light, Lumen, Intensity, Candle power, Lamp efficiency, Specific consumption, Glare, Space to height ratio, Waste light factor, Depreciation factor, various Illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, Energy saving in illumination systems, Design of a lighting scheme for a residential and commercial premises, Flood lighting.

UNIT-III (11 Hours)

Industrial Electrical Systems – I: HT connection, Industrial substation, Transformer selection, Industrial loads, Motors, Starting of motors, SLD, Cable and Switchgear selection, Lightning protection, Earthing design, Power factor correction;kVAR calculations, type of Compensation, Introduction to PCC, MCC panels, Specifications of LT Breakers, MCB and other LT panel components.

UNIT-IV (11 Hours)

Industrial Electrical Systems – II: DG systems, UPS system, Electrical systems for the elevators, Battery banks, Sizing the DG, UPS and battery banks, Selection of UPS and batterybanks.

Industrial Electrical System Automation: Study of basic PLC, Role in automation, Advantages of process automation, PLC based control system design, Panel metering and introduction to SCADA system for distribution automation.

Recommended Text Books / Reference Books:

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

NON-LINEAR & DIGITAL CONTROL SYSTEMS

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELED1-612	3	0	0	3	

Course Objectives:

1. To introduce to discrete system analysis.
2. To introduce to stability aspects of discrete time systems.
3. To introduce to design of digital control and discrete output feedback control.

Course Outcomes:

Students can:

1. Represent discreteLTIsystems.
2. Analyse stability of open loop and closed loop discrete-timesystems.
3. Design and analyse digitalcontrollers.
4. Design state feedback and output feedback controllers.

UNIT-I (10 Hours)

Discrete Representation of Continuous Systems:

Basics of digital control systems, Discrete representation of continuous systems, Sample and hold circuit, Mathematical Modeling of sample and hold circuit, Sampling and Quantization, Choice of sampling frequency, ZOHequivalent.

UNIT-II (12 Hours)

Discrete System Analysis:

Z-Transform and Inverse Z Transform for analyzing discrete time systems, Pulse Transfer function, Pulse transfer function of closed loop systems, Mapping from S-plane to Z plane,

Solution of Discrete time systems, Time response of discrete time system.

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

UNIT-III (12 Hours)

State Space Approach for Discrete Time Systems:

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.

Design of Digital Control System:

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.

UNIT-IV (11 Hours)

Discrete Output Feedback Control:

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

Introduction to Optimal Control and Non-linear Control:

Performance indices, Regulator problem, Tracking problem, Nonlinear system, Basic concepts and analysis.

Recommended Text Books / Reference Books:

1. K.Ogata,"DigitalControlEngineering",PrenticeHall,EnglewoodCliffs,1995.
2. K.Ogata,"ModernControlEngineering",PrenticeHall,1991.
3. M.Gopal,"DigitalControlEngineering", WileyEastern,1988.
4. B.C.Kuo,"DigitalControlSystem",Holt,RinehartandWinston,1980.
5. B. C. Kuo, " Automatic Control System",Prentice Hall, 1995.
6. I. J. Nagrath and M. Gopal, " Control Systems Engineering", New Age International, 2009
7. G. F. Franklin, J. D. Powell and M. L. Workman, " Digital Control of Dynamic Systems", Addison-Wesley,1998.

COMPUTER ARCHITECTURE

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELED1-613	3	0	0	3	

Course Objectives:

1. To develop the concept of computer architecture and its operation.
2. To understand the concepts of microprocessors, their principles andpractices.
3. To know about memory organisation.

Course Outcomes:

1. Organize a modern computer system and be able to relate it to realexamples.
2. Write efficient programs in assembly language of the 8086 family ofmicroprocessors.
3. Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protectedmodes.

UNIT-I (11 Hours)

Introduction to Computer Organization:

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.

UNIT-II (12 Hours)

Memory Organization: System memory, Cache memory, Types and organization, Virtual memory and its implementation, Memory management unit, Magnetic hard disks, Optical disks.

Input – output Organization: Accessing I/O devices, Direct memory access (DMA) and its controller, Interrupts and interrupt controllers, Arbitration, Multilevel bus architecture, Interface circuits, Parallel and serial port, Features of PCI and PCI express bus.

UNIT-III (11 Hours)

16 and 32 Microprocessors: 80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in80x86

UNIT-IV (11 Hours)

Pipelining: Introduction to pipelining, Instruction level pipelining (ILP), Compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch prediction, Influence on instruction set.

Different Architectures:

VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor andprogramming.

Recommended Text Books / 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. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice Hall,2004.
6. Y. C. Lieu and G. A. Gibson, "Microcomputer Systems: The 8086/8088 Family", Prentice Hall India,1986.
7. J. Uffenbeck, "The 8086/8088 Design, Programming, Interfacing", Prentice Hall,1987.
8. B. Govindarajalu, "IBM PC and Clones", Tata McGraw Hill,1991.
9. P. Able, "8086 Assembly Language Programming", Prentice HallIndia.

COMPUTATIONAL ELECTROMAGNETICS

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELED1-614	3	0	0	3	

Course Objectives:

1. To introduce to the basic concepts ofelectromagnetics and analytical methods.
2. To understand computational techniques for computingfields.

Course Outcomes:

1. Explain the basic concepts ofelectromagnetics.
2. Use computational techniques for electromagneticfields.
3. Apply the techniques to simple real-lifeproblems.

UNIT-I (15 Hours)

Introduction:

Conventional design methodology, Computer aided design aspects, Advantages, Review of basic fundamentals of Electrostatics and Electromagnetics, Development of Helmhotz equation, Energy transformer vectors, Poynting and Slepian, Magnetic diffusion-transients and time-harmonics.

Analytical Methods:

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

UNIT-II (15 Hours)

Finite Difference Method (FDM):

Finite difference schemes, Treatment of irregular boundaries, Accuracy and stability of FD solutions, Finite-difference time-domain (FDTD) method, Uniqueness and convergence.

Finite Element Method (FEM):

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.

UNIT-III (15 Hours)

Special Topics:

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.

Applications:

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.

WIND & SOLAR ENERGY SYSTEMS					
Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45 (Hrs.)**
BELED1-621	**3**	**0**	**0**	**3**	

Course Objectives:

1. To understand the energy scenario and the consequent growth of the power generation from renewable energysources.
2. To develop the understanding about the issues related to the grid-integration of solar and wind energysystems.

Course Outcomes:

Students will be enabled:

1. To explain the basics of wind power powergeneration.
2. To elaborate the basics of solar power powergeneration.
3. To intrepret the network integration issuesand the power electronic interfaces for wind and solargeneration.

UNIT-I (15 Hours)

Physics of Wind Power: 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 distributionfunctions.

Wind Generator Topologies: 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.

UNIT-II (15 Hours)

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

Solar Photovoltaic:
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.

UNIT-III (15 Hours)

Network Integration Issues:

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.

Solar Thermal Power Generation:

Technologies, Parabolic trough, Central receivers, Parabolic dish, Fresnel, Solar pond, Elementary analysis.

Text / References:

1. T.Ackermann,"WindPowerinPowerSystems",JohnWileyand SonsLtd.,2005.
2. G. M. Masters, "Renewable and Efficient Electric Power Systems**",** John Wiley and Sons,2004.
3. S.P.Sukhatme,"SolarEnergy:Principlesof ThermalCollectionandStorage",McGrawHill,1984.
4. H. Siegfried and R. Waddington, " Grid integration of wind energy conversion systems" John Wiley and Sons Ltd.,2006.
5. G.N.TiwariandM.K.Ghosal,"RenewableEnergyApplications",Narosa Publications,2004.
6. J. A. Duffie and W. A. Beckman, " Solar Engineering of Thermal Processes", John Wiley & Sons, 1991.

HVDC TRANSMISSION SYSTEMS					
Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45 (Hrs.)**
BELED1-622	**3**	**0**	**0**	**3**	

Course Objectives:

1. To know about the components and typesof HVDC systems.
2. To know the role of power electronic converters in HVDC transmission.
3. To know about the use of HVDC transmission systems for power system stability.

Course Outcomes:

Students will be able:

1. To knowthe advantages of DC transmission over ACtransmission.
2. To explain the operation of Line Commutated Converters and Voltage Source converters.
3. To apply control strategies used forHVDC transmissionsystem.
4. Toimprovepower system stability usingHVDCsystem.

UNIT-I (12 Hours)

DC Transmission Technology: Comparison of AC and DC transmission;Economics, Technical performance and Reliability, Application of DC transmission, Types of HVDC systems, Components of a HVDC system, Line commutated converter, Voltage source converter basedsystems.

Analysis of Line Commutated Converters: Line commutated converters (LCCs), Six pulse converter, Analysis neglecting commutation overlap, Harmonics, Twelve pulse converters, Inverter operation, Effect of commutation overlap, Expressions for average DC voltage, AC current and reactive power absorbed by the converters, Effect of commutation failure, Misfire and current extinction in LCClinks.

UNIT-II (12 Hours)

Voltage Source Converters (VSCs);

Two and Three-level VSCs, PWM schemes; Selective harmonic elimination, Sinusoidal pulse width modulation, Analysis of six pulse converter, Equations in the rotating frame, Real and reactive power control using a VSC.

Control of HVDC Converters:

Principles of Link Control in a LCC HVDC 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 voltageregulation.

UNIT-III (10 Hours)

Components of HVDC Systems: Smoothing reactors, Reactive power sources and Filters in LCC HVDC systems DC line: Corona Effects, Insulators, Transient over-voltages, DC line faults in LCC systems, DC line faults in VSC systems, DC breakers, Mono-polar operation, Ground electrodes.

UNIT-IV (11 Hours)

Stability Enhancement using HVDC Control: Basic Concepts: Power system angular, voltage and frequency stability, Power modulation, basic principles, Synchronous and asynchronous links, Voltage stability problem in AC/DCsystems.

MTDC Links: 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.

Recommended Text Books / Reference Books:

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.

EHVAC TRANSMISSION SYSTEMS

Subject Code:	L	T	P	C	Duration: 45 (Hrs.)
BELED1-623	3	0	0	3	

Course Objectives:

1. To familiarize the students with the need and advantages associated with EHVAC Transmission.
2. To acquaint the students with the reactive parameters of lines and methods of voltage control.
3. To make them aware about voltage gradients of conductors and effects ofcorona.

Course Outcomes:

Students will be enabled:

1. To explain the advantages of EHVAC Transmission and problems associated withit.
2. To examinethe reactive parameters of lines and use methods of voltagecontrol.
3. To compute the voltage gradients of conductors and explain the associated bad effects of corona.

UNIT-I (11 Hours)

Preliminaries:

Necessity of extra high voltage (EHVAC)transmission, Advantages and Problems, Power handling capacity and Line losses, Mechanical considerations, Resistance of conductors, Properties of bundled conductors, Bundle spacing and bundle radius, Examples.

Line and Ground Reactive Parameters:

Line inductance and capacitance, Sequence inductances and capacitances, Modes of propagation, Ground return, Examples.

UNIT-II (12 Hours)

Travelling Wave Theory:

Traveling wave expression and solution, Source of excitation, Terminal conditions, Open circuited and Short-circuited end reflection and refraction coefficients, Lumped parameters of distributed lines, Generalized constants, No load voltage conditions and Charging current.

Voltage Control:

Power circle diagram and its use, Voltage control using synchronous condensers, Cascade connection of shunt and series compensation, Sub synchronous resonance in series capacitor, Compensated lines, Static VAR compensating system.

UNIT – III (11 Hours)

Voltage Gradients of Conductors:

Electrostatics, field of sphere gap, field of line charges and properties, Charge, Potential relations for multi-conductors, Surface voltage gradient on conductors, Distribution of voltage gradient on sub conductors of bundle, Electrostatic field, Calculation of electrostatic field of EHV/AC lines, Effect on humans, animals and plants, Electrostatic induction in un-energized circuit of double-circuit line, Electromagnetic interference, No load voltage conditions and chargingcurrent.

UNIT-IV (11 Hours)

Corona Effects:

Power loss and audible noise (AN), Corona loss formulae, Charge voltage diagram, Generation, Characteristics, Limits and Measurements of AN, Relation between 1- phase and 3-phase AN levels, Radio interference (RI), Corona pulses: generation, properties, limits, frequency spectrum, Modes of propagation, Excitation function, measurement of RI, RIV and Excitation functions.

Recommended Text Books / Reference Books:

1.R.D. Begamudre, 'EHVAC Transmission Engineering', New Academic Science, 4th Edn.,**2011**.

2.S. Rao, 'EHVAC and HVDC Transmission and Distribution Engineering', 3rd Edn., Khanna Publishers,**2008**.

FACTS DEVICES IN TRANSMISSION & DISTRIBUTION NETWORKS					
Subject Code:	**L**	**T**	**P**	**C**	**Duration: 45 (Hrs.)**
BELED1-624	**3**	**0**	**0**	**3**	

Course Objectives:

1. To know about the need of shunt and series reactive power compensation.
2. To become familiar with the working principles of FACTS devices, theiroperating characteristics, and applications.
3. To understand the basic concepts of powerquality.

Course Outcomes:

1. To analyze the characteristics of AC transmission.
2. To explain the effect of shunt and series reactive power compensation.
3. To apply FACTS devices to control power flow and toimprove power quality.

UNIT-I (11 Hours)

Transmission Lines and Series/Shunt Reactive Power Compensation:

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 shuntcompensation.

Thyristor-based Flexible AC Transmission Controllers (FACTS):

Description and characteristics of Thyristor-based FACTS devices, Static VAR compensator (SVC), Thyristor controlled series capacitor (TCSC), Thyristor controlled braking resistor and Single pole single throw (SPST) switch, Configurations/Modes of operation, Harmonics and control of SVC and TCSC, Fault current limiter.

UNIT-II (11 Hours)

Voltage Source Converter based (FACTS) Controllers:

Voltage source converters (VSC), Six pulse VSC, Multi-pulse and Multi-level converters, Pulse-width modulation for VSCs, Selective harmonic elimination, Sinusoidal PWM 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 currentlimiter.

UNIT-III (12 Hours)

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

Power Quality Problems in Distribution Systems:

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

UNIT-IV (11 Hours)

DSTATCOM (Distribution Static Compensator):

Reactive Power Compensation, Mitigation of harmonics and unbalance in distribution systems using DSTATCOM and shunt active filters, Synchronous reference frame, Extraction of reference currents, Current control techniques for DSTATCOM.

Dynamic Voltage Restorer and Unified Power Quality Conditioner:

Voltage sag and swell mitigation: Dynamic Voltage Restorer; Working principle and control strategies, Series active filtering, Unified power quality conditioner (UPQC): Working principle, capabilities and control strategies.

Recommended Text Books / Reference Books:

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,"ElectricalPowerSystemsQuality",McGrawHillEducation,2012.
5. G. T. Heydt, "Electric Power Quality" , Stars in a Circle Publications,1991

INTRODUCTION TO INDUSTRIAL MANAGEMENT

Subject Code: BELES1-606 **L T P C** **Duration: 45 Hrs**
3 0 0 3

Course Objectives

The aim of this course is:

1. To introduce the concepts of Industrial Management
2. To provide knowledge about various Costs and Inventory Management
3. To highlight the latest trend in Industrial Management

Course Outcome

After completing this course, the students will be able to:

1. Understand the theories and principles of modern management
2. Apply the concepts to the management of organizations in private and public sector
3. Plot and analyze inventory control models and techniques.
4. Understand JIT, MRP and Six Sigma

UNIT-I (10 Hrs.)

Concepts of Industrial Management: Introduction: Concept and scope of Industrial Management. Productivity: Definition, measurement, productivity index, types of production system, Industrial Ownership. Functions of Management, Evolution of Management Thought : Taylor's Scientific Management, Fayol's,Principles of Management, Douglas Mc-Gregor's Theory X and Theory Y, Mayo's Hawthorne, Experiments, Hertzberg's Two Factor Theory of Motivation, Maslow's Hierarchy of Human Needs

Introduction to Human resources management: Nature of HRM, functions and importance of HRM.

UNIT-II (10 Hrs.)

Designing Organizational Structures: Concept, Importance and characteristics of organization, Types of organization - Project, matrix and informal organization. Span of control, Delegation of authority.

Work Study: Introduction, Definition, Objectives, Steps in Work Study, Method Study: Definition, Objectives, Steps of Method Study,

Work Measurement: Purpose, Types of study:Stop Watch Methods-Steps, allowances, Standard Time Calculations, Work Sampling, Production Planning and Control

UNIT-III (11 Hrs.)

Cost Analysis: Cost classification: Prime cost, Overhead cost, Selling and Distribution Cost, Fixed cost, Variable cost, Implicit cost, Explicit cost, Replacement cost, Opportunity cost, Marginal cost

Inventory Control: Inventory, Cost, Models of inventory control: EOQ, ABC, VED

UNIT-IV (14 Hrs.)

Quality Control: Statistical Quality Control, Control charts for variables and attributes, Acceptance Sampling- Single sampling- Double sampling plans,

Recent Trends in Industrial Management–Material Requirement Planning (MRP), Enterprise Resource Planning (ERP), Just in Time (JIT), Six Sigma-Concept and benefits.

Recommended Books

1. O.P Khanna, Industrial Engineering.
2. M.S. Saiyada, 'Minappa and Personnel Managements'.Tata Mc Graw Hill
3. C.B. Mamoria, 'Personnel Management', Himalaya Publications
4. Ravi Shankar, 'Industrial Engineering', Galgotia