Semester V

Course Code		*BELECPS525*				*Semester*	*Semester V*	
Course Title		Power Systems – I					*Max marks*	
Scheme & Credits		*Hours Per Week*				*Credits*	*Theory*	*Practical*
		L	*T*	*P*	*Total*			
		2	*1*	*2*	*5*	*4*	*100*	*100*
Prerequisites		*Nil*					*200*	

Course Learning Outcomes (CLOs)

CLO1	Explain modern power systems and apply per-unit concepts .
CLO2	Calculate transmission line parameters and conductor configurations
CLO3	Analyze short, medium and long transmission lines using ABCD constants
CLO4	Evaluate voltage regulation, efficiency and power transfer capability
CLO5	Analyze insulation systems, underground cables and corona phenomena, smart grids, renewable integration and

Syllabus

Units	Content
1	Introduction to modern power systems, generation, transmission and distribution, single line diagrams, impedance/reactance diagrams, per-unit system, interconnected grids, smart grid fundamentals and renewable energy integration..
2	Transmission line parameters, conductor types, bundled conductors, resistance, inductance, capacitance calculations, transposition and line parameter evaluation.
3	Short, medium and long transmission lines, nominal π and T models, ABCD constants, Ferranti effect, surge impedance loading, voltage regulation, efficiency and power transfer capability..
4	Mechanical design of transmission lines, sag-tension calculations, towers and insulators, string efficiency, underground cables, cable construction, insulation, grading, losses and fault location..
5	Corona, critical voltages, corona loss, insulation coordination, overvoltages, AC distribution systems, feeders, distributors, ring main systems and distribution automation.

EXPERIMENTS

1	Study of various types of overhead line insulators and transmission line hardware.
2	Determination of string efficiency of suspension insulator strings.
3	Study of conductor materials used in overhead transmission lines.
4	Measurement of transmission line parameters using transmission line models
5	Study of corona phenomenon using corona demonstration kit (if available)
6	Study of underground cable construction and cable accessories.
7	Study of different types of distribution systems: Radial distribution, Ring main distribution, Interconnected distribution
8	Study of transmission line towers and tower components.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	2.8	2.6	1.4	1.6	1.6	0.2	0.8	0.2	0	1	0	2	1.183333333

Suggested Reading

1	Wadhwa, C. L., Electrical Power Systems, 7th ed., New Age International Publishers, New Delhi, 2021.
2	Nagrath, I. J. and Kothari, D. P., Modern Power System Analysis, 6th ed., McGraw Hill Education, New Delhi, 2022.
3	Grainger, J. J. and Stevenson, W. D., Power System Analysis, International ed., McGraw-Hill Education, New York, 2017.
4	Kundur, Prabha, Power System Stability and Control, 2nd ed., McGraw-Hill Education, New York, 2022.

Teaching-Learning Strategies

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	*BELECPE525*					*Semester*	*Semester V*	
Course Title	**Power Electronics**						*Max marks*	
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*				
	2	1	2	5		4	100	100
Prerequisites	*Nil*						**200**	

Course Learning Outcomes (CLOs)

CLO1	Explain the operating principles, characteristics, switching behavior, gate-drive circuits, and protection methods of power semiconductor devices used in power electronic converters.
CLO2	Analyze and evaluate the performance of single-phase and three-phase AC–DC converters under different loading conditions.
CLO3	Design and analyze single-phase and three-phase DC–AC inverters, and evaluate PWM techniques and harmonic reduction methods for improved converter performance.
CLO4	Analyze the operation and applications of AC voltage controllers, cycloconverters, and DC–DC converters for industrial and renewable energy applications.
CLO5	Apply power electronic converters using simulation tools for modern applications such as electric vehicles, renewable energy systems, motor drives, and power supplies.

Syllabus

Units	Content
1	Review of power semiconductor devices including Diode, SCR, TRIAC, MOSFET, IGBT, and introduction to SiC and GaN devices. Static and switching characteristics, gate-drive circuits, protection techniques, snubber circuits, and thermal management with heat sink design.
2	Single-phase and three-phase uncontrolled, semi-controlled, and fully controlled rectifiers with R and RL loads. Performance analysis, effect of source inductance, input power factor, and industrial applications of controlled rectifiers.
3	Single-phase half-bridge and full-bridge inverters, three-phase voltage source inverters with 180° and 120° conduction modes. PWM techniques, harmonic reduction methods, and applications in UPS, motor drives, and renewable energy systems.
4	Principle and operation of AC voltage controllers using ON–OFF and phase-angle control techniques. Performance analysis with different loads, introduction to cycloconverters, and their industrial applications.
5	Operation and performance of buck, boost, and buck–boost converters under continuous and discontinuous conduction modes. Introduction to modern DC–DC converters and their applications in battery charging, electric vehicles, renewable energy systems, and switched-mode power supplies.

EXPERIMENTS

1	Study of power semiconductor devices (Diode, SCR, TRIAC, MOSFET, and IGBT) and their V–I
2	Performance analysis of single-phase half-wave and full-wave uncontrolled rectifiers with R and RL loads.
3	Performance analysis of single-phase fully controlled bridge rectifier using SCRs.
4	Performance analysis of three-phase uncontrolled and controlled rectifiers.
5	Study of single-phase half-bridge and full-bridge voltage source inverters with R and RL loads.
6	Performance analysis of three-phase voltage source inverter using 180° and 120° conduction modes (simulation/hardware).
7	Implementation and analysis of PWM techniques for harmonic reduction in inverters.
8	Study and performance evaluation of single-phase AC voltage controller with resistive and inductive loads.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	2.8	2.6	1.4	1.6	1.6	0.2	0.8	0.2	0	1	0	2	1.183333333

Suggested Reading

1	Power Electronics: Converters, Applications and Design, Ned Mohan, Tore M. Undeland & William P. Robbins, 2023.
2	Power Electronics: Circuits, Devices and Applications, Muhammad H. Rashid, Pearson Education, 4th Edition, 2014.
3	Power Electronics, P. S. Bimbhra, Khanna Publishers, 6th Edition, 2022.
4	Power Electronics Handbook, Muhammad H. Rashid (Ed.), Butterworth-Heinemann (Elsevier), 4th Edition, 2018.

Teaching-Learning Strategies

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	*BELECPP525*				*Semester*	*Semester V*		
Course Title	**Power Station Practices**					*Max marks*		
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*	
	L	*T*	*P*	*Total*				
	2	*1*	*0*	*3*	*3*	*100*		
Prerequisites	*Nil*					***100***		

Course Learning Outcomes (CLOs)

CLO1	Explain the principles of power generation economics, including cost components, load curves, interconnection of generating stations and the selection of generating unit size and number
CLO2	Analyze the impact of power factor on power system performance and evaluate suitable power factor improvement methods and tariff structures for economical operation
CLO3	Compare and evaluate operating principles, characteristics, and application of various power generating stations and their auxillary systems
CLO4	Explain and analyze different neutral grounding and earthing methods, and select appropriate grounding schemes for ensuring safety and reliable power system operation
CLO5	Classify and evaluate different types of electrical substations, their configurations and applications for efficient transmission and distribution of electrical power

Syllabus

Units	**Content**
1	Factors affecting cost of generation, fixed capital, running capital, annual cost, running charges, fixed charges, reduction of costs by interconnection of stations, curves useful in system operation, choice of of size and number of generating units
2	Disadvantages of low-power factor, methods of improving power factor, location of power factor improvement apparatus, and economics of power factor improvement, power tariff, factors influencing the rate of tariff, designing tariff, different types of tariff, flat rate tariff, block rate tariff, two part tariff, maximum demand tariff,
3	Thermal power plants, Hydroelectric stations, Nuclear power stations, Deisel power stations, and Gas turbine plant
4	Neutral Grounding, solid grounding, resistance grounding, reactance grounding, arc suppression coil, earthing transformers, choice of methods of neutral grounding equipment, grounding for safety
5	Classification of substation, comparison of indoor and outdoor substation, transformer substation, pole mounted substation, underground substation

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	**2.8**	**2.6**	**1.4**	**1.6**	**1.6**	**0.2**	**0.8**	**0.2**	**0**	**1**	**0**	**2**	**1.183333333**

Suggested Reading

1	V.K.Mehta Principles of Power Systems
2	A, Chakrabarti et.al, A text book on Power System Engineering.

Teaching-Learning Strategies

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	*BELECED525*					*Semester*	*Semester V*	
Course Title	**Electric Drives & Control**						*Max marks*	
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*				
	2	*1*	*2*	*5*		*4*	*100*	*100*
Prerequisites	*Nil*						**200**	

Course Learning Outcomes (CLOs)

CLO1	Explain the fundamentals of electric drives, industrial drive systems, load characteristics, energy-efficient operation, thermal considerations, and selection of motors for diverse industrial applications.
CLO2	Analyze the performance, speed–torque characteristics, and control of DC motor drives using conventional, converter-fed, and regenerative techniques.
CLO3	Design and evaluate closed-loop DC drive systems employing power electronic converters, digital controllers, current, torque, speed, and position control strategies.
CLO4	Analyze and implement speed control, braking, and efficiency enhancement techniques for three-phase induction motor drives using variable-frequency drives (VFDs), PWM inverters, and industrial control methods.
CLO5	Evaluate advanced induction motor drive systems, vector control, direct torque control (DTC), sensorless control, industrial automation interfaces, and Industry 4.0 enabled electric drive applications.

Syllabus

Units	**Content**
1	Fundamentals of Electric Drives Introduction to electric drives; classification and applications; components of electric drive systems; drive dynamics; duty cycles (continuous, short-time, intermittent); load characteristics; thermal loading; motor rating and selection; energy efficiency; IE motor classes; introduction to EV and renewable energy drive applications; industrial safety and relevant IEC/IS standards.
2	DC Motor Drives Characteristics of DC motors; armature, field and voltage control; converter-fed DC drives; phase-controlled rectifiers; regenerative, plugging and dynamic braking; four-quadrant operation; industrial case studies and laboratory simulation.
3	Chopper Controlled DC Drives and Digital Control DC-DC chopper drives; PWM techniques; closed-loop current, torque, speed and position control using PI/PID controllers; digital implementation using DSP/microcontrollers; multi-motor coordination; comparison of converter technologies; MATLAB/Simulink based analysis.
4	AC Drives and Variable Frequency Drives Three-phase induction motor characteristics; scalar (V/f) control; PWM VSI drives; regenerative and dynamic braking; variable frequency drives (VFDs); energy-efficient motor operation; industrial automation using PLC/VFD integration; harmonics and power quality
5	Advanced Induction Motor Drives Rotor resistance and slip power recovery methods; Kramer and Scherbius drives; vector control (FOC); direct torque control (DTC); sensorless control; current regulated VSI drives; electric vehicle traction drives; Industry 4.0, IoT-enabled condition monitoring, predictive maintenance, and smart manufacturing applications.

EXPERIMENTS

1	Determine the torque-speed characteristics for various types of mechanical loads to evaluate appropriate motor ratings and thermal loading.
2	Implement and analyze speed control, regenerative braking, and dynamic braking of a DC motor using a fully controlled converter.
3	Perform a MATLAB/Simulink-based analysis of a DC-DC chopper drive, utilizing PI/PID controllers to achieve closed-loop current and speed control.
4	Evaluate the performance, speed regulation, and energy efficiency of a three-phase induction motor using scalar (V/f) control via a Variable Frequency Drive (VFD).
5	Simulate Field-Oriented Control (FOC) or Direct Torque Control (DTC) strategies for an induction motor to analyze its dynamic response and suitability for electric vehicle traction drives.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	2.8	2.6	1.4	1.6	1.6	0.2	0.8	0.2	0	1	0	2	1.183333333

Suggested Reading

1	G. K. Dubey, Fundamentals of Electric Drives, Narosa Publishing.
2	Vedam Subrahmanyam, Electric Drives: Concepts and Applications, McGraw Hill.
3	R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Pearson.
4	Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson.

Teaching-Learning Strategies

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	*BELEEMC525*				*Semester*	*Semester V*			
Course Title	**Microprocessors**					*Max marks*			
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*		
	L	*T*	*P*	*Total*					
	2	*1*	*2*	*5*	*4*	*100*	*100*		
Prerequisites	*Nil*					***200***			

Course Learning Outcomes (CLOs)

CLO1	Explain architecture and operation of microprocessors and microcontrollers.
CLO2	Develop assembly language programs.
CLO3	Analyze interrupt handling and memory organization.
CLO4	Design interfacing schemes for peripheral devices.
CLO5	Develop embedded applications using modern microcontrollers.

Syllabus

Units	Content
1	Introduction to Microprocessors and Microcontrollers, 8085 architecture, buses, registers, memory organization, machine cycle and instruction cycle.
2	Instruction set, addressing modes, assembly language programming, stack operations, subroutines and delay routines.
3	Interrupts, memory interfacing, memory mapped I/O and I/O mapped I/O.
4	8255, 8259, 8254, DMA controller, peripheral interfacing and serial communication.
5	8086 introduction, ARM Cortex, Arduino, ESP32, embedded systems, IoT and industrial applications.

EXPERIMENTS

1	Study of 8085 Architecture and Instruction Set
2	Addition and subtraction of 8-bit and 16-bit numbers
3	Multiplication and division programs
4	Largest and smallest number in an array
5	ADC and DAC interfacing
6	Stack and subroutine programming
7	Interrupt handling, Arduino programming
8	Seven-segment display interfacing

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	2.8	2.6	1.4	1.6	1.6	0.2	0.8	0.2	0	1	0	2	1.183333333

Suggested Reading

1	Hall, D. V., Microprocessors and Interfacing: Programming and Hardware, 3rd ed., McGraw-Hill Education, New York, 2017.
2	Gaonkar, R. S., Microprocessor Architecture, Programming and Applications with the 8085, 6th ed., Penram International Publishing (India) Pvt. Ltd., Mumbai, 2013.
3	Raj Kamal, Embedded Systems: Architecture, Programming and Design, 3rd ed., McGraw-Hill Education, New Delhi, 2018.
4	Mazidi, M. A., Mazidi, J. G., and McKinlay, R. D., The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 2nd ed., Pearson Education, Noida, 2011.

Teaching-Learning Strategies

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	*BELEPIT525*					*Semester*	*Semester V*	
Course Title	**Industrial Training**						*Max marks*	
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*				
	0	*0*	*2*	*2*		*1*		*100*
Prerequisites	*Nil*						***100***	

Course Learning Outcomes (CLOs)

CLO1	Understand the organizational structure, workflow, safety practices, and professional ethics followed in industries or organizations.
CLO2	Apply theoretical knowledge of electrical engineering to observe, analyze, and understand industrial processes, equipment, and engineering practices.
CLO3	Develop technical, communication, teamwork, and problem-solving skills through active participation in industrial training or internship activities.
CLO4	Prepare a comprehensive internship report and effectively present the learning outcomes, observations, and practical experiences gained during the training.
CLO5	Demonstrate the ability to identify engineering problems, propose practical solutions, and exhibit lifelong learning and adaptability in professional work environments.

Syllabus

Units	**Content**
1	Provide exposure to industrial and professional work environments.
2	Bridge the gap between classroom learning and industry practices.
3	Develop technical and communication skills.
4	Documentation: Maintenance of a daily/weekly training diary; documentation of processes, equipment specifications, and observations; collection of relevant technical data.
5	Reporting and Presentation: Preparation of the industrial training report as per the prescribed format; seminar presentation of the training experience before the departmental committee; viva-voce.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	1	0	0	0	0	1	0	2	0.9166666667
CLO2	3	3	1	2	2	0	0	0	0	1	0	2	1.166666667
CLO3	3	3	1	2	2	0	1	0	0	1	0	2	1.25
CLO4	3	3	2	2	2	0	1	0	0	1	0	2	1.333333333
CLO5	2	2	2	1	1	1	2	1	0	1	0	2	1.25
Avg PLO	**2.8**	**2.6**	**1.4**	**1.6**	**1.6**	**0.2**	**0.8**	**0.2**	**0**	**1**	**0**	**2**	**1.183333333**

Suggested Reading

1	Training/technical manuals and documentation provided by the host organization, specific to the processes observed.
2	Relevant IS/IEC/IEEE standards applicable to the host organization's operations, as identified during training.

Teaching-Learning Strategies

- Structured industrial exposure under the supervision of a designated industry mentor.
- Periodic monitoring by a faculty coordinator through the training diary.
- Guided observation and documentation of industrial processes and equipment.
- Post-training seminar and group discussion on the industrial experience.
- Feedback-based report writing under faculty guidance.

Evaluation Scheme

Theory	NA
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Semester VI

Course Code	BELECPS625					Semester	Semester VI	
Course Title	Power Systems – II						Max marks	
Scheme & Credits	Hours Per Week					Credits	Theory	Practical
	L	T	P	Total				
	2	1	2	5		4	100	100
Prerequisites	Power Systems – I						200	

Course Learning Outcomes (CLOs)

CLO1	Describe the layout and equipment of electrical substations of various types.
CLO2	Analyze methods of neutral grounding and their effect on system performance.
CLO3	Describe overvoltage phenomena and insulation coordination in power systems.
CLO4	Analyze the design and operation of primary and secondary distribution systems.
CLO5	Evaluate methods of power-factor improvement and voltage control in distribution systems.

Syllabus

Units	Content
1	Per Unit Representation of Power Systems: Single line diagram, impedance and reactance diagram of a system, per unit calculations, per unit representation of a power system.
2	Fault Analysis (Balanced & Unsymmetrical Faults): Faults, types of faults, symmetrical 3-phase balanced faults calculation of fault currents, current limiting reactors. Symmetrical components, sequence impedances, sequence networks, unsymmetrical faults single line to ground, line to-line, double line to ground faults on unloaded alternators and on power systems
3	Insulation Coordination: Generation of overvoltages in a power system, lightning phenomena, lightning surges, switching surges-interruption of short circuits and switching operations, switching surges interruption of capacitive circuits, resonance over voltages, protection of power system components against over voltages ground wires, lightning arrestors. Concept of insulation coordination, Basic impulse insulation level, standard impulse test wave, volt-time curve, location and rating of lightning arrestors
4	Surge Performance of Transmission Lines: Traveling waves on transmission lines, open-end line, short-circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at a T-junction, line terminated through a capacitance, line terminated through an inductance. Attenuation of traveling waves.
5	Interference of Power Lines with Communication Circuit: Electrostatic and Electromagnetic effects.

EXPERIMENTS

1	Formulation of the impedance and reactance diagram for a given multi-machine power system and computation of its per-unit representation using MATLAB.
2	Simulation and analysis of balanced three-phase faults on a power system network to calculate fault currents and size current-limiting reactors using ETAP or MATLAB/Simulink.
3	Computation of positive, negative, and zero sequence impedances, and the simulation of unsymmetrical faults (Single Line-to-Ground, Line-to-Line, and Double Line-to-Ground) on unloaded alternators and interconnected systems.
4	MATLAB/Simulink-based modeling and analysis of the propagation, reflection, and refraction of traveling waves on transmission lines under various termination conditions (open-circuited, short-circuited, and resistive/capacitive terminations).
5	Simulation of lightning and switching surges in a power network to evaluate overvoltage generation, resonance effects, and the protective performance and volt-time characteristics of lightning arresters.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	2	1	1	1	1	0	0	1	0	1	1.083333333
CLO2	3	3	2	1	1	1	0	0	0	1	0	1	1.083333333
CLO3	2	2	2	1	1	1	1	0	0	1	0	1	1
CLO4	3	3	3	2	2	1	1	0	0	1	0	1	1.416666667
CLO5	3	3	2	2	2	1	1	0	0	1	0	1	1.333333333
Avg PLO	2.8	2.6	2.2	1.4	1.4	1	0.8	0	0	1	0	1	1.183333333

Suggested Reading

1	C.L. Wadhwa, Electrical Power Systems, New Age International.
2	S.N. Singh, Electric Power Generation, Transmission and Distribution, PHI Learning.
3	Turan Gönen, Electric Power Distribution Engineering, CRC Press.
4	William D. Stevenson, Elements of Power System Analysis, McGraw Hill.
5	J.B. Gupta, Transmission and Distribution of Electrical Power, S.K. Kataria & Sons.

Teaching-Learning Strategies

- Classroom lectures supported by substation single-line diagrams and equipment photographs.
- Tutorial sessions on grounding, distribution, and power-factor-correction numericals.
- Laboratory sessions/simulation on distribution-system load-flow and voltage-profile studies.
- Case studies of substation layouts and lightning-protection schemes.
- Site visit to a substation/distribution facility, wherever feasible.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	BELECPG625	Semester	Semester VI	
Course Title	Power System Protection & Switchgear		Max marks	
Scheme & Credits	Hours Per Week: L 2, T 1, P 2, Total 5	Credits 4	Theory 100	Practical 100
Prerequisites	Power Systems – I		200	

Course Learning Outcomes (CLOs)	
CLO1	Describe the fundamentals of power system protection and the characteristics of protective relays.
CLO2	Analyze overcurrent, differential, and distance protection schemes for power system elements.
CLO3	Design protection schemes for generators, transformers, and busbars.
CLO4	Analyze protection schemes for transmission and distribution feeders.
CLO5	Describe the construction, operation, and rating of circuit breakers used in power systems.

Syllabus

Units	Content
1	Protective Relaying: Function, fundamental principle, primary and backup relaying, characteristics. Classification of relays, operating principles and characteristics of the following electromechanical relays: Current, voltage, directional, current balance, voltage balance, differential relays, and distance relays.
2	Protection of Generators: Short-circuit protection of stator windings, protection against turn-to-turn fault, stator ground-fault protection, stator open circuit protection.
3	Transformer Protection: Short circuit protection, over current and earth-fault protection differential protection, Use of biased relay for differential protection, Buchholz relay, protection of parallel transformer banks.
4	Protection of Feeders, Busbars and Transmission lines: Protection of feeders, time limit fuse, overcurrent protection for radial feeders, protection of parallel feeders, differential protection for parallel feeders, protection of ring mains, differential pilot wire protection, Circulating current protection, protection for bus-bars, frame leakage protection, differential protection, for bus bars, protection for double bus-bar system, transmission line protection, using over- current relays, using distance relays. Setting of overcurrent and distance relays, coordination of relays. Phase fault and earth fault protection.
5	Fuses & Circuit Breakers: Fusing element, classification of fuses, current carrying capacity of fuses, high rupturing capacity, characteristics of H.R.C. fuses, selection of HRC fuses. Types of circuit breakers, basic principle of operation, phenomena of arc, initiation, maintenance & arc extinction, d. c. circuit breaking, a.c. circuit breaking, arc voltage and current waveforms in a.c. circuit breaking, restriking and recovery voltages, deionization and current chopping, ratings of circuit breakers, oil circuit breakers, air blast circuit breakers, SF6 Circuit breakers Vacuum breakers.

EXPERIMENTS

1	Study of various types of relays.
2	Characteristics of fuses.
3	Characteristics of inverse time over current relays.
4	Time graded protection using inverse time O/C relay.
4	Study of circuit breakers.
5	Study of differential protection schemes.
6	Study of an oil circuit breaker.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	1	2	0	1	0	0	1	0	1	1
CLO2	3	3	2	2	2	0	0	0	0	1	0	1	1.166666667
CLO3	3	3	3	2	2	0	0	0	0	1	0	1	1.25
CLO4	3	3	2	2	2	1	1	0	0	1	0	1	1.333333333
CLO5	2	2	1	1	1	0	0	0	0	1	0	1	0.75
Avg PLO	2.8	2.6	1.8	1.6	1.8	0.2	0.4	0	0	1	0	1	1.1

Suggested Reading

1	Badri Ram, D.N. Vishwakarma, Power System Protection and Switchgear, McGraw Hill.
2	Y.G. Paithankar, S.R. Bhide, Fundamentals of Power System Protection, PHI Learning.
3	Sunil S. Rao, Switchgear and Protection, Khanna Publishers.
4	J.L. Blackburn, T.J. Domin, Protective Relaying: Principles and Applications, CRC Press.
5	C.L. Wadhwa, Electrical Power Systems, New Age International.

Teaching-Learning Strategies

- Classroom lectures integrating relay theory with protection-coordination case studies.
- Tutorial sessions on relay-setting and grading calculations.
- Laboratory sessions on characteristics of overcurrent/differential relays using relay test kits or simulation.
- Simulation of distance and differential protection schemes using MATLAB or relay-simulation software.
- Case studies of major protection mal-operations/blackouts and their analysis.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

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Course Code	*BELECAE625*				*Semester*	*Semester VI*			
Course Title	**Advanced Power Electronics**					*Max marks*			
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*		*Practical*	
	L	*T*	*P*	*Total*					
	2	*1*	*2*	*5*	*4*	*100*		*100*	
Prerequisites	*Power Electronics*					***200***			

Course Learning Outcomes (CLOs)

CLO1	Explain the operation and control of DC–DC switched-mode converters under different operating conditions.
CLO2	Analyze the performance of switched DC power supply converters used in isolated power conversion.
CLO3	Evaluate the operation and design aspects of Uninterruptible Power Supply (UPS) systems and battery backup requirements.
CLO4	Analyze the operation and modulation techniques of cascaded H-bridge multilevel inverters for power conversion applications.
CLO5	Compare diode-clamped and flying-capacitor multilevel inverters based on topology, modulation, and applications.

Syllabus

Units	**Content**
1	DC-DC Switched Mode Converters: Introduction, control of dc-dc converters, Continuous and discontinuous conditions of buck, boost and buck-boost converters, Cuk dc-dc converter, full bridge dc-dc converter Study and simulation of Buck, Boost, and Buck-Boost DC-DC converters under continuous and discontinuous conduction
2	Switched DC Power Supplies: Flyback converter, forward and push-pull converter
3	Uninterruptible Power Supply (UPS): Off-line UPS, On-line UPS, rating of battery bank and calculation of backup time.
4	Cascaded H-Bridge Multilevel Inverters: Introduction, bipolar and unipolar modulation for H-bridge inverters, multilevel inverter topologies, carrier-based PWM schemes, staircase modulation and applications.
5	Diode-Clamped and Flying-Capacitor Multilevel Inverters: Introduction, three-level inverter, neutral-point voltage control, carrier-based PWM schemes, other modulation schemes and applications.

EXPERIMENTS

1	Study and simulation of Buck, Boost, and Buck–Boost DC–DC converters under continuous and discontinuous conduction modes.
2	Study and performance analysis of Cuk and Full-Bridge DC–DC converters.
3	Study and comparison of Flyback, Forward, and Push–Pull converters.
4	Design of battery bank rating and calculation of backup time for an Uninterruptible Power Supply (UPS).
5	Study and performance analysis of Off-line and On-line UPS systems under different loading conditions.
6	Simulation of a Single-Phase Cascaded H-Bridge Multilevel Inverter using Bipolar and Unipolar PWM techniques.
7	Implementation and comparison of Carrier-Based PWM and Staircase Modulation techniques for Cascaded H-Bridge Multilevel Inverters.
8	Simulation and performance evaluation of Three-Level Diode-Clamped and Flying-Capacitor Multilevel Inverters with Neutral-Point Voltage Control.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	3	2	2	2	0	0	0	0	1	0	2	1.25
CLO2	3	3	2	2	2	0	0	0	0	1	0	2	1.25
CLO3	3	3	2	2	2	0	1	0	0	1	0	1	1.25
CLO4	3	3	3	2	2	0	0	0	0	1	0	2	1.333333333
CLO5	3	2	3	2	2	0	0	0	0	1	0	2	1.25
Avg PLO	3	2.8	2.4	2	2	0	0.2	0	0	1	0	1.8	1.266666667

Suggested Reading

1	Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press.
2	Ned Mohan, T.M. Undeland, W.P. Robbins, Power Electronics: Converters, Applications and Design, Wiley.

Teaching-Learning Strategies

Interactive lectures using multimedia presentations and concept-based discussions to explain power electronic converters and inverter topologies.
Tutorial sessions focusing on numerical problem-solving and design-oriented exercises related to converter and UPS systems.
Laboratory experiments to study the operation and performance of DC–DC converters, UPS systems, and multilevel inverters.
Simulation-based learning using MATLAB/Simulink, PSIM, or PLECS to analyze converter performance and modulation techniques.
Seminars, assignments, and technical presentations on emerging trends and applications in power electronics and renewable energy systems.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.

Course Code	*BELEDAC625*				*Semester*	*Semester VI*		
Course Title	**Advanced Control Systems**					*Max marks*		
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*	
	L	*T*	*P*	*Total*				
	2	*1*	*0*	*3*	*3*	*100*		
Prerequisites	*Control Systems*					***100***		

Course Learning Outcomes (CLOs)

CLO1	Develop state-space models of dynamic systems from transfer functions and block diagrams.
CLO2	Analyze state variable systems and design state feedback controllers.
CLO3	Evaluate controllability, observability and state estimation techniques.
CLO4	Analyze sampled-data and digital control systems.
CLO5	Design digital controllers and understand modern control strategies.

Syllabus

Units	Content
1	State Space Modelling: State variable modelling, state space representation, state equations, conversion of transfer functions to state-space form, block diagrams, transfer functions and signal flow graphs in state space.
2	State Variable Analysis and Design: Solution of state vector equations, state transition matrix, state variable analysis, system response, design using state variable feedback, state feedback control.
3	Controllability and Observability: Concepts of controllability and observability, state estimation, pole allocation, stability and reproducibility, design of full state observers, reduced order observers, design using separation principle.
4	Digital Control Systems: Hardware elements of digital control systems, advantages of digital control systems, practical aspects of sampling, choice of sampling rate, multirate sampling, basic discrete-time signals, quantization and sampling.
5	Discrete Data Systems and Advanced Controllers: Zero-order hold, pulse transfer functions, difference equations, design of discrete data systems, digital P, PI and PID controllers, introduction to fuzzy logic control, neural network control and predictive control.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	2	2	3	1	1	0	0	0	1	1	0	1	1
CLO2	2	3	3	2	1	0	0	0	1	1	0	1	1.166666667
CLO3	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	3	1	3	1	1	0	0	0	1	1	0	2	1.083333333
Avg PLO	2.2	2.4	2.2	1.6	1	0	0	0	1	1	0	1.2	1.05

Suggested Reading

1	M. Gopal, State Variable Methods and Digital Control, Tata McGraw Hill.
2	Norman S. Nise, Control Systems Engineering, John Wiley.
3	K. Ogata, Discrete Time Control Systems, Pearson.
4	A. Anand Kumar, Control Systems, PHI Learning Pvt. Ltd.
5	Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems, Pearson.

Teaching-Learning Strategies

- Classroom lectures supported by numerical examples.
- Tutorial sessions on state-space analysis and controller design.
- Simulation-based learning using MATLAB/Simulink.
- Assignment-based problem solving.
- Seminar presentations on modern control techniques.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	*BELEDPQ625*				*Semester*	*Semester VI*	
Course Title	**Power Quality**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	*1*	*0*	*3*	*3*	*100*	
Prerequisites	*Basic Electrical Circuits, Power Electronics, Control Systems*					*100*	

Course Learning Outcomes (CLOs)

CLO1	Identify and analyze various power quality disturbances.
CLO2	Understand standards and recommended practices related to power quality.
CLO3	Evaluate passive and active compensation techniques.
CLO4	Analyze operation and control of custom power devices.
CLO5	Apply power quality improvement techniques in modern power systems.

Syllabus

Units	**Content**
1	Introduction to Power Quality: Definition of power quality, power quality problems, causes and consequences, voltage sags, voltage swells, interruptions, flicker, reactive power and harmonics, load current compensation, reactive power compensation
2	Shunt Compensation Techniques: Passive compensation techniques, active load compensation, D-STATCOM, operating principles, design aspects, control strategies and phasor analysis.
3	Series Compensation Techniques: Source voltage compensation, dynamics of voltage sags and swells, passive series compensation, active series compensation, Dynamic Voltage Restorer (DVR) with and without energy support, design, control and phasor
4	Unified Power Quality Conditioner: Combined compensation techniques, Unified Power Quality Conditioner (UPQC), right shunt and left shunt topologies, operating characteristics and applications.
5	Power Quality Monitoring and Applications: Harmonic mitigation techniques, power quality monitoring, IEEE power quality standards, applications of custom power devices, case studies on power quality improvement.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	3	1	2	1	0	0	0	1	1	0	1	1.083333333
CLO2	3	1	1	1	1	3	0	2	1	1	0	1	1.25
CLO3	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	2	2	1	1	0	0	0	1	1	0	2	1
Avg PLO	2.4	2.4	1.2	1.6	1	0.6	0	0.4	1	1	0	1.2	1.066666667

Suggested Reading

1	B. Singh and A. Chandra, Power Quality Problems and Mitigation Techniques, Wiley.
2	Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley.
3	A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer.
4	C. Sankaran, Power Quality, CRC Press.
5	Roger C. Dugan, Mark F. McGranaghan and H. Wayne Beaty, Electrical Power Systems Quality, McGraw Hill.

Teaching-Learning Strategies

- Classroom lectures with practical examples from utility systems.
- Tutorial sessions on power quality calculations.
- Simulation studies of custom power devices.
- Assignments based on power quality standards and case studies.
- Seminar presentations on emerging power quality solutions.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	BELEDPV625					Semester	Semester VI	
Course Title	Design of Photovoltaic Systems						Max marks	
Scheme & Credits	Hours Per Week					Credits	Theory	Practical
	L	T	P	Total				
	2	1	0	3		3	100	
Prerequisites	Power Electronics						100	

Course Learning Outcomes (CLOs)

CLO1	Understand the operating principles and characteristics of photovoltaic cells and modules.
CLO2	Analyze series and parallel interconnections of PV cells and modules.
CLO3	Estimate solar energy availability using solar geometry concepts.
CLO4	Design standalone and grid-connected photovoltaic systems.
CLO5	Understand MPPT techniques and PV system applications.

Syllabus

Units	Content
1	Fundamentals of Photovoltaic Cells: Historical development of photovoltaic technology, PV cell characteristics, equivalent circuit, short-circuit current, open-circuit voltage, maximum power point, datasheet study, cell efficiency, fill factor, effect of temperature and PV cell simulation.
2	PV Cell and Module Interconnections: Series and parallel interconnection of PV cells and modules, identical and non-identical cells, load line analysis, protection of cells, interconnection techniques and performance analysis.
3	Solar Radiation and Energy Estimation: Solar radiation fundamentals, insolation and irradiance, solar geometry, declination angle, sunrise and sunset hour angles, energy estimation on horizontal and tilted surfaces, atmospheric effects and clearness index.
4	PV System Design and Sizing: Sizing of PV systems, load profiling, battery selection, battery capacity and efficiency, days of autonomy, PV array sizing, energy storage options and PV system design considerations.
5	MPPT and PV Applications: MPPT concepts and algorithms, DC-DC converters for PV systems, PV-battery interface, PV water pumping systems, grid-connected PV systems and life-cycle costing.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	2	2	1	1	3	0	3	0	1	1	0	1	1.25
CLO4	2	2	3	1	3	0	0	0	1	1	0	1	1.166666667
CLO5	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
Avg PLO	2.4	1.8	1.4	1.2	2.2	0	0.6	0	1	1	0	1	1.05

Suggested Reading

1	Chetan Singh Solanki, Solar Photovoltaic Technology and Systems, Prentice Hall India.
2	Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India.
3	L. Umanand, Design of Photovoltaic Systems, NPTEL Course Material.
4	Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley.
5	Roger Messenger and Jerry Ventre, Photovoltaic Systems Engineering, CRC Press.

Teaching-Learning Strategies

- Classroom lectures supported by numerical examples.
- Tutorial sessions on PV system design calculations.
- Software-based simulations of PV systems.
- Assignments and case studies on solar energy applications.
- Seminar presentations on emerging photovoltaic technologies.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

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Course Code	*BELEDMD625*				*Semester*	*Semester VI*		
Course Title	**Electrical Machine Design**					*Max marks*		
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*	
	L	*T*	*P*	*Total*				
	2	*1*	*0*	*3*	*3*	*100*		
Prerequisites	*Electrical Machines*					***100***		

Course Learning Outcomes (CLOs)

CLO1	Understand the principles and considerations involved in electrical machine design.
CLO2	Design transformers based on electrical, magnetic and thermal requirements.
CLO3	Design induction motors considering performance and operational constraints.
CLO4	Design synchronous machines and estimate their performance parameters.
CLO5	Apply machine design principles to practical engineering problems.

Syllabus

Units	Content
1	Fundamentals of Electrical Machine Design: Major considerations in machine design, electrical engineering materials, space factor, specific electrical and magnetic loading, thermal considerations, heat flow, temperature rise and rating of electrical machines.
2	Design of Transformers: Output equation, main dimensions, window space factor, overall dimensions, operating characteristics, regulation, no-load current, temperature rise, cooling methods and design of cooling tanks.
3	Design of Induction Motors: Output equation, main dimensions, air-gap selection, rotor slots, squirrel cage rotor design, wound rotor design, leakage reactance, magnetizing current, short-circuit current and operating characteristics.
4	Design of Synchronous Machines: Output equation, main dimensions, salient pole machines, short-circuit ratio, armature design, air-gap length, rotor design, field winding design and turbo alternator design.
5	Performance Evaluation and Computer-Aided Design: Estimation of machine performance, optimization of design parameters, introduction to computer-aided design of electrical machines and contemporary design practices.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	3	1	1	0	0	0	1	1	0	1	1
CLO2	2	2	3	1	1	0	0	0	1	1	0	1	1
CLO3	2	2	3	1	3	0	0	0	1	1	0	1	1.166666667
CLO4	2	2	3	1	1	0	0	0	1	1	0	1	1
CLO5	2	2	3	1	1	0	0	0	1	1	0	1	1
Avg PLO	2.2	1.8	3	1	1.4	0	0	0	1	1	0	1	1.033333333

Suggested Reading

1	A. K. Sawhney, A Course in Electrical Machine Design, Dhanpat Rai Publications.
2	V. N. Mittle, Design of Electrical Machines, Standard Publishers.
3	R. K. Agarwal, Principles of Electrical Machine Design, Kataria & Sons.
4	S. K. Sen, Principles of Electrical Machine Design, Oxford & IBH Publishing.
5	M. G. Say, The Performance and Design of Alternating Current Machines, CBS Publishers.

Teaching-Learning Strategies

- Classroom lectures emphasizing design procedures.
- Tutorial sessions involving machine design calculations.
- Design-oriented assignments and problem-solving exercises.
- Use of design software and computational tools.
- Case studies on transformer and motor design.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	*BELEDMA625*				*Semester*		*Semester VI*	
Course Title	**Electrical Materials**						*Max marks*	
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*				
	2	*1*	*0*	*3*		*3*	*100*	
Prerequisites	*Nil*						***100***	

Course Learning Outcomes (CLOs)

CLO1	Understand crystal structures and energy band theory of solids.
CLO2	Analyze properties and applications of insulating materials.
CLO3	Understand dielectric materials and polarization mechanisms.
CLO4	Analyze magnetic materials and their characteristics.
CLO5	Select suitable electrical materials for engineering applications.

Syllabus

Units	**Content**
1	Crystal Structure and Energy Bands: Atomic packing, crystal lattices, crystal structures, silicon and germanium structures, energy band theory, electrons in periodic potentials, concept of holes, Brillouin zones and elementary concepts of elastic waves and photons.
2	Insulating Materials: Introduction to insulating materials, dielectric behaviour, properties of insulating materials, insulators in static and alternating electric fields, classification based on temperature rise and practical insulating materials including solids, liquids and gases.
3	Dielectric Materials: Polarization mechanisms, dielectric constants, internal fields in solids and liquids, ferroelectric and piezoelectric materials, dielectric losses, dipolar relaxation and dielectric breakdown mechanisms.
4	Magnetic Materials: Magnetic field concepts, orbital magnetic moments, classification of magnetic materials, spontaneous magnetism, Curie-Weiss law, ferromagnetic, antiferromagnetic materials, ferrites and their applications.
5	Advanced Electrical Materials and Applications: Conducting, semiconducting and magnetic materials used in electrical engineering, material selection criteria and applications in modern electrical equipment.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	1	1	1	0	1	0	1	1	0	1	0.9166666667
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	2	2	1	1	0	0	0	1	1	0	1	0.9166666667
Avg PLO	**2.4**	**2**	**1.2**	**1.4**	**1**	**0**	**0.2**	**0**	**1**	**1**	**0**	**1**	0.9333333333

Suggested Reading

1	S. P. Seth and P. V. Gupta, Electrical Engineering Materials, Dhanpat Rai Publications.
2	Raghavan, Electrical Engineering Materials, PHI Learning.
3	Allison, Materials, Electronics Engineering and Devices.
4	A. J. Dekker, Electrical Engineering Materials, Prentice Hall.
5	Ian P. Jones, Materials Science for Electrical and Electronic Engineers, Oxford University Press.

Teaching-Learning Strategies

- Classroom lectures supported by illustrations and material samples.
- Tutorial sessions on material properties and applications.
- Assignments based on material selection and comparison.
- Seminar presentations on advanced electrical materials.
- Case studies involving materials used in electrical equipment.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	*BELEOCS625*					*Semester*	*Semester VI*			
Course Title	**Communication Systems**						*Max marks*			
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*		*Practical*	
	L	*T*	*P*	*Total*						
	1	*1*	*0*	*2*		*2*	*100*			
Prerequisites	*Nil*						***100***			

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamentals of analog and digital communication systems.
CLO2	Analyze various analog modulation and demodulation techniques.
CLO3	Evaluate the performance of communication systems in the presence of noise.
CLO4	Understand pulse modulation and digital communication techniques.
CLO5	Analyze and compare various digital modulation schemes.

Syllabus

Units	**Content**
1	Fundamentals of Communication Systems: Introduction to Fourier series and Fourier transform, properties of Fourier transform, modulation theorem, amplitude spectrum of pulse train and pulse waveform, introduction to communication systems, basic elements of analog and digital communication systems, importance and applications of communication systems in electrical engineering.
2	Amplitude Modulation Techniques: Need for modulation, amplitude modulation (AM), DSB-SC, SSB and VSB systems, generation, detection, waveforms, mathematical representation and applications.
3	Angle Modulation Techniques: Frequency modulation and phase modulation, narrowband FM, wideband FM, mathematical representation, generation, detection, applications and comparison of modulation techniques.
4	Radio Receivers and Noise Analysis: AM and FM transmitters, AM and FM radio receivers, noise and its types, performance of AM and FM systems in the presence of noise, threshold effect, pre-emphasis and de-emphasis techniques.
5	Digital Communication and Digital Modulation: Sampling, quantization, quantization noise, coding, PCM, DPCM, ADPCM, delta modulation, PWM and PPM. Digital modulation techniques including ASK, FSK, PSK, QPSK, DPSK, GMSK and QAM, constellation diagrams and comparative analysis.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO4	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
CLO5	2	3	1	2	1	0	0	0	1	1	0	1	1
Avg PLO	2.4	2.2	1	1.6	1	0	0	0	1	1	0	1	0.9333333333

Suggested Reading

1	George Kennedy and Bernard Davis, Electronic Communication Systems, McGraw Hill Education.
2	Taub and Schilling, Principles of Communication Systems, McGraw Hill Education.
3	Simon Haykin, Communication Systems, Wiley India.
4	B. P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press.
5	Wayne Tomasi, Electronic Communication Systems, Pearson Education.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Numerical problem-solving sessions.
- Tutorial assignments on modulation techniques.
- Simulation-based demonstrations of communication systems.
- Student seminars and presentations on modern communication technologies.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	*BELEOTE625*				*Semester*		*Semester VI*	
Course Title	**Thermal Engineering**						*Max marks*	
Scheme & Credits	*Hours Per Week*					*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*				
	1	*1*	*0*	*2*		*2*	*100*	
Prerequisites	*Nil*						*100*	

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamentals of thermodynamics and steam properties.
CLO2	Analyze thermodynamic cycles used in power generation systems.
CLO3	Understand the construction and performance of steam turbines.
CLO4	Analyze the operation and performance of internal combustion engines.
CLO5	Understand gas turbine cycles and their engineering applications.

Syllabus

Units	**Content**
1	Fundamentals of Thermodynamics: System and surroundings, Zeroth law of thermodynamics, temperature scales, equation of state, first law of thermodynamics, steady flow energy equation, isochoric, isobaric, isothermal, adiabatic and polytropic processes.
2	Steam Power Cycles: Properties of steam, second law of thermodynamics, entropy and entropy change, reversible and irreversible processes, Carnot cycle, Rankine cycle, modified Rankine cycle, flow through nozzles.
3	Steam Turbines: Impulse and reaction turbines, velocity and pressure compounding, work output, losses and efficiency, degree of reaction, regenerative and reheat cycles, governing of steam turbines and fields of application.
4	Internal Combustion Engines: Otto, Diesel and Dual cycles, ignition systems, detonation and pre-ignition, octane number, diesel knock, cetane number, fuels, carburetion and fuel injection systems, lubrication, cooling, governing and applications of I.C. engines.
5	Gas Turbines: Introduction to gas turbines, basic gas turbine cycles, thermal refinements, jet propulsion systems, present status, future trends and applications of gas turbines.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	3	1	3	1	1	0	0	0	1	1	0	1	1
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	3	1	1	1	1	0	0	0	1	1	0	1	0.8333333333
Avg PLO	2.6	1.8	1.4	1.4	1	0	0	0	1	1	0	1	0.9333333333

Suggested Reading

1	Bartlett, Steam Turbine Performance and Economics, McGraw Hill.
2	Kearton, Steam Turbine Theory and Practice, CBS Publishers.
3	W. W. Loe, Theory and Design of Steam and Gas Turbines, McGraw Hill.
4	Cohn and Rogers, Gas Turbines: Theory and Practice, Pearson.
5	S. M. Yahya, Turbomachines, McGraw Hill.
6	P. K. Nag, Engineering Thermodynamics, McGraw Hill.
7	R. K. Rajput, Thermal Engineering, Laxmi Publications.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Numerical problem-solving sessions.
- Tutorials on thermodynamic cycles and turbine performance.
- Case studies on thermal power plants and propulsion systems.
- Student seminars and assignments on modern thermal engineering technologies.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

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Course Code		*BELEOEA625*					*Semester*	*Semester VI*	
Course Title		**Energy Audit and Management**						*Max marks*	
Scheme & Credits		*Hours Per Week*					*Credits*	*Theory*	*Practical*
		L	*T*	*P*	*Total*				
		1	*1*	*0*	*2*		*2*	*100*	
Prerequisites		*Nil*						***100***	

Course Learning Outcomes (CLOs)

CLO1	Understand the present energy scenario and the importance of energy conservation.
CLO2	Apply principles of energy management and energy auditing.
CLO3	Analyze financial aspects of energy conservation projects.
CLO4	Identify energy-saving opportunities in electrical systems.
CLO5	Evaluate the performance of energy-efficient technologies and practices.

Syllabus

Units	**Content**
1	Energy Scenario and Conservation: Energy needs of a growing economy, long-term energy scenario, energy pricing, energy sector reforms, energy and environment, air pollution, climate change, energy security, importance of energy conservation, energy strategies for the future, Energy Conservation Act 2001 and its features.
2	Energy Management and Energy Audit: Energy management concepts, definition and need of energy audit, types of energy audits, energy management approach, understanding energy costs, benchmarking, energy performance evaluation, matching energy use to requirements, maximizing system efficiency, fuel and energy substitution.
3	Energy Audit Methodology and Instruments: Energy audit instruments, facility as an energy system, process flow diagrams, identification of energy conservation opportunities, data collection, analysis and reporting procedures.
4	Financial Management for Energy Projects: Investment need, project appraisal criteria, simple payback period, return on investment, net present value, internal rate of return, cash flow analysis, risk and sensitivity analysis, financing options, energy performance contracts and role of ESCOs.
5	Energy Efficiency in Electrical Systems: Electricity tariff, load management and maximum demand control, power factor improvement, transformer and distribution losses, induction motor efficiency, rewinding and motor replacement issues, energy-efficient motors, lighting systems, luminance requirements, energy conservation opportunities in lighting applications.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	1	1	1	2	3	0	1	1	0	1	1.25
CLO2	2	2	2	1	1	2	1	0	1	1	3	1	1.416666667
CLO3	2	3	1	2	1	2	3	0	1	1	0	1	1.416666667
CLO4	3	1	1	1	1	2	1	0	1	1	0	1	1.083333333
CLO5	2	3	1	2	1	2	1	0	1	1	0	1	1.25
Avg PLO	2.4	2	1.2	1.4	1	2	1.8	0	1	1	0.6	1	1.283333333

Suggested Reading

1	S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill.
2	Bureau of Energy Efficiency (BEE), Success Stories of Energy Conservation, New Delhi.
3	Guide Book for National Certification Examination for Energy Managers and Energy Auditors – Book 1: General Aspects, Bureau of Energy Efficiency.
4	Guide Book for National Certification Examination for Energy Managers and Energy Auditors – Book 3: Electrical Utilities, Bureau of Energy Efficiency.
5	W. R. Murphy and G. Mckay, Energy Management, Butterworth-Heinemann.
6	Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, CRC Press.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Case studies on industrial and commercial energy audits.
- Problem-solving sessions on energy performance evaluation.
- Analysis of real-world energy conservation projects.
- Student seminars, assignments and technical presentations.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	NA

Course Code	BELELES625				Semester	Semester VI	
Course Title	Embedded Systems					Max marks	
Scheme & Credits	Hours Per Week				Credits	Theory	Practical
	L	T	P	Total			
	1	1	2	4	3	100	100
Prerequisites	Microprocessors, Digital Electronics					200	

Course Learning Outcomes (CLOs)

CLO1	Describe the architecture of embedded systems and microcontroller-based system design.
CLO2	Develop embedded C programs for microcontroller-based applications.
CLO3	Interface sensors and actuators with a microcontroller.
CLO4	Implement communication protocols for embedded system interfacing.
CLO5	Design and demonstrate a simple embedded system application.

Syllabus

Units	Content
1	Introduction to Embedded Systems: Characteristics of embedded systems; embedded system design process; classification — microcontroller-based, DSP-based, FPGA-based systems; introduction to real-time operating systems (RTOS) — basic concepts.
2	Microcontroller Architecture and Programming: Architecture of a typical microcontroller (e.g., ARM Cortex-M/AVR); memory organization, GPIO, timers; embedded C programming — data types and control structures specific to embedded programming; programming using an IDE and toolchain.
3	Sensor and Actuator Interfacing: Interfacing of digital and analog sensors (temperature, light, proximity); ADC/DAC interfacing; interfacing of actuators — relays, DC motors, servo motors, stepper motors via driver circuits; PWM-based control.
4	Communication Protocols: Serial communication — UART; interfacing protocols — I2C, SPI; wireless communication modules — Bluetooth/Wi-Fi — basic interfacing for IoT-enabled applications.
5	Embedded System Design Project: Requirement analysis and design of a simple embedded application; integration of sensors, actuators, and communication modules; testing and debugging; demonstration of the developed embedded system.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	2	2	2	1	2	0	0	0	0	1	0	1	0.9166666667
CLO2	2	2	2	2	3	0	0	0	1	1	0	1	1.166666667
CLO3	2	2	3	2	3	0	0	0	1	1	0	2	1.333333333
CLO4	2	2	2	2	3	0	0	0	1	1	0	2	1.25
CLO5	2	2	3	2	3	0	0	0	2	2	1	2	1.583333333
Avg PLO	2	2	2.4	1.8	2.8	0	0	0	1	1.2	0.2	1.6	1.25

Suggested Reading

1	Rajkamal, Embedded Systems: Architecture, Programming and Design, McGraw Hill.
2	Shibu K.V., Introduction to Embedded Systems, McGraw Hill.
3	Joseph Yiu, The Definitive Guide to ARM Cortex-M Microcontrollers, Newnes.
4	Simon Monk, Programming Arduino: Getting Started with Sketches, McGraw Hill.
5	Michael Barr, Anthony Massa, Programming Embedded Systems, O'Reilly.

Teaching-Learning Strategies

- Interactive lectures integrating embedded-architecture concepts with hands-on coding demonstrations.
- Laboratory sessions on embedded C programming and sensor/actuator interfacing using development boards.
- Hands-on exercises on serial and wireless communication interfacing.
- Case-based learning through small interfacing challenges.
- Mini-project on an integrated embedded system application.

Evaluation Scheme

Theory	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks
Practical	Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc) Semester End Examination (SEE): 50 marks.