Semester VII

Course Code	BELECPA725				*Semester*	*Semester VII*	
Course Title	Power System Analysis					*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, Power Systems – II*					200	

Course Learning Outcomes (CLOs)

CLO1	Represent power system components in per-unit and formulate the bus admittance (Ybus) and impedance (Zbus) matrices.
CLO2	Perform load-flow analysis of power systems using the Gauss–Seidel and Newton–Raphson methods.
CLO3	Analyze symmetrical (three-phase) fault conditions using per-unit and Zbus-based methods.
CLO4	Analyze unsymmetrical faults using the method of symmetrical components.
CLO5	Evaluate power system stability using the swing equation and the equal-area criterion.

Syllabus

Units	Content
1	Per-Unit System and Network Modelling: Per-unit representation and selection of base quantities; conversion of per-unit impedances between bases; one-line diagrams and impedance/reactance diagrams; formation of Ybus by inspection; network graphs, incidence matrices, and the building algorithm for Zbus.
2	Load-Flow Analysis: Formulation of the load-flow problem; classification of buses (slack, PV, PQ); Gauss–Seidel iterative method; Newton–Raphson method in polar form; fast decoupled load flow; comparison of methods and convergence behaviour.
3	Symmetrical Fault Analysis: Transients in RL circuits during short circuits; three-phase symmetrical fault analysis using Thevenin's theorem and the Zbus matrix; fault-current calculations; selection criteria for circuit breakers and current-limiting reactors.
4	Unsymmetrical Fault Analysis: Symmetrical components and their properties; sequence impedances and sequence networks of generators, lines and transformers; analysis of single line-to-ground, line-to-line, and double line-to-ground faults using sequence networks.
5	Power System Stability: Steady-state and transient stability concepts; the swing equation and its derivation; equal-area criterion for transient stability assessment; factors affecting transient stability; methods of improving system stability.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	3	2	1	2	0	0	0	0	1	0	1	1.08
CLO2	3	3	3	2	3	0	0	0	1	1	0	2	1.5
CLO3	3	3	2	2	2	1	0	0	0	1	0	1	1.25
CLO4	3	3	2	2	2	1	0	0	0	1	0	1	1.25
CLO5	2	3	2	2	1	1	1	0	0	1	0	1	1.166666667
Avg PLO	2.8	3.0	2.2	1.8	2.0	0.6	0.2	0.0	0.2	1.0	0.0	1.2	1.3

Suggested Reading

1	Hadi Saadat, Power System Analysis, McGraw Hill.
2	J. Duncan Glover, M.S. Sarma, T.J. Overbye, Power System Analysis and Design, Cengage Learning.
3	I.J. Nagrath, D.P. Kothari, Modern Power System Analysis, McGraw Hill.
4	C.L. Wadhwa, Electrical Power Systems, New Age International.
5	William D. Stevenson, Elements of Power System Analysis, McGraw Hill.

Teaching-Learning Strategies

- Classroom lectures integrating theoretical concepts with numerical problems.
- Tutorial sessions on load-flow and fault-analysis computations.
- Simulation-based laboratory sessions using MATLAB/ETAP/PSCAD for load-flow and fault studies.
- Assignment-based problem solving on standard IEEE test systems (e.g., 5-bus, 14-bus).
- Case studies of real power system disturbances and blackouts.

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,

Course Code	BELECEV725				Semester	Semester VII	
Course Title	Electric Vehicles					Max marks	
Scheme & Credits	Hours Per Week				Credits	Theory	Practical
	L	T	P	Total			
	2	1	2	5	4	100	100
Prerequisites	Power Electronics, Electric Drives & Control					200	

Course Learning Outcomes (CLOs)

CLO1	Describe the architecture and configurations of electric and hybrid electric vehicles.
CLO2	Analyze vehicle dynamics and estimate the power and energy requirements for propulsion.
CLO3	Evaluate electric machines and motor drives used in EV propulsion systems.
CLO4	Analyze energy storage systems and battery management systems used in EVs.
CLO5	Describe EV charging infrastructure, charging standards, and vehicle-to-grid integration.

Syllabus

Units	Content
1	Introduction to Electric and Hybrid Vehicles: Limitations of conventional vehicles; brief history and drivers for electrification; EV configurations — BEV, HEV, PHEV, FCEV; hybrid architectures — series, parallel, series-parallel; concept and degree of hybridization.
2	Vehicle Dynamics and Propulsion: Vehicle mechanics and forces resisting motion; tractive effort and road-load equation; power and energy requirements for propulsion; gradeability and acceleration performance; vehicle performance characteristics.
3	Electric Machines and Drives for EVs: DC motor drives; induction motor drives; permanent magnet synchronous motor drives; switched reluctance motor drives; comparative evaluation of motor/drive types for EV traction applications.
4	Energy Storage Systems: Battery types and characteristics — lead-acid, NiMH, Li-ion; battery modelling and state-of-charge estimation; battery management systems; ultracapacitors and hybrid energy-storage combinations; introduction to fuel cells.
5	Charging Infrastructure and Grid Integration: Conductive and inductive charging methods; charging standards — CCS, CHAdeMO, Type 2/IEC 62196; levels of charging; vehicle-to-grid (V2G) concept; impact of EV charging on the distribution grid; smart/coordinated charging.

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	2	1.17
CLO2	3	3	2	2	2	1	1	0	0	1	0	1	1.333333333
CLO3	3	2	3	2	2	0	1	0	0	1	0	2	1.333333333
CLO4	2	2	3	2	2	1	2	0	0	1	0	2	1.416666667
CLO5	2	2	2	1	2	2	3	0	1	1	1	2	1.583333333
Avg PLO	2.6	2.2	2.4	1.6	1.8	1.0	1.6	0.0	0.2	1.0	0.2	1.8	1.4

Suggested Reading

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley.
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles, Wiley.
5. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer.

Teaching-Learning Strategies

- Classroom lectures supported by case studies of commercial EV models.
- Tutorial sessions on vehicle dynamics and propulsion power/energy calculations.
- Laboratory/simulation sessions on motor drives and battery modelling using MATLAB/Simulink.
- Assignment-based problem solving on EV design and range estimation.
- Seminar presentations on emerging trends in EV technology and charging infrastructure.

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,

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Course Code	BELEDSC725				*Semester*	*Semester VII*	
Course Title	SCADA Systems					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Basic Electrical Engineering*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamentals of SCADA systems.
CLO2	Understand communication technologies used in SCADA.
CLO3	Analyze SCADA architecture and components.
CLO4	Understand data acquisition and supervisory control functions.
CLO5	Apply SCADA systems in industrial and power system applications.

Syllabus

Units	**Content**
1	Introduction to SCADA Systems: Introduction, evolution of SCADA systems, supervisory control, data acquisition concepts, advantages and applications.
2	SCADA Components and Architecture: SCADA architecture, remote terminal units (RTUs), programmable logic controllers (PLCs), master stations, communication interfaces and human machine interfaces.
3	Communication Systems for SCADA: Communication media, communication protocols, telemetry systems, Modbus, DNP3, IEC standards and networking concepts.
4	Data Acquisition and Supervisory Control: Data collection, monitoring, alarms and event management, database systems, supervisory control functions and visualization.
5	Applications of SCADA Systems: SCADA applications in power systems, substations, industries, water systems and smart grid environments, cyber security considerations.

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	1.00
CLO2	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO3	2	3	1	2	3	0	0	0	1	1	0	1	1.166666667
CLO4	3	1	1	1	1	0	0	0	1	1	0	1	.833333333
CLO5	2	2	2	1	3	0	0	0	1	1	0	1	1.083333333
Avg PLO	2.6	1.6	1.2	1.2	2.6	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition.
2	Gordon Clarke, Deon Reynders and Edwin Wright, Practical Modern SCADA Protocols.
3	Bailey and Wright, Practical SCADA for Industry.
	Krishna Kant, Computer-Based Industrial Control.
	David Bailey and Edwin Wright, Practical SCADA for Industry, Elsevier.

Teaching-Learning Strategies

- Classroom lectures.
- Demonstrations of SCADA software.
- Assignments on industrial automation.
- Case studies on SCADA implementation.
- Seminar 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	BELEDPP725				*Semester*	*Semester VII*	
Course Title	Power Plant Engineering					*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 the layout and operation of thermal power plants.
CLO2	Analyze diesel, gas turbine and combined cycle power plants.
CLO3	Understand nuclear power plant systems and reactor technologies.
CLO4	Analyze hydroelectric power plants and their components.
CLO5	Compare different power generation technologies and their applications.

Syllabus

Units	**Content**
1	Coal Based Thermal Power Plants: Rankine cycle, modern thermal power plant layout, supercritical boilers, FBC boilers, turbines, condensers, fuel and ash handling systems, feed water treatment, cogeneration and binary cycles.
2	Diesel, Gas Turbine and Combined Cycle Plants: Otto, Diesel, Dual and Brayton cycles, components of diesel and gas turbine plants, combined cycle power plants and integrated gasifier combined cycle systems.
3	Nuclear Power Plants: Basics of nuclear engineering, nuclear plant layout, BWR, PWR, CANDU, breeder reactors, gas-cooled reactors, liquid metal cooled reactors and safety measures.
4	Hydroelectric Power Plants: Classification of hydroelectric plants, plant layout, turbines, governing systems and operational characteristics.
5	Emerging Power Generation Technologies: Renewable energy power plants, environmental aspects, hybrid power generation systems and future trends in power generation.

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	0.83
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	.833333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	3	1	2	1	0	0	0	1	1	0	1	1
Avg PLO	2.4	2.2	1.0	1.6	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	0.9

Suggested Reading

1	P. K. Nag, Power Plant Engineering, Tata McGraw Hill.
2	M. M. El-Wakil, Power Plant Technology, McGraw Hill.
[illegible]	Arora and Domkundwar, Power Plant Engineering, Dhanpat Rai Publications.
[illegible]	Frederick T. Morse, Power Plant Engineering Handbook.
5	Black and Veatch, Power Plant Engineering, Springer.

Teaching-Learning Strategies

- Classroom lectures.
- Numerical and design tutorials.
- Industrial case studies.
- Power plant layout analysis.
- Seminar presentations and assignments.

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	BELEDOE725				Semester	Semester VII	
Course Title	Optimization for Engineering Design					Max marks	
Scheme & Credits	Hours Per Week				Credits	Theory	Practical
	L	T	P	Total			
	2	1	0	3	3	100	
Prerequisites	Engineering Mathematics					100	

Course Learning Outcomes (CLOs)

CLO1	Formulate complex electrical and engineering design problems into rigorous mathematical optimization models.
CLO2	Analyze the mathematical properties of optimization problems, distinguishing between convex and non-convex sets and functions.
CLO3	Apply linear programming techniques and the simplex method to solve resource allocation and design problems.
CLO4	Solve constrained and unconstrained non-linear optimization problems utilizing Karush-Kuhn-Tucker (KKT) conditions and numerical methods.
CLO5	Evaluate and implement modern heuristic optimization techniques (e.g.. Genetic Algorithms) for practical engineering design scenarios.

Syllabus

Units	Content
1	Introduction to Optimization and Convexity Need for optimization in engineering design, formulation of optimization problems: design variables, objective functions, constraints, and bounds. Classification of optimization problems. Mathematical foundations: Taylor series, gradient and Hessian matrices. Introduction to convex optimization: convex sets, convex functions, and generalized inequalities.
2	Classical and Unconstrained Optimization Necessary and sufficient conditions for local and global extrema in single and multivariable functions. Unconstrained numerical optimization techniques: Steepest Descent (Gradient) method, Newton's method, Quasi-Newton methods (BFGS), and Conjugate Gradient method. Line search methods and convergence analysis.
3	Linear Programming (LP) Standard form of linear programming problems, geometry of linear programs, and convex polyhedra. The Simplex algorithm: basic feasible solutions, pivoting, and two-phase method. Duality theory in linear programming, dual simplex method, and sensitivity analysis. Applications of LP in electrical network design and power dispatch.
4	Constrained Non-linear Optimization Optimization with equality and inequality constraints. Method of Lagrange multipliers. Karush-Kuhn-Tucker (KKT) optimality conditions. Convex optimization problems: linear programming, quadratic programming, and quadratically constrained quadratic programming (QCQP). Numerical methods for constrained optimization: penalty function methods, barrier function methods, and interior-point methods.
5	Modern Optimization Techniques Introduction to heuristic and meta-heuristic search methods for complex, non-differentiable, and non-convex engineering problems. Genetic Algorithms (GA): representation, fitness function, selection, crossover, and mutation operators. Particle Swarm Optimization (PSO) and Simulated Annealing (SA). Application of modern optimization techniques to power system operation, smart grids, and machine design.

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	1	0	0	0	0	1	0	1	1.08
CLO2	3	3	2	2	1	0	0	0	0	1	0	1	1.08
CLO3	3	3	2	2	2	0	0	0	0	1	1	2	1.33
CLO4	3	3	3	3	3	0	0	0	0	1	0	2	1.5
CLO5	3	2	3	3	3	0	1	0	0	1	0	3	1.58
Avg PLO	3.0	2.8	2.4	2.4	2.0	0.0	0.2	0.0	0.0	1.0	0.2	1.8	1.3

Suggested Reading

1	Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press.
2	Singiresu S. Rao, Engineering Optimization: Theory and Practice, 4th Edition, John Wiley & Sons.
3	Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, 2nd Edition, PHI Learning.
4	Edwin K. P. Chong and Stanislaw H. Zak, An Introduction to Optimization, 4th Edition, Wiley.

Teaching-Learning Strategies

Interactive classroom lectures focusing on the rigorous mathematical derivation of optimal control laws.
Numerical problem-solving sessions analyzing continuous and discrete-time system formulations.
Simulation-based exercises using MATLAB to solve the Riccati equation, simulate LQR control, and visualize switching curves for bang-bang control.

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	**BELEDES725**				*Semester*	*Semester VII*	
Course Title	**Energy Storage Systems**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Basic Electrical Engineering, Renewable Energy Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the need and applications of energy storage systems.
CLO2	Analyze electrochemical energy storage technologies.
CLO3	Understand mechanical and thermal energy storage systems.
CLO4	Evaluate energy storage integration with renewable energy systems.
CLO5	Assess energy storage technologies for smart grid applications.

Syllabus

Units	**Content**
1	Introduction to Energy Storage Systems: Need for energy storage, applications, classification of storage technologies, role in renewable energy integration and smart grids.
2	Electrochemical Energy Storage: Lead-acid batteries, lithium-ion batteries, sodium-sulphur batteries, flow batteries, battery characteristics and performance parameters.
3	Mechanical and Thermal Energy Storage: Pumped hydro storage, compressed air energy storage, flywheel energy storage, thermal energy storage systems.
4	Hydrogen and Emerging Storage Technologies: Hydrogen storage systems, fuel cells, supercapacitors, hybrid energy storage systems and emerging technologies.
5	Grid Integration and Applications: Energy storage for renewable integration, microgrids, peak shaving, load leveling, frequency regulation and smart grid 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	0	1	0	1	1	0	1	0.92
CLO2	2	3	1	2	1	0	1	0	1	1	0	1	1.083333333
CLO3	3	1	1	1	1	0	1	0	1	1	0	1	.916666666
CLO4	2	3	1	2	1	0	3	0	1	1	0	1	1.25
CLO5	2	3	1	3	1	0	1	0	1	1	0	2	1.25
Avg PLO	2.4	2.2	1.0	1.8	1.0	0.0	1.4	0.0	1.0	1.0	0.0	1.2	1.1

Suggested Reading

1	Ru-Shiin Liu et al., Energy Storage Devices for Future Hybrid Electric Vehicles, CRC Press.
2	Trevor M. Letcher, Storing Energy, Elsevier.
3	Bent Sørensen, Energy Storage, Academic Press.
4	Robert Huggins, Energy Storage, Springer.
5	James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley.

Teaching-Learning Strategies

- Interactive lectures.
- Case studies on energy storage projects.
- Design-oriented assignments.
- Simulation exercises.
- Student seminars.

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	BELEDSM725				*Semester*	*Semester VII*	
Course Title	Special Electrical Machines					*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 construction and operation of synchronous reluctance motors.
CLO2	Analyze the characteristics and control of stepper motors.
CLO3	Understand the operation of brushless DC motors.
CLO4	Analyze permanent magnet synchronous motors.
CLO5	Select suitable special machines for industrial applications.

Syllabus

Units	Content
1	Synchronous Reluctance Motors: Constructional features, axial and radial flux motors, operating principles, variable reluctance motors, voltage and torque equations, phasor diagram, characteristics and applications.
2	Stepper Motors: Construction, principle of operation, variable reluctance and hybrid stepper motors, torque equations, excitation modes, drive circuits, microprocessor control, closed-loop control and applications.
3	Brushless DC Motors: Permanent magnet materials, magnetic characteristics, operating principle, types, magnetic circuit analysis, EMF and torque equations, commutation, converter circuits, characteristics and applications.
4	Permanent Magnet Synchronous Motors: Principle of operation, EMF and torque equations, armature MMF, synchronous reactance, phasor diagram, torque-speed characteristics and applications.
5	Control and Applications of Special Machines: Power controllers, converter requirements, control strategies, industrial applications and comparison of special electrical machines.

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	1.00
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	.833333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	2	2	1	1	3	0	0	1	1	0	1	.166666667
Avg PLO	2.4	2.0	1.6	1.4	1.0	0.6	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill.
2	Stephen J. Chapman, Electric Machinery Fundamentals, McGraw Hill.
3	I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill.
4	K. Venkataratnam, Special Electrical Machines, Universities Press.
5	E. G. Janardanan, Special Electrical Machines, PHI Learning.

Teaching-Learning Strategies

- Classroom lectures.
- Tutorials on machine characteristics.
- Simulation exercises.
- Case studies and industrial applications.
- Student 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	BELEDHV725				*Semester*	*Semester VII*	
Course Title	**High Voltage Engineering**					*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 breakdown mechanisms in gaseous, liquid and solid dielectrics.
CLO2	Analyze insulating materials used in high-voltage equipment.
CLO3	Understand generation and measurement of high voltages and currents.
CLO4	Apply non-destructive testing techniques for insulation assessment.
CLO5	Evaluate testing procedures of high-voltage electrical apparatus.

Syllabus

Units	Content
1	Breakdown in Gaseous Dielectrics: Gases as insulators, ionization processes, Townsend breakdown, Paschen's law, streamer theory, corona discharge and insulation applications.
2	Breakdown in Liquid and Solid Dielectrics: Conduction and breakdown in liquid dielectrics, intrinsic, thermal and electromechanical breakdown of solid dielectrics, composite insulation systems.
3	Insulating Materials and Applications: Insulating materials used in transformers, rotating machines, circuit breakers, cables, capacitors and electronic equipment.
4	Generation and Measurement of High Voltages: Generation of high AC, DC and impulse voltages and currents, measurement techniques for high voltages and currents.
5	High Voltage Testing and Diagnostics: Measurement of dielectric properties, partial discharge measurement, non-destructive testing, testing of insulators, bushings, circuit breakers, cables, transformers and surge arresters.

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	0.83
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	3	1	1	3	1	0	0	0	1	1	0	1	1
CLO4	2	3	2	3	1	0	0	0	1	1	0	1	.166666667
CLO5	2	3	1	3	1	0	0	0	1	1	0	1	.083333333
Avg PLO	2.4	2.2	1.2	2.4	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	E. Kuffel and W. S. Zaengl, High Voltage Engineering Fundamentals, Newnes.
2	M. S. Naidu and V. Kamaraju, High Voltage Engineering, Tata McGraw Hill.
3	Dieter Kind and Kurt Feser, High Voltage Test Techniques, Newnes.
4	Subir Ray, An Introduction to High Voltage Engineering, PHI.
5	C. L. Wadhwa, High Voltage Engineering, New Age International.

Teaching-Learning Strategies

- Classroom lectures.
- Tutorial sessions.
- Laboratory demonstrations.
- Case studies on insulation failures.
- Seminar presentations on modern HV 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	**BELEODS725**				*Semester*	*Semester VII*	
Course Title	**Digital Signal Processing**					*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 the fundamentals of discrete-time signals and systems.
CLO2	Analyze signals and systems using Fourier and Z-transform techniques.
CLO3	Understand sampling and signal reconstruction processes.
CLO4	Analyze and realize discrete-time systems using suitable structures.
CLO5	Design and evaluate digital filters for signal processing applications.

Syllabus

Units	**Content**
1	Discrete-Time Signals and Systems: Discrete-time signals and sequence operations, discrete-time systems, linear time-invariant systems, impulse response, causality and stability, frequency-domain representation of discrete-time signals and systems, Fourier transform and its properties.
2	Sampling and Signal Reconstruction: Sampling of continuous-time signals, periodic sampling, frequency-domain representation of sampling, signal reconstruction, discrete-time processing of continuous-time signals, continuous-time processing of discrete-time signals, sampling rate conversion.
3	Z-Transform and System Analysis: Z-transform, region of convergence, properties of Z-transform, inverse Z-transform, frequency response of LTI systems, system functions, linear constant coefficient difference equations, FIR and IIR systems.
4	Realization of Discrete-Time Systems: Block diagram representation of linear constant coefficient difference equations, signal flow graph representation, realization structures for IIR systems, transposed forms, realization structures for FIR systems.
5	Digital Filter Design: Design of discrete-time IIR filters from continuous-time filters, impulse invariance method, bilinear transformation, Butterworth, Chebyshev and Elliptic approximations, low-pass, high-pass, band-pass and band-stop filters, FIR filter design using window techniques, Hamming, Hanning and Kaiser windows.

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	0.83
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	2	3	3	2	1	0	0	0	1	1	0	1	1.166666667
Avg PLO	2.4	2.2	1.8	1.6	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, Prentice Hall.
2	John G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall.
3	J. R. Johnson, Introduction to Digital Signal Processing, Prentice Hall.
4	L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall.
5	S. Salivahanan, A. Vallavaraj and C. Gnanapriya, Digital Signal Processing, McGraw Hill.
6	Sanjit K. Mitra, Digital Signal Processing: A Computer-Based Approach, McGraw Hill.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Tutorial sessions on transform analysis and filter design.
- Numerical problem-solving exercises.
- MATLAB/Octave-based demonstrations of DSP concepts.
- Student assignments and seminar presentations on signal processing applications.

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	BELEOEB725				*Semester*	*Semester VII*	
Course Title	Energy Management in Buildings					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Basic understanding of Energy Sustainability and Risk Management*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand energy consumption patterns and conservation opportunities in buildings.
CLO2	Analyze heat transfer mechanisms and thermal performance of buildings.
CLO3	Evaluate lighting systems and daylight utilization techniques for energy-efficient buildings.
CLO4	Understand heating, cooling and ventilation requirements of buildings.
CLO5	Apply building energy management principles and relevant standards for sustainable building design.

Syllabus

Units	Content
1	Energy Use in Buildings: Energy consumption in buildings, factors affecting energy use, energy conservation opportunities, climatic factors, climatic zones, building orientation, shading and sizing of shading devices.
2	Thermal Comfort and Heat Transmission: Thermal comfort criteria and parameters, psychrometric chart, indoor air quality requirements in residential, commercial and hospital buildings. Heat transmission through walls, windows and roofs, surface coefficients, air cavities, overall thermal transmittance, heat transfer due to ventilation and infiltration.
3	Building Thermal Performance: Internal heat gains, solar temperature effects, steady-state methods for building heat transfer analysis, Trombe wall, water wall and solarium concepts, thermal performance improvement techniques.
4	Lighting and Daylighting Systems: Lighting fundamentals, visual performance, illumination calculations, energy-efficient lighting systems, estimation of available daylight, daylighting systems, advantages and limitations of daylight utilization in buildings.
5	HVAC Systems and Building Energy Codes: ASHRAE methods and standards for heating, cooling and ventilation load estimation, ventilation requirements for different building types, air quality control equipment, conditioned air distribution systems, building design considerations for different climatic zones, thumb rules for building system design and building energy codes.

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	1	0	1	1	0	1	1.08
CLO2	2	3	1	2	1	2	0	0	1	1	0	1	1.166666667
CLO3	2	3	1	2	1	2	1	0	1	1	0	1	1.25
CLO4	3	1	1	1	1	2	0	0	1	1	0	1	1
CLO5	2	2	3	1	3	3	3	2	1	1	3	1	2.083333333
Avg PLO	2.4	2.0	1.4	1.4	1.4	2.2	1.0	0.4	1.0	1.0	0.6	1.0	1.3

Suggested Reading

1	M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive: Building Science and Design, Pergamon Press.
2	T. A. Markus and R. N. Morris, Building, Climate and Energy, Spottiswoode Ballantyne Ltd., London.
3	D. Buddhi, Energy Storage Technologies, School of Energy and Environmental Studies, DAVV, Indore.
4	J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall.
5	B. Givoni, Man, Climate and Architecture, Elsevier.
6	ASHRAE Handbook – Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Case studies on energy-ef
- Interactive classroom lectures.
- Case studies on energy-efficient and green buildings.
- Numerical exercises on heat transfer and lighting calculations.
- Analysis of building energy performance and conservation measures.
- Student seminars and assignments on sustainable building 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	**BELEOIT725**				*Semester*	*Semester VII*	
Course Title	**Internet of Things for Engineers**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Basic Knowledge of Computers and Communication Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamentals and architecture of Internet of Things (IoT).
CLO2	Explain the role of sensors, actuators and embedded devices in IoT systems.
CLO3	Understand communication protocols and networking technologies used in IoT.
CLO4	Analyze cloud-based IoT platforms and data management techniques.
CLO5	Design simple IoT solutions for engineering and industrial applications.

Syllabus

Units	**Content**
1	Introduction to Internet of Things: Evolution of IoT, definition and characteristics of IoT, IoT architecture, enabling technologies, components of IoT systems, applications of IoT in smart homes, smart cities, healthcare, agriculture and industry.
2	Sensors, Actuators and Embedded Systems: Introduction to sensors and actuators, sensor characteristics, embedded systems for IoT, microcontrollers and single-board computers, data acquisition, interfacing techniques and IoT hardware platforms.
3	IoT Communication and Networking: IoT communication models, wired and wireless communication technologies, Wi-Fi, Bluetooth, ZigBee, RFID, NFC, LoRaWAN, cellular IoT, MQTT, CoAP and other application layer protocols.
4	Cloud Computing and Data Analytics for IoT: Introduction to cloud computing, IoT cloud platforms, data storage and management, IoT data analytics, real-time monitoring, visualization techniques and cybersecurity considerations in IoT systems.
5	Industrial and Engineering Applications of IoT: Industrial Internet of Things (IIoT), smart energy systems, smart grid applications, remote monitoring and control, predictive maintenance, IoT-based automation systems, case studies and emerging trends in IoT.

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	1.00
CLO2	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO3	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO4	2	3	1	2	3	0	0	0	1	1	3	1	.416666667
CLO5	2	2	3	1	3	3	0	0	1	1	0	1	.416666667
Avg PLO	2.6	1.6	1.4	1.2	3.0	0.6	0.0	0.0	1.0	1.0	0.6	1.0	1.2

Suggested Reading

1	Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press.
2	Raj Kamal, Internet of Things: Architecture and Design Principles, McGraw Hill Education.
3	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, Cisco Press.
4	Olivier Hersent, David Boswarthick and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley.
5	Srinivasa K. G. and Siddesh G. M., Internet of Things, Cengage Learning.
6	Samuel Greengard, The Internet of Things, MIT Press.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Demonstrations of IoT hardware and software platforms.
- Case studies on industrial and smart system applications.
- Mini-projects involving IoT-based monitoring and control systems.
- 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

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Course Code	BELEPMP725				*Semester*	*Semester VII*	
Course Title	Minor Project					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	0	0	3	3	3	100	
Prerequisites	*As per relevant core courses of Semesters III–VI*					100	

Course Learning Outcomes (CLOs)

CLO1	Identify a real-world electrical engineering problem and conduct a literature survey to establish the project's scope and objectives.
CLO2	Formulate a design or investigation methodology appropriate to the identified problem.
CLO3	Implement or simulate the proposed design/investigation using appropriate tools and techniques.
CLO4	Test, validate and analyze the results obtained from the implemented work.
CLO5	Document the project work and present the findings through a technical report and viva-voce.

Syllabus

Units	Content
1	Problem Identification and Literature Survey: Identification of a problem in the domain of electrical/electronics engineering; preliminary literature survey; formulation of objectives and scope; feasibility study and identification of required resources.
2	Project Planning and Design: Detailed literature review; selection of methodology/approach; system design or theoretical formulation; planning of resources, tools, and timeline; submission of the project proposal/synopsis.
3	Implementation: Development of the hardware/software/simulation model as applicable; execution of the proposed design; iterative refinement based on preliminary results and supervisor feedback.
4	Testing and Validation: Testing of the developed system or model; validation against the stated objectives; analysis of results; comparison with existing approaches where applicable.
5	Documentation and Presentation: Preparation of the project report as per the prescribed departmental format; preparation of presentation material; viva-voce examination before the departmental evaluation committee.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	2	3	1	2	1	1	1	0	1	1	1	1	1.25
CLO2	2	2	3	2	2	1	1	0	1	1	1	2	1.5
CLO3	1	2	2	3	3	1	1	0	2	1	2	2	1.666666667
CLO4	1	2	2	3	2	1	1	1	1	2	1	1	1.5
CLO5	1	1	1	1	1	1	1	1	3	3	2	2	1.5
Avg PLO	1.4	2.0	1.8	2.2	1.8	1.0	1.0	0.4	1.6	1.6	1.4	1.6	1.5

Suggested Reading

1	Relevant technical literature (journals, standards, patents) identified through the literature survey specific to the chosen project topic, in consultation with the supervisor.
2	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.

Teaching-Learning Strategies

- Periodic one-on-one guidance and review meetings with the project supervisor.
- Milestone-based progress reviews before a departmental committee.
- Peer review and group discussion of project proposals and progress.
- Hands-on implementation/simulation work carried out under supervision.
- Structured technical report writing and presentation practice.

Semester VIII

Course Code	BELEDSG825				*Semester*	*Semester VIII*	
Course Title	Smart Grid					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Power Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the architecture and components of smart grids.
CLO2	Analyze distributed generation and wide-area monitoring systems.
CLO3	Understand smart grid protection and energy storage integration.
CLO4	Analyze operation and control of AC, DC and hybrid microgrids.
CLO5	Apply demand-side management and energy management techniques in smart grids.

Syllabus

Units	**Content**
1	Introduction to Smart Grids: Evolution of electric power systems, concept of smart grid, architecture of smart grid systems, standards, technologies and key components of smart grids.
2	Monitoring and Protection Systems: Distributed generation resources, wide area monitoring systems, phasor measurement units, phasor estimation, digital relays and smart grid protection.
3	Smart Grid Components and Storage: Islanding detection techniques, smart grid protection, modelling of energy storage devices, modelling of DC smart grid components.
4	Microgrid Operation and Control: Operation and control of AC microgrids, DC microgrids and AC–DC hybrid microgrids, distributed energy resource management.
5	Demand Side Management and Energy Management: Demand side management, demand response, energy management systems, smart grid design considerations and analysis of AC/DC smart grids.

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	2	0.92
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	3	1	1	1	1	0	1	0	1	1	0	2	1
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	2	2	1	1	0	1	0	1	1	3	2	.333333333
Avg PLO	2.4	2.0	1.2	1.4	1.0	0.0	0.4	0.0	1.0	1.0	0.6	1.6	1.1

Suggested Reading

1	Ali Keyhani and Mohammad Marwali, Smart Power Grids.
2	Arun G. Phadke and James S. Thorp, Computer Relaying for Power Systems.
3	Nikos Hatziargyriou, Microgrids: Architecture and Control, Wiley.
4	Fang Lin Luo and Hong Ye, Renewable Energy Systems.
5	James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Tutorials on smart grid applications.
- Simulation studies using software tools.
- Case studies on smart grid projects.
- Seminar presentations on emerging smart grid 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	**BELEDDM825**				*Semester*	*Semester VIII*	
Course Title	**Distribution System Modelling & Analysis**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Power Systems – I, Power Systems – II*					100	

Course Learning Outcomes (CLOs)

CLO1	Model the series impedance of overhead and underground distribution lines using Carson's equations and matrix (Kron) reduction.
CLO2	Develop shunt admittance and generalized line models for radial distribution feeders.
CLO3	Represent distribution loads and construct three-phase transformer and step-voltage-regulator models.
CLO4	Apply the ladder iterative technique to perform unbalanced three-phase power-flow analysis on radial feeders.
CLO5	Perform short-circuit analysis on distribution feeders and model center-tapped transformers and secondaries.

Syllabus

Units	**Content**
1	Introduction to Distribution Systems and Load Characteristics: Distribution substation, primary and secondary feeders, distribution transformers and their role in the power system; the nature of loads: demand, maximum demand, diversity factor, load factor, loss factor; individual customer load and distribution transformer loading; approximate/balanced methods of feeder analysis.
2	Series Impedance of Distribution Lines: Series impedance of overhead lines, Carson's equations and modified Carson's equations, primitive impedance matrix, Kron reduction to the phase impedance matrix; series impedance of underground cables — concentric neutral and tape-shielded cable models.
3	Shunt Admittance and Distribution Line Models: Shunt admittance of overhead and underground lines, calculation of the capacitance matrix; the generalized (two-port) line model, exact and modified line-segment models, approximate line-segment model; application of line models in feeder studies.
4	Voltage Regulation and Three-Phase Transformer Models: Step-voltage regulators, single-phase and three-phase regulator models, line-drop compensation; three-phase transformer models for standard connections — grounded wye–delta, ungrounded wye–delta, open-delta — and generalized transformer matrices.
5	Load Models, Feeder Analysis and Center-Tapped Transformers: Load models — constant impedance, constant current, constant power and combination loads; induction machine as motor and generator; the ladder iterative technique for unbalanced three-phase power-flow analysis; short-circuit analysis of distribution feeders; center-tapped transformer and secondary models.

CLO-PLO Mapping Matrix

CLO/PLO	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**	**PLO12**	**Avg CLO**
CLO1	3	3	2	1	2	0	0	0	0	1	0	1	1.08
CLO2	3	2	3	1	2	0	0	0	0	1	0	1	1.083333333
CLO3	2	3	2	2	2	1	1	0	0	1	0	1	1.25
CLO4	3	3	3	2	3	0	0	0	1	1	0	2	1.5
CLO5	2	3	2	2	2	1	0	0	0	1	0	1	1.166666667
Avg PLO	2.6	2.8	2.4	1.6	2.2	0.4	0.2	0.0	0.2	1.0	0.0	1.2	1.2

Suggested Reading

1	William H. Kersting, Distribution System Modeling and Analysis, 4th ed., CRC Press, 2018. [Prescribed text — course content and unit structure follow this book]
2	Turan Gönen, Electric Power Distribution Engineering, 3rd ed., CRC Press, 2014.
3	IEEE Std 399, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
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 integrating theory with the worked numerical examples from Kersting's text.
- Tutorial sessions on per-unit-length impedance/admittance calculations and Kron reduction.
- Computational exercises (MATLAB or equivalent) implementing the ladder iterative technique for feeder power-flow.
- Assignment-based problem solving using standard IEEE test feeders (e.g., 4-bus, 13-bus).
- Seminar presentations on smart-grid and distributed-generation impacts on distribution 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	NA

Course Code	BELEDMG825				*Semester*	*Semester VIII*	
Course Title	Microgrids and Distributed Generation					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Power Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand distributed generation technologies.
CLO2	Analyze planning and integration of distributed generation.
CLO3	Understand microgrid architecture and components.
CLO4	Analyze operation and control of microgrids.
CLO5	Evaluate protection and energy management strategies in microgrids.

Syllabus

Units	Content
1	Distributed Generation Fundamentals: Introduction to distributed generation, technologies, benefits, challenges, renewable and non-renewable distributed energy resources.
2	Integration of Distributed Generation: Grid interconnection requirements, power quality issues, voltage regulation, protection coordination and standards.
3	Microgrid Architecture and Components: AC microgrids, DC microgrids, hybrid microgrids, distributed energy resources, storage systems and control architecture.
4	Operation and Control of Microgrids: Grid-connected and islanded modes of operation, power sharing, frequency and voltage control, energy management systems.
5	Protection and Applications: Protection of microgrids, reliability considerations, smart microgrids, community microgrids and practical 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	0	0	0	1	1	0	1	0.83
CLO2	2	3	1	2	1	0	0	0	1	1	3	1	1.25
CLO3	3	1	1	1	1	0	0	0	1	1	0	1	.833333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	3	1	2	1	0	1	0	1	1	3	1	.333333333
Avg PLO	2.4	2.2	1.0	1.6	1.0	0.0	0.2	0.0	1.0	1.0	1.2	1.0	1.1

Suggested Reading

1	Nikos Hatziargyriou, Microgrids: Architecture and Control, Wiley.
2	S. Chowdhury, S. P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks.
3	Math Bollen and Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley.
4	James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley.
5	H. Lee Willis and Walter G. Scott, Distributed Power Generation, CRC Press.

Teaching-Learning Strategies

- Classroom lectures.
- Tutorials and design exercises.
- Simulation studies.
- Case studies on operational microgrids.
- Student seminars.

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	BELEDFS825				*Semester*	*Semester VIII*	
Course Title	FACTS					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Power Electronics, Power Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the need and applications of FACTS controllers.
CLO2	Analyze power flow in compensated transmission systems.
CLO3	Understand the operation and characteristics of shunt FACTS devices.
CLO4	Analyze series compensation techniques and FACTS controllers.
CLO5	Evaluate advanced FACTS devices for power flow and stability improvement.

Syllabus

Units	Content
1	Introduction to FACTS Technology: Introduction to FACTS technology, types of FACTS controllers, FACTS versus HVDC, benefits of FACTS technology, transmission line performance equations, active and reactive power flow, uncompensated transmission lines, need and functions of compensation.
2	Shunt Compensation Techniques: Ideal shunt compensation, ideal series compensation, phase angle control, advantages of shunt and series compensation, Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitor (TSC).
3	Static VAR Systems and Series Controllers: Static VAR Compensator (SVC), Static Synchronous Compensator (STATCOM), comparison of SVC and STATCOM, GTO Controlled Series Capacitor (GCSC), Thyristor Switched Series Capacitor (TSSC), Thyristor Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC).
4	Voltage and Phase Angle Controllers: Thyristor Controlled Voltage Regulator (TCVR), Thyristor Controlled Phase Angle Regulator (TCPAR), voltage regulation and phase angle control.
5	Advanced FACTS Controllers: Series-shunt compensators, Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC), Thyristor Controlled Braking Resistor (TCBR), applications of FACTS controllers in modern power systems.

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	0.83
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	.833333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	3	1	2	1	0	0	0	1	1	0	2	1.083333333
Avg PLO	2.4	2.2	1.0	1.6	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.2	1.0

Suggested Reading

	N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Wiley.
2	K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International.
3	Xiao-Ping Zhang, Christian Rehtanz and Bikash Pal, Flexible AC Transmission Systems: Modelling and Control, Springer.
4	R. Mohan Mathur and Rajiv K. Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, Wiley.
5	Narain G. Hingorani, Flexible AC Transmission, IEEE Press.

Teaching-Learning Strategies

- Classroom lectures with numerical examples.
- Tutorial sessions on power flow and compensation calculations.
- Simulation studies using MATLAB/Simulink.
- Case studies on FACTS installations.
- Seminar presentations on emerging FACTS 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	BELEDOC825				Semester	Semester VIII	
Course Title	Optimal Control					Max marks	
Scheme & Credits	Hours Per Week				Credits	Theory	Practical
	L	T	P	Total			
	2	1	0	3	3	100	
Prerequisites	Control Systems, Engineering Mathematics					100	

Course Learning Outcomes (CLOs)

CLO1	Formulate optimal control problems by defining appropriate state variable models, physical constraints, and performance measures.
CLO2	Apply the principle of optimality and dynamic programming to solve discrete-time and continuous-time optimal control problems.
CLO3	Utilize the fundamental concepts of the calculus of variations to derive necessary conditions for the extremization of functionals.
CLO4	Apply Pontryagin's Minimum Principle to determine optimal control laws for constrained and unconstrained dynamic systems.
CLO5	Design Linear Quadratic Regulators (LQR) and time-optimal (bang-bang) controllers for linear systems

Syllabus

Units	Content
1	Introduction to Optimal Control and Performance Measures Introduction to the optimal control problem, state variable representation of dynamic systems. Formulation of the optimal control problem: plant, performance index, and constraints. Typical performance measures: minimum-time, minimum-energy, minimum-fuel, and tracking problems. Formulating the objective function and basic mathematical prerequisites.
2	Dynamic Programming The principle of optimality, application of the principle of optimality to decision-making. Discrete-time linear quadratic regulator (LQR) problem, discrete dynamic programming approach. Continuous-time systems: the Hamilton-Jacobi-Bellman (HJB) equation, closed-loop optimal control, and numerical solution of the HJB equation.
3	The Calculus of Variations Fundamental concepts of the calculus of variations, functionals, the variation of a functional. Necessary conditions for an extremum: the Euler-Lagrange equation. Boundary conditions, transversality conditions, piecewise-smooth extremals. Constrained extremization of functionals using Lagrange multipliers.
4	The Variational Approach and Pontryagin's Minimum Principle Necessary conditions for optimal control using the variational approach. State and costate (adjoint) equations. Boundary condition equations. Pontryagin's Minimum Principle: formulation of the Hamiltonian, necessary conditions for unconstrained and control-constrained systems. State-variable inequality constraints.
5	Linear Quadratic Regulator (LQR) and Minimum-Time Problems The Continuous-Time Linear Quadratic Regulator (LQR) problem, derivation of the matrix Riccati equation, steady-state Riccati equation, and closed-loop pole placement. Minimum-time control of linear time-invariant systems, bang-bang control, switching curves and surfaces, minimum-effort control problems.

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	1	0	0	0	0	1	0	1	1.08
CLO2	3	3	2	2	2	0	0	0	0	1	0	1	1.16
CLO3	3	3	1	2	1	0	0	0	0	1	0	1	1
CLO4	3	3	2	2	2	0	0	0	0	1	0	2	1.25
CLO5	3	3	3	3	3	0	0	0	0	1	0	2	1.5
Avg PLO	3.0	3.0	2.0	2.2	1.8	0.0	0.0	0.0	0.0	1.0	0.0	1.4	1.2

Suggested Reading

1	Donald E. Kirk, Optimal Control Theory: An Introduction, Dover Publications.
	Desineni Subbaram Naidu, Optimal Control Systems, CRC Press.
	Frank L. Lewis, Draguna Vrabie, and Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley.
	Arthur E. Bryson and Yu-Chi Ho, Applied Optimal Control: Optimization, Estimation and Control, Taylor & Francis.

Teaching-Learning Strategies

•Interactive classroom lectures focusing on the rigorous mathematical derivation of optimal control laws.
•Numerical problem-solving sessions analyzing continuous and discrete-time system formulations.
•Simulation-based exercises using MATLAB to solve the Riccati equation, simulate LQR control, and visualize switching curves for bang-bang control.

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		BELEDHV825				Semester	Semester VIII	
Course Title		HVDC Transmission					Max marks	
Scheme & Credits		Hours Per Week				Credits	Theory	Practical
		L	T	P	Total			
		2	1	0	3	3	100	
Prerequisites		Power Systems					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the need and advantages of HVDC transmission.
CLO2	Analyze converter and inverter operation in HVDC systems.
CLO3	Understand control and protection of HVDC transmission.
CLO4	Analyze reactive power requirements and harmonics in HVDC systems.
CLO5	Evaluate the impact of HVDC transmission on power system performance and stability.

Syllabus

Units	Content
1	Introduction to HVDC Transmission: Comparison of AC and DC transmission, economic considerations, advantages and limitations of HVDC systems, types of HVDC links, applications of HVDC transmission.
2	HVDC Converters and Inverters: Line commutated converters, converter and inverter operation, converter circuits, converter transformers, converter characteristics and performance.
3	Control and Protection of HVDC Systems: Control characteristics, firing angle control, extinction angle control, power control, current control, protection of HVDC systems and converter stations.
4	Reactive Power and Harmonics: Reactive power requirements, harmonic generation, harmonic filters, smoothing reactors and reactive power compensation techniques.
5	Modern HVDC Systems and Applications: Voltage source converter (VSC) based HVDC systems, multi-terminal HVDC systems, HVDC for renewable integration and improvement of power system stability.

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	0.83
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	.833333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	2	3	1	2	1	0	0	0	1	1	0	1	1
Avg PLO	2.4	2.2	1.0	1.6	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	0.9

Suggested Reading

1	K. R. Padiyar, HVDC Power Transmission Systems, New Age International.
2	J. Arrillaga, High Voltage Direct Current Transmission, IET Publications.
3	E. W. Kimbark, Direct Current Transmission, Wiley.
4	Prabha Kundur, Power System Stability and Control, McGraw Hill.
5	Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International.

Teaching-Learning Strategies

- Classroom lectures and tutorials.
- Numerical problems on HVDC performance.
- Simulation studies using software tools.
- Case studies of existing HVDC projects.
- Student seminars on modern HVDC 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

mHarish Raheen

Course Code	BELEDFL825				*Semester*	*Semester VIII*	
Course Title	Fuzzy Logic and Neural Networks					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Digital Logic*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamentals of artificial neural networks.
CLO2	Analyze various neural network architectures and learning strategies.
CLO3	Apply neural network models to engineering problems.
CLO4	Understand fuzzy logic concepts and inference systems.
CLO5	Analyze hybrid intelligent systems based on neural networks and fuzzy logic.

Syllabus

Units	**Content**
1	Introduction to Neural Networks: Humans and computers, biological neurons, artificial neuron models, characteristics of ANN, McCulloch-Pitts model, historical development and applications of neural networks.
2	Fundamentals of Artificial Neural Networks: Artificial neuron operation, activation functions, ANN architectures, neural dynamics, supervised, unsupervised and reinforcement learning strategies, learning rules.
3	Learning Paradigms and ANN Models: Back propagation algorithm, pattern classification, clustering, Kohonen self-organizing maps, radial basis function networks, support vector machines, Hopfield networks, associative memory and engineering applications.
4	Fuzzy Logic Systems: Fuzzy sets, membership functions, fuzzy relations, operations on fuzzy sets, fuzzification, defuzzification, fuzzy inference systems and applications.
5	Hybrid Intelligent Systems: Genetic algorithms, neuro-fuzzy systems, adaptive neuro-fuzzy inference systems, evolutionary neural networks and applications in engineering and power systems.

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	1.00
CLO2	2	3	1	2	3	0	0	0	1	1	0	1	1.166666667
CLO3	2	2	2	1	3	0	0	0	1	1	0	1	1.083333333
CLO4	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO5	2	3	1	2	3	0	0	0	1	1	0	2	1.25
Avg PLO	2.4	2.0	1.2	1.4	3.0	0.0	0.0	0.0	1.0	1.0	0.0	1.2	1.1

Suggested Reading

1	Jacek M. Zurada, Introduction to Artificial Neural Systems, PWS Publishing Company.
2	S. Haykin, Neural Networks: A Comprehensive Foundation, Pearson.
3	Valluru Rao and Hayagriva Rao, Neural Networks and Fuzzy Logic, BPB Publications.
4	Freeman, Neural Networks, Pearson Education.
5	Rajasekaran and Pai, Genetic Algorithms: Concepts and Applications, Prentice Hall India.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Tutorials on neural network algorithms.
- Software-based demonstrations and simulations.
- Assignments on fuzzy and intelligent systems.
- Seminar presentations and case studies.

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	**BELEDRP825**				*Semester*	*Semester VIII*	
Course Title	**Restructuring of Power Systems**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Power Systems – I, Power Systems – II*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the concept of restructuring and deregulation of electricity markets and the need for reforms in the power sector.
CLO2	Analyze various market models for electricity trading and evaluate transmission congestion management techniques.
CLO3	Apply Locational Marginal Pricing (LMP) and Financial Transmission Rights (FTR) to solve transmission pricing problems.
CLO4	Evaluate ancillary service management, pricing of network usage, loss allocation, and market power issues.
CLO5	Assess the reforms in the Indian power sector and understand the regulatory framework and challenges of deregulation.

Syllabus

Units	Content
1	Introduction to Restructuring of the Power Industry and Fundamentals of Economics: Overview of traditional vertically integrated power systems; Motivation for restructuring and deregulation; Objectives and challenges of electricity market reform; Key players in a deregulated power system; Money, power and information flow; Basic economics of electricity: supply, demand, cost curves, marginal cost, price elasticity; Economic efficiency and welfare concepts applied to electricity markets.
2	Philosophy of Market Models and Transmission Congestion Management: Pool model, bilateral contracts model and hybrid models; Single buyer model, competitive wholesale market, retail competition; Spot market, day-ahead market, real-time market; Role of system operator and market operator; Transmission congestion: definition, causes and impacts; Congestion management methods — pro-rata curtailment, locational pricing, market splitting, transmission rights; Security-constrained economic dispatch.
3	Locational Marginal Prices (LMP) and Financial Transmission Rights (FTR): Concept and calculation of Locational Marginal Prices (LMP); LMP components — energy, congestion and loss components; DC optimal power flow for LMP calculation; Impact of congestion on LMPs; Financial Transmission Rights (FTR): definition, types (obligations and options); FTR revenue adequacy; Simultaneous feasibility test; Ancillary service management: definition and types — frequency regulation, voltage support, black-start, spinning reserve, reactive power supply; Procurement and pricing of ancillary services.
4	Pricing of Transmission Network Usage, Loss Allocation and Market Power: Transmission pricing approaches — postage stamp, MW-mile method, contract path method; Distribution factors: PTDF, OTDF; Marginal cost-based and embedded cost-based transmission pricing; Loss allocation methods — pro-rata, marginal loss coefficients; Revenue reconciliation; Market power in electricity markets: definition, indicators and measurement (Lerner index, HHI); Generator bidding strategies — single-unit and multi-unit bidding; Mitigating market power: regulatory and market-based solutions.
5	Reforms in the Indian Power Sector: Historical overview of the Indian power sector; Electricity Act 2003 and its key provisions; Unbundling of generation, transmission and distribution; State Electricity Regulatory Commissions (SERCs) and Central Electricity Regulatory Commission (CERC); Availability Based Tariff (ABT) mechanism; Open access and its implementation; Power exchanges in India — IEX and PXIL; Renewable energy integration challenges in the deregulated framework; Future roadmap and challenges of power sector reforms in India.

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	2	1	0	1	1	1	1	1.25
CLO2	2	3	2	2	1	1	0	0	1	1	0	2	1.25
CLO3	3	3	2	2	2	0	0	0	1	1	0	1	1.25
CLO4	2	3	2	2	2	1	0	1	1	1	1	1	.416666667
CLO5	2	2	1	1	1	3	1	1	1	1	2	2	1.5
Avg PLO	2.4	2.6	1.6	1.6	1.4	1.4	0.4	0.4	1.0	1.0	0.8	1.4	1.3

Suggested Reading

1	Daniel Kirschen and Goran Strbac, Fundamentals of Power System Economics, John Wiley & Sons.
	Kankar Bhattacharya, Jaap E. Daadler and Math H. J. Bollen, Operation of Restructured Power Systems, Kluwer Academic Publishers.
	Mohammad Shahidehpour and Muwaffaq Alomoush, Restructured Electrical Power Systems, Marcel Dekker.
	Allen J. Wood, Bruce F. Wollenberg and Gerald B. Sheblé, Power Generation, Operation and Control, John Wiley & Sons.
	A. J. Conejo, E. Castillo, R. Minguez and R. Garcia-Bertrand, Decomposition Techniques in Mathematical Programming, Springer.

Teaching-Learning Strategies

- Interactive classroom lectures with real-world electricity market case studies.
- Tutorial sessions on LMP calculation, FTR problems and transmission pricing methods.
- Case studies on deregulated power markets (PJM, UK, Nordpool) and India's ABT mechanism.
- Assignments on market model analysis and generator bidding strategy problems.
- Seminars and group discussions on Indian power sector reform and regulatory issues.

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

MAasish Laheen

Course Code	BELEDUT825				*Semester*	*Semester VIII*	
Course Title	Utilization and Traction					*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 electric drives and their industrial applications.
CLO2	Analyze electric traction systems and performance characteristics.
CLO3	Understand electric and hybrid electric vehicle technologies.
CLO4	Design and analyze illumination systems.
CLO5	Understand electric heating and welding applications.

Syllabus

Units	**Content**
1	Electric Drives: Factors governing selection of electric drives, control devices for industrial motors, motors for particular services and applications of electric drives.
2	Electric Traction: Requirements of ideal traction, systems of traction, speed-time curves, tractive effort, adhesion, traction motors, speed control methods, braking methods and energy consumption.
3	Electric and Hybrid Vehicles: Configuration and performance of electric vehicles, traction motor characteristics, transmission requirements, vehicle performance and energy consumption.
4	Illumination Engineering: Laws of illumination, lighting calculations, factory lighting, flood lighting, street lighting, incandescent, fluorescent, CFL and LED lamps, glare and its remedies.
5	Electric Heating and Welding: Resistance heating, induction heating, dielectric heating, arc furnaces, electric welding, arc welding, welding equipment and control devices.

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	3	0	0	1	1	0	1	1.08
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	.833333333
CLO4	2	3	3	2	1	0	0	0	1	1	0	1	1.166666667
CLO5	3	1	1	1	1	0	0	0	1	1	0	1	.833333333
Avg PLO	2.6	1.8	1.4	1.4	1.0	0.6	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	E. Openshaw Taylor, Utilization of Electric Energy.
2	Mehrdad Ehsani et al., Modern Electric, Hybrid Electric and Fuel Cell Vehicles.
3	H. Partab, Art and Utilization of Electric Energy.
4	J. B. Gupta, Utilization of Electric Power and Electric Traction.
5	C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy.

Teaching-Learning Strategies

- Classroom lectures.
- Numerical tutorials.
- Design assignments.
- Industrial application case studies.
- Seminar 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

Manish Naheen

Course Code	**BELEDIE825**				*Semester*	*Semester VIII*	
Course Title	**Insulation Engineering and Diagnostics**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	2	1	0	3	3	100	
Prerequisites	*Electrical Materials, High Voltage Engineering*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand insulation systems used in electrical equipment.
CLO2	Analyze insulation ageing and degradation mechanisms.
CLO3	Apply insulation testing and diagnostic techniques.
CLO4	Evaluate insulation condition of power apparatus.
CLO5	Understand condition-based maintenance practices for insulation systems.

Syllabus

Units	**Content**
1	Fundamentals of Insulation Engineering: Electrical insulating materials, dielectric properties, insulation systems, electric stress and insulation coordination.
2	Insulation Ageing and Failure Mechanisms: Thermal ageing, electrical ageing, moisture effects, contamination, mechanical degradation and insulation failures.
3	Insulation Testing and Diagnostics: Insulation resistance measurement, polarization index, dielectric loss measurement, capacitance testing and partial discharge testing.
4	Diagnostics of Electrical Equipment: Transformer insulation diagnostics, dissolved gas analysis, cable insulation testing, rotating machine insulation assessment and switchgear diagnostics.
5	Condition Monitoring and Asset Management: Thermal imaging, online monitoring techniques, condition assessment, remaining life estimation, predictive maintenance and asset management practices.

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	0.83
CLO2	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO3	2	2	2	3	1	0	0	0	1	1	0	1	1.083333333
CLO4	2	3	1	2	1	0	0	0	1	1	0	1	1
CLO5	3	1	1	1	3	0	0	0	1	1	3	1	1.25
Avg PLO	2.4	2.0	1.2	1.8	1.4	0.0	0.0	0.0	1.0	1.0	0.6	1.0	1.0

Suggested Reading

1	A. J. Kelen, Insulation Coordination for Power Systems.
2	M. S. Naidu and V. Kamaraju, High Voltage Engineering.
3	E. Kuffel and W. S. Zaengl, High Voltage Engineering Fundamentals.
4	T. J. Gallagher and A. J. Pearmain, High Voltage Measurement, Testing and Design.
5	A. H. Sharbaugh, Electrical Insulation and Dielectric Phenomena.

Teaching-Learning Strategies

- Classroom lectures.
- Demonstrations of diagnostic techniques.
- Case studies on insulation failures.
- Technical assignments.
- Seminar 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

mHarish Jaheen

Course Code	BELEOAI825				*Semester*	*Semester VIII*	
Course Title	Artificial Intelligence Applications in Engineering					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	1	1	0	2	2	100	
Prerequisites	*Basic Knowledge of Mathematics, Programming and Engineering Systems*					100	

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamental concepts and techniques of Artificial Intelligence.
CLO2	Apply search and knowledge representation techniques to engineering problems.
CLO3	Understand machine learning and neural network concepts.
CLO4	Analyze the role of AI in automation, optimization and decision-making.
CLO5	Evaluate engineering applications of AI in various domains.

Syllabus

Units	**Content**
1	Introduction to Artificial Intelligence: Introduction to Artificial Intelligence, history and evolution of AI, intelligent agents, characteristics of intelligent systems, AI problem-solving approaches, applications of AI in engineering, opportunities and challenges of AI technologies.
2	Knowledge Representation and Search Techniques: Problem formulation, state space representation, uninformed search techniques, informed search techniques, heuristic search, knowledge representation methods, semantic networks, rule-based systems and expert systems.
3	Machine Learning Fundamentals: Introduction to machine learning, supervised and unsupervised learning, classification and regression concepts, clustering techniques, model evaluation, engineering applications of machine learning.
4	Neural Networks and Intelligent Systems: Artificial neural networks, perceptron model, multilayer neural networks, learning algorithms, deep learning concepts, fuzzy logic systems, neuro-fuzzy systems and intelligent decision-making techniques.
5	AI Applications in Engineering: AI applications in power systems, renewable energy systems, industrial automation, robotics, predictive maintenance, fault diagnosis, smart manufacturing, intelligent transportation systems, smart grids and emerging trends in AI.

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	0.83
CLO2	2	2	2	1	1	0	0	0	1	1	0	1	.916666666
CLO3	3	1	1	1	3	0	0	0	1	1	0	1	1
CLO4	2	3	1	2	3	0	0	0	1	1	0	1	1.166666667
CLO5	2	3	1	2	3	0	0	0	1	1	0	1	1.166666667
Avg PLO	2.4	2.0	1.2	1.4	2.2	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0

Suggested Reading

1	Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2	Elaine Rich and Kevin Knight, Artificial Intelligence, McGraw Hill.
3	S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning.
4	Simon Haykin, Neural Networks and Learning Machines, Pearson Education.
5	Ethem Alpaydin, Introduction to Machine Learning, MIT Press.
6	S. Kaushik and Sunita Jain, Artificial Intelligence, Cengage Learning.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Demonstrations of AI tools and engineering applications.
- Case studies on AI-based industrial and engineering solutions.
- Mini-projects involving AI-based problem-solving.
- 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

mHarish Raheen

Course Code	BELEOSC825				*Semester*	*Semester VIII*	
Course Title	Electrical Safety and Energy Conservation					*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 electrical hazards and safety requirements in domestic, commercial and industrial installations.
CLO2	Apply safe working practices and electrical protection techniques.
CLO3	Understand relevant electrical safety standards and regulations.
CLO4	Analyze energy consumption patterns and identify energy conservation opportunities.
CLO5	Evaluate energy-efficient technologies and sustainable energy management practices.

Syllabus

Units	Content
1	Fundamentals of Electrical Safety: Introduction to electrical safety, electrical hazards, effects of electric shock on the human body, causes of electrical accidents, safe working practices, safety procedures and personal protective equipment (PPE).
2	Electrical Protection and Safety Standards: Earthing and grounding systems, protection against electric shock, overcurrent and short-circuit protection, fuses, MCBs, ELCBs and RCCBs, electrical safety regulations, Indian Electricity Rules and safety standards.
3	Industrial and Domestic Electrical Safety: Safety in residential, commercial and industrial installations, electrical fire hazards, hazardous locations, maintenance safety, lockout-tagout procedures, first aid and emergency response during electrical accidents.
4	Energy Conservation Principles: Energy scenario and conservation, importance of energy efficiency, energy conservation techniques in electrical systems, energy-efficient motors, transformers, lighting systems and appliances, power factor improvement and demand-side management.
5	Energy Management and Sustainable Practices: Energy auditing basics, energy performance assessment, renewable energy for energy conservation, green buildings, sustainable energy management practices, energy conservation policies and case studies.

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	3	0	2	1	1	0	1	1.25
CLO2	2	2	2	1	1	0	0	0	1	1	0	1	.916666666
CLO3	3	1	1	1	1	3	0	2	1	1	0	1	1.25
CLO4	3	3	1	2	1	2	3	0	1	1	0	1	1.5
CLO5	2	3	1	2	3	2	3	0	1	1	3	1	1.833333333
Avg PLO	2.6	2.0	1.2	1.4	1.4	2.0	1.2	0.8	1.0	1.0	0.6	1.0	1.4

Suggested Reading

1	S. Rao, Electrical Safety, Fire Safety Engineering and Safety Management, Khanna Publishers.
2	B. L. Theraja and A. K. Theraja, A Textbook of Electrical Technology, S. Chand.
3	S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill.
4	Bureau of Energy Efficiency (BEE), Energy Conservation Building Code and Energy Efficiency Manuals.
5	Guide Books for National Certification Examination for Energy Managers and Energy Auditors, Bureau of Energy Efficiency.
6	John Cadick et al., Electrical Safety Handbook, McGraw Hill.

Teaching-Learning Strategies

- Interactive classroom lectures.
- Demonstrations of electrical safety equipment and protection devices.
- Case studies on electrical accidents and safety practices.
- Energy conservation audits and analysis exercises.
- 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	BELEOHR825				*Semester*	*Semester VIII*	
Course Title	Organisation of Engineering Systems and Human Resource 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	An understanding of the principles of Organisation of engineering systems & HR Management
CLO2	The ability to perceive issues from an overall management perspective.
CLO3	The means to analyse developments in an organisation's systems, functioning and capabilities
CLO4	The means to effectively understand organizational functioning and its human elements
CLO5	The ability to become a performance-oriented manager of systems

Syllabus

Units	**Content**
1	**Introduction to Organization of Engineering Systems and HR Management:** Introducing the core concepts of organisation and HRM.
2	**Organization Structure and Engineering Business Systems:** Basics of organizations and HR management: Understanding organizations: nature and functions, Concerns of organising engineering business and systems, Concerns of organising engineering business and systems, Structure and process issues in running organisations, Design issues in running organisations Operating organizations
3	**Organizational Effectiveness and Systems Approach:** Effectiveness and performance: Cybernetics and systems framework,Socio-technical systems, Dealing with efficiency and excellence, Man-machine relationship, Longitudinal Thinking.
4	**Human Resource Management in Engineering Organizations:** Human elements of functioning organizations: Recruitment and Concerns of recruitment, selection and its process, skill formation and redeployment, Employee engagement and retention.
5	**Leadership, Motivation and Industrial Relations:** Developing teams and leadership, Understanding motivation, Motivation theories and applications, Elements of HR planning, Indian Industrial Law and managing industrial relations

CLO-PLO Mapping Matrix

CLO/PLO	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**	**PLO12**	**Avg CLO**
CLO1	0	0	0	0	0	1	0	1	2	1	3	2	0.83
CLO2	0	1	0	0	0	1	0	1	2	2	3	2	1
CLO3	0	1	0	0	0	1	0	1	2	1	3	2	0.92
CLO4	0	0	0	0	0	1	0	2	3	2	3	1	1
CLO5	0	0	0	0	0	1	0	2	3	2	3	3	1.17
Avg PLO	0.0	0.4	0.0	0.0	0.0	1.0	0.0	1.4	2.4	1.6	3.0	2.0	1.0

Suggested Reading

1	The Heart of Enterprise by Stafford Beer (1975) — Penguin Press, London
2	The Future of Organisation: Achieving Excellence through Business Transformation by Colin Coulson-Thomas — Kogan Page
3	Cybernetics and Applied Systems by Constantin Virgil Negoita — CRC Press, USA
4	Business, Marketing, and Management Principles for IT and Engineering by Dimitris N. Chorafas — Taylor & Francis, USA
5	Comparative Manpower Planning Practices: Select Indian Experiences by Vinayshil Gautam — National Publishing House, New Delhi

Teaching-Learning Strategies

- Interactive classroom lectures.
- Case studies.
- 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

MAasish Raheen

Course Code	**BELEPMP825**				*Semester*	*Semester VIII*	
Course Title	**Major Project**					*Max marks*	
Scheme & Credits	*Hours Per Week*				*Credits*	*Theory*	*Practical*
	L	*T*	*P*	*Total*			
	0	0	12	12	12		100
Prerequisites	*Minor Project*					100	

Course Learning Outcomes (CLOs)

CLO1	Formulate a comprehensive, original engineering problem in electrical engineering with defined objectives, scope, and an in-depth literature review.
CLO2	Design a complete solution methodology, including system architecture and the theoretical, simulation, or experimental approach.
CLO3	Execute the design through implementation, integrating hardware, software, or simulation components as required.
CLO4	Rigorously test, validate, and analyze the developed system against the defined objectives and performance metrics.
CLO5	Communicate project outcomes through a comprehensive technical report, public demonstration, and viva-voce defense, while demonstrating professional and ethical project-management competence.

Syllabus

Units	Content
1	Problem Formulation and Comprehensive Literature Review: Identification of an original, substantial engineering problem; in-depth literature survey and critical review; gap analysis; formulation of objectives, scope and expected outcomes; feasibility and resource assessment.
2	System Design and Methodology: Detailed system architecture or theoretical framework; selection and justification of design methodology, tools and platforms; preparation of design specifications; risk assessment and mitigation planning.
3	Implementation: Development and integration of hardware/software/simulation components; iterative development with milestone-based progress reviews; troubleshooting and design refinement.
4	Testing, Validation and Performance Evaluation: Comprehensive testing protocols; validation against design specifications and objectives; performance evaluation using relevant metrics; comparative analysis with existing solutions or benchmarks.
5	Documentation, Demonstration and Viva-Voce: Preparation of the comprehensive project report as per the prescribed format; public demonstration of the working system or outcome; defense of the work through viva-voce before an expert committee; reflection on project management, ethics, and teamwork.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	2	3	2	2	2	1	1	0	1	2	1	2	1.58
CLO2	2	2	3	2	3	1	1	0	1	2	2	2	1.75
CLO3	2	2	3	3	3	1	1	1	2	2	2	2	2
CLO4	2	3	2	3	2	1	1	1	1	2	1	2	1.75
CLO5	1	2	1	1	1	2	1	2	3	3	3	3	1.916666667
Avg PLO	1.8	2.4	2.2	2.2	2.2	1.2	1.0	0.8	1.6	2.2	1.8	2.2	1.8

Suggested Reading

1	Relevant technical literature (journals, standards, patents) identified through the literature survey specific to the chosen project topic, in consultation with the supervisor.
2	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.

Teaching-Learning Strategies

- Regular supervisory guidance with documented progress reviews at defined milestones.
- Mid-semester evaluation before a departmental expert committee.
- Peer benchmarking and technical seminars on related work.
- Independent hands-on implementation, integration, and testing carried out under supervision.
- Comprehensive report writing, public demonstration, and viva-voce preparation.