Kavayitri Bahinabai Chaudhari
NORTH MAHARASHTRA UNIVERSITY, JALGAON (M.S.)

Syllabus for

Final Year Electrical Engineering

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
3rd Cycle

Syllabus Structure
Semester - VII and VIII
w. e. f. 2020 – 21

Syllabus Structure for Final Year Engineering (Semester – VII) (Electrical) (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Electrical Drives	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course -III	E	3	-	-	3	40	60	-	-	100	3
Professional Elective Course -IV	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course – III	F	3	-	-	3	40	60	-	-	100	3
Electrical Drives Lab	D	-	-	2	2	-	-	25	25(PR)	50	1
MATLAB and its applications	D	1	-	2	3	-	-	25	25(OR)	50	2
Project (Stage -I)	G	-	-	12	12	-	-	50	50(OR)	100	6
Essence of Indian Traditional Knowledge	H	-	-	-	-	-	-	-	-	-	-
		13		**16**	**29**	**160**	**240**	**100**	**100**	**600**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

Professional Elective Course – III		Professional Elective Course – IV		Open Elective Course – III	
1	Electrical Energy Conservation and Auditing	1	Power System Dynamics and Control	1	VLSI Design and Technology
2	Electrical Machines Modelling and Analysis	2	Power Electronics and Distributed Generation	2	Artificial Intelligence
3	Power Generation and Economics	3	Industrial Electrical Systems	3	Virtual Reality
4	Digital Control System	4	Power System Design Practice	4	Bio-Medical Instrumentation

Syllabus Structure for Final Year Engineering (Semester – VIII) (Electrical) (w.e.f. 2020 – 21)

Name of the Course	Group	Teaching Scheme				Evaluation Scheme					Credits
						Theory		Practical		Total	
		Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE	ESE	ICA	ESE		
Power System Protection	D	3	-	-	3	40	60	-	-	100	3
Professional Elective Course - V	E	3	-	-	3	40	60	-	-	100	3
Professional Elective Course -VI	E	3	-	-	3	40	60	-	-	100	3
Open Elective Course - IV	F	3	-	-	3	40	60	-	-	100	3
Power System Protection Lab	D	-	-	2	2	-	-	25	25(PR)	50	1
High Voltage Laboratory	D	2	-	2	4	-	-	25	25(OR)	50	3
Project	G		-	6	6	-	-	50	50(OR)	100	3
		14	**0**	**10**	**24**	**160**	**240**	**100**	**100**	**600**	**19**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

Professional Elective Course – V		Professional Elective Course – VI		Open Elective Course – IV	
1	Flexible AC Transmission System & Power Quality	1	Electric and Hybrid Vehicles	1	Digital Signal Processing
2	Power Converter Applications	2	Advanced Electric Drives	2	Embedded System
3	HVDC Transmission Systems	3	EHVAC Transmission Systems	3	Robotics
4	Power System Restructuring	4	Illumination Engineering	4	Cyber Security

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Syllabus for

Final Year Electrical Engineering

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
3rd Cycle

COURSE OUTLINE

Semester – VII

w. e. f. 2020 – 21

Electrical Drives					
COURSE OUTLINE					
Course Title:	**Electrical Drives**	**Short Title:**	**ED**	**Course Code:**	

Course description:

The course aims to give a broad view of Electrical Drive System. It is considered that students have prior knowledge of Electrical Machines and Power Electronics. The control principles for AC and DC motors fed converters are discussed. Principles of selection for AC DC motors are also discussed. Some of the applications related to AC and DC drives are also highlighted.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Electrical Machines, Control Systems, Power Electronics

Course objectives:

The main objective of the course is to: Analyze most of the widely used converters for ac and dc motors, Understand performance of converter fed AC and DC motors and its speed torque characteristics and learn various control methods for ac and dc drive.

Course outcomes:

After successful completion of this course the student will be able to:

1. Select a drive for a particular application based on power rating.
2. Select a drive based on mechanical characteristics for a particular drive application.
3. Operate and maintain solid state drives for speed control of DC and AC machines.
4. Operate and maintain solid state drives for speed control of various special electrical machines
5. Identify and select AC drives for different applications.

COURSE CONTENT

Electrical Drives		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 08 Hours	Marks: 12

Fundamentals of Electric Drive: Electric Drives and its parts, advantages of electric drives Classification of electric drives Speed-torque conventions and multi-quadrant operations Constant torque and constant power operation Types of load torque: components, nature and classification.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Dynamics of Electric Drive: Dynamics of motor-load combination Steady state stability of Electric Drive Transient stability of electric Drive Selection of Motor Power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of motor power rating for continuous duty, short time duty and intermittent duty. Load equalization.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12
Electric Braking: Purpose and types of electric braking, braking of DC, three phase induction and synchronous motors Dynamics during Starting and Braking: Calculation of acceleration time and energy loss during starting of DC shunt and three phase induction motors, methods of reducing energy loss during starting. Energy relations during braking, dynamics during braking.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Power Electronic Control of DC Drives: Single phase and three phase controlled converter fed separately excited DC motor drives (continuous conduction only), dual converter fed separately excited DC motor drive, rectifier control of DC series motor. Supply harmonics, power factor and ripples in motor current Chopper control of separately excited DC motor and DC series motor.		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Power Electronic Control of AC Drives: Three Phase induction Motor Drive: Static Voltage control scheme, static frequency control scheme (VSI, CSI, and cyclo – converter based) static rotor resistance and slip power recovery control schemes. Three Phase Synchronous motor: Self controlled scheme Special Drives: Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications.		
Text Books:		
1. G.K. Dubey, "Fundamentals of Electric Drives", Narosa publishing House, 2nd edition, 2002. 2. S.K. Pillai, "A First Course on Electric Drives", New Age International Publishers, 3rd edition, 2012. 3. B.N. Sarkar, "Fundamental of Industrial Drives", Prentice Hall of India Ltd., 2012.		
Reference Books:		
1. M. Chilkin, "Electric Drives", Mir Publishers, Moscow. 2. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore, 2nd edition, 2017. 3. N. K. De, Prashant K. Sen, "Electric Drives", Prentice Hall of India Ltd., 2014. 4. V. Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill, 1994.		

Electrical Energy Conservation and Auditing (Professional Elective Course – III)					
COURSE OUTLINE					
Course Title:	**Electrical Energy Conservation and Auditing**	**Short Title:**	**EECA**	**Course Code:**	

Course description: The course explores the knowledge of current energy Scenario, sources of primary energy and Scope of conservation in view of environment and climate change. This course provides knowledge of limited conventional energy generation, energy audit and conservation, Energy Conservation Act, energy efficient motors and other electrical gazed, scope of energy saving in domestic, industrial, agricultures sectors and demand side managements .Energy conservation is mandatory and answerable to next generation.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Course objectives: The Objectives of subject are to understand the need of energy audit and conservation, social and environmental cause as per Energy conservation Act. Students will able to know the methodology of energy audit for industries and priority of action plan Students will able to understand scope demand side management, energy efficient motor and energy conservation in motors, lighting and refrigeration. Students will able to do energy performance assessment of electrical installation and understand the financial analysis for energy audit like payback period.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the current energy scenario and importance of energy conservation in view of social and environmental cause.
2. Apply basic knowledge of engineering to understand need of energy audit, identify methods, and analyze technical and economic feasibility. Also able to summarize all possible suggestion for fruitful results.
3. Identify methods for energy management by IT tools including prediction and modeling to complex engineering problems, analyze the energy data and electric tariff for implementation of demand side management in every sector of consumer.
4. Conduct an investigation the consumption in motive, illumination, heating and cooling system for conserving electrical energy by professional and ethical way and able to solve complex engineering problems.
5. Apply appropriate techniques, resources, for analyzing performance assessment of motors. Cooling system, pumps and lighting system. Students also able to recognized the importance of financial analysis.

Electrical Energy Conservation and Auditing		
COURSE CONTENT		
Electrical Energy Conservation and Auditing	**Semester:**	**VII**
Teaching Scheme:	**Examination scheme**	

Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Energy Scenario and Scope of conservation: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, energy strategy for the future, Energy Conservation Act-2001 and its features. Progress made in energy conservation in India. Scope of energy conservation in different sectors

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Energy Audit: Principles of energy audit, type and methodology of energy audit: preliminary energy audit and detailed energy audit, procedures of carrying out energy audit, energy audit implementation priority, understanding energy cost, bench marking energy performance, fuel and energy substitution, energy audit report writing, instruments used for energy audit.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Energy Management : Concept of energy management ,review of load and utilization factors, bench marking, fuel and energy substitution , power factor improvement, power demand monitoring. Impact of electric tariff on energy management. Billing methods Concept of demand side management (DSM), scope of DSM, Load control methods, DSM planning and implementation, load management as DSM strategy Advantages of DSM to consumers, utility and society.

Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**

Energy Efficiency and Conservation: Motive power: potential for saving electrical energy in motors - over sizing or under loading, improving efficiency of an existing motor, energy efficient motor, use of variable or adjustable speed drives for energy conservation, effect of rewinding on performance and consumption. Transformer losses, energy efficient transformer and energy efficiency rating. Lighting: level of illumination for different areas. Use of right source of lamp for different applications, energy efficient lamps, energy conservation scope in lighting system Energy efficiency in air conditioning, control strategies and energy conservation opportunities

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Performance Assessment: Energy performance assessment of variable speed drives, performance terms, points for user, testing performance evolutions, format for data collection. Energy performance assessment of refrigeration and air conditioning system, performance terms, performance evolutions. Energy performance assessment of water pumps. Energy performance assessment of lighting system. Financial analysis.

Text Books:

1. Umesh Rathore, "Energy Management", S. K. Kataria and Sons, 2nd Edition, 2014.
2. S. C. Tripathy, "Electrical Energy Utilization and Conservation",Tata McGraw-Hill, 1991.

Reference Books:

1. Guide books for National Certification Examination for Energy Manager/Energy Auditors Book-1, General Aspects (online).
2. Guide books for National Certification Examination for Energy Manager/Energy Auditors Book-3, Electrical Utilities (online)
3. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)
4. B. E. Kushare, "Hand Book on Energy Efficient Motors", International Cooper Proposition Council.

Electrical Machines Modelling and Analysis (Professional Elective Course – III)						
COURSE OUTLINE						
Course Title:	**Electrical Machines Modelling and Analysis**		**Short Title:**	**EMMA**	**Course Code:**	
Course description:						
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**		
	03	**14**	**42**	**03**		
Prerequisite course(s):						
Electrical Machines-I and II						
Course objectives:						
The objective of this course is to provide the students In-depth understanding of generalized machine theory which forms the basis of Machine modelling. Explore the concept of transformation of variables to develop mathematical model of machines. It provides good initiation to develop Mathematical modelling and analysis. The concepts & techniques of Speed control of electrical machines which are essential for high performance drives. An in-depth exposure to the various equivalent circuits and their application to performance analysis of Electrical Machines.						
Course outcomes:						
After successful completion of this course the student will be able to: 1. Explain generalized theory of electrical machines 2. Apply linear transformations to Electrical machines. 3. Develop mathematical models of DC machines and its analysis under normal and perturbation. 4. Develop mathematical models of synchronous machines and its analysis under normal and perturbation. 5. Develop mathematical models of induction machines and its analysis under normal and perturbation.						
COURSE CONTENT						
Electrical Machines Modelling and Analysis			**Semester:**	**VII**		
Teaching Scheme:			**Examination scheme**			
Lectures:	**3 hours/week**		**End Semester Exam (ESE):**		**60 marks**	
			Duration of ESE:		**03 hours**	
			Internal Sessional Exams (ISE):		**40 marks**	
Unit–I:		**No. of Lectures: 09 Hours**		**Marks: 12**		
Basic Principles of Electrical Machine Analysis: Magnetically Coupled Circuits, Electromechanical Energy Conversion, Machine Windings and Air-gap MMF, Winding Inductances and Voltage equations, basic two pole machine, per unit system, transformer with movable secondary, analysis of electrical machine.						
Unit–II:		**No. of Lectures: 09 Hours**		**Marks: 12**		

Linear Transformation in Machines: Invariance of Power, transformation from a displaced brush axis, transformation from three phase to phase, transformation from rotating axis to stationary axis, physical concept of Park's transformation, apply generalized theory to electrical machines.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Modelling and Analysis of DC Machines: Separately excited dc generator and motor, interconnection of machines, transfer function of dc machine (DC Series and DC Shunt), linearization techniques for small perturbation and electrical braking of DC motor.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Modelling and Analysis of Synchronous Machine: Basic synchronous machine parameters, general machine equations, balance steady state analysis, steady state power angle analysis, short circuit ratio, transient analysis, transient analysis a qualitative approach, transient reactance and time constant from equivalent circuit, transient power angle characteristics.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Modelling and Analysis of polyphone Induction Machine : Electrical performance equations, analysis of equivalent circuit, torque slip characteristic, effect of voltage and frequency variation on performance, operation under unbalance, effect of space harmonics on performance and analysis.

Text Books:

1. P.S. Bimbhra, "The Generalised Theory of Electrical Machines", Khanna Publishers, 6th Edition, 2011.

Reference Books:

1. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 6th Edition, 2013.
2. E. Clayton, N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 3rd Edition, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 3rd Edition, 2002.
4. J. Nagrath, D. P. Kothari, "Electric Machines", McGraw Hill Education, 4th Edition, 2010.
5. P.C. Krause, "Analysis of Electric Machinery", McGraw Hill, NY, 3rd Edition, 1987
6. C.V. Jones, "The unified Theory of Electrical Machines", Butterworth-London, 1967
7. Dhar R.N., "Computer Aided Power System Operation and Analysis", Tata McGraw Hill

Power Generation and Economics (Professional Elective Course – III)					
COURSE OUTLINE					
Course Title:	**Power Generation and Economics**	**Short Title:**	**PGE**	**Course Code:**	

Course description:

This course provides an introduction to power generation by using conventional sources. This course covers the working, selection of site, different elements of various conventional power plants. This course also provides an introduction to the economics consideration of the power plants.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The objectives of this subject are that students will be able to understanding the working, selection of site, different elements, and general arrangement of Hydro Power plants, Thermal Power plants and Nuclear power plants. The objectives of this subject are that students will be able to understand cost analysis, effects of various loads on power system, load sharing. Choice of size and number of generating plants. The students will able to understand effect of power factor on power system and methods to improve power factor.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain the arrangement and operation of hydroelectric power plant.
2. Explain the arrangement and working of Thermal Power plants.
3. Explain the arrangement and working of Nuclear Power plant.
4. Define cost analysis of power plants.
5. Define effects of power factor on power system and methods for improving the power factor.

COURSE CONTENT

Power Generation and Economics		Semester:	VII
Teaching Scheme:		Examination scheme	
Lectures:	3 hours/week	End Semester Exam (ESE):	60 marks
		Duration of ESE:	03 hours
		Internal Sessional Exams (ISE):	40 marks

Unit–I:	No. of Lectures: 08 Hours	Marks: 12

Hydroelectric Power Plant: Hydrology, run off and stream flow, hydrograph, flow duration curve, Mass curve, reservoir capacity, dam storage. Hydrological cycle, merits and demerits of hydroelectric power plants, Selection of site. General arrangement of hydel plant, elements of the plant, Classification of the plants based on water flow regulation, water head and type of load the plant has to supply. Water

turbines– Pelton wheel, Francis, Kaplan and propeller turbines. Characteristic of water turbines Governing of turbines, selection of water turbines. Underground, small hydro and pumped storage plants. Choice of size and number of units, plant layout and auxiliaries.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Thermal Power Plant: Introduction, Efficiency of steam plants, Merits and demerits of plants, selection of site. Working of steam plant, Power plant equipment and layout, Steam turbines, Fuels and fuel handling, Fuel combustion and combustion equipment, Coal burners, Fluidized bed combustion, Combustion control, Ash handling, Dust collection, Draught systems, Feed water, Steam power plant controls, plant auxiliaries.

Diesel Power Plant: Introduction, Merits and demerits, selection site, elements of diesel power plant, applications.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Nuclear Power Plants: Introduction, Economics of nuclear plants, Merits and demerits, selection of site, Nuclear reaction, Nuclear fission process, Nuclear chain reaction, Nuclear energy, Nuclear fuels, Nuclear plant and layout, Nuclear reactor and its control, Classification of reactors, power reactors in use, Effects of nuclear plants, Disposal of nuclear waste and effluent, shielding.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Economics Considerations I: Introduction, classification of costs, Cost analysis of power plants. Interest and Depreciation, Methods of determination of depreciation- Diminishing Value or Declining method, Sinking fund method, Economics of Power generation, Effect of variable load on power system, different terms considered for power plants and their significance, load sharing. Choice of size and number of generating plants and numerical.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Economics Considerations II: Tariffs, objective, factors affecting the tariff, types. Types of consumers and their tariff. Power factor, disadvantages of low power factor, causes of low power factor, methods of power factor improvement, Location of Power factor correction equipment, Advantages of power factor improvement, economics of power factor improvement and comparison of methods of increasing power supplied, Choice of equipment.

Text Books:

1. B.R. Gupta, “Generation of Electrical Energy”, Eurasia Publishing House (Pvt.) Ltd, Seventh Edition, 2017.
2. J.B. Gupta, “A Course in Electric Power”, S.K. Kataria and Sons, Fourteenth Edition, 2013.

Reference Books:

1. Olle L. Elgerd, “Electrical Energy System Theory, An Introduction”, McGraw Hill, Second Edition, 2017.
2. D.P. Kothari, I.J. Nagrath, “Modern Power System Analysis”, Tata McGraw Hill Education, Fourth Edition, 2011.

3. William D. Stevenson, "Elements of Power System Analysis", Tata McGraw Hill, 4th Edition, 1985.
4. Leon K. Kirchmayer, "Economic Operation of Power Systems", Wiley India Pvt. Ltd, 2009.
5. C. L. Wadhwa, "Electrical Power System Analysis", New Age International Publication, Seventh Edition, 2017.
6. Hadi Saadat, "Power System Analysis", Tata McGraw Hill, 2nd Edition, 2009.
7. A. Chakrabarti, M.L. Soni, P.V. Gupta & U.S. Bhatnagar, "A Text Book on Power System Engineering", Dhanpat Rai & Co. limited, 2016.
8. S. N. Singh, "Electric Power Generation: Transmission and Distribution", PHI Learning, 2nd Edition, 2008.
9. Tanmoy Deb, "Electrical Power Generation", Khanna Publishing House, 1st Edition, 2018.
10. http://nptel.iitm.ac.in

Digital Control System (Professional Elective Course – III)					
COURSE OUTLINE					
Course Title:	**Digital Control System**	**Short Title:**	**DCS**	**Course Code:**	

Course description:

Digital control is a branch of control theory that uses digital computers as system controllers. This course provides the knowledge about the basic signals, state space analysis, different methods used for stability analysis. This course designed to introduce to the students basic design and Applications of Digital Control System.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Signals and systems, control system.

Course objectives:

Digital controllers are used in a wide variety of systems ranging from disk drives to aircrafts. Thus, it is very important to be well-versed in the analysis and design of digital control systems. The course objectives include equipping students with: 1. Understanding the various issues related to digital control systems such as effects of discrete time signals and models, 2. Design and implementation of digital controllers. The digital controllers will also take into account the practical implementation issues like aliasing and quantization to achieve the desired performance specifications.

Course outcomes:

After successful completion of this course the student will be able to:

1. To make students understand basic concepts of discrete signals and systems.
2. To understand the concept of state and to be able to represent a system in the state space format and to solve the state equation and familiarize with STM and its properties.
3. To educate students to analyze the stability of digital systems.
4. To be able to analyze and design a digital control system including realization of digital controllers.
5. To explore application of the theory of digital control to practical problems.

COURSE CONTENT

Digital Control System		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Discrete systems and Signals Standard discrete test signals, Basic operations on signals, Classification of discrete systems, Detail analysis of frequency aliasing & quantization, Brief review of Sampling theorem, Z-transform, Laplace transform and Fourier transform, Transfer function of ZOH, Frequency domain characteristics of ZOH.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

State - Space analysis: Solution of LTI Discrete –time state equation, State Transition Matrix (STM) and properties of STM, Computation of STM by Z-transform method, by power series expansion method, by Cayley Hamilton theorem, by Similarity transformation method, Discretization of continuous time state space equation.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Stability Analysis: Pulse transfer function, Mapping between S-plane and Z-plane, Stability analysis of closed loop system in the Z-Plane, Jury's stability test, Nyquist stability criteria, Lyapunov stability theorem, Stability analysis by use of Bilinear transformation & Routh-Hurwitz Stability Criterion, Digital compensator design using frequency response (Bode plot).

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Design of Digital Control System: Introduction to PID controller, individual effect of Proportional controller, Integral controller and Derivative controller on overall system performance, Concepts of Controllability and observability, Effect of pole- zero cancellation on controllability and observability of the system. Pole placement design by state variable feedback, Necessity of observer, Lead compensator design using Bode plot, Lag compensator design using Bode plot, Lag-lead compensator design in frequency domain.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Applications of Digital Control System: Digital temperature control - first order temperature system, process model, design of PID controller, control law for temperature control. Position control-position control system, position control system using speed feedback.

Text Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., 5th edition, 2015.
2. J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2009.

Reference Books:

1. Astrom Karl Johan and Wittenmark Bjorn, "Computer-Controlled Systems: Theory and Design", Prentice-Hall, 3rd Edition, 2011.
2. M. Gopal, "Digital Control Engineering", New age international pvt.ltd, 2nd Edition, 2014.
3. Kuo B. C., "Automatic Control System", Prentice Hall, 7th edition, 2001.

Power System Dynamics and Control (Professional Elective Course – IV)					
COURSE OUTLINE					
Course Title:	**Power System Dynamics and Control**	**Short Title:**	**PSDC**	**Course Code:**	

Course description:

Modern power systems have grown larger, expanding over wide geographical area. Interconnection of grids has led to more complex operational problems. Such large systems require very advance computing facilities and techniques. This course explores knowledge of economic load scheduling and dispatch. The course provides knowledge of power system operation and control, need and important, voltage and frequency control. The course also provides knowledge of steady state and transient stability of a power system.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The objectives of this course are to study about the economic load dispatch and optimal operation of power system. In this course knowledge of Automatic voltage control, excitation systems, static performance and dynamic response of AVR loops should be provided. The course objectives are to study about the Automatic load frequency control, Concept of control area. In this course we will try to understand how to assess the stability of a power system, how to improve the stability and finally how to prevent system becoming unstable.

Course outcomes:

After successful completion of this course the student will be able to:

1. Know the optimal load scheduling, function & operation of load dispatch centre for economic growth of electric utilities.
2. Know the concept of automatic voltage control, their mathematical modeling, static and dynamic analysis.
3. Know the concept of frequency control, mathematical modeling, static and dynamic response of single area system.
4. Describe steady state stability of a power system
5. Describe transient stability of a power system.

COURSE CONTENT

Power System Dynamics and Control	Semester:	VII
Teaching Scheme:	**Examination scheme**	

Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Economic Load Dispatch & Optimal Operation of Power System: Input Output characteristics, Heat-rate characteristics, Incremental fuel rate and cost, Incremental production cost, optimum scheduling of generation between different units. (Neglecting transmission losses), Transmission loss as a function of plant generation (A simple system connection two generating plants to load) and incremental transmission loss for optimum economy, Calculation of loss coefficients (Two plants system), Optimum scheduling of generation between different plants considering transmission loss concept and significance of penalty factor, Automatic load dispatch, function and applications.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Generator Voltage Control: Automatic voltage control, generator controllers, Cross coupling between P–f and Q–V control channel, automatic voltage regulator, types of exciters and excitation systems, exciter modeling, transfer function modeling for control static performance and dynamic response of AVR loops.

Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**

Load Frequency Control: Automatic load frequency control, speed governing system and hydraulic valve actuator for individual generator, Turbine modeling, generator and load modeling, transfer function representation of power control mechanism of generator. Load frequency of single areas power system with and without integral controls. Introduction to pool operation.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction: Meaning of stability, types of stability, rotor angle of synchronous machines, voltage and frequency stability

Steady State Stability: Steady state stability limit, Effects of losses on steady state stability, Effect of inertia on steady state stability, Effect of automatic voltage regulator, calculation of steady state stability limit, methods to improve SSSL.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Transient Stability: Meaning of transient stability, Sudden short circuit on synchronous machine and reactances. Assumptions made for swing equation, swing equation, shortcoming of classical model, Equal area criterion, Critical clearing angle and time, sudden short circuit on one of parallel transmission line, methods to improve transient stability.

Text Books:

1. Olle L. Elgerd, "Electrical Energy System Theory, An Introduction", McGraw Hill, Second Edition, 2017.
2. E.W. Kimbark, "Power System Stability", Vol. I, II, III, Wiley-Blackwell, 1995.

Reference Books:

1. D. P. Kothari, I. J. Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education, Fourth

Edition, 2011
2. William D. Stevenson, "Elements of Power System Analysis", Tata McGraw Hill, 4th Edition, 1985.
3. C. L. Wadhwa, "Electrical Power System Analysis", New Age International Publication, Seventh Edition, 2016
4. Dr. K. Uma Rao, "Power System Operation and Control", Wiley India Pvt. Ltd., 2012.
5. Aderson and Ford, "Power System Control and Stability", Wiley India Pvt. Ltd. Second Edition, 2008.
6. P. S. Bimbhra, "The Generalised Theory of Electrical Machines", Khanna Publishers, 6th Edition, 2011.
7. Peter W. Sauer and M A Pai, Joe H. Chow "Power System Dynamics and Stability", Wiley-IEEE Press, Second Edition, 2017.
8. http://nptel.iitm.ac.in

Power Electronics and Distributed Generation (Professional Elective Course – IV)

COURSE OUTLINE

Course Title:	**Power Electronics and Distributed Generation**	**Short Title:**	**PE&DG**	**Course Code:**	

Course description:

Introduction to distribution systems, distribution system equipment, grounding, sequence analysis and fault calculations, relaying requirements for Distributed Generation (DG) systems. Intentional and unintentional islanding, power converter topologies for grid interconnection, inverter modeling, filtering requirements. Selection of power converter components, DC bus designs, considerations for power loss and reliability in the design procedure, thermal cycling of power semiconductor modules, insulation grade selection, and thermal design implications. Control of grid interactive power converters, synchronization and phase locking techniques, current control, DC bus control, converter faults, grid parallel and standalone operation. Power quality, voltage unbalance, harmonics, flicker, voltage and frequency windows, and recent trends in power electronic DG interconnection.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Electric Power System, Power Electronics and Power System Protection

Course objectives:

1. Introduce the concept of distributed generation.
2. Investigate the technical challenges of Distributed Generation interconnection relaying and various power quality issues.
3. Analyze power converter design for the Distributed Generation.
4. Analyze the Semiconductor device selection in DG applications.
5. Investigate the various issues related to the protection, power quality, insulation ageing and filter designs for DG.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain the basics of distributed generation.
2. Analyze the use of different network distribution grids and impact of DG operation
3. Explain the use of Intentional and unintentional islanding systems for DG, their technologies and Control.
4. Interpret the performance analysis and life time estimation of power converters for DG.
5. Discharge professional duties in power industry with innovative ideas of operation and control of distributed generation.

COURSE CONTENT

Power Electronics and Distributed Generation	**Semester:**	**VII**

Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Distributed Generation (DG) - Overview and technology trends. Introduction to distribution systems. Radial distribution system protection: Fuse, circuit breakers, reclosers, sectionalizers. Per-unit analysis, fault analysis, sequence component analysis, sequence models of distribution system components. Implications of DG on distribution system protection coordination.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Power quality requirements and source switching using SCR based static switches. Distribution system loading, line drop model, series voltage regulators and on line tap changers. Loop and secondary network distribution grids and impact of DG operation. Relaying and protection, distributed generation interconnection relaying, sensing using CTs and PTs.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Intentional and unintentional islanding of distribution systems. Passive and active detection of unintentional islands, non detection zones. DG planning cost implications of power quality, cost of energy and net present value calculations and implications on power converter design. Power converter topologies and model and specifications for DG applications.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Capacitor selection, choice of DC bus voltage, current ripple, capacitor aging and lifetime calculations. Switching versus average model of the power converter and EMI considerations in DG applications. Semiconductor device selection, device aging due to thermal cycling, and lifetime calculations.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Issues in output ac filter design, filter inductor selection. Insulation aging issues. Packaging issues in the power converter. Calculation of damage due to thermal cycles. Thermal impedance models. Control of DG inverters; phase locked loops, current control and DC voltage control for standalone and grid parallel operations. Protection of the converter. Complex transfer functions, VSI admittance model in DG applications. Power quality implication, acceptable ranges of voltage and frequency, flicker, reactive power compensation, and active filtering and low voltage ride through requirements.

Text Books:

1. Math H. J. Bollen and Fainan Hassan, "Integration of Distributed Generation in the Power System", Wiley, 2018.

Reference Books:

1. Arthur R. Bergen, Vijay Vittal, "Power Systems Analysis", Pearson Education India, 2nd edition, 2009.

2. Ned Mohan, Tore M. Undeland, William P. Robbins "Power Electronics: Converters, Applications and Design", John Wiley & Sons, Third Edition, 2014.

Industrial Electrical Systems (Professional Elective Course – IV)

COURSE OUTLINE

Course Title:	**Industrial Electrical systems**	**Short Title:**	**IES**	**Course Code:**	

Course description:

The subject explores the knowledge of Electrical System Components, Residential and Commercial Electrical Systems, Illumination Systems, Industrial Electrical Systems: HT connection, Industrial Electrical System Automation. Recognize the need for technical change & ability to learn in the broadest knowledge of Technical Advancement in Electrical System, Illumination and other Applications.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Electrical Machines and mathematics

Course objectives:

To provide in-depth understanding of Electrical System Components, Residential and Commercial Electrical Systems, Industrial Electrical Systems: HT connection, industrial substation, Transformer selection, Role of Engineer in automation, advantages of process automation

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
2. Understand various terms regarding light, lumen, intensity, candle power, lamp efficiency, and specific consumption.
3. Understand various components of industrial electrical systems, Industrial loads, Switchgear selection
4. Analyze and select the proper size of Transformer.
5. Understand Role of in automation, PLC based control system design, Panel Metering

COURSE CONTENT

Industrial Electrical systems		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Electrical System Components: LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB,

inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

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

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

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

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

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

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Industrial Electrical System Automation: Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation

Text Books:

1. S. L. Uppal, G. C. Garg, "Electrical Wiring, Estimating & costing", Khanna publishers, 6th edition, 2008.

Reference Books:

1. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 1st edition, 2007.
2. S. Singh, R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 2nd edition, 2010.
3. J. B. Gupta, "Utilization of Electric Power & Electric Traction", S.K. Kataria & Sons, 2nd edition, 2014.
4. H. Joshi, "Residential Commercial and Industrial Systems", Volume I, McGraw Hill Education, 2008.

Power System Design Practice (Professional Elective Course – IV)					
COURSE OUTLINE					
Course Title:	**Power System Design Practice**	**Short Title:**	**PSDP**	**Course Code:**	
Course description:					
This course deals with design aspects of transmission and Distribution sector. Electric power systems including power flow analysis. The course has abundant information about tender filling requirements of various equipments along with their testing. The course sets high standards in corporate sector as it deals with on field concepts of power system.					

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	3	12	42	3

Prerequisite course(s):

Power System I, Power System II

Course objectives:

1. To educate students about the process of restructuring of power system
2. To familiarize students about the operation of power system
3. To teach students about designing concepts
4. To gain knowledge of fundamental concept of protection devices.
5. To analyze the terms required for tender filing.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze the aspects of designing various electrical systems
2. Model the distribution systems with complex technical constraints.
3. Identify different abnormal conditions and design protection system.
4. File the tenders for several power system sectors.
5. Classify different Earthing systems and design it.

COURSE CONTENT

Power System Design Practices		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**
Unit–I:		**No. of Lectures: 09 Hours**	**Marks: 12**
Design of Transmission System:			

Selection of insulation parameters, selection of voltage level, choice of type of conductor, Design aspects of Transmission systems(GMD and GMR), Characteristic impedance and its significance, Radio interference and transposition.
Mechanical design of transmission line, Sag, Tension, wind effect and ice loading.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Design of Distribution System:
Types of distribution system arrangements, Primary and secondary distribution design, calculation of distribution sizes: voltage drops, efficiency, voltage regulation, types of cables used, design of rural and industrial distribution systems.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Design of Protection Systems:
Operating mechanism, ratings and specifications, types of circuit breakers.
Operating mechanism, ratings and specifications, types of Lightning Arrestors.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Tenders Filing in Power System:
Special characteristics to be defined in tender filing of Circuit Breakers, Lightning Arrestors, Transformers, Cables, Shunt Capacitors.
Testing of Circuit Breakers, Lightning Arrestors, Shunt Capacitors.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Earthing Systems:
Need of Earthing, various ways of Earthing according to voltage levels.
Different Earthing done for transmission and distribution lines.
Earthing Systems- step potential, touch potential, transfer potential.

Text Books:

1. M. V, Deshpande, “Restructured E;lectrical Power System Design”, Tata McGraw Hill, 2014.
2. B. R. Gupta, “Power System Analysis and Design” S Chand & Company, 2005.

Reference Books:

1. Pratapsing Satnam, P. V. Gupta, “ Substation Design Equipments” Dhanpat Rai and Sons
2. K. B Raina and S. K. Bhattacharya, “Electrical Design-Estimation and Costing”, New age international publishers, 2007.

VLSI Design and Technology (Open Elective Course – III)					
COURSE OUTLINE					
Course Title:	**VLSI Design and Technology**	**Short Title:**	**VLSIDT**	**Course Code:**	
Course description:					
This course provides the basic knowledge necessary to understand how to simulate systems using hardware description languages. System here includes various digital logic circuits, such as adders, multiplexers, flip-flops, counters etc. VHDL is a hardware description language that can be used to model a digital system. It contains elements that can be used to describe the behavior or structure of the digital system. The language provides support for modeling the system hierarchically and also supports top-down and bottom-up design methodologies.					

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Course objectives:

VLSI Design provides fundamental concepts in classical manual digital design, design entry using hardware description language. It emphasizes the HDL-based design because it is the most efficient design method to use in practice. This subject describes in details the IEEE Standard VHDL language.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the modeling and design concepts of digital systems domains for different combinational and sequential circuits. Also understand the concepts of data-flow description in VHDL. Identify the signal assignment statement. Recognize the levels of modeling using VHDL.
2. Understand the concepts sequential statements and how differ from concurrent statement. Also identify the basic statement of behavioral description.
3. Understand the concepts of structural description, including the binding of modules.
4. Understand the concept of describing and simulating digital systems using transistors. Also identify the basic statements of switch-level package that matches the switch-level functions.
5. Understand the function of simulator, synthesizer and PLDs. Also the concepts of states and their implementation.

COURSE CONTENT

VLSI Design and Technology		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**

	Internal Sessional Exams (ISE):	**40 marks**
Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction: History of HDL: Brief history of VHDL. Structure of VHDL module: Structure of Entity/ Module, Port. Operators in VHDL: Logical, Relational, Arithmetic Shift and Rotate Operators. Data types of VHDL. Types of Architectures. Simulation and Synthesis and comparison between them. **Data-flow Description (VHDL):** Structure of Data-flow Description: Signal declaration and Signal assignment statements, Concurrent Signal assignment statements, Constant declaration and assignment statements, Assigning a delay to the signal assignment statements, VHDL Programming using Data-flow description.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Behavioral Description (VHDL): Structure of Behavioral Description for both VHDL. VHDL variable assignment statement. Sequential statements for VHDL: IF statement, Signal and variable (only for VHDL) assignment, Case statement, Loop statement. VHDL Programming using Behavioral description. Procedures and Functions (VHDL).		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Structural Description (VHDL): Organization of structural design, Binding, State machines, Generic (VHDL), VHDL Programming using Structural description.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Switch-Level Description (VHDL): Single NMOS and PMOS switches: NMOS and PMOS switch description for VHDL, Serial and parallel combinations of switches. Switch level description of: Primitive gates, Combinational logics, Sequential circuits. CMOS switch. Bidirectional switches. Mixed-Type description.		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Finite state machine: Moore machine, Mealy machine, State diagram, State table, State Assignment. **Programmable Logic Devices:** Architectures of Xilinx 9500 series CPLD, Xilinx Spartan 4000 series FPGA. **Testing of Logic Circuits:** Fault model, path sensitizing, random test. Design of testability, BIST (Built-in-self-test), Boundary scan test.		
Text Books:		
1. Nazeib M. Botros, "HDL programming Fundamentals VHDL and Verilog", Second Indian Edition, DA Vinci Engineering Press, Hingham, Massachusetts, 2011. 2. Stephen Brown and Zvonko Vranesic, "Fundamentals of Digital Logic with VHDL design", McGraw Hill Education (India) Private Limited, New Delhi, Third Edition, 2012. 3. J. Bhaskar, "A VHDL Primer", Pearson, Third Edition, 2006.		
Reference Books:		
1. John F. Wakerly, "Digital Design, Principles and Practices", Pentice Hall Publication, 4th edition, 2007.		

2. Douglas L. Perry, "VHDL: Programing by example", Tata MC-Graw Hill, New Delhi, Fourth Edition, 2005.
3. Volnei A. Pedroni, "Circuit Design with VHDL", Prentice-Hall of India Private Limited, New Delhi, 2nd edition, 2011.
4. Xilinx data manual, The Programmable Logic data Book.

Artificial Intelligence (Open Elective Course – III)					
COURSE OUTLINE					
Course Title:	**Artificial Intelligence**	**Short Title:**	**AI**	**Course Code:**	
Course description:					
It is to introduce the students to the fundamentals of Artificial Intelligence, NLP and Neural Networks and enable them to apply these concepts for solving real world problems.					
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	03	**14**	**42**	**03**	
Prerequisite course(s):					
Course objectives:					
1. To understand AI Problem and AI Techniques. 2. To learn heuristic search techniques in AI 3. To learn various ways to represent knowledge in AI 4. To understand planning and game playing strategies in AI 5. To understand basics of Neural Networks					
Course outcomes:					
After successful completion of this course the student will be able to:					
1. Apply AI techniques to solve different AI problems. 2. Apply appropriate search algorithms to solve AI problems. 3. Use different knowledge representational strategies to represent an AI problem. 4. Apply appropriate algorithm for game playing. 5. Understand the role of neural networks in AI.					
COURSE CONTENT					
Artificial Intelligence			**Semester:**	**VII**	
Teaching Scheme:			**Examination Scheme:**		
Lectures:	**3 hours/week**		**End Semester Exam (ESE):**		**60 marks**
			Duration of ESE:		**03 hours**
			Internal Sessional Exam (ISE):		**40 marks**
Unit–I		**No. of Lectures: 09 Hours**		**Marks: 12**	
Introduction to Artificial Intelligence: Definitions of Artificial Intelligence, AI Problems, AI Techniques Defining Problem as a State Space Search: 8 Queens Problem / 8 Puzzle Problem and its solution using production system, Water Jug problem and its solution using production system.					
Unit–II		**No. of Lectures: 09 Hours**		**Marks: 12**	

Heuristic Search in AI

Breadth First Search, Depth First Search

Best First Search: OR Graph, A* Algorithm

Problem Reduction: AND-OR Graph, AO* Algorithm

Unit–III	No. of Lectures: 08 Hours	Marks: 12

Knowledge Engineering:

Knowledge Representation Issues

Knowledge Representation Schemes: Logical Knowledge Representation, Procedural Knowledge Representation, Structural Knowledge Representation

Unit–IV	No. of Lectures: 08 Hours	Marks: 12

Planning and Game Playing:

Planning, Types of Planning

Goal Stack Planning: Overview, Block World Problem

Game Playing: Game Tree, Min Max Search Algorithm

Unit–V	No. of Lectures: 08 Hours	Marks: 12

Neural Networks:

Biological Neural Network, Artificial Neural Network, Difference between Biological and Artificial Neural Network, Types of Artificial Neural Network, Models of Neuron: McCulloch-Pitts Model, Perceptron, Adeline Topology

Text Books:

1. Elaine Rich, Kevin Knight, Shivshankar Nair "Artificial Intelligence". 3rd Edition, TMH.
2. B. Yegnanarayana “Artificial Neural Networks”, PHI, 2006.

Reference Books:

1. S. Rajasekaran, G.A. Vijayalakshmi, “Neural Networks, Fuzzy Logic, and Genetic Algorithms”, PHI, 2013.
2. Timothy J Ross, “Fuzzy Logic with Engineering Application”, Wiley, 3rd edition, 2010,
3. Dan W. Patterson, “Introduction to artificial intelligence and expert system”, PHI, 1st edition, 2015.

Virtual Reality (Open Elective Course – III)					
COURSE OUTLINE					
Course Title:	**Virtual Reality**	**Short Title:**	**VR**	**Course Code:**	
Course description:					
Virtual Reality (VR) is the use of computer technology to create a simulated environment. In the simulated artificial environment, the user is able to explore the various artifacts and proceedings as they might in the real world.					
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	03	**14**	**42**	**03**	
Prerequisite course(s):					
Course objectives:					
1. To understand Virtual Reality and Virtual environment. 2. To know Different illumination models. 3. To understand Geometric Transformation 4. To Know about Virtual Hardware and Software 5. To learn Virtual Reality applications.					
Course outcomes:					
After successful completion of this course the student will be able to:					
1. Describe Virtual Reality and Virtual environment. 2. Explain different illumination models. 3. Use Geometric Transformations for creation of various geometric objects 4. Explain Virtual Hardware and Software 5. Analyze Virtual Reality applications.					
COURSE CONTENT					
Virtual Reality			**Semester:**	**VII**	
Teaching Scheme:			**Examination Scheme:**		
Lectures:	**3 hours/week**		**End Semester Exam (ESE):**	**60 marks**	
			Duration of ESE:	**03 hours**	
			Internal Sessional Exam (ISE):	**40 marks**	
Unit–I:	**No. of Lectures: 09 Hours**		**Marks: 12**		

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark, 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Simple 3D modeling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image. Geometric Modeling: Introduction, From 2D to 3D, 3D boundary representation.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Geometrical Transformations: Introduction, Frames of reference, Modeling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection. Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, VR Systems.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Animating the Virtual Environment: Introduction, The dynamics of numbers, shape & object inbetweening, free from deformation, particle system. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modeling virtual world, Physical simulation, VR toolkits, Introduction to VRML.VR Applications: Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction.

Text Books:

1. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2011.

Reference Books:

1. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
2. Grigore C. Burdea, Philippe Coiffet, "Virtual Reality Technology", Wiley Inter Science, 2nd Edition, 2006.
3. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2nd edition, 2018.

Bio-Medical Instrumentation (Open Elective Course – III)

COURSE OUTLINE

Course Title:	**Bio-Medical Instrumentation**	**Short Title:**	**BMI**	**Course Code:**	

Course description:

This course provides knowledge about biomedical instruments used in medical application medical recording and monitoring at patient monitoring system.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Course objectives:

1. To introduce the electrical engineering students with biomedical measurement in patient monitoring system.
2. To understand operation of various electrical transducer for medical measurement
3. To study the patient Monitoring system and importance of Patient Safety related with electric shock hazards.
4. To understand principle and operation of instrument for blood pressure and cardiac measurement.
5. To study the modern imaging system and Electrotherapy equipment.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the importance of biomedical measurement in patient monitoring system.
2. Understand the application of the electronic systems in medical applications.
3. Understand and able to interpret the signals like ECG, EMG and EEG.
4. Understand the blood pressure measurement, causes of cardiac failure and remedies for cardiac failure.
5. Understand operation and applications of modern imaging system and Electrotherapy equipment in medical diagnosis.

COURSE CONTENT

Bio-Medical Instrumentation		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures: 03	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**

	Internal Sessional Exams (ISE):	**40 marks**
Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**
Bioelectric signals: Brief introduction to human physiology, Biochemical system, Cardiovascular system, Respiratory system, Nervous system. Origin of bioelectric Signals ECG, EEG, EMG. Electrode Tissue interface, Metal Electrolyte interface, Electrolyte Skin interface, Recording electrode for ECG- Floating electrode, Limb electrode. Electrode for EEG, Electrode for EMG.		
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Transducers and Biomedical Recorder: Pressure transducer-LVDT, strain gage transducer. Transducer for Temperature measurement, Thermocouples, Thermometer, Thermistor. Pulse sensor-Photo Electric pulse sensor. Recording Systems-Basic recording system, General consideration for bioelectric recorder amplifier, Sources of noise in low level recording system.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
Patient Monitoring and Patient Safety: ECG machine, isolated amplifier in ECG machine. EEG machine, EMG machine. Patient monitoring system- Bedside monitor, Patient Safety-Electric shock hazards, Leakage currents, Precautions to minimize Electric shock hazards, Types of Leakage currents, Methods to reduce Leakage currents, Test instruments for checking safety parameter of biomedical equipment.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Biomedical Measurement and Therapeutic Equipments: Measurement of heart rate, Average heart meter. Instantaneous heart rate meter. Blood pressure measurement-Direct method, Indirect method of blood pressure measurement - korotkoff' method, Rheographic method. Cardiac pacemakers-External pacemakers, implantable pacemakers, programmable pacemaker. Cardiac defibrillators-DC defibrillators, Defibrillator electrode.		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Modern imaging system and Electrotherapy Equipment: Properties of x-ray, units of X-ray, production of x-Rays, x ray machine, X-ray image intensifier television system. Computed Tomography Principle, System component. Electrotherapy equipment-Shortwave diathermy machine Microwave diathermy machine, ultrasonic diathermy machine.		
Text Books:		
1. Leslie Cromwell, Fred J. Weibell, Erich Pfeiffer, "Biomedical Instrumentation and Measurement", PHI, Eastern Economy Edition, Second edition, 2003. 2. John. G. Webster, "Medical Instrumentation, Application and Design", John Wiley and sons publication, Fourth Edition, 2010.		
Reference Books:		
1. R. S. Khandpur, Hand book of biomedical Instrumentation, , Tata McGraw Hill publishing Company limited, Third Edition, 2014.		

Electrical Drives Laboratory					
LAB COURSE OUTLINE					
Course Title:	**Electrical Drives Laboratory**	**Short Title:**	**EDL**	**Course Code:**	
Course description:					
The course aims to give a practical exposure to Electrical Drive System. It is considered that students have prior knowledge of Electrical Machines and Power Electronics. The control techniques for AC and DC motors fed converters are discussed. Different applications related to AC and DC drives are also highlighted.					
Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	02	**14**	**28**	**01**	
End Semester Exam (ESE) Pattern:		**Practical (PR)**			
Prerequisite course(s):					
Electrical Machines, Control System, Power Electronics					
Course objectives:					
The object is to select proper motor for given load characteristic. Selection of motor based on load characteristic, electrical, mechanical characteristic and service duty. The practical also provides the knowledge of electric drives, operation and control of electrical drives. The subject provides brief knowledge of four quadrant operation of drives.					
Course outcomes:					
Upon successful completion of lab Course, student will be able to:					
1. Apply the knowledge of electrical engineering subjects in different application of industries like manufacturing, maintenance, operation and safety. 2. Understand different speed control methods in D.C and A.C motors using thyristors based control schemes. 3. Understand the characteristic of load and selection of derive in industrial sectors. 4. Conduct practical and analyze data for proper selection of derive in realistic constrain of load requirement. 5. Understand the impact of electrical characteristic of motor in electric traction system.					
LAB COURSE CONTENT					
Electrical Drives Laboratory		**Semester:**	**VII**		
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**End Semester Exam (ESE):**		**25 marks**	
		Internal Continuous Assessment (ICA):		**25 marks**	
Teacher should facilitate learning following lab experiments:					

1. Determination of Speed Torque characteristic of d.c. motor controlled using single phase half controlled rectifier.
2. Determination of Speed Torque characteristic of d.c. motor controlled using single phase fully controlled rectifier.
3. Performance analysis of one quadrant chopper control of d.c. motor.
4. Performance analysis of two quadrant chopper control of d.c. motor.
5. Speed control of single phase induction motor using a.c. voltage regulator.
6. Study of stepper motor drive circuit.
7. Speed control of universal motor.
8. Study of closed loop control of d.c. motor.
9. Study of vector control method for induction motor.
10. Study of reversible drives

Note: Lab file should consist of minimum Eight experiments.

Text Books:

1. G.K. Dubey, "Fundamentals of Electric Drives", Narosa publishing House, 2nd edition, 2002.
2. S.K. Pillai, "A First Course on Electric Drives", New Age International Publishers, 3rd edition, 2012.
3. B.N. Sarkar, "Fundamental of Industrial Drives", Prentice Hall of India Ltd., 2012.

Reference Books:

1. M. Chilkin, "Electric Drives", Mir Publishers, Moscow.
2. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore, 2nd edition, 2017.
3. N. K. De, Prashant K. Sen, "Electric Drives", Prentice Hall of India Ltd., 2014.
4. V. Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill, 1994.

Guide lines for ICA:

ICA shall be based on continuous evaluation of student performance throughout semester and practical assignment submitted by the student in the form of journal.

Guidelines for ESE:

ESE will be based on the Laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work, performance and understanding.

MATLAB and its Applications					
LAB COURSE OUTLINE					
Course Title:	**MATLAB and its Applications**	**Short Title:**	**MATLAB LAB**	**Course Code:**	

Course description:

The objective of this course is to introduce the students to the fundamental concepts of MATLAB and enable them to apply these concepts for solving real world problems. This course includes the basic structure and statements required for simple mathematical problems in MATLAB. This course provides the basic concepts of plot and other useful tools required to solve the problems.

	Hours/week	No. of weeks	Total hours	Semester credits
Lecture	**01**	**14**	**14**	**02**
Laboratory	**02**	**14**	**28**	

End Semester Exam (ESE) Pattern: **Oral (OR)**

Prerequisite course(s):

Basic sciences, mathematics and subjects of Electrical Engineering, C and C++

Course objectives:

1. To familiarize the student in introducing and exploring MATLAB/Simulink.
2. To enable the student on how to approach for solving Engineering problems using simulation tools.
3. To prepare the students to use MATLAB/Simulink in their project works
4. To provide a foundation in use of this softwares for real time applications.
5. To use the MATLAB/Simulink for solving complex engineering problems.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Implement small and medium programs of varying complexity using the most commonly used features of the language.
2. Employ good programming style, standards and practices during program development.
3. Solve the different numerical techniques and perform Matrix operations
4. Understand and use of MATLAB/Simulink for solving simple electrical engineering problems.
5. Use modern engineering tools in MATLAB/Simulink which are useful for analyzing and designing of electrical power system

LAB COURSE CONTENT

MATLAB and its Applications		**Semester:**	**VII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**1 hours/week**	**End Semester Exam (ESE):**	**25 marks**
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA):**	**25 marks**

Theory:

Unit–I: Introduction to Matlab/Simulink

Standard Matlab windows, Operations with variables: naming, checking existence, clearing and operations, Arrays: columns and rows: creation and indexing, size & length, multiplication, division, power and operations.

Unit–II: Writing script

Writing script files: logical variables and operators , flow control and loop operators

Writing functions: input/output arguments, function visibility, path and Matlab Startup Simple graphics : 2D and 3D plots and figures and subplots

Unit–III: Data and data flow in Matlab

Data types: Matrix, string, cell and structure, creating, accessing elements and manipulating of data of different types. File Input-Output: Matlab files, text files, binary files, mixed text-binary files.

Unit–IV: Introduction to Simulink

Simulation steps, Types of mathematical model, developing a model, Simulink solution of differential equation, solvers, Assigning variables, Observing variable during simulation. Storing or saving data, linking script file with model file, Data import/export, Creating and masking subsystems

Unit–V: Applications of MATLAB/Simulink

Simulation of R-L-C series circuit, Finding laplace transform and inverse laplace transform using MATLAB, Step response using MATLAB, Root locus and Bode plot, Simulation of Single phase half wave and full wave rectifiers, battery charger, Effect of source inductances, Simulation of controlled converters and AC voltage controller.

Teacher should facilitate learning following lab experiments:

1. A. Simple Arithmetic Calculation: Perform simple arithmetic calculations:
    a. Addition, subtraction, multiplication, division and exponentiation.
    b. Assign values to variables.
    c. Suppress screen output.
    d. Control the appearance of floating point numbers on the screen.
2. Create: Simple sine plot, line plot, an exponentially decaying sine plot, space curve, log scale plot, Overlay plot and Fancy plots.
3. Write a program to find transient response in RC and RL circuit.
4. Write a program to plot voltage and current in inductive and capacitive circuit
5. Build a simple circuit with Power System blocks and connect it to other Simulink Blocks
6. Create an electrical subsystem, simulate transients, and discretize simple circuits
7. Single phase fully controlled converter using R and RL load using MATLAB /Simulink.
8. Single phase AC voltage regulator using MATLAB / SIMULINK
9. Step response without and with derivative control
10. Obtain the step and ramp response of the control system.

Note: Lab file should consist of minimum **Eight** experiments.

Text Books:

1. Dr. Shailendra Jain, “Modeling & Simulation using MATLAB-Simulink”, Wiley India, 2013.

2. Rudra Pratap, "Getting Started With Matlab: A Quick Introduction For Scientists And Engineers" Oxford University Press, 2011.

Reference Books:

1. Using MATLAB Graphics, Version 10, The Math Works, Inc., 2012.
2. MATLAB Release Notes for Release 12, The Math Works, Inc., 2012.
3. Sivanandam S.N., Sumathi S., Deepa S. N., "Introduction to Fuzzy Logic using MATLAB", Springer-Verlag Berlin Heidelberg, 1st edition, 2007.
4. S. Sivanandam, S. Sumathi, "Introduction to Neural Networks Using MATLAB", McGraw Hill Education, 1st Edition, 2017.

Guide lines for ICA:

ICA shall be based on continuous evaluation of student performance throughout semester and practical assignment submitted by the student in the form of journal.

Guidelines for ESE:

ESE will be based on the Laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work, performance and understanding.

Project (Stage – I)					
LAB COURSE OUTLINE					
Course Title:	**Project (Stage – I)**	**Short Title:**	**PROJ-SI**	**Course Code:**	
Course description:					
Project represents the culmination of study towards the Bachelor of Engineering degree. The project offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.					
Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	12	**14**	**168**	**06**	
End Semester Exam (ESE) Pattern:			**Oral (OR)**		
Prerequisite course(s):					
Course objectives:					
1. To understand the basic concepts & broad principles of projects. 2. To understand the value of achieving perfection in project implementation & completion. 3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach. 4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.					
Course outcomes:					
Upon successful completion of lab Course, student will be able to:					
1. Demonstrate a sound technical knowledge of their selected project topic. 2. Undertake problem identification, formulation and solution. 3. Design engineering solutions to complex problems utilizing a systems approach. 4. Conduct an engineering project 5. Demonstrate the knowledge, skills and attitudes of a professional engineer.					
LAB COURSE CONTENT					
Project (Stage – I)		**Semester:**		**VII**	
Teaching Scheme:		**Examination scheme:**			
Practical:	**12 hours/week**	**End Semester Exam (ESE): (OR)**		**50 marks**	
		Internal Continuous Assessment (ICA):		**50 marks**	
At the final year the students shall carry out a project in a group of maximum up to 5 students. The project work spans both the semesters. By the end of Semester – VII the students shall complete the partial work,					

and by the end of Semester – VIII the students shall complete remaining part of the project. Assessment for the project shall also include presentation by the students. Each teacher can guide maximum 04 groups of projects.

The students should take project work, as specified in the curriculum, based on the knowledge acquired by the students during the degree course till Semester – VI and/or during Internship. The project shall involve both theoretical and practical work to be assigned by the Department. The work may also be on specified task or project assigned to the students during Internship or R & D work.

Project (Stage – I) may involve literature survey, problem identification, work methodology preparing specification and material procurement, collection of data etc. The project work shall involve sufficient work so that students get acquainted with different aspects of fabrication, design or analysis. Approximately more than 50% work should be completed by the end of Semester – VII. Each student group should submit partial project report in the form of thermal bound at the end of Semester –VII.

Each student group is required to maintain separate log book for documenting various activities of the project.

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge / skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Project (stage – I) in Semester – VII shall be as per the guidelines given in Table – 1.

Table – 1

		Assessment by Guide					**Assessment by Departmental Committee**		
Sr. No.	Name of the Student	Attendance / Participation	Problem Identification / Project Objectives	Literature Survey	Methodology / Design	Report	Depth of Understanding	Presentation	Total
	Marks	5	5	5	5	5	10	15	50

Guidelines for ESE:

In End Semester Examination (ESE), the student may be asked for presentation/demonstration and questions on Project. Evaluation will be based on answers given by students in oral examination.

Essence of Indian Traditional Knowledge

Course objective:

The course aims at imparting basic principles of thought process, reasoning and inferencing, sustainability is at the core of Indian traditional knowledge system connecting society and nature. Holistic life style of yogic science and wisdom capsules in Sanskrit literature are also important in modern society with rapid technological advancements and societal disruptions. The course focuses on introduction to Indian knowledge systems, Indian perspective of modern scientific world-view, and basic principles of yoga and holistic health care system, Indian artistic tradition.

Outcomes:

Ability to understand, connect up and explain basics of Indian traditional knowledge in modern scientific perspective.

Course Contents:

Introduction to:

1. Ayurveda, Charaka Samhita, Sushruta Samhita
   Principles and Terminology: Vatha, Pitha, Kapha, Ether, Earth, Water, fire and Air Tatva, Influence of these on human health.
2. Architecture: Temple Architecture, Indo – Islamic Architecture, Mughal Architecture, Indian Rock Cut Architecture, Vastu Shastra.
3. Importance of Yoga for Physical and Mental health, Yoga Sutras of Patanjali, Meditation, International day of Yoga.
4. Indian Classical Music, Hindustani and Carnatic Music, Raga, Tala, Dhrupad, Khyal, Tarana and Thumri, Sangitaratnakara, Work of Tansen, Purandara Dasa, Bhimsen Joshi, Ustad Bismillah Khan, Bal Gandharva etc.
   Folk Music and Dances such as Rajasthani, Marathi, Gujrati, Punjabi etc.
5. Indian Classical Dances: Shastriya Nritya, Natya Shastra, Bharatanatyam, Kathak, Kuchipudi, Odissi, Kathakali, Sattriya, Manipuri, Mohiniyattam and Chhau dance forms.

References:

1. Amit Jha, “Traditional knowledge system in India”, Atlantic Publisher, ISBN 978812691223
2. Basanta Kumar Malhotra, “Traditional Knowledge System and Technology in India”, Pratibha Prakashan, ISBN 8177-023101
3. Nitin Singhania, “Indian Art and Culture”, McGraw Will Publication.
4. Dr. Bramhand Tripathi, “Charak Sanhita”, Chaukhambha Surbharti Prakashan, ISBN: 9381-4847-59
5. Dr. Anantram Sharma, “Sushrut Samhita”
6. Valiatham M.S., “An Introduction to Ayurveda” Orient Bkackswan Publication.
7. Valiathan M.S., “The legacy of Charaka” University Press.
8. Valiathan M.S., “The legacy of Susruta” University Press.
9. Garg Maheshwari, “Ancient Indian Architecture”, CBS Publisher and Distributors
10. Sharmin Khan, “History of Indian Architecture”, CBS Publisher and Distributors.
11. Bindia Thapar, Surat ku. Manto, Suparana Bhalla, “Introduction to Indian Architecture”, Periplus Editions Ltd.
12. Vijay Prakash Singh, “An Introduction to Hindustani Classical Music”, Lotus Publisher
13. Leeta Venkataraman, Avinash Pasricha, “Indian Classical Dance” Lustre Publisher
14. Shovana Narayan, “Indian Classical Dances” New Dawn Press
15. Kapila Vatsyayan, “Indian Classical Dance”, Ministry of Information and Broadcasting, Govt of India.
16. Mahadevan Ramesh, “A Gentle introduction to Carnatic Music”, Oxygen books Publisher.

Kavayitri Bahinabai Chaudhari NORTH MAHARASHTRA UNIVERSITY, JALGAON (M.S.)

Syllabus for

Final Year Electrical Engineering

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
3rd Cycle

COURSE OUTLINE

Semester – VIII

w. e. f. 2020 – 21

Power System Protection					
COURSE OUTLINE					
Course Title:	**Power System Protection**	**Short Title:**	**PSP**	**Course Code:**	

Course description:

A protection scheme in a power system is designed to continuously monitor the power system to ensure maximum continuity of electrical supply with minimum damage to life, equipment and property. The subject explores the knowledge of arc interruption, different type of circuit breakers and relay. This knowledge is help full for understanding the characteristic feature and proper selection of protective elements in different protective scheme. The subject also provides knowledge different protection for major and individual power system elements.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The objectives of subject are that students will able understanding the fault characteristic of individual power system elements. One should also be knowledgeable about the tripping characteristics of various protective relays. The students able to understand the job of protection engineer is to devise such scheme where closest possible match between the fault characteristic and tripping characteristic is obtained. The students will able to understand protected zone and able to design protective scheme such that relay will detect undesirable conditions and then trip to disconnect the area affected, but remain restrained at all other time. Student should be equipped with sound concept of power system protection to enable those handling unforeseen circumstances in real life.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply the basic knowledge of science for understanding arc generation and interruption in medium and high voltage circuit.
2. Discuss construction operation and specifications of different circuit breakers used in power system.
3. Define basic relay and their role in protection system.
4. State relay based on modern techniques and their role in protection scheme.
5. State different protection scheme used in power system.

COURSE CONTENT

Power System Protection		Semester:	VIII
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**

	Duration of ESE:	**03 hours**
	Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Arc Phenomena and Interruption: Basic requirement of Switching and protection, arc phenomenon, maintenance of arc, properties of arc, interruption theories, transient recovery Voltage, transient analysis, RRRV, Interruption of capacitive current, current chopping.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Circuit Breakers and Fuses: Construction & Operation, class, breaking capacity, characteristic and application of: Minimum oil circuit breaker, air blast circuit breaker, SF6, Vacuum Circuit Breaker, Earth leakage & Miniature circuit breaker, HRC fuses and HVDC circuit breaker.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Protective Relay-I: Protection system and its attributes: sensitivity, selectivity, speed, reliability and dependability, trip circuit, organization of protection, zones of protection and maloperation. Construction, working and characteristic features of electromagnetic relay: Over current, instantaneous over-current, definite time over-current, inverse time over-current relay, directional over current relay and differential relay.

Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**

Protective Relay-II: Construction, working and characteristic features of electromagnetic relay: Impedance relay, reactance relay, Mho relay and their trip law using universal torque equation. Static Over current relay: Single and double actuating quantity relay, basic principle of static over current relay and directional over current relay.

Evolution Digital relay: basic component of digital relay, digital sub units digital relay as unit. Microprocessors based relay, block diagram, relay for motor and advantages.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Protection Schemes: Different type of protective scheme: Over current protection, Differential protection, earth fault protection, distance protection and carrier aided protection. Protective scheme for generator, transformer, bus-bar, transmission line and motor.

Text Books:

1. Sunil S. Rao, "Switchgear Protection and Power Systems", Khanna Publishers, 14th edition, 2019.

Reference Books:

1. Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", PHI Publications, Second Edition, 2013.
2. T.S. Madharao, "Power System Protection: Static Relays with Microprocessor Applications", Tata McGraw Hill, Second Edition, 2017.
3. B. Ravindranath, M. Chandar, "Power System Protection & Switchgear", New Age International Publishers, Second Edition, 2018.

4. B. Ram, D.N. Vishwakarma, "Power System Protection & Switch Gear", Mc Graw Hill Education, Second Edition, 2017.
5. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", Wiley Blackwell Publications, Third Edition,.2008.
6. J.B. Gupta, "Fundamentals of Switchgear and Protection", S.K. Kataria and Sons Publishers, 2013.
7. http://nptel.iitm.ac.in

Flexible AC Transmission System and Power Quality (Professional Elective Course – V)

COURSE OUTLINE

Course Title:	**Flexible AC Transmission System and Power Quality**	**Short Title:**	**FPQ**	**Course Code:**	

Course description:

Flexible AC Transmission System (FACTS) is one aspect of the power electronics revolution that is taking place in all area of electric energy. In the transmission area, application of power electronics consists of HVDC and FACTS. Is a new technology based on power electronics offers an opportunity to enhance controllability, stability and power transfer capability of AC transmission system. The subject also explores the knowledge of power quality, effect and source of power quality.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Power System, Power Electronics

Course objectives:

This course will develop an understanding of the control and operation of Flexible AC Transmission system. The effect of different FACTs devices to the operation and control of power system will be presented. This course also studies the enhancement of controllability, stability and power transfer capability of AC transmission system. Study the fundamental concept of power quality and different power quality issues.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply basic knowledge power electronic for enhancing power transfer capability of AC transmission system.
2. Understand FACTS, concepts its location in transmission network.
3. Analyze the characteristics FACTS controller and able to solve engineering problems.
4. Understand the sources of harmonics and its mitigation.
5. Discharging duties as power system engineer in technical and professional way.

COURSE CONTENT

Flexible AC Transmission System and Power Quality		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

FACTS Concept: Transmission interconnection and opportunity for FACTS, Basic type of FACTS controller, Brief description of FACTs controller: Shunt, series and combination of shunt and series. Comparison of HVDC and FACTS.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Static Shunt Compensators: SVC and STATCOM: Object of shunt compensation, Midpoint voltage regulation for line segmentation, end of line voltage support. Method of controllable VAR generation: variable impedance type and switching type VAR generators, STATCOM.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Static Series Compensators: Objectives of Series Compensation: Concept of series capacitive compensation, voltage stability. Variable impedance type series compensators: Thyristor switched series capacitor (TSSC) and Thyristor controlled series capacitor (TCSC).

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Power Quality: Power quality definition, need for power quality, nonlinear loads, Type of power quality problems: voltage sags, voltage swells, under-voltage, interruption, transients, voltage unbalance, voltage fluctuation, harmonics and electrical noise. Sources of power quality problems.

Unit–V:	No. of Lectures: 08 Hours	Marks: 12

Power Quality effects and Solutions: Effect of harmonics in pure resistive, inductive and capacitive circuit, effect of harmonic on induction motor, transformer, power factor correction and lighting installation. Power quality standard and mitigation by active and passive filter.

Text Books:

1. N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of FACTS Systems", Wiley-IEEE Press, 1st edition, 1999
2. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Pvt Ltd; 2nd edition, 2016.
3. R. C. Dugan, "Electrical Power Systems Quality", McGraw Hill Education, 3rd edition, 2017.

Reference Books:

1. T. J. E. Miller, "Reactive Power Control in Electric Systems", Wiley India Pvt Ltd., 2010.
2. G. T. Heydt, "Electric Power Quality", Stars in Circle Publications, 2nd edition, 1991.

Power Converter Applications (Professional Elective Course – V)					
COURSE OUTLINE					
Course Title:	**Power Converter Applications**	**Short Title:**	**PCA**	**Course Code:**	

Course description:

Power electronics converters stresses a power semiconductor devices beyond the rating, how to relieving the problems. Power electronics has already found an important place in modern technology and has revolutionized control of power and energy. As the voltage and current ratings and switching characteristics of power semiconductor devices keep improving, the range of applications continues to expand in areas such as lamp controls, power supplies to motion control, factory automation, transportation, energy storage, megawatt industrial drives, photovoltaic system and electric power transmission and distribution. The syllabus of Power Converter Applications deals with Switching dc Power Supply, Power conditioners and Uninterruptible Power Supplies, residential and industrial applications and programmable power electronic system etc.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Power Electronics

Course objectives:

Power Electronics provides the interface between two major divisions of electrical engineering viz. electric power and electronics. It is the art of converting electrical energy from one form to another in an efficient, clean, compact and robust manner for convenient utilization. The objectives of Power Converter Applications is to create an awareness about the general nature of Power electronic devices, key features of various industrial applications, the most important among them being high-voltage dc transmission, static VAR control, switch mode power supplies and programmable power electronic system.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze and design of switch mode power supplies.
2. Describe the role of Power conditioners and Uninterruptible Power Supplies as an enabling technology in various applications.
3. Understand the utilization of power converters for residential applications.
4. Understand the utilization of power converters for industrial applications.
5. Describe the control strategies of power converters using microcontroller and DSP processor.

COURSE CONTENT

Power Converter Applications	**Semester:**	**VIII**
Teaching Scheme:	**Examination scheme**	

Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Switching dc Power Supply: Linear power supply, Overview of switching power supply, dc-dc converters with electrical isolation, Control of switch-mode power supply, Power supply protection, Electrical isolation in feedback loop, Designing meet the power supply specifications.

Unit–II:	**No. of Lectures: 09Hours**	**Marks: 12**

Power conditioners and Uninterruptible Power Supplies: Power line disturbances, Power conditioners, Uninterruptible Power Supplies: on-line, off line.
High-Voltage dc Transmission, control of HVDC transmission, Static VAR control

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Residential Applications: Static switch using Thyristor, Static switch using Traic, DC static switch, low power flasher, Solid-state relays, Light dimmer, Electronic timer, Electronic alarm, Electronic Crowbar, Battery charger, Battery charging regulator, Emerging lighting system.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Industrial Applications: Temperature control, Liquid-level control, Alarm actuator, Ambient-light control power switch, Constant slope ramp generator, High frequency welding system, Induction heating system.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Programmable Power Electronic System: Microprocessor based firing circuit for thyristor converters, Microprocessor based electric drives, Microprocessor based speed control of an AC motors, Microprocessor based process control system, DSP based control, Fuzzy logic control of DC drives, Fuzzy logic control of an induction motor, Fuzzy logic control of a stepper motor.

Text Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins "Power Electronics: Converters, Applications and Design", John Wiley & Sons, Third Edition, 2014.
2. V. R. Moorthy, "Power Electronics Devices Circuit and Industrial Applications", Oxford University Press, First Edition, 2015.
3. Alok Jain, "Power Electronics and its Applications", Penram International Publishing (India) Pvt. Ltd., Third Edition, 2016.

Reference Books:

1. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2014.
2. Philip T. Krein, "Elements of Power Electronics", Oxford University Press, International Second Edition, 2016.
3. SCR manual, General Electric, Sixth Edition, 1979.

HVDC Transmission Systems (Professional Elective Course – V)

COURSE OUTLINE

Course Title:	**HVDC Transmission Systems**	**Short Title:**	**HVDCTS**	**Course Code:**	

Course description:

This course introduces the fundamental concepts, principles; analysis and design of high voltage direct current transmission system. Modern DC power transmission is relatively new technology because of advent of thyristor valves and related technology. The HVDC technology is still undergoing many changes due to continuing innovations directed at improving reliability and reducing cost of converting station. The subject explores the knowledge of HVD in economic and technical constraint.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Power System, Power Electronics

Course objectives:

1. To understand the concept, planning of DC power transmission and comparison with AC Power transmission.
2. To analyze HVDC converters.
3. To study about the HVDC system control.
4. To analyze voltage stability problem in DC system.
5. To model and analysis the DC system under study state.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the advantages of dc transmission over ac transmission.
2. Understand the operation of Line Commutated Converters and Voltage SourceConverters.
3. Understand the control strategies used in HVDC transmission system.
4. Understand the improvement of power system stability using an HVDC system.
5. Understand the multi terminal HVDC transmission system.

COURSE CONTENT

HVDC Transmission Systems		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

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

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Analysis of Line Commutated and Voltage Source Converters: Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Control of HVDC Converters: Principles of Link Control in LCC HVDC system. Control Hierarchy, Firing Angle Controls– Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVDC system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Components of HVDC systems: Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems DC line: Corona Effects. Insulators, Transient Over-voltages. DC line faults in LCC systems. DC line faults in VSC systems. DC breakers. Monopolar Operation. Ground Electrodes. Stability Enhancement using HVDC**.** Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

MTDC Links: Multi-Terminal and Multi-In feed Systems. Series and Parallel MTDC systems using LCCs. MTDC systems using VSCs. Modern Trends in HVDC Technology. Introduction to Modular Multi-level Converters.

Text Books:

1. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 3rd edition, 2017.
2. S. Rao, “EHVAC & HVDC Transmission Engineering & Practice”, Khanna Publications, 3rd edition, 1993.

Reference Books:

1. J. Arrillaga, “High Voltage Direct Current Transmission”, Institution of Electrical Engineers, 2nd edition, 2008.
2. E. W. Kimbark, “Direct Current Transmission”, Vol.1, Wiley-Interscience, 1971.

Power System Restructuring (Professional Elective Course – V)

COURSE OUTLINE

Course Title:	**Power System Restructuring**	**Short Title:**	**PSR**	**Course Code:**	

Course description:

The restructuring of power industry has changed the way of operation of the power systems. Along with the secured and reliable operation of power systems, the economic efficiency has become an equally important consideration. Unlike the knowledge of conventional operation of power systems, understanding the restructured power systems requires basic knowledge of electrical engineering, power systems, and also the economics. This course is intended to provide a comprehensive treatment towards understanding of the new dimensions associated with the power systems. The course will initially bring out the differences between the conventional power system operation and the restructured one. Before tackling taxing issues involving techno-commercial solutions, the course will prepare a background with fundamentals of microeconomics.
The design of power markets and market architectural aspects will be discussed next. With this foundation, the changes in operational aspects with new operational challenges like congestion management and ancillary service management will be elaborated. Efficient pricing of transmission network usage is a must to bring economic efficiency in the power market operation. These issues will follow next. There will be separate modules on Genco bidding strategies and market power with mitigation techniques. Towards the end, the discussion on restructuring experiences of different countries all around the world will be provided.
Also, there will be exclusive module on reform practices in developing countries with special focus on Indian power system. The course will be enriched with solved examples in order to illustrate various concepts. Also, case studies on deeply researched topics will be provided. The emphasis of the course will be on bringing out new concepts in a simple and lucid manner.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**12**	**42**	**03**

Prerequisite course (s):

Power System I, Power System II

Course objectives:

1. To educate students about the process of restructuring of power system
2. To familiarize students about the operation of restructured power system
3. To teach students pricing of electricity.
4. To gain knowledge of fundamental concept of congestion management
5. To analyze the concept of location marginal pricing and transmission rights.
6. To provide in-depth understanding of operation of deregulated electricity market systems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Describe various types of regulations in power systems.
2. Identify the need of regulation and deregulation.
3. Define and describe the Technical and Non-technical issues in Deregulated Power Industry.
4. Identify and give examples of existing electricity markets.
5. Classify different market mechanisms and to summarize the role of various entities in the market.

COURSE CONTENT

Power System Restructuring		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Power Sector in India: Institutional structure before reforms. Roles of various key entities in India. Necessity of Deregulation or Restructuring. RC Act 1998 and Electricity Act 2003 and its implications for Restructuring & Deregulation. Institutional structure during reform. National Energy policy. Introduction to Energy Exchange and trading of Renewable Energy Credits and Carbon Credits.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

Fundamentals of Economics: Introduction to various concepts such as capital cost, debt and equity, depreciation, fixed and variable costs, working capital, profitability indices etc. Typical cost components of utilities such as return in equity, depreciation, interest and finance charges, O and M expenses. Key Indices for assessment of utility performances. Principles of Tariff setting, Phases of Tariff determination, consumer tariff & non-price issues.

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Power Sector Regulation and Congestion Issues: Regulatory process in India, types and methods of Regulation, cost plus, performance-based regulation, price cap, revenue cap regulation, rate of return regulation, benchmarking or yardstick regulation. Role of regulatory commission. Considerations of socio economic aspects in regulation.

Congestion in power network, reasons for congestion, classification of congestion management, useful definitions. Methods of congestion management, Locational Marginal Pricing (LMR), Firm Transmission Right (FTR). Availability based Tariff (ABT) in India.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Restructuring: Introduction, models based on energy trading or structural models – monopoly, single buyer, wholesale competition, retail competition. Models based on contractual arrangements – pool model, bilateral dispatch, pool and bilateral trades, multilateral trades, ownership models, ISO models. Competition for the market vs competition in the market, International experience with electricity reform – Latin America, Nordic Pool, UK, USA, China and India. California Energy Crisis.

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Electricity Markets: Trading – electricity market places, rules that govern electricity markets, peculiarity of electricity as a commodity, various models of trading arrangements – integrated trading model, wheeling trading model, decentralized trading model. Various electricity markets such as spot, day ahead, forward, future options, reserve, ancillary services market. Market operation, settlement process, Market Clearing Price (MCP), Market power, market efficiency. Spot, dynamic and locational pricing.

Text Books:

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility", CRC Press, 2017.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Springer Science & Business Media, 2012.

Reference Books:

1. Sally Hunt, "Making competition work in electricity", John Willey and Sons Inc., 2002.
2. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
3. Lorrin Philipson, H. Lee Willis, "Understanding electric utilities and de-regulation", CRC Press, 2nd edition, 2018.

Electric and Hybrid Vehicles (Professional Elective Course – VI)

COURSE OUTLINE

Course Title:	**Electric and Hybrid Vehicles**	**Short Title:**	**EHV**	**Course Code:**	

Course description:

This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. The material for this course will be prepared in such a manner that it will be useful for post-graduate students, teachers, practitioners and final year undergraduate students.

This course goes deeper into the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc. Each topic will be developed in logical progression with up-to-date information.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Electric Machines and Drives, Power Electronics

Course objectives:

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3. Analyze various electric drives suitable for hybrid electric vehicles
4. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
5. Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Analyze the use of different power electronics devices and electrical machines in hybrid Electric vehicles.
3. Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology
4. Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.
5. Analyze the use of different energy management strategies used in hybrid and electric vehicles

COURSE CONTENT			
Electric and Hybrid Vehicles		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction: Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**

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

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

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

Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**

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

Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.
Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Books:

1. C. Mi, M. A. Masrur, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", Wiley-Blackwell, 2nd edition, 2017.

2. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer; 1st edition, 2015.

Reference Books:

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2nd edition, 2011.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 1st edition, 2004.
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 1st edition, 2008.
4. T. Denton, "Electric and Hybrid Vehicles", Routledge, 1st edition, 2016.

Advanced Electric Drives (Professional Elective Course – VI)					
COURSE OUTLINE					
Course Title:	**Advanced Electric Drives**	**Short Title:**	**AED**	**Course Code:**	
Course description:					
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	03	**14**	**42**	**03**	
Prerequisite course(s):					
Electrical Machines, Control Systems, Power Electronics					
Course objectives:					
Electrical drives play an important part as electromechanical energy converters in transportation, materials handling and most advanced production processes. The course tries to give unified treatment of complete electrical drive systems, including the mechanical parts, electrical machines, and power converters and control.					
Course outcomes:					
After successful completion of this course the student will be able to: 1. To acquire the knowledge of selection of drives as per practical operational industrial requirement. 2. To apply their knowledge to prepare control schemes as per different types of motors used in industries. 3. To estimate & solve harmonic and power factor related problems in controlling AC and DC drives. 4. To acquire knowledge of various control techniques used in electoral drives. 5. To study the practical use of drives and its control for different applications.					
COURSE CONTENT					
Advanced Electric Drives		**Semester:**	**VII**		
Teaching Scheme:		**Examination scheme**			
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**		
		Duration of ESE:	**03 hours**		
		Internal Sessional Exams (ISE):	**40 marks**		
Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**			
DC Motor Drive and its Operational Strategies & Modeling and Control of DC Drives: Dynamic model of machine with armature voltage control only and converters with continuous conduction only; Closed loop control using single (speed) and two loops (speed, current), Implementation using circulating current type three phase dual converter and four quadrant transistorized chopper. State feedback control and sliding mode control of excited DC machine in field–excited DC machine, Modeling and control of separately–separately weakening region and discontinuous converter conduction mode, Control of DC series machine.					
Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**			

Open-loop Dynamic Performance of AC & DC Drives: Starting & reversal time, Energy consumption & energy savings principle. Drives Application Engineering for Fan, Pump, Compressor, Lift-Elevator, Kiln, Winder-Un-Winder, Traction application. Synchronization and master-slave configuration.		
Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**
AC Drives and its Operational Strategies: Variable frequency operation of three phase symmetrical–induction machine, Scalar control methods for constant power an constant torque modes, Vector control of induction machine, Methods of field sensing and estimation, Field orientation methods: Implementation of IRFO scheme using current controlled PWM, VSI and implementation of DSFO scheme using CSI, Performance of vector controlled permanent magnet machine.		
Unit–IV:	**No. of Lectures: 09 Hours**	**Marks: 12**
Control and Estimation of AC Drives: Introduction to speed control of Switched Reluctance Machine, Induction motor drive, basic of Scalar & Vector control V/f Control, Sensorless vector control, Field Oriented Control, Direct torque control and flux observation, Speed control of wound rotor induction motors: Converter based static rotor resistance control, Static scherbius drive using line commutated converter cascade, Analysis and estimation of harmonics and power factor, Vector control of wound rotor induction machine using self-commutated converter cascade and improvement in power factor, Variable speed constant frequency (VSCF) generation.		
Unit–V:	**No. of Lectures: 09 Hours**	**Marks: 12**
Control of Permanent Magnet Machine & Compatibility to Motor & Drives: Power Electronics Control of Permanent magnet synchronous machine, Brushless DC machine, Surface permanent magnet machine and interior, Effects of drives on motor - dV/dt, THD, Common Mode Voltage, Shaft Voltage and Bearing Current, Sound & Vibration Laboratory Work: Closed loop current-speed control of AC & variable–DC drives, Variable voltage frequency control, Vector control mechanism, Position control of stepper motor.		
Text Books:		
1. P. C. Krause, O. Wasynczuk, S. D. Sudoff, "Analysis of Electric Machinery and Drive System", John Wiley and Sons, 2013. 2. B.K. Bose, "Modern Power Electronics and Electric Drives", Pearson Education, Asia, 2003. 3. B.N. Sarkar, "Fundamental of Industrial Drives", Prentice Hall of India Ltd.		
Reference Books:		
1. M. Chilkin, "Electric Drives", Mir Publishers, Moscow. 2. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore. 3. N.K. De and Prashant K. Sen, "Electric Drives", Prentice Hall of India Ltd. 4. V. Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill.		

EHV AC Transmission Systems (Professional Elective Course – VI)					
COURSE OUTLINE					
Course Title:	**EHV AC Transmission Systems**	**Short Title:**	**EHVAC**	**Course Code:**	

Course description:

This course introduces the concepts of extra high voltage AC transmission. It also emphasis on the behavior of the line parameters for extra high voltages, voltage gradients of the transmission line conductors gradients, the effect of corona, electro static field calculations, voltage control when the line carries extra high voltages.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The need for energy is very urgent in the developing countries, and national policies and their relation to other countries are sometimes based on energy requirements, chiefly nuclear, hydro-electric and coal or oil-fired stations are located very far from load centers for various reasons which require the transmission of the generated electric power over very long distances. This requires very high voltages for transmission. The very rapid strides taken by development of DC transmission since 1950 are playing a major role in extra-long-distance transmission, complementing or supplementing EHV AC transmission.

Course outcomes:

After successful completion of this course the student will be able to:

1. To understand the need of EHV Transmission system.
2. To calculate line and ground parameters.
3. To describe the impact of high voltage level on the environment.
4. To understand Electrostatic and Magnetic fields of EHV lines.
5. To understand corona and its effect on EHV Transmission system.

COURSE CONTENT

EHV AC Transmission Systems		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**

Introduction, Transmission Line Trends and Preliminaries: Basic aspects of AC Power Transmission, Need for EHV transmission lines, Role of EHV AC Transmission, Power handling capacity and line loss, Examples on giant power pools and number of lines, Cost of Transmission lines and equipment, Mechanical considerations in line performance- types of vibrations and oscillations.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Calculation of line and Ground parameters: Resistance of conductors, Temperature rise of conductors and current carrying capacity, Properties of bundled conductors, Inductance of EHV line configurations, line capacitance calculations, sequence inductance and capacitances.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

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

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Electrostatic and Magnetic fields of EHV lines: Electric shock and threshold currents, Effects of high electrostatic fields on humans, animals and plants, Calculation of electrostatic field of single circuit of three phase line, Profile of electrostatic field of line at ground level. Electrostatic field of a double circuit 3 phase AC line, Insulated ground wire and induced voltage in insulated ground wires.
Magnetic field calculation of horizontal configuration of single circuit of three phase lines, Effects of power frequency magnetic fields on human health.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Corona and its effects: Corona formation, visual critical voltage, corona power loss, corona loss formulae, charge-voltage diagram, increase in effective radius of conductor and coupling factors, attenuation of travelling waves due to corona loss. Audible noise – generation and characteristics, limits for audible noise, AN measurement and meters- microphones, weighting networks.

Text Books:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Publishers, Third Edition, 2007.

Reference Books:

1. A. Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay, “Performance Operation and Control of EHV Power Transmission Systems”, Wheeler Publishing, 1999.
2. S. Rao, “EHV-AC, HVDC Transmission and Distribution Engineering”, Khanna Publishers, Third Edition, 2017.
3. http://nptel.iitm.ac.in

Illumination Engineering (Professional Elective Course – VI)					
COURSE OUTLINE					
Course Title:	**Illumination Engineering**	**Short Title:**	**IE**	**Course Code:**	

Course description:

The explores the knowledge of types of illumination , lighting systems, lighting Scheme , measurement of might, laws of illumination, design of Interior Lighting, Indian standard recommendation and standard practices for illumination levels in various areas, design of outdoor lighting and special features of aesthetic lighting .

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Course objectives:

To provide an introduction to the fundamentals of illumination engineering and architectural lighting design. To impart lighting fundamentals, measurement, and technology and their application in the analysis and design of architectural lighting systems. Factors to be considering while designing indoor and outdoor illumination schemes.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply basic engineering to understand concept of lighting system, selection of lighting factors effecting on lighting scheme.
2. Identify the criteria for the selection of lamps, measurement of light and law of illuminations. and lighting systems for an indoor or outdoor space .
3. Design and Evaluate different types of lighting scheme designs for indoor lighting and selection of luminary to meet the specified needs with appropriate consideration.
4. Perform calculations on photometric performance of light sources and luminaries for outdoor purposes.
5. Design special lighting scheme to meet the specified needs with appropriate consideration in monument Sports and aviation lighting.

Illumination Engineering

COURSE CONTENT

Illumination Engineering		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**

	Duration of ESE:	**03 hours**
	Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction of Light: Radiation, colour and eye vision. Types of illumination, Day lighting, Supplementary artificial lighting and total lighting, Quality of good lighting, Factors affecting the lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localized

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Light Source and measurement light: Incandescent, electric discharge, fluorescent and LED light, Luminaries and control circuits. Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance, Laws of illumination, Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source, Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source

Unit–III:	**No. of Lectures: 08 Hours**	**Marks: 12**

Design of Interior Lighting: Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors affecting it, Illumination required for various work planes, Space to mounting height ratio, Types of fixtures and relative terms used for interior illumination, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaries, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.

Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**

Design of Outdoor Lighting: Street Lighting : Types of street and their level of illumination required, Terms related to street and street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaries, Calculation of their wattage, Number and arrangement, Calculation of space to mounting height ratio, Calculation of illumination level available on road .Flood Lighting Types of fixtures and their suitable applications, Selection of lamp and projector, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**

Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Auditorium lighting and aviation and transport lighting. Lighting for displays and signaling- neon sign, LED LCD displays and lighting for surveillance.

Text Books:

1. Gupta J. B., "Utilization of Electric Power & Electric Traction" S. K. Kataria & Sons, 2nd edition, 2012.
2. Uppal S. L, "Electrical Power", Khanna Book Publication, 13th edition, 1988.

3. Partab H. P., "Art & Science of Utilization of Electrical Engineering", Dhanpat Rai Publications, 2017.

Reference Books:

1. Jack L. Lindsey, "Applied Illumination Engineering", Fairmont Pr; 2nd edition, 1996.
2. John Matthews, "Introduction to the Design and Analysis of Building Electrical Systems", Springer Science & Business Media, 1993.
3. M.A. Cayless, "Lamps and Lighting", Routledge; 4th edition, 2012.
4. O. E. Taylor, "Utilization of Electrical Energy", Longman, 1971.
5. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy
6. Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher -York, PA: Visions Communications, 1994.

Digital Signal Processing (Open Elective Course – IV)					
COURSE OUTLINE					
Course Title:	**Digital Signal Processing**	**Short Title:**	**DSP**	**Course Code:**	

Course description:

Digital Signal Processing (DSP) is concerned with the representation, transformation and manipulation of signals on a computer. After half a century advances, DSP has become an important field, and has penetrated a wide range of application systems, such as consumer electronics, digital communications, medical imaging, power applications and so on. With the dramatic increase of the processing capability of signal processing, it is the expectation that the importance and role of DSP is to accelerate and expand.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	03	14	42	03

Prerequisite course(s):

Course objectives:

The objective of this course is to provide an understanding of Digital Signal Processing. Topics include: Introduction to digital signal processing and application, discrete time signals and systems; Analysis of LTI systems; Structures of discrete time systems; Filter designing techniques; DFT and FFT.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze Discrete Time systems with Discrete Fourier Transform
2. Design digital filters IIR and FIR filters
3. Analyze finite word length effects in signal processing
4. Design filters using
5. Understand Digital Signal Controllers and their Applications

COURSE CONTENT

Digital Signal Processing		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE):	**40 marks**

Unit–I:	No. of Lectures: 08 Hours	Marks: 12

Discrete-Time Signals and Systems: Sequences, discrete time systems, LTI systems, frequency domain representation of discrete time signals and systems, discrete time signals and frequency domain representation, Fourier Transform. Implementation of discrete time systems: Structure for FIR system, Structure for IIR systems.

Unit–II:	No. of Lectures: 09 Hours	Marks: 12

Sampling of Continuous Time Signals: Sampling and reconstruction of signals, frequency domain representation of sampling, discrete time processing of continuous time signals, continuous time processing of discrete time signals, changing the sampling rate using discrete time processing, multi rate signal processing, digital processing of analog signals, over sampling and noise shaping in A/D and D/A conversion.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Transform Analysis of LTI Systems: Frequency response of LTI systems, system functions, frequency response for rational system functions, magnitude-phase relationship, all pass systems, minimum phase systems, and linear systems with generalized linear phase Discrete Fourier Transform: Discrete Fourier Transform, properties, linear convolution and circular convolution.

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Filter Design Techniques: Design of IIR filters using Impulse Invariant Response method and Bilinear Transformation method. Butterworth filters and chebyshev Filter's response, Design of FIR filters by windowing, Kaiser Window method, optimum approximations of FIR filters.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Efficient computation of the DFT: FFT algorithms- decimation in time and decimation in frequency, Goertzel algorithm, Implementation of the DFT using convolution, Introduction to wavelet transform: Wavelet comparison with Fourier transforms, Applications of Wavelet cosine transform, Discrete cosine transform (DCT), Block Diagram and features of DSP processors from Texas Instrument i.e TMS320C2812.

Text Books:

1. S. Salivahanan, "Digital Signal Processing", McGraw Hill Education; 3rd edition, 2017.
2. P. Ramesh Babu, "Digital Signal Processing", Scitech Publications (India) Pvt. Ltd., 6th edition, 2014.
3. Oppenheim A.V., Schafer, Ronald W. & Buck, John R, "Discrete Time Signal processing", Pearson Education, 2nd edition, 1999.
4. Proakis, J.G., Manolakis, D.G., "Digital Signal Processing: Principles Algorithms and Applications", Pearson Education India; 4th edition, 2007.

Reference Books:

1. Rabiner, L.R., Gold B., "Theory and applications of DSP", Prentice Hall of India, 2016.
2. Oppenheim, Alan V., Willsky, Alan S., "Signals and Systems", Prentice Hall of India, 2nd Edition, 2015.
3. Johnson, J.R., "Introduction to Digital Signal Processing", Prentice Hall of India, 1st edition, 2015.

Embedded System (Open Elective Course – IV)					
COURSE OUTLINE					
Course Title:	**Embedded System**	**Short Title:**	**ES**	**Course Code:**	
Course description:					
The course explores knowledge of embedded system fundamentals and its design aspects. The course comprises of basic understanding of embedded system concepts, role , characteristics and real time implementation in various application with real time operating system concepts etc.					
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	03	**14**	**42**	**03**	
Prerequisite course(s):					
Course objectives:					
Students have knowledge about the basic functions, structure, concept, application and development of embedded systems and enable the learner to design a system with combination of hardware and software for a specific real time application.					
Course outcomes:					
After successful completion of this course the student will be able to:					
1. Able to understand the role and concept of embedded systems 2. Able to understand the extension in processor, pipelines, memory architecture. 3. Understand the concepts of ARM interfacing in advanced embedded system. 4. Able to identify communicate and interface embedded network protocol 5. Demonstrate the use of open source RTOS and embedded system application, design issues for the same.					
COURSE CONTENT					
Embedded System			**Semester:**	**VIII**	
Teaching Scheme:			**Examination scheme**		
Lectures:	**3 hours/week**		**End Semester Exam (ESE):**		**60 marks**
			Duration of ESE:		**03 hours**
			Internal Sessional Exams (ISE):		**40 marks**
Unit–I:		**No. of Lectures: 09 Hours**		**Marks: 12**	
Introduction to Embedded Systems: Introduction to embedded systems, history, design challenges - optimizing design metrics, time to market concept, top-down design process and technology, applications of embedded systems and recent trends in embedded systems, processor technology, IC technology and design technology, trade-offs in embedded systems. Custom Single-Purpose Processor Design: Design of general purpose processor: controller and data path design.					
Unit–II:		**No. of Lectures: 08 Hours**		**Marks: 12**	

System Architecture: Introduction to Advance Reduced Instruction Set Computer (RISC) Machine (ARM) embedded systems - RISC versus Complex instruction set computer (CISC) machines, ARM design philosophy, ARM processor fundamentals, ARM extension family, operating modes, pipeline, memory management, bus architecture, exception handling and interrupt structure. Brief introduction to ARM-7 processor LPC2148 block diagram.

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

LPC 2148 Interfacing and Programming: need of interfacing, interfacing techniques, basic embedded C programs for GPIO and interfacing of different devices like switches, keypad, Light Emitting Diode (LED), Liquid Crystal Display (LCD), Relay, Stepper Motor. Study and programming of on-chip peripherals like timers, counters, on-chip Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), Universal Asynchronous Receiver/Transmitter (UART), Real Time Clock (RTC) modules, Watch Dog Timer (WDT), phase locked loop (PLL), Pulse Width Modulator (PWM).

Unit–IV:	No. of Lectures: 08 Hours	Marks: 12

Communication Protocol: Basic protocol concept, study of protocols like Serial Peripheral Interface (SPI), Inter-Integrated Circuits (I2C), Controller Area Network (CAN), Ethernet. Wireless Protocols: Infrared Data Association (IrDA), Bluetooth, IEEE802.11 (Wi-Fi), ZigBee, RF modules, etc. Case study of Complementary Metal Oxide Semiconductor (CMOS) camera (without codes), requirement specification, different ways to design of camera.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Real Time Operating System (RTOS) Concept: Need of RTOS in embedded system software, foreground/background systems, multitasking, context switching, IPC, scheduler policies, architecture of kernel, task scheduler, ISR, semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services in contrast with traditional OS. Introduction to µC/OS-II RTOS, study of kernel structure of µC/OS-II, synchronization in µCOS-II, inter-task communication in µC/OS-II, memory management in µC/OS-II, porting of RTOS of ARM 2148, Application developments using µC/OS-II.

Text Books:

1. Raj Kamal, “Embedded Systems”, McGraw Hill Education (India) Private Limited, Third edition, 2017.
2. Dr.K.V.K.K. Prasad, “Embedded/Real Time Systems Programming Black Book”, Dreamtech Press, New edition, 2003.
3. Frank Vahid, Tony Givargis, “Embedded Systems Design: A Unified Hardware/Software Introduction”, John & Wiley Publications, 2002.

Reference Books:

1. Andrew Sloss, “ARM System Developer guide”, Elsevier India; First edition, 2004.
2. Data sheet and User manual of LPC2148.
3. Steve Furber, “ARM System-on-Chip Architecture”, Pearson, Second edition, 2014.
4. Jean J.Labrose, “Micro C / OS-II”, Indian Low Price Edition, second edition, 2002.

5. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", Second Edition, 2007.

Robotics (Open Elective Course – IV)

COURSE OUTLINE

Course Title:	**Robotics**	**Short Title:**	**ROB**	**Course Code:**	

Course description:

In this course, students take on the roles of mechanical engineers, computer scientists and electrical engineers. Students research dynamics, kinematics and sensors. Topics such as such as motion planning and obstacle avoidance, velocity and acceleration, serial chain mechanisms, pneumatic actuators, and drive circuits are covered.

Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**
	03	**14**	**42**	**03**

Prerequisite course(s):

Course objectives:

1. To understand structures and classifications in robotics
2. To gain knowledge of types of actuators and sensors in robotics.
3. To understand and learn robotic transformations.
4. To know different analysis techniques for robotic kinematics and dynamics.
5. To learn control techniques for robotic programming.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain structure and classification of robots.
2. Define role of actuators, sensors and vision system in robotics
3. Describe various transformations in robots.
4. Analyze the different kinematics and dynamics in robots.
5. Apply control techniques for programming in robotics

COURSE CONTENT

Robotics		**Semester:**	**VIII**
Teaching Scheme:		**Examination Scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to Robotics: Robots, History of Robots, Robots Usage, Basic Structure of Robots, Classification of Robots by Applications, classification by Coordinate Systems, Classification by Actuation System, Classification by Control System, Robot classification by programming method.

Unit–II:	**No. of Lectures: 08 Hours**	**Marks: 12**
Robot Actuators, Sensors and Vision: Robot Actuators: Pneumatic, Hydraulic and Electric Robot Sensors: Sensor classification, Internal Sensors, External Sensors, Sensor selection Vision System in Robots.		
Unit–III:	**No. of Lectures: 09 Hours**	**Marks: 12**
Transformations and Statics in Robotics: Robot Architecture, Pose of Rigid Body, Coordinate Transformation, Denavit and Hartenberg (DH) Parameters, Forces and Moment balance, Recursive Calculations, Equivalent Joint Torque, Role of Jocobian in Statics.		
Unit–IV:	**No. of Lectures: 08 Hours**	**Marks: 12**
Kinematics and Dynamics: Forward Position Analysis, Inverse Position Analysis, Velocity Analysis, Inerita Properties, Eular- Lagrange Formulation, Newton – Eular Formulation, Recursive Newton – Eular Algorithm		
Unit–V:	**No. of Lectures: 08 Hours**	**Marks: 12**
Robotic Control and Programming: Control Techniques, Second Order Linear Systems, Feedback Control and its Performance, Non Linear Trajectory Control, State Space Representation and Control, Stability, Cartesian and Force Controls, Robotic Programming		
Text Books:		
1. Saha S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.		
Reference Books:		
1. Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", Wiley; 2nd edition, 2011. 2. Mittal R.K., Nagrath I.J., "Robotics and Control", Tata McGraw Hill, 2003. 3. Mukherjee S., "Robotics and Automation", Khanna Publishing House, Delhi. 4. Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 3rd edition, 2009. 5. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005. 6. Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003.		

Cyber Security (Open Elective Course – IV)					
COURSE OUTLINE					
Course Title:	**Cyber Security**	**Short Title:**	**CS**	**Course Code:**	
Course description:					
Cyber Security course focuses on cyber threats and cyber security that provides the much needed awareness in the times of growing cybercrime episodes.					
Lecture	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	03	**14**	**42**	**03**	
Prerequisite course(s):					
Course objectives:					
1. To understand Cybercrime and Cyber offenses. 2. To understand Cybercrime through portable devices. 3. To understand tools and methods used in Cybercrime. 4. To understand Phishing and Identity theft. 5. To understand Computer Forensics.					
Course outcomes:					
After successful completion of this course the student will be able to:					
1. Determine the act of Cyber offenses. 2. Determine the Cybercrime through portable devices. 3. Determine the methods used in Cybercrime. 4. Determine Phishing and Identity theft. 5. Describe Computer Forensics.					
COURSE CONTENT					
Cyber Security		**Semester:**	**VIII**		
Teaching Scheme:		**Examination scheme:**			
Lectures:	**3 hours/week**	**End Semester Exam (ESE):**		**60 marks**	
		Duration of ESE:		**03 hours**	
		Internal Sessional Exam (ISE):		**40 marks**	
Unit–I:	**No. of Lectures: 08 Hours**	**Marks: 12**			
Introduction to Cybercrime: Introduction, Cybercrime: Definition and Origins of the Word, Cybercrime and Information Security, Who are Cybercriminals?, Classifications of Cybercrimes.					

Cyber offenses: How Criminals Plan Them: Introduction, How Criminals Plan the Attacks, Social Engineering, Cyber stalking, Cyber cafe and Cybercrimes, Botnets: The Fuel for Cybercrime, Attack Vector, Cloud Computing.

Unit–II:	No. of Lectures: 08 Hours	Marks: 12

Cybercrime: Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile device related security issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops

Unit–III:	No. of Lectures: 08 Hours	Marks: 12

Tools and Methods Used in Cybercrime: Introduction, Proxy Servers and Anonymizers, Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Trojan Horses and Backdoors, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Attacks on Wireless Networks

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Phishing and Identity Theft: Introduction, Phishing, Identity Theft (ID Theft)

Understanding Computer Forensics: Introduction, Historical Background of Cyberforensics, Digital Forensics Science, The Need for Computer Forensics, Cyberforensics and Digital Evidence, Forensics Analysis of E-Mail.

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Computer Forensics: Digital Forensics Life Cycle, Chain of Custody Concept, Network Forensics, Approaching a Computer Forensics Investigation, Computer Forensics and Steganography, Relevance of the OSI 7 Layer Model to Computer Forensics, Forensics and Social Networking Sites: The Security/Privacy Threats, Challenges in Computer Forensics, Special Tools and Techniques, Forensics Auditing, Anti forensics

Text Books:

1. Nina Godbole, Sunil Belapure, “Cyber Security”, Wiley India Publication, 2011.

Reference Books:

1. Nina Godbole, “Information Systems Security”, Wiley India Publication, 2nd edition, 2017.
2. V.K. Pachghare, “Cryptography and Information security”, PHI Learning Pvt Ltd, 2nd edition, 2015.

Power System Protection Laboratory					
LAB COURSE OUTLINE					
Course Title:	**Power System Protection Laboratory**	**Short Title:**	**PSP Lab**	**Course Code:**	

Course description:

Switchgear and Protection is a fascinating subject. A protection scheme in a power system is designed to continuously monitor the power system to ensure maximum continuity of electrical supply with minimum damage to life, equipment and property. The subject practical explores the knowledge of arc interruption, different type of circuit breakers and relay. This knowledge is help full for understanding the characteristicfeatureandproperselectionofprotectiveelementsindifferentprotective scheme. The practical also provide knowledge different protection for major and individual power system elements.

Laboratory	Hours/week	No. of weeks	Total hours	Semester credits
	02	14	28	01

End Semester Exam (ESE) Pattern:	Practical (PR)

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The objectives of subject that students will able understand the fault characteristic of individual power system elements. One should also be knowledgeable about the tripping characteristics of various protective relays. The students able to understand the job of protection engineer is to devise such scheme where closest possible match between the fault characteristic and tripping characteristic is obtained. The students will able understand protected zone and able to design protective scheme such that relay will detect undesirable conditions and then trip to disconnect the area affected, but remain restrained at all other time. Student should be equipped with sound concept of power system protection to enable those handling unforeseen circumstances in real life.

Course outcomes:

Upon successful completion of lab Course, student will be able to:

1. Analyze the arc formation and arc extinction phenomenon.
2. Analyze Over current & earth fault protection scheme for alternator.
3. Explain Protection of 3 phase transformer using differential relay.
4. Explain differential protection scheme applied to transformer.
5. Demonstrate microprocessor based protection.

LAB COURSE CONTENT

Power System Protection Laboratory		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**End Semester Exam (ESE):**	**25 marks**
		Internal Continuous Assessment (ICA):	**25 marks**

Teacher should facilitate learning following lab experiments:

1. To conduct and study of Arc extinction phenomenon: Application in air circuit breaker.
2. Study of relaying components and control circuit developments.
3. To conduct and plot the characteristic of rewirable fuses and MCB.
4. To conduct and plot operating characteristics of Inverse time over current relay.
5. To conduct over current & earth fault protection scheme for alternator.
6. To conduct Protection of 3 phase transformer using differential relay (Merz- Price protection scheme).
7. To conduct and study the through fault stability of differential protection scheme applied to transformer.
8. To conduct Protection of transmission line.
9. Study of MHO distance relay to plot. a) R- X diagram b) Relay voltage Vs Admittance characteristic.
10. Study of Static relay.
11. Demonstration of microprocessor base protection.

Note: Lab file should consist of minimum Eight experiments.

Text Books:

1. Sunil S. Rao, "Switchgear Protection and Power Systems", Khanna Publishers, 14th edition, 2019.

Reference Books:

1. Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", PHI Publications, Second Edition, 2013.
2. T.S. Madharao, "Power System Protection: Static Relays with Microprocessor Applications", Tata McGraw Hill, Second Edition, 2017.
3. B. Ravindranath, M. Chandar, "Power System Protection & Switchgear", New Age International Publishers, Second Edition, 2018.
4. B. Ram, D.N. Vishwakarma, "Power System Protection & Switch Gear", Mc Graw Hill Education, Second Edition, 2017.
5. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", Wiley Blackwell Publications, Third Edition.2008.
6. J.B. Gupta, "Fundamentals of Switchgear and Protection", S.K. Kataria and Sons Publishers, 2013.
7. http://nptel.iitm.ac.in

Guide lines for ICA:

ICA shall be based on continuous evaluation of student performance throughout semester and practical

assignment submitted by the student in the form of journal.
Guidelines for ESE:
ESE will be based on the Laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work, performance and understanding.

High Voltage Engineering laboratory					
LAB COURSE OUTLINE					
Course Title:	**High Voltage Engineering laboratory**	**Short Title:**	**HVELAB**	**Course Code:**	
Course description:					
In this laboratory, course emphasis on imparting practical knowledge and understanding of high voltage testing equipment's, different insulating materials and its breakdown phenomenon, high voltage laboratories and testing of high voltage equipment. The lab course also provides the platform to understand generation and measurement of high voltages.					

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Lecture	**02**	**14**	**28**	**03**
Laboratory	**02**	**14**	**28**	

End Semester Exam (ESE) Pattern:	**Oral (OR)**

Prerequisite course(s):
Basic sciences, mathematics and subjects of Electrical Engineering
Course objectives:
The objective of the laboratory is to impart the fundamental knowledge of high voltage generating, measuring and testing instruments. The students will able to understand concept and breakdown phenomenon of dielectrics, corona discharges, methods of generation and Measurement of high voltages and currents and testing of high voltage equipment's. In this lab course, students will be familiar with the use of different equipment's, safety precautions on work place. This makes bridge on theoretical knowledge and practical practices.
Course outcomes:
Upon successful completion of lab Course, student will be able to:
1. Apply the concepts of High Voltage Engineering through laboratory experimental work and Connect the circuit to perform experiments, measure, analyze the observed data to come to a conclusion 2. Evaluate the performance of breakdown testing of various dielectrics. 3. Calibrate the breakdown voltage of air using sphere-gap assembly. 4. Visualize and analyze the corona effect. 5. Understand the methods of generation and Measurement of high voltages and currents and testing of various electrical equipments.

LAB COURSE CONTENT			
High Voltage Engineering laboratory		**Semester:**	**VIII**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**End Semester Exam (ESE):**	**25 marks**
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA):**	**25 marks**

Theory:

Unit–I: Introduction to High voltage Labs

Classification of high voltage laboratories, High voltage laboratory layout, testing facility requirements, High Voltage laboratories all over the world.

Unit–II: Breakdown in Gases

Gases as insulating media, collision process, ionization process, Breakdown in Electronegative Gases, Corona Discharges, Breakdown in Vacuum.

Unit–III: Breakdown in Liquids and solids

Liquids as Insulators, Conduction and Breakdown in Pure Liquids and Commercial Liquids. Solid dielectrics and composite dielectrics, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown.

Unit–IV: Generation and measurement of High Voltages and currents

Methods of Generation of high dc voltages, ac voltages and impulse voltage, voltage doubler circuit, voltage multiplier circuit, multistage impulse generator, impulse current generator. Spark gap for measurement of high dc, ac and impulse voltages, Klydonograph, other techniques for impulse current measurements

Unit–V: High Voltage Testing of Electrical Apparatus

Various standards for HV Testing of electrical apparatus, IS, ANSI, IEC standards, testing of overhead line insulators, testing of power capacitor, testing of circuit breakers, testing of cables, test voltage.

Teacher should facilitate learning following lab experiments:

1. Study of 100 kV high voltage testing set.
2. Determination of insulating break-down strength of solid, liquid and gaseous dielectric media.
3. Study of corona discharge.
4. Double voltage double frequency withstand test on transformer.
5. Calibration of sphere gap.
6. Study of Impulse Voltage Generator
7. Parametric Analysis of Impulse Voltage Waveform
8. Study of Impulse Current Generator
9. Parametric Analysis of Impulse Current Waveform
10. Critical Flashover of a Sphere Gap using IVG
11. Functioning of Voltage Doubler
12. 3-Stage Cockroft Walton Voltage Multiplier

Note: Lab file should consist of minimum Eight experiments.

Text Books:

1. M. S. Naidu and V. Kamaraju, “High Voltage Engineering”, McGraw Hill Education, Fifth Edition, 2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age publishers, New Delhi, 3rd edition, 2010.
3. D. V. Razevig (Translated by Dr. M. P. Chourasia), “High Voltage Engineering Fundamentals”, Khanna Publishers, 1993.
4. R. Arora, W. Mosch “High Voltage and Electrical Insulation Engineering”, Wiley-IEEE Press; 1st edition, 2011.
5. http://nptel.iitm.ac.in/courses.php

Reference Books:

1. E. Kuffel, W. S. Zaengl and J. Kuffel, “High Voltage Engineering Fundamentals”, Newnes Publication, 2nd edition, 2008.
2. Rakosh Das Begamudre, “High Voltage Engineering, Problems and Solutions”, New Age International Publishers, New Delhi, 2010.
3. D. V. Razevig, “High Voltage Engineering Fundamentals”, Khanna Publishers, 2nd edition, 1993.

Guide lines for ICA:

ICA shall be based on continuous evaluation of student performance throughout semester and practical assignment submitted by the student in the form of journal.

Guidelines for ESE:

ESE will be based on the Laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work, performance and understanding.

Project					
LAB COURSE OUTLINE					
Course Title:	**Project**	**Short Title:**	**PROJ**	**Course Code:**	
Course description:					
Project represents the culmination of study towards the Bachelor of Engineering degree. The project offers the opportunity to apply and extend material learned throughout the program. The emphasis is necessarily on facilitating student learning in technical, project management and presentation spheres.					
Laboratory	**Hours/week**	**No. of weeks**	**Total hours**	**Semester credits**	
	06	**14**	**84**	**03**	
End Semester Exam (ESE) Pattern:	**Oral (OR)**				
Prerequisite course(s):					
Course objectives:					
1. To understand the basic concepts & broad principles of projects. 2. To understand the value of achieving perfection in project implementation & completion. 3. To apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach. 4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.					
Course outcomes:					
Upon successful completion of lab Course, student will be able to:					
1. Demonstrate a sound technical knowledge of their selected project topic. 2. Undertake problem identification, formulation and solution. 3. Design engineering solutions to complex problems utilizing a systems approach. 4. Conduct an engineering project 5. Demonstrate the knowledge, skills and attitudes of a professional engineer.					
LAB COURSE CONTENT					
Project		**Semester:**	**VIII**		
Teaching Scheme:		**Examination scheme:**			
Practical:	**6 hours/week**	**End Semester Exam (ESE): (OR)**		**50 marks**	

	Internal Continuous Assessment (ICA):	**50 marks**

In continuation with Project (Stage – I) at Semester – VII, by the end of Semester – VIII, the students should complete implementation of ideas as formulated in Project (Stage – I). It may involve fabrication / coding, experimentation, data analysis within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability. It may also include testing, results and report writing. Each student group should submit complete project report at the end of Semester-VIII in the form of Hard bound.

Each student group is required to maintain separate log book for documenting various activities of the project.

Guide lines for ICA:

The Internal Continuous Assessment (ICA) for project shall be based on continuous evaluation of students' performance, active participation, knowledge/skill acquired throughout semester and presentation by the students. The assessment shall be done jointly by the guide and departmental committee. A three-member departmental committee including guide, appointed by Head of the department, shall be constituted for the assessment. The assessment for Project in Semester – VIII shall be as per the guidelines given in Table – 2.

Table – 2

		Assessment by Guide				**Assessment by Departmental Committee**			
Sr. No.	Name of the Student	Attendance / Participation	Implementation	Results	Report	Depth of Understanding	Presentation	Demonstration	Total
	Marks	5	5	5	5	10	10	10	50

Guidelines for ESE:

In End Semester Examination (ESE), the student may be asked for presentation/demonstration and questions on Project. Evaluation will be based on answers given by students in oral examination.