NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

NEW SYLLABI FOR THE CURRICULAM OF UG COURSE

(B.TECH. IN ELECTRICALENGINEERING)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To learn the fundamentals of Electric Circuits and Network theorems.
• CO2: To develop an idea on Magnetic circuits, Electromagnetism
• CO3: To learn about single phase and polyphase AC circuits.
• CO4: Introduction to single phase transformer.
• CO5: Introduction to the transient analysis of RLC circuits with DC excitation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Electric Circuits: Ohm’s laws, Kirchhoff’s laws, Independent and Dependent sources, Analysis of simple circuits. (3)

Network theorems. (4)

Magnetic field, Concept of magnetic circuits, Magnetomotive Force, Reluctance, Ampere’s circuital law and Biot-Savart law, Determination of B/H curve, Comparison of electric and magnetic circuit, Electromagnetic induction, Faraday’s laws of electromagnetic induction, Direction and Magnitude of induced E.M.F. (7)

Self and mutual Inductance, Inductances in series and parallel, Energy stored in inductor, Capacitance, Capacitance in series and parallel, Relationship between charge, voltage and current, Energy stored in capacitor (5)

Transients with D.C. excitation. (5)

Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behaviour of A.C. circuits, Resonance in series and parallel R-L-C circuits (7)

Single-Phase Transformer , equivalent circuits, open circuit and short circuit tests (6)
Polyphase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Electrical & Electronic Technology by Hughes, Pearson Education India
Reference Books:
1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd
2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Education India</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
</table>

NIL	CT+EA
Course Outcomes	• CO1: To understand the principle of superposition. • CO2: To understand the principle of maximum power transfer • CO3: To understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: To understand the calibration of energy meter. • CO5: To understand open circuit and short circuit test of single phase transformer. • CO6: To analyse RLC series and parallel circuits • CO7: To understand three phase connections
Topics Covered	**List of Experiments:** 1.To verify Superposition and Thevenin theorem 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit
Text Books, and/or reference material	Text Books: 1. Suggested Text Books: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC301	NETWORK ANALYSIS AND SYNTHESIS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MAC02(MATHEMATICS –II) , EEC01(ELECTRICAL TECHNOLOGY)		CT+EA					
Course Outcomes	Upon successful completion of this course, students should be able to: • CO1: Apply the knowledge of basic circuital law, like nodal analysis and mesh analysis, to write the equations for large linear and coupled circuits. • CO2: Apply Thevenin's and Norton's theorems to analyze and design for maximum power transfer. • CO3: Apply the Laplace transform to linear circuits and systems and analyze the signal synthesis. • CO4: Evaluate the performance of RL, RC, and RLC circuits by the application of Laplace transform. • CO5: Analyze the given network using graph theory technique. • CO6: Analyze the given network using different two port network parameters. • CO7: Determine the response of a network using the network function and draw pole-zero plots, Bode plot etc. • CO8: They will also able to synthesize the network functions. • CO9: Students should be able to design the passive filters.						
Topics Covered	Networks Theorems: Analysis of networks with dependent sources, mesh analysis, nodal analysis, source transformation technique, superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention) (8)						

	Network Topology: Network graph, Tree, Incidence matrix - Fundamental cut-sets and fundamental loops – Tie set and cut set schedules. Formulation of equilibrium equation on loop basis and node basis, Formulation of equilibrium equation in matrix form – Duality, Construction of dual of a network. (6) Time and Frequency response of circuits Voltage/current relations for R, L, C and their equations in time domain. Initial and final conditions, first and second order differential equations, steady state and transient response. Analysis of transient and steady state responses using Classical technique as well as by Laplace transforms. Steady state response to step, ramp, impulse and sinusoidal input functions. (12) Two-Port parameters: Open circuit, Short circuit, transmission and hybrid parameters, relationship between parameter sets, reciprocity and symmetry conditions, parallel connections, parallel connection of two port networks. Network equivalents – Analysis of T, π , ladder and lattice networks . (8) Network Functions: poles and zeros Network functions for one port and two port networks, Driving point and transfer functions, ladder network, general network, poles and zeros of network functions, restrictions on Pole and zero locations for driving point functions and Transfer functions, time domain behavior from pole and zero plot. Bode plot. (4) Fundamentals of Network Synthesis:Causality and stability, Hurwitz polynomials, positive real functions, synthesis of one port networks with two kinds of elements. Properties and synthesis of L-C, R-C, R-L driving point impedances, synthesis of R-L-C functions. Properties of transfer functions, zeros of transmission, synthesis of Y21 and Z21 with a 1-Ohm termination, synthesis of constant – resistance networks. (12) Passive Filter as a Two Port Network – Characteristics of Ideal Filter – Low pass and High Pass Filter.Design of constant K, m derived and composite filters (6)
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. 3. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Department of Electrical Engineering							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC302	ELECTRICAL & ELECTRONIC MEASUREMENT	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To develop an idea about the measurement processes • CO2: To learn the operating principle of ammeter, voltmeter, wattmeter and energy meter • CO3: To gain knowledge about Potentiometer and various resistance measurement techniques • CO4: Introduction to AC Bridges & Instrument Transformers • CO5: Familiarisation with CRO and introduction to Digital Instrumentation						
Topics Covered	Basics of Measurement: Significance of measurement, Direct & Indirect methods of measurement, Classification of instruments, Static and dynamic characteristics of						

	measurement system, Various types of error in measurement system, Error analysis by conventional and statistical methods, uncertainty analysis. (6) Basic electrical Instruments: Various torques in electrical instruments, various types of damping in instruments, Principle of operation of Permanent Magnet Moving Coil (PMMC) instrument, use of shunt and multiplier to extend the range of PMMC instruments, Temperature compensation of PMMC instruments, principle of operation of Moving Iron (MI) instruments, Linearisation of scale of MI instrument, extension of range of moving coil and iron instrument, Measurement of 3-phase power and wattmeters errors. Principle of operation of single phase energy meter, Creep in energy meter and its compensation, testing of energy meter, Phantom loading (14) Potentiometers: Basic principle of ordinary slide wire potentiometer, principle of operation of DC Crompton's Potentiometer, Measurement of voltage, current, resistance and power by potentiometer, calibration of voltmeter, ammeter and wattmeter by potentiometer, Drysdale polar potentiometer, Gall Tinsley Coordinate potentiometer (6) Measurement of Resistance: Measurement of medium resistance by wheatstone bridge, measurement of low resistance by Kelvin Double Bridge, measurement of high resistance by direct deflection method, loss of charge method and Megger. (4) AC Bridges: Comparison of measurement methods with wheastone bridge, Measurement of inductance, capacitance and frequency by AC Bridges(8) Instrument Transformers: Disadvantages of using shunts and multipliers for very high current and voltage measurement, Use of Current transformer for measurement of current, construction of current transformer, current transformer errors, effect of sudden open circuit of current transformer, use of potential transformer for voltage measurement, construction of potential transformer, potential transformer errors. (6) Measurement of phase and frequency: Measurement of frequency by electrical resonance frequency meter and weston frequency meter. Measurement of phase or power factor by dynamometer type instrument, moving iron power factor meters, measurement of phase difference by synchroscope. (4) Cathode Ray Oscilloscope: Construction and principle of operation, Measurement of current, phase difference and frequency by CRO, Sampling Oscilloscope, Theory of storage oscilloscope, Digital Storage Oscilloscope. (4) Digital Instruments: Advantages of digital instruments over their analog counterparts, Different types of digital voltmeters, digital multimeter, digital frequency meter. (4)
Text Books, and/or reference material	Text Books: 1. Electrical Measurements & Measuring Instruments by Golding & Widdis, Wheeler's Student Edition Reference Books: 2. Electronic Instrumentation by HS Kalsi, Tata McGraw- Hill. 3. A course in Electrical and Electronic Measurements and Instrumentation by A.K.Sawhney, Dhanpat Rai & Co.

Department of Electrical Engineering							
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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EES351	ELECTRICAL & ELECTRONIC MEASUREMENT LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	• CO1: To measurepower and energy in single phase and three phase circuit. • CO2: To understand the operation of DC potentiometer • CO3: Introduction to industrial power measurement with CT and PT • CO4: Measurement of inductance, capacitance and capacitance by AC bridges. • CO5: To measure earth resistance • CO6: To measure displacement, force, pressure by transducers
Topics Covered	**List of Experiments:** 1. Measurement of power in single phase circuit by three voltmeter and ammeter method 2. Measurement of power in three phase circuit by two wattmeter method 3. Calibration of DC potentiometer 4. Calibration of Energy meter 5. Measurement of power by CT and PT 6. Measurement of Earth resistance by three electrode method 7. Measurement of displacement by LVDT 8. Measurement of inductance by Anderson's Bridge 9. Measurement of capacitance by Schering Bridge 10. Measurement of frequency Wien's Bridge
Text Books, and/or reference material	Suggested Text Books: 1. Electrical Measurements& Measuring Instruments by E.W. Golding & F.C. Widdis 2. Electronic Measurement & Instrumentation by H.S. Kalsi Reference Books: 1. Electrical & Electronic Measurement & Instrumentation by A.K.Sawhney

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EEC401	POWER SYSTEMS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: From the knowledge of this chapter, students can select economical system for specific application for supply of electrical energy to consumers. They are also able to find out economical voltage for transmission of electrical energy. Further, they are able to calculate the minimum consumer voltage for different kinds of loads and can suggest remedy to improve the voltage if needed. • CO2: On completion of this chapter, students can calculate line parameters like inductance and capacitance for different geometry of the line, useful for finding out performances of the line thereof. • CO3: This chapter helps students to select suitable supporting structure for overhead supply systems. Further, they are able to calculate sag for different configurations of overhead line conductors, with or without the influences of ice and wind. They also become conversant with the application of stringing chart and sag template. Subsequently, students can calculate spacing and ground clearance of overhead line conductors for seamless and secure operation of the system. • CO4: From the knowledge of this chapter, students can calculate voltage distribution in string insulators and string efficiency, necessary for safe operation of the systems. They can show that use of grading ring improves the voltage distribution along string of suspension type insulators. Besides, they can also suggest use arcing horns for protection of insulator strings against flashovers. • CO5: This chapter helps the students to determine operating voltage, charging current, charging kVAR, insulation resistance and dielectric power loss of power cables. • CO6: Noesis of this chapter helps students to evaluate the performance of short, moderately long (T or π) and long transmission lines. They can also determine

	generalised circuit parameters of transmission lines. • CO7: On completion of this chapter, students can calculate critical disruptive voltage, local corona voltage and losses due to corona. • CO8: Here, in this chapter students calculate the induced voltage on neighbouring communication line conductors due to inductive and electrostatic interference of power line conductors.
Topics Covered	Distribution Systems:Systems of distribution, economics and copper efficiencies, calculations on distribution and feeders, Kelvin Law. (10) Electrical Design of Overhead Lines:Conductor materials, resistance, inductance, self and mutual GMD calculations for single, twin and multi- circuit lines including bundled conductors, cases of symmetrical and unsymmetrical lines.Capacitance: calculation for single twin and multi circuit lines effect of earth. Choice of transmission voltage, influencing factors, spacing between conductors, current rating of overhead lines. (10) Mechanical Design of Overhead Lines:Mechanical properties of different types of overhead conductors, factors of safety in relation to working conditions, calculation of sag. Supports at different levels: effect of change of temperature and loading: sag templates and stringing charts. Supports for overhead lines: low voltage high voltage and extra high voltage lines. Span length: basic and economic spans. Ground clearance of conductors. (6) Insulators:Materials used, types of insulators for low voltage, high voltage and extra high voltage lines and outdoor switchyard, bushing insulators, voltage distribution in a string of suspension insulators, methods of potential equalization; arching horns and grading rings, reasons of overhead line insulator failure, puncture and flashover voltage, design criteria. (7) Insulated Cables:Types of L. V. Cables for distribution systems: conductor materials, important types of insulating materials, high voltage cables, Stresses developed, economical stress and grading of dielectric materials, screened and pressure cables, mechanism of cable break down charging Current, power factor and losses in cables, determination of current Rating of cables. (8) Transmission and Performance:Classification of transmission lines, calculation of regulation and efficiency, Nominal T. Nominal II and rigorous methods, generalized circuit parameters (A,B,C and D constants) Ferranti effect and losses in open circuited lines. Calculation of phase modifier capacity. (7) Corona:Reasons for corona, critical disruptive voltage and visual critical voltage Effects of pressure, temperature and irregularity of conductor surface, Losses in corona and its reduction. (4) Inductive interference:Electrostatic and electromagnetic interference with adjacent lines.(4)
Text Books, and/or reference material	Text Books: 1. The Transmission and Distribution of Electrical Energy by H. Cotton & H. Barber,Publisher: Hodder Arnold,ISBN 13: 9780340147719, ISBN 10 : 0340147717. 2. Power System Analysis by D. P. Kothari & I. J. Nagrath,Publisher: Tata McGraw Hill Education,ISBN: 0-07-049489-4 Reference Book: 1. Power system analysis by John J. Grainger & William D. Stevenson,Publisher: Tata McGraw Hill Education,ISBN 10: 0070585156, ISBN 13: 978-0070585157

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC402</td><td>ELECTRICAL MACHINES - I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01(ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Able to understand the fundamental principles and classification of electromagnetic machines.
• CO2: Ability to design an armature winding
• CO3: Able to learn about the constructional details and principle of operation of dc machines.
• CO4: Acquire knowledge about the working of dc machines as generators and motors.
• CO5: Acquire knowledge about the constructional details, principle of operation of transformers.
• CO6: Acquire knowledge about testing and applications of dc machines & transformers.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">DC Machines: Armature winding: Lap winding, wave winding, equalizer rings. (8)

Generator: Construction of dc machines, Emf equation, types of generator, losses, efficiency, armature reaction, commutation, interpoles, compensating windings, dc generator characteristics, voltage build-up of a dc shunt generator, parallel operation of dc generators. (12)

Motor: DC motor principle, counter Emf, speed and torque equations, load characteristics, speed control, starting of dc motors, three-point and four-point starters, testing of dc machines. (12)

Transformer: Single-phase transformer: Construction and types, principle of operation, Emf equation, transformer on no-load, transformer on load, equivalent resistance, magnetic leakage, equivalent circuit, phasor diagram, open and short circuits tests, voltage regulation, losses, efficiency, all-day efficiency, separation of hysteresis and eddy current losses, parallel operation, auto transformer. (12)

Three-phase transformer: Three-phase transformer connections and vector groups, equivalent circuit, determination of equivalent circuit parameters, parallel operation, three phase to two-phase conversion and vice-versa, tap-changers on transformers, testing of transformers, cooling. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc.
2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill.
Reference Books:
1. M.G. Say, Alternating Current Machines, Pitman Publishing.
2. Alexander S. Langsdorf, Theory of Alternating Current Machinery, Tata McGraw-Hill.</td></tr>
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<tr><td>EEC403</td><td>DIGITAL ELECTRONICS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course assessment methods (continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire an idea about digital electronics and its applications
• CO2: To learn the fundamentals of different numbers systems and codes and code conversion techniques.
• CO2: To study about the Boolean algebra and basic logic gates along with their digital design procedure using elementary logic gates.
• CO3: To learn about the different sequential and combinational logic circuits and their use in digital electronics applications.
• CO4: Learn about the Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), and data conversion and acquisition techniques.
• CO5: To study the different types of Codes (Gray code, Excess-3 code, BCD Code etc.) and Code converters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Digital Electronics: History and Evolution of Computation and Computers, Application of Digital Electronics in Modern Society. (4)

Number Systems and Codes: Decimal Number System, Binary Numbers System, Octal Number System, Hexadecimal Numbers System, Numbers Conversions, Gray Code, Excess-3 Code, BCD Code, Hamming Code, Code Conversion, BCD to 7-Segment Decoder: Error Detection and Correction Codes - error detection by parity checking, Principle of error correction. (6)

Boolean Algebra and Logic Gates: Binary arithmetic, Binary Addition, Binary Subtraction, Binary Multiplication, Binary Division, 1s Complement, 2s Complement, Signed Binary Number, Introduction to Logic Gates, Basic Logic Gate Operations, Universal Gates, Realization of logic gates using switches. (6)

Digital Arithmetic and Arithmetic Circuits: Half Adder, Full Adder, Half Subtractor, Full Subtractor, Multi-Bit Ripple-Carry Adder and Subtractor circuits, Basics of Binary Multiplier and Divider Circuits. (5)

Logic Families: Transistors (MOS and BJT) as switch, Different logic families such as RTL, DCTL, DTL, HTL, TTL, ECL, MOS & CMOS logic family their importance and applications. (5)

Minimization Techniques Logic Synthesis: Demorgan’s Theorem, SOP/POS forms, Minimization of logical function, Algebraic method, Karnaugh Map method, Quine Mccluskey Method. (6)

Combinational Circuits: Multiplexer, Demultiplexer, Decoder, Encoder, Decoder Driver, Combinational Circuit Design and Their Applications. (6)

Sequential Circuits: Definition, Moore and Miley Machines; Elements of Sequential Circuits - Latches and Registers, Different kinds of Flip-Flops – R-S, J-K, Master-Slave arrangement, D, and T Type Registers; Typical sequential circuits -counters, shift registers and sequence generator; synchronous and asynchronous circuits. (8)

Multivibrators: Definition of different types of Multivibrators, their realization by logic gates, op-amp and transistors, 555 Timer IC and Schmitt Trigger circuit and their applications. (6)

A/D & D/A Converter: Need for Data conversion, Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), and data conversion and acquisition techniques, Different types of DAC & ADC ICs, data conversion and acquisition techniques, Introduction to GUI and PC Based Data Acquisition Systems, Data Acquisition System</td></tr>
</table>

	Components (Software and Hardware).(4)
Text Books, and/or Reference Material	Text Books: 1. Fundamentals of Digital Logic – Anand Kumar – PHI 2. Digital Electronics – G. K. Kharate – Oxford 3.Digital Logic and Computer Design – M. Morris Mano – PHI Reference Books: 1. Digital Fundamentals – Floyd, UBS 2. Digital Systems: Principles and Applications – Tocci, Widmer and Moss, Pearson Edu.

Department of Electrical Engineering							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO440	FUNDAMENTALS OF POWER SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					

Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material • CO2: Given Specification leads to study of suitable system parameters and incorporating laws of Power systems to choose the most applicable. • CO3: Given Specification emphasises on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification facilitates the design of equipments on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults.
Topics Covered	Power System Network: Single phase transmission, three phase transmission, complex power, Basic Structure of power system, overhead and underground systems, overhead line conductors, Transmission and distribution systems in India. (2) Generating Stations: Steam Power station, Hydro-electric power station, Gas turbine power station, Nuclear power station, classification, Comparison of various power stations. (5) Supply Systems: AC power supply scheme, Comparison of DC and AC transmission, Advantages of High transmission voltage, various systems of power transmission, comparison of conductor material in overhead system, comparison of conductor material in underground system, Choice of transmission voltage. (5) Line Parameters and Performance of Transmission Lines: Line resistance, Inductance, Capacitance, Representation of Lines, per unit method, advantages of per unit systems, Short transmission line, medium length transmission line, long transmission line, Evaluation of ABCD parameter, equivalent pi and T circuit. (8) Conductors: Introduction, Type of Conductor, Skin effect, Kelvin's economy law, modified Kelvin's law, Limitations of Kelvin's law (4) Overhead Line Insulators: Type of insulator, voltage distribution over insulator string. (3) Tariffs: Introduction, Types of Tariff-Flat demand tariff, straight line meter rate tariff, Block meter type tariff, Two part tariff, Power factor tariff, Peak load tariff, three part tariff (3) Power Factor Improvement: Introduction, Disadvantages of low power factor, causes of low power factor, power factor improvement, power factor correction by static capacitor. Economics of power factor improvement.(5)

	Power Systems Fault and Protection: Symmetrical components, Symmetrical faults and unsymmetrical faults, Switches, fuses, circuit breakers, protective systems, protective relays, (5) Power System Earthing: Type and methods of earthing, earth resistance, Design of Earthing grid, Tower footing resistance, measurement of earth resistance, neutral grounding. (2)
Text Books, and/or reference material	Text Books: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder Arnold 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Power System Analysis, Tata McGraw Hill Education.

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EEO441	CONCEPT OF INDUSTRIAL ELECTRONICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ECC 331 (ANALOG ELECTRONICS), EEC 403(DIGITAL ELECTRONICS)		CT+EA					
Course Outcomes	• CO1: Acquire an idea about semiconductor devices • CO2: To learn the basic operation of the ac-dc/ dc-dc/ dc-ac/ ac-ac components • CO3: To identify the application of the components in different fields of Engineering • CO4: To identify the utilisation of the components in Industry						
Topics Covered	Review of Power Electronic Systems: Overview of Some Modern Power Semiconductor Devices. (2) Digital Electronics: Overview, Number Systems, Integrated Circuits, Logic Families, Pin Identification.(6) Uncontrolled rectifiers: Single phase and multiphase different circuit arrangements and their operation, analysis, performance evaluations. (6) Controlled rectifier: Semi Controlled and fully controlled converters, single phase and multiphase, different circuit arrangements and their operation analysis performance evaluations. (6) DC-DC Converters: Classification, principles of operation, step down (Buck) and step up (Boost) switched mode power supply, Buck-Boost Converter. (6) Inverters: Classification, theory of operation, Square wave Inverter, PWM switching topology, performance evaluation, applications. (6) Applications: DC Drives, AC Drives, Power Conditioners and Uninterruptible Power Supplies, Power Line Disturbances, Power Conditioners, UPS. (6) Other Residential and Industrial Applications. (4)						
Text Books, and/or reference material	Text Books: 1. B. K. Bose, Power Electronics and AC Drives, Prentice- Hall 2. N. Mohan, T. M. Underland&Riobbins, Power Electronics: Converters, Applications & Design, John-Wiley.						

	Reference Books: 1. L. Umanand, Power Electronics, Essentials & Applications, Wiley India Pvt. Ltd.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO442	ENERGY CONSERVATION, AUDIT AND ICT & IOT APPLICATION FOR MONITORING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+EA					
Course Outcomes	• CO1: To understand the Overall Energy Scenario (National & International • CO2: To build the skill in Energy management • CO3: To be able to conduct the energy audit. • CO4: To understand the energy saving • CO5 :To understand the energy monitoring through ICT & IoT						
Topics Covered	Overall understanding Energy Scenario National and International perspective, Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification, relative merits and demerits, Carbon emission, carbon credit, International environmental meet for awareness of Green House emission (GHG). (10) Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy.(6) Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.(6) Procedures and Techniques for Energy Audit, Data gathering : Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering. Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.(8) Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation.(6) Basics of Information Communication Technology (ICT), Internet of Things (IoT). Basic sensors for Energy Monitoring and Evaluation, Application of ICT and IoT for energy monitoring. Remote supervision of Energy use. (6)						
Text Books, and/or reference material	1.Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern). 2. Energy policy for : B.V. Desai (Weiley Eastern), 3. Modeling approach to long term demand and energy implication : J.K.Parikh. 4. Energy Policy and Planning: B.Bukhootsow.						

	5. TEDDY Year Book Published by Tata Energy Research Institute (TERI), 6. World Energy Resources : Charles E. Brown, Springer 2002. 7. 'International Energy Outlook' -EIA annual Publication 8. Energy Management: W.R.Murphy, G.Mckay (Butterworths). 9. Energy Management Principles: C.B.Smith (Pergamon Press). 10. Efficient Use of Energy : I.G.C.Dryden (Butterworth Scientific)

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO443</td><td>NETWORK THEORY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MAC02(MATHEMATICS –II), EEC01(ELECTRICAL TECHNOLOGY)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Apply the knowledge of basic circuital law, like nodal analysis and mesh analysis, to write the equations for large linear and coupled circuits.
• CO2: Apply Thevenin's and Norton's theorems to 12nalyse and design for maximum power transfer.
• CO3: Apply the Laplace transform to linear circuits and systems and 12nalyse the signal synthesis.
• CO4: Evaluate the performance of RL, RC, and RLC circuits by the application of Laplace transform.
• CO5: Analyze the given network using graph theory technique.
• CO6: Analyze the given network using different two port network parameters.
• CO7: Determine the response of a network using the network function and draw pole-zero plots, Bode plot etc.
• CO8: They will also able to synthesize the network functions.
• CO9: Students should be able to design the passive filters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to circuit variables and circuit elements, Review ofKirchhoff's Laws, Independent and dependent Sources, SourceTransformations. Solution methods applied to dc and phasor circuits: Mesh and node analysis of network containing independent and dependent sources Network topology, Network graphs, Trees, Incidence matrix, Tie-set matrix and Cut-set matrix. (8)

Network theorems applied to dc and phasor circuits: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Millman's theorem, Maximum power transfer theorem. (6)

Laplace transform, properties Laplace Transforms and inverse Laplace transform of common functions, Important theorems: Time shifting theorem, Frequencyshifting theorem, Time differentiation theorem, Time integration theorem, s domain differentiation theorem, s domain integration theorem, Initial value theorem, Final value theorem Partial Fraction expansions for inverse Laplace transforms, Solution of differential equations using Laplace transforms Transformation of basic signals and circuit into s-domain Transient analysis of RL, RC, and RLC networks with impulse, step, pulse, exponential and sinusoidal inputs. (8)

Two-Port parameters:Open circuit, Short circuit, transmission and hybrid parameters,</td></tr>
</table>

	relationship between parameter sets, reciprocity and symmetry conditions, parallel connections, parallel connection of two port networks. Network equivalents – Analysis of T, π , ladder and lattice networks . (8) Network functions for the single port and two ports, properties of driving point and transfer functions, Poles and Zeros of network functions, Significance of Poles and Zeros. Time domain response from pole zero plot, Impulse Response Network functions in the sinusoidal steady state, Magnitude and Phase response. (5) Resonance: Series resonance, bandwidth, Q factor and Selectivity, Parallel resonance. Coupled circuits: single tuned and double tuned circuits, dot convention, coefficient of coupling, Analysis of coupled circuits. (7)
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. 3. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Department of Electrical Engineering							
OFFERED FOR EC DEPARTMENT							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EEC431	CONTROL SYSTEM ENGINEERING	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
ECC 303(SIGNALS AND SYSTEMS)		CE+EA					
Course Outcomes	• CO1: To get the knowledge of basic objectives of control system design • CO2: To derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics • CO3: To justify stability of systems based on their transfer functions, time domain and frequency domain specifications • CO4: To develop concepts on root pattern with variable gains and comment on the stability • CO5: To determine the stability of closed-loop system based on open loop frequency response • CO6; To be able to design controllers so as to meet design specifications both in time as well as frequency domain • CO7: To be able to realize the controller both in software simulation through MATLAB coding as well as in real-time environment						
Topics Covered	Introduction to control systems:Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4) Mathematical Models of Physical Systems:Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula.(4) Introduction to State Variable Approach:Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix.(2) Representation of Control Components: Electrical components, Mechanical						

	components,Electromechanical Components. (2) Time domain analysis and design specification of linear systems:Standard signals, Transient response and S-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (8) Concepts of Stability and Algebra Criterion:Concept of stability, characteristic equation necessary conditions for stability, Routh-Hurwitz stability criteria. (4) Root Locus Technique:The root locus concept, construction of Root Loci, Important properties parameters design byRoot locus method, Root-locus Plots with MATLAB. (4) Frequency Response Analysis and Stability Studies in Frequency Domain:Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, Conditionally stable system, M and N loci on complex and gain phase plan MATLAB tools and case studies. (10) Design and Compensation Technique:Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and S-plane design techniques,Example of control systems. Design with MATLAB. (4)
Text Books, and/or reference material	Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic control system, John Wiley & Sons Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

Department of Electrical Engineering							
OFFERED FOR ME DEPARTMENT							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EEC432	ELECTRICAL MACHINES	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
EEC01(ELECTRICAL TECHNOLOGY)		CE+EA					
Course Outcomes	• CO1: Theory of electromechanical energy conversion, the concepts of voltage generation and fundamentaltorque equation. • CO2: Basic understanding of the principles of operation and construction of direct and alternating current machines and transformers. • CO3: A study of theory and concept of Electric Machines (AC & DC). • CO4: Deriving equivalent circuit of electrical machines. • CO5: Studying the performance and characteristics of Electrical machines (AC & DC).						
Topics Covered	Basic principle of Faraday's law of electro-magnetic induction, energy conversion and magnetic circuit. (4) Transformer: Construction and principle of operation of single phase transformer, Step-up and Step-down transformer, E.M.F. equation, Equivalent circuits, phasor diagram, Open circuit and short circuit tests, losses and efficiency, All day efficiency, Auto transformer. (8) D.C. Machines Construction, Methods of excitation and classifications, Simple lap and wave windings, emf equation, characteristics of different dc generator, armature reaction,						

	Commutation, Back e.m.f in a d.c. motor, Motor Starter, Speed and torque equations, Speed vs torque characteristics and speed control of DC motors, losses in dc machines, Applications. (12) Induction Motor: Pulsating and rotating magnetic field construction and principle of operation of Single and three phase induction motors, cage and wound rotor induction motors, comparison between them slip, equivalent circuits, No load and blocked rotor tests, Circle diagram, Torque/speed curve Starting and speed control, Applications of single phase and three phase induction motors. (12) Synchronous Machines: Construction-alternators-turbo & hydro generators, principle of operation, emf equation, excitation control, synchronization load sharing synchronous motor operation,Synchronous condenser, applications of synchronous generator and motor. (6)
Text Books, and/or reference material	Text Books: 1. Electrical Machinery by P S Bimbhra 2. Electrical Technology Vol-II by B L Thereza Reference Books: 1. Electrical Machines by J B Gupta

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EES451	NETWORK AND CIRCUIT LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
		CE+EA					

Course Outcomes	• CO1: Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner. • CO2: Students will get the basic concepts of passive components and their configurations and about how to use experimental equipments such as function generator, CRO, regulated power supply etc. • CO3: Predict and measure the transient and sinusoidal steady-state responses of simple RL, RC and RLC circuits. • CO4: Able to apply linearity and superposition concepts to analyze RL, RC, and RLC circuits in time and frequency domains. • CO5: Able to analyze resonant circuits both in time and frequency domains. • CO6: Able to construct and make time and frequency domain measurements on elementary RL, RC, and RLC circuits. • CO7: Evaluate the parameters of two port networks to analyze the performance of transmission lines • CO8: Apply computer mathematical and simulation programs to solve circuit problems.
Topics Covered	**List of Experiments:** 1. Determination of transient response of current in RL and RC circuits with step voltage input. 2. Determination of transient response of current in RLC circuit with step voltage input for under-damped, critically damped and over-damped cases. 3. Determination of frequency response of current in RLC circuit with sinusoidal ac input. 4. Determination of frequency response characteristics of a low pass and high pass active filters. 5. Determination of z and h parameters (dc only) for two port network. 6. Determination of the driving point and transfer impedance of coupling circuit.

	7. Generation of Periodic, Exponential, Sinusoidal, Damped sinusoidal, Step, Impulse, Ramp signals using MATLAB in both discrete and analog form. 8. Determination of transient and frequency response characteristics of RL, RC and RLC circuits using PSpice. 9. Determination of transient and frequency response characteristics of RL, RC and RLC circuits using Matlab. 10 Determination of frequency response characteristics of a low pass and high pass passive filters using MATLAB
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. 3. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

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OFFERED FOR EC DEPARTMENT							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EES481	CONTROL SYSTEMS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
ECC303(SIGNALS AND SYSTEMS)		CE+EA					
Course Outcomes	• CO1: To understand the dynamic behaviour of real-time systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAB programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration.						
Topics Covered	**List of Experiments:** 1. DC Servo Speed Control System 2. DC Servo Position Control System 3. Temperature Control System 4. Linear System Simulator 5. Lead and Lag Network 6. P, PI and PID controller 7. Study of Different real-time systems through Simulation in MATLAB 8. PID Design Method for DC motor Speed Control using MATLAB 9. Root Locus Design Method for DC motor Speed Control using MATLAB 10.DC motor Speed Control Based on Frequency Response using MATLAB						
Text Books, and/or reference material	Suggested Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age InternationalPublishers. 2. K. Ogata, Modern Control Engineering, Prentice Hall. Suggested Reference Books:						

	1. B. Shahian, M. Hassul, Control System Design using MATLAB, Prentice Hall. Laboratory Manuals

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OFFERED FOR ME DEPARTMENT							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES482	ELECTRICAL MACHINES LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EES51(ELECTRICAL TECHNOLOGY LAB), EEC432 (ELECTRICAL MACHINES)		CT+EA					
Course Outcomes	• CO1:Ability to determine the equivalent circuit parameters of a single-phase transformer • CO2: Ability to determine the parameters of single-phase as well as three phase induction motor. • CO3: Ability to determine the characteristics of dc shunt generator and series generator • CO4: Ability to control the speed of a dc shunt motor • CO5: Ability evaluate the voltage regulation of an alternator • CO6: Ability to determine the efficiency of dc machines						
Topics Covered	**List of Experiments:** Determination of equivalent circuit parameters of a single-phase transformer. 2. No-load and load characteristics of a dc shunt generator. 3. Speed control of a dc shunt motor. 4. Open-circuit and load characteristics of a dc series generator. 5. Voltage regulation of an alternator. 6. To perform no-load and blocked-rotor tests on a three-phase Induction Motor. 7. To perform no-load and blocked-rotor tests on a single-phase Induction Motor. 8. Swinburne's test of a dc machine.						
Text Books, and/or reference material	Text Books: 1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc. 2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill. Reference Books: 1. Laboratory manuals						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC501	ELECTRICAL MACHINES - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC402 (ELECTRICAL MACHINES - I)		CT+EA					

Course Outcomes	• CO1: Ability to design an armature winding • CO2: Ability to determine alternator voltage regulation • CO3: Ability to Synchronize an alternator with infinite bus • CO4: Ability to understand starting methodology and determine the variation of synchronous machine performance with excitation • CO5: Ability to assess performance of an induction motor based on appropriate experimentation • CO6: Ability to start an induction motor by appropriate means & controlling its speed in effective way
Topics Covered	Synchronous Generator: Constructional Features of Salient Pole and Non-Salient Pole Machines, Arrangement of Field Winding in the two types of Machines. Armature Winding. (12) Cylindrical Rotor Theory: Phasor Diagram, Open Circuit and Short Circuit Characteristics, Synchronous Reactance, Load Characteristics, Zero Power Factor Characteristics, Voltage Regulation by different methods, Power Angle Characteristics. (12) Salient-Pole Theory: Blondel's Two-Reaction Concept, Direct Axis and Quadrature Axis Synchronous Reactance, Power Angle Characteristics, Slip Test. Parallel Operation of generators. (6) Synchronous Motor: Constructional features, Phasor Diagram, Torque and Power Relations in Non-Salient Pole and Salient Pole Motors, V-Curves, Various Types of Excitation, Synchronous Condenser, Methods of Starting, Applications. (8) Three Phase Induction Motor: Constructional Features of Slip Ring and Squirrel Cage Type Motors, Principle of Operation, Flux and MMF Wave, No-Load Speed and Slip, Rotor Quantities Referred to Stator, Relationship Between Input Voltage and Current, Equivalent Circuit, Analysis of Equivalent Circuit. (8) Torque Speed Characteristics, Starting, Maximum and Full Load Torque, Condition for Maximum Torque, Regions of Stable and Unstable Operations, Effect of rotor resistance and supply frequency on Speed Torque Characteristics, Losses, Efficiency, Performance Characteristics, The Circle Diagram, Starting of Slip Ring and Squirrel Cage Motors, High Starting Torque Motors. Speed Control: Various methods. (6) Single phase induction motor: Constructional features, various types, Rotating magnetic field theory, Equivalent circuit, Determination of constants, methods of starting, Applications.(4)
Text Books, and/or reference material	Text Books: 1. A. S. Langsdorf, Theory of A. C. Machines, Tata McGraw Hill. Reference Books: 2. I. L. Kosow, Electric Machinery & Transformers, PHI. 3. E. Fitzgerald, C.M. Kingsley (Jr) and S. D. Umans, Electric Machinery, Tata McGraw Hill.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC502</td><td>CONTROL SYSTEMS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC301(NETWORK ANALYSIS AND SYNTHESIS), ECC331 (ANALOG ELECTRONICS),EEC402 (ELECTRICAL MACHINES-1), EEC403 (DIGITAL ELECTRONICS)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire the knowledge and skills to identify the basic elements and structures of feedback control systems.
• CO2: To develop the mathematical model of the physical systems.
• CO3: To analyze the time response of the open loop & closed loop systems.
• CO4: To analyze the stability of control systems using different tools.
• CO5: To learn frequency response analysis and stability studies in Frequency Domain
• CO6: To learn control system design using various kinds of compensator & to apply computer skills with MATLAB
• CO7: To develop and analyze state space models</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to control systems: Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (6)

Mathematical Models of Physical Systems: Modeling of electrical networks, modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason’s Gain formula. (6)

Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (4)

Time domain analysis and design specification of linear systems: Standard signals, Transient response and S-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (8)

Concepts of Stability and Algebra Criterion: Concept of stability, characteristic equation necessary conditions for stability, Routh-Hurwitz stability criteria. (4)

Root Locus Technique: The root locus concept, construction of Root Loci, Important properties parameters design by Root locus method, Root-locus Plots with MATLAB. (6)

Frequency Response Analysis and Stability Studies in Frequency Domain: frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, Conditionally stable system, M and N loci on complex and gain phase plot MATLAB tools and case studies. (10)

Design and Compensation Technique: Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and S-plane design techniques, Example of control systems. Design with MATLAB. (6)

Introduction to State Variable Approach: Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix, Controllability and Observability. (6)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1.J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic control system, John Wiley & Sons Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC503	POWER SYSTEMS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
EEC401(POWER SYSTEMS – I)		CT+EA					

Course Outcomes	• CO1: From the knowledge of this chapter, students can calculate fault current and fault MVA (or KVA) for different types of power systems faults, viz. Symmetrical, LG, LLG and LL faults, necessary for selection of suitable protective scheme and circuit breakers. Further, they can also calculate suitable value of current limiting reactors to be placed at particular locations for expansion of existing systems. • CO2: After learning this chapter, students are able to select bus bar arrangements suitable for substations and generating stations. Further, they also become acquainted with the layout of substation equipment. • CO3: On completion of this chapter, students become conversant with various terminologies used in relation to switchgears and their selections. Besides, they also get familiar with different types of circuit breakers along with their properties. • CO4: From this chapter students learn various schemes of primary and backup relaying as employed in electric power systems. • CO5: This chapter familiarizes students about various types of relays along with their characteristics and connections, used in practice for protection of different power systems elements. • CO6: This important chapter makes the students conversant about the diverse schemes used in practice to protect power systems elements like transmission line, generator, transformer etc. • CO7: From this chapter students learn about various neutral grounding schemes as used in practice.
Topics Covered	Short circuit calculation: Symmetrical and asymmetrical short circuits, factors influencing short circuit capacity, methods of limiting short circuit levels. Symmetrical components, sequence impedance, analysis of unsymmetrical short circuit in power systems, methods of measuring sequence components for protective relays. (15) System of Bus bars: Different bus bar arrangements, indoor and outdoor substations, bus bar materials spacing etc. conventional layout representation. (6) Circuit Interruption Devices:Fuses and their characteristics, circuit breakers, arc-characteristics, mechanism of arc extinction, current chopping, resistance switching, L.V. air and oil circuit breakers H.V. oil circuit breakers, Air blast circuit Breakers for H.V. and E.H.V. systems, Sulphur Hexafluoride (SF_6) circuit breaker, Vacuum circuit breaker, Multi break devices, miniature circuit breakers, Circuit breaker contacts, material and construction rating of circuit breakers, testing and maintenance. (8) Protective Relays: Basic requirement of protective relays and classification on their application and principle of operation. Over current relays, directional relays, characteristics and connections. Distance relays, impedance, reactance and mho relays. Differential relays, percentage differential relays, biased beam relay, Translay relay, negative sequence relay,

	static relays. (12) Protective Relaying Schemes: Protection of alternators and transformers, circulating current protection, Relay plug setting and time multiplier setting. Busbar, feeders and transmission line protection time graded protection differential protection distance protection and carrier current protection. (15)
Text Books, and/or reference material	Text Books: 1. The Art and Science of Protective Relaying, by: C. R. Mason, Published by: Wiley Eastern Limited, ISBN: 978-81-7409-232-3 2. Relays: Their Theory and Practice, by: A. R. Van C. Warrington, Publisher: Springer, ISBN: 9780412153808, 0412153807 Reference Books: 1. Switchgear Protection and Power Systems, by: S. S. Rao, Publisher: Khanna Publishers, ISBN: 978-81-7409-232-3 2. Power System Engineering, by: D. P. Kothari and I. J. Nagrath, Publisher: Tata McGraw Hill, ISBN: 9780070647916

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC504	POWER ELECTRONICS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ECC331 (ANALOG ELECTRONICS), EEC403 (DIGITAL ELECTRONICS)		CT+EA					
Course Outcomes	• CO1: Acquire an idea about semiconductor devices • CO2: To learn the detailoperation of the ac-dc components • CO3: To learn the detailoperation of the dc-dc components • CO4: To learn the detailoperation of the dc-ac components • CO5: To learn the detailoperation of the ac-ac components • CO6: To identify the utilisation of the components in Industry						
Topics Covered	Characteristics and specifications, operations, V-1 characteristics, Two transistor analogy, Turn OFF and Turn ON characteristics, Series and Parallel operation of Thyristors, Protection against over voltage and overcurrent, Thermal characteristic protection against dv/dt and di/dt, commutation methods of Thyristors. Different triggering circuits and their design. Similar characteristics for BJT, MOSFET, IGBT (12) Uncontrolled rectifiers: Single phase and multiphase different circuit arrangements and their operation, analysis, performance evaluations. (6) Controlled rectifier: Semi Controlled and fully controlled converters, single phase and multiphase, different circuit arrangements and their operation analysis performance evaluations. (7) DC-DC Converters: Classification, principles of operation, step down (Buck) and step up (Boost) switched mode power supply, Buck-Boost Converter, H-bridge converter, their analysis, design, performance evaluation, applications. (12) Inverters: Classification, theory of operation, 1200, 1800 mode of conduction, PWM switching topology, performance evaluation, applications. (12) AC-AC voltage regulator using Thyristor and TRIAC, Cycloconverters: Theory and their applications. (5) Industrial applications. (2)						

Text Books, and/or reference material	Text Books: 1. B. K. Bose, Power Electronics and AC Drives, Prentice- Hall 2. N. Mohan, T. M. Underland&Riobbins, Power Electronics: Converters, Applications & Design, John-Wiley. Reference Books: 1. L. Umanand, Power Electronics, Essentials & Applications, Wiley India Pvt. Ltd. 2. Robert W. Erickson & D. Maksimovic, Fundamentals of Power Electronics, Springer International Edition.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO540	MEASUREMENTS AND INSTRUMENTATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+EA					

Course Outcomes	• CO1: Given specifications of different measuring instruments for measurement of particular parameter of some known electrical system, compare and judge to find the most suitable one. • CO2: Given application of electrical engineering for measurement of particular parameter along with specified range and accuracy, choose most suitable measuring instrument with the understanding of individual working principles, also judge to fit the given application. • CO3: For some specific parameter to be measured, along with the given range, resolution, accuracy and output format, choose suitable sensor, design associated signal conditioning and analog/digital processing circuit to meet the desired specification. • CO4: Given parameters to identify the location of fault.
Topics Covered	Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors. (3) Measurement of Voltage and Current: Principle of operation and torque equation of Moving coil, Moving iron instruments.(5) Extension of instrument ranges. (2) Measurement of Power & Energy: Principle of operation of Electrodynamic & Induction type wattmeter, Power measurement by two wattmeter, Construction, theory and application of AC energy meter. (6) Measurement of resistance: Measurement of medium, low and high resistances, Megger (6) AC Bridges: Measurement of Inductance, Capacitance, Frequency, mutual inductance (8) Localization of Cable fault: Methods used for localization of ground and short circuit fault. (4) Sensors & Transducers: Introduction to sensors & Transducers, Strain gauge, LVDT, Temperature transducers, Piezo-electric transducer, pressure transducer, Flow measurement using magnetic flow measurement. (8)
Text Books, and/or reference material	Text Books: 1. K. Sawhney, A course in Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai& sons. 2. E. W. Golding & F. C. Widdis, Electrical Measurement & Measuring Instruments,

	Wheeler Publishing Reference Books: 1. H. S. Kalsi, Electronics Instrumentation, Mc-Graw Hill Education. 2. A. J. Bouwens, Digital Instrumentation, Tata Mc-Graw hill.

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>EEO541</td><td>FUNDAMENTALS OF CONTROL SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">MAC01(MATHEMATICS-I)
MAC02 (MATHEMATICS-II)</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To get the knowledge of basic objectives of control system design
• CO2: To derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics
• CO3: To justify stability of systems based on their transfer functions, time domain and frequency domain specifications
• CO4: To develop concepts on root pattern with variable gains and comment on the stability
• CO5: To determine the stability of closed-loop system based on open loop frequency response
• CO6: To be able to design controllers so as to meet design specifications both in time as well as frequency domain
• CO7: To be able to realize the controller both in software simulation through MATLAB coding as well as in real-time environment.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to control systems: Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4)

Mathematical Models of Physical Systems: Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason’s Gain formula. (6)

Introduction to State Variable Approach: Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix. (4)

Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (2)

Time domain analysis and design specification of linear systems: Standard signals, Transient response and s-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (6)

Concepts of Stability and Algebra Criterion: Concept of stability, characteristic equation necessary conditions for stability, Routh-Hurwitz stability criteria. (4)

Root Locus Technique: The root locus concept, construction of Root Loci, Root-locus Plots with MATLAB. (4)

Frequency Response Analysis and Stability Studies in Frequency Domain: Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, Conditionally stable system, M and N loci on complex and gain phase plane, MATLAB tools and case studies. (8)

Design and Compensation Technique: Preliminary considerations of classical Design,</td></tr>
</table>

	Realization of Basic compensators, Frequency domain and s-plane design techniques, Example of control systems. Design with MATLAB. (4)
Text Books, and/or reference material	Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic Control system, John Wiley & Sons Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO542	POWER SYSTEM ANALYSIS AND DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					
Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material, considering the factors like sag, tension and corona. • CO2: Given Specification leads to study of suitable system parameters and incorporating laws of Power systems to choose the most applicable. • CO3: Given Specification emphasises on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification emphasise on the design of equipments, on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults.						
Topics Covered	Fundamentals of Power systems: Transmission line (single phase and three phase), per unit systems, Line constants .(1) Load characteristics: Introduction, Connected load, variable Load on Power Station, Load Curves, Important terms and factors, Load duration curve-Load curves and selection of generating units, base load and peak load of power station. (6) Mechanical Design of Overhead Lines, Sag and Tension: General consideration, Line supports, type of steel towers, Sag and tension, Sag and tension calculation, Parabolic method, Catenary method, Sag and tension charts. (7) Corona: Phenomenon of corona, disruptive critical voltage, visual critical voltage, corona loss, factors and conditions affecting corona loss. (3) Balanced and unbalanced fault: Introduction, effects of faults, symmetrical fault, symmetrical components, unsymmetrical faults. (5) Load flow studies: Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. Advantages and disadvantages. (7) Power system stability: Steady state stability, transient stability, equal area criteria, swing equation, multi machine stability concept and methods for improving stability. (8) Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, transmission loss as a function of plant generation, General loss formula, Optimum load dispatch considering transmission losses.(5)						
Text Books, and/or	Text Books: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder						

reference material	Arnold 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Education.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EES552	CONTROL SYSTEMS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
EEC301(NETWORK ANALYSIS AND SYNTHESIS) ECC 331 (ANALOG ELECTRONICS),EEC402 (ELECTRICAL MACHINES-1), EEC403 (DIGITAL ELECTRONICS)		CE+EA					
Course Outcomes	• CO1: To understand the dynamic behaviour of real-time systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAM programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration.						
Topics Covered	**List of Experiments** 1. DC Servo Speed Control System 2. DC Servo Position Control System 3. Temperature Control System 4. Process Simulator 5. Linear System Simulator 6. Lead and Lag Network 7. P, PI and PID controller 8. Determination of Transfer Function of DC Motor 9. Study of Different real-time systems through Simulation in MATLAM environment. 10. PID Design Method for DC motor Speed Control using MATLAB 11. Root Locus Design Method for DC motor Speed Control using MATLAB 12. DC motor Speed Control Based on Frequency Response using MATLAB						
Text Books, and/or reference material	Suggested Text Books: 1. J.Nagrath and M Gopal, Control system Engineering, New Age InternationalPublishers. 2. K. Ogata, Modern Control Engineering, Prentice Hall Suggested Reference Books: 1. B. Shahian, M. Hassul, Control System Design using MATLAB, Prentice Hall. Laboratory Manuals						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES553</td><td>ELECTRICAL MACHINES LABORATORY - I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EES51 (ELECTRICAL TECHNOLOGY LAB.), EEC402 (ELECTRICAL MACHINES-I)</td><td colspan="6">CT+EA</td></tr>
<tr><td>CourseOutcomes</td><td colspan="7">• CO1:Ability to determine the equivalent circuit parameters and evaluate the efficienc of a single-phase transformer
• CO2: Ability to connect three single-phase transformers as a three-phase transforme in different configurations
• CO3: Ability to determine the characteristics of dc shunt and series generators
• CO4: Ability to start and control the speed of a dc shunt motor
• CO5: Ability to connect two single-phase transformers in parallel
• CO6: Ability to determine the losses in a dc machine and evaluate the efficiency.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. Determination of equivalent circuit parameters of a single-phase transformer.
2. No-load and load characteristics of a dc shunt generator.
3. Speed control of a dc shunt motor.
4. Open-circuit and load characteristics of a dc series generator.
5. Ward Leonard method of speed control of a dc shunt motor.
6. Three-phase transformer connections.
7. Parallel operation of single-phase transformers.
8. Swinburne’s test of a dc machine.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc.
2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill.
Reference Books:
1. M.G. Say, Alternating Current Machines, Pitman Publishing.
2. Laboratory manuals</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC601</td><td>ADVANCED POWER SYSTEMS</td><td>PCR</td><td>4</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC401 (POWER SYSTEM-1), EEC503 (POWER SYSTEM-1I)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand basics of High Voltage Engineering & power system stability
• CO2: To design the insulation systemand load management module
• CO3: To design the High Voltage test system and Laboratory
• CO4: To learn about the testing of High Voltage power apparatus
• CO5 To understand on line monitoring and conditioned monitoring
• CO6: Given specification of stability analysis leads to modeling of power system equipment's like transmission line, generator and design system to obtain operating limits to satisfy the reliability criteria.
• CO7: Given specification leads to knowledge of regulation of active, reactive power and frequency of any system and its application in optimal load flow and scheduling</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overview of Insulation, Air as an Insulation, Concept of Dielectric Strength, Electric field and electrode configuration, Parameters responsible for Break down Voltage of Insulating material (4)

Introduction to Breakdown of Insulation. Breakdown mechanism of insulting systems of Gas, Liquid, Solid, and Vacuum (7)

Generation of AC high voltages and DC High Voltages, Generation of impulse voltages and currents:- Analysis of different circuits, Marx multi-stage impulse generator (8)

Testing of High Voltage power Apparatus. Brief reviews of high voltage testing-Methods for High Voltage Power Apparatus, Introduction to Lightning phenomenon, Insulation Coordination.(5)

Introduction to partial discharge phenomena and concepts of Online testing(3)

Planning and Designing of High Voltage laboratory , Introduction of High Voltage virtual Laboratory (HVVL) and ICT enabled High Voltage laboratory (3)

HVDC Transmission: Introduction, classification, Stability limits, HVDC cable transmission, economic comparison, conversion of three phase AC line to DC line, Advantages of HVDC transmission, Economic distance of HVDC transmission, components of an HVDC transmission (4)

HVDC Converter station, converter unit, converter transformer, filters, reactive power source, smoothing reactor, HVDC system pole, ground electrodes, back to back HVDC station, two terminal HVDC systems, Multi terminal DC systems, DC circuit breakers, Limitations of HVDC transmission, application of HVDC transmission. (7)

Control of voltage and reactive power: Introduction, methods of voltage control, tap changing transformer, shunt reactor, shunt capacitor, series compensation, location of series capacitors, protective schemes for series capacitor, problems associated with series capacitors, series capacitor versus shunt capacitor, synchronous phase modifier, static VAR systems (SVS), SVS schemes, advantages of SVS and application of SVS Thyristor controlled reactor (TSR) , Thyristor switched capacitor (TSC),TSC-TCR scheme. (7)

Power system stability: Steady state stability, transient stability, Infinite bus, stability limit, power angle curve, swing equation, swing curve, M and H constants, equivalent systems equal area criteria, multi machine stability concept and methods for improving stability. (8)</td></tr>
<tr><td>Text Books, and/or</td><td colspan="7">Text Books:
1. C.L.Wadhwa, High Voltage Engineering</td></tr>
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reference material	2.M S Naidu & Kamraju, High Voltage Engineering Reference Books: 1. D.P. Kothari & I.J. Nagrath, Modern Power System Analysis, Tata Mc-Graw Hill 2. Subir Ray, Electrical Power Systems, PHI

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC602</td><td>MICROPROCESSOR & MICROCONTROLLER</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC403 (DIGITAL ELECTRONICS)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller.
• CO2: Describe key H/W and S/W attributes of microprocessors/microcontrollers.
• Outline of the major architectural features of microprocessors.
• CO3: Identify—and exercise—opportunities for hardware and software trade-offs.
• CO4: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor based system.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of digital and microprocessors based systems. (6)

Basic microprocessor architectures,organizations and functional components. Instruction sets, assembly language programming, Micro operations of instructions. (10)

Memory Classification: ROM, EPROM, EEPROM, RAM, Memory Interfacing with 8085, Address decoding for Memory mapped I/O and I/O mapped I/O. (8)

Various types of Interrupts in 8085.(4)

Programmable Peripheral Devices and Interfacing with 8085: 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications.(10)

8051 Architecture and Special Function Registers, Organizations and Pin out details, Instruction sets, Special Function Registers, Assembly language programming, Memory Interfacing with 8051, Practical applications.(10)

8086 Microprocessor, Architectures, Organizations and Pin out details, Interrupts, Minimum and Maximum modes of operation, Instruction sets, Assembly language programming.(8)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. The 8085 Microprocessor: Author : Ramesh Gaonkar, Pub: PRI
2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi & J. G. Mazidi.
3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd.
Reference Books:
1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newness,
2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001.
3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE610</td><td>NUMERICAL ANALYSIS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To acquire an idea about engineering mathematics and linear algebra
• CO2: To learn the Basic concept of numerical computation
• CO3: To learn about solution techniques for linear and nonlinear equations
• CO4: To understand and learn the numerical solution of ordinary differential equation and integration.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Preliminaries of Computing: Basic Concepts, round-off errors, floating point arithmetic, convergence. (2)

Numerical solution of Nonlinear Equations: Bisection Method, fixed point iteration, Newton’s method, error analysis for iterative methods, computing roots of polynomials.(6)

Interpolation and polynomial approximation: Lagrange polynomial, divided differences, Hermite interpolation. (4)

Numerical Integration and Differentiation: Trapezoidal rule, Gaussian quadrature, Euler – Maclaurian formula. (6)

Applied Linear Algebra: Direct methods for solving linear systems, numerical factorization, eigenvalue problems. (4)

Initial Value Problem (IVP) of Ordinary differential equation (ODE): Euler’s method, Taylor’s method, Classical and higher order Runge-Kutta methods Convergence and stability analysis, Multistep method. (6)

Numerical Linear Algebra: Direct methods, Iterative methods, Jacobi or simultaneous iterations, Gauss – Seidel or Successive iterations. (8)

Approximation Theory: Least – square approximation. (2)

Approximating Eigenvalues: Power method, Householder’s method. (2)

Boundary Value problem for ODE: Shooting methods. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 9th Edition, Cengage Learning
2. J. Matthews and K. Fink, Numerical Methods Using MATLAB, Prentice Hall, 1999.
Reference Books:
Reference Books:
1. Introductory Methods of Numerical Analysis - S. S. Satry, 4th Edition, Prentice Hall of India Limited</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE611</td><td>INSTRUMENTATION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">ECC331 (ANALOG ELECTRONICS), EEC403 (DIGITAL ELECTRONICS)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Given specifications of different measuring instruments for measurement of particular parameter of some known electrical system, compare and judge to find the most suitable one.
• CO2: Given application of electrical engineering for measurement of particular parameter along with specified range and accuracy, choose most suitable measuring instrument with the understanding of individual working principles, also judge to fit the given application.
• CO3: For some specific parameter to be measured, along with the given range, resolution, accuracy and output format, choose suitable sensor, design associated signal conditioning and analog/digital processing circuit to meet the desired specification.
• CO4: Give multi-parameter control application of electrical engineering design a suitable instrumentation, using PLC, suitable measuring instruments and actuators (including PLC programming).
• CO5: Design a suitable Data Acquisition System for some complex electrical system such as. Power system sub-station, motor protection and control etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic Concepts of Measurements, Purpose of Instrumentation, Process Variables, Generalized configurations and Functional Descriptions of Measuring Instruments, Generalized Performance Characteristics of Instruments. (4)

Principles of Transducers, Functions and General Classification of Transducers. Resistive, Inductive, Capacitive, Piezo-electric, Photo-electric, Thermo-electric, Hall, Magnetostrictive etc. (8)

Measurement of Process Variables, Pressure, Flow, Temperature, Liquid Level, Strain, Force, Torque, Linear and angular displacement/speed etc.(6)

Ultrasonic Instrumentation: Ultrasonic transmitter and receiver properties, propagation through medium and interfaces, application in Non-destructive Testing (NDT), measurement of process variables such as flow, level, thickness etc. (4)

Microprocessor based Instrumentations, Different Digital Instrumentation, Digital Measurement of Power Factor, Frequency and Time Period, Counters, Embedded systems, Microprocessor/Microcontrollers, classification, different field of application, design of microcontroller based measuring instrument(4)

Programmable Logic Controller (PLC): Introduction, Application, Physical and functional components, Timers, Counters, Shift Registers, Memory, Ladder Diagram, PLC Programming, Interfacing with sensors and actuators. Advance PLCs, analog input output, HMI, SCADA, Communication protocols, PID control through PLC. (10)

Data Acquisition Systems: Objective of a DAS, single channel DAS, Multi-channel DAS, Components used in DAS– Converter Characteristics-Resolution-Non-linearity, settling time, Monotonicity. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Transducess and Instrumentation- D.V.S. Murthy Prentice-Hill.
2. Instrumentations: Devices and Systems- C.S.Rangan, G.R. Sarma, V.S.V. Mani.
3. Principles of Industrial Instrumentation – D. Patranabis. Tata Mc. Graw Hill.</td></tr>
</table>

	Reference Books: 1. Instrumentation, Measurement And Analysis, Author: B. C. Nakra, K. K. Chaudhry - 2004. 2. Programmable Logic Controllers, Author: William Bolton, Newness Supervisory Control And Data Acquisition, Author: Stuart A. Boyer International Society of Automation. 3. Doebelin, Ernest O. Measurement system. Tata McGraw-Hill Education, 1968. Webster, John-G., ed. The Measurement, Instrumentation, and Sensors: Handbook. Springer, 1999.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>EEE612</td><td>MODERN CONTROL SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEE502 (CONTROL SYSTEMS)</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the states for physical systems
• CO2: To analyse LTI continuous systems with state variable representation
• CO3: To understand the advantages of state variable feedback control
• CO4: To understand optimal control
• CO5: To learn the concept of optimal filtering and state estimation as an essential part of control system design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">State Variable Analysis and Design: Concepts of state, variables and state model state models for linear continuous time systems.(4)
Conversion of state variables models to transfer functions, solutions of state equations, state transition matrix, state transition flow graphs.(4)
Eigenvalues, eigenvectors and stability similarity transformation, decompositions of transfer functions.(4)
Canonical state variable models, controllability and observability.(4)
Linear State variable Feedback, Observer design.(4)
MATLAB tools and case studies. (6)
Optimal Feedback Control: Parameter optimization and optimal control problems, quadratic performance index, state regulator design, Linear Quadratic Optimal Control, Solving quadratic optimal control problems with MATLAB. (8)
Stochastic Optimal Linear Estimation and Control: Linear Quadratic Guassian Control, Optimal filtering, Estimation, Kalman Bucy filter, Kalman filtering (8)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Digital control and state variable methods- M. Gopal
2. Discrete time control systems- K Ogata
3. Modern Control Engineering- K. Ogata
4. Digital Control of Dynamic systems. G.Franklin, J.Powell, M.L. Workman.
5. Nonlinear Systems – H. K. Khalil
Reference Books:
1. Nonlinear System Analysis – M. Vidyasagar
2. Applied Nonlinear Control - Jean-Jacques E Slotine, Weiping Li</td></tr>
</table>

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE613</td><td>SPECIAL ELECTRICAL MACHINES</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Ability to understand the operation of AC Commutator machines and AC Series motor
• CO2: To develop clear concept of Universal motor and Repulsion motor
• CO3: To analyze and control the operation of Stepper motor
• CO4: To analyze the operation of Switched Reluctance motor
• CO5: To understand the operation of PM dc motor and Brushless dc motor
• CO6: To learn the working of Single-phase synchronous motors</td></tr>
<tr><td>Topics Covered</td><td colspan="7">AC Commutator machines: Production of different induced emfs, torque equations, characteristics. (3)

AC Series motor: Introduction, compensated and uncompensated series motors, emf and torque equations, phasor diagrams, characteristics (3)

Universal motor: Operating principle with ac and dc, comparison of speed for dc and ac supplies and characteristics. (3)

Repulsion motor: Construction, principle of operation, phasor diagram and characteristics.(2)

Stepper Motors: Introduction, operating principle, full step, half step, micro step, classification of stepper motors, motor windings, permanent magnet stepper motor, variable reluctance stepper motor, hybrid stepper motor, energization with 2-phases at a time, single-phase stepper motor, mathematical analysis of stepper motor, open loop control of 2-phase stepper motor, open loop control of 3-phase VR stepper motor, closed loop control of a stepper motor, slew speed, ramping, applications. (8)

High speed operation of stepper motor: Introduction, Pull-out torque-speed characteristics for hybrid stepper motor, Pull-out torque-speed characteristics for variable reluctance stepper motor. (4)

Switched Reluctance motor: Introduction; principle of operation; differences between SR and conventional reluctance motor, Torque expression, characteristics, control, advantages and disadvantages. (5)

Permanent magnet materials and motors: Introduction; minor hysteresis loops and recoil line; stator frames of conventional PM dc motors; Equivalent circuit of a permanent magnet. (5)

Brushless dc motor: Types of construction, principle of operation, modeling, motor characteristics and control, advantages and disadvantages. (5)

Single-phase synchronous motors: Single-phase reluctance motor, hysteresis motor, Linear Induction motor.(4)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Special Electrical Machines: K. Venkataratnam, Universities Press.
2. Stepping Motors and Their Microprocessor Controls: T. Kenjo, Clarendon Press.
Reference Books:
1.Permanent Magnet and Brushless DC Motors: T. Kenjo and S. Nagamori, Oxford University Press.
2. Electric Machinery Fundamentals: Stephen J. Chapman,McGraw-Hill Education.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>EEE614</td><td>SIGNALS AND SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the properties continuous and discrete signals and systems, sampling process.
• CO2: To analyze LTI discrete time systems in time domain.
• CO3: To understand and frequency response of continuous and discrete time signals and system.
• CO4: To learn time frequency characterization of signal and systems
• CO5: To get the knowledge of communication systems
• CO6: To understand the concept of linear feedback system .</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Signals, systems and sampling(2)
Discrete-time Signals and Systems: Discrete time signals and systems, Analysis of LTI system, system described differential and difference equation(4)
Fourier Series Representation of Periodic Signals and Filtering (4)
Frequency Domain Analysis: Frequency analysis of continuous-time and discrete-time signals and LTI systems, Continuous time Fourier Transform (6)
Discrete Fourier Transform: Properties and Applications, Analysis using DFT (4)
Fast Fourier Transform Algorithms: FFT algorithms and Applications, linear filtering approach to computation of DFT (6)
Time and Frequency characterization of Signals and Systems: The magnitude and phase representation of Frequency Response of LTI systems (6)
Communication systems: Sinusoidal Amplitude Modulation, Demodulation sinusoidal AM, Discrete time Modulation (4)
The Z-transform: Review, Analysis of LTI system in z-domain. (4)
Feedback LTI Systems. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Signals and Systems, A. V. Oppenheim, Alan A. Willsky and S. Hamid
2. Signals, Systems and Inference, A. V. Oppenheim, G. C. Varghese
Reference Books:
1. Linear Signals and Systems, B. P. Lathi</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO640</td><td>CONCEPT OF ELECTRICAL MACHINES & DRIVES</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Able to understand the fundamentals of an electric drive
• CO2: Ability to cenceptualize the staring, speed control and braking operation of the dc drives
• CO3: Ability to cenceptualize the staring, speed control and braking operation of the dc drives
• CO4: Ability to select Electrical Drives for an industrial application.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Concept of electrical drives; Classification, group, individual, multi-motor electric drives; Classification of control schemes and components of electric drives, closed loop control of industrial drives.(6)

Speed-Torque characteristics of dc drives; Basic parameter, types of load, quadrant diagram. Speed-Torque characteristics of dc shunt and series motor. Types of starter and braking (dynamic, regenerative braking) of dc drives. (8)

Speed control of dc motor: Basic parameters, method of speed control of dc shunt and series motor. Speed control of dc series motor in a crane using dynamic braking. Introduction to soft control of dc drive. (8)

Induction Motor Drives: Three phase I.M., analysis and performance. Operation with unbalanced source voltages and single phasing, analysis of I.M. fed from Non-sinusoidal voltage supply. Starting, Braking. Speed control methods of IM, v/f controlled induction motors, controlled current and controlled slip operation and its application.(12)

Stepper, universal, servo and switch reluctance motor drives, solar and battery powered drives, Energy conservation in Electrical Drives. (5)

Industrial application of electrical drives: Electric traction, paper mill, textile mill, and coal mines.(3)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001.
Reference Books:
1. N. K. De and P. K. Sen, Electric Drives, PHI, 2001.</td></tr>
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Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO641	BIOMEDICAL INSTRUMENTATIONI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Familiarisation with biomedical equipments and transducers • CO2: Introduction to biomedical signal conditioners • CO3: Acquiring knowledge about development of bio potentials and their measurements. • CO4: Introduction patient health care monitoring • CO5: Introduction to computerized imaging techniques						
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits. (8) Various types of signal conditioners, signal conditioning processes.(8) Generation of Nernst Potential, Establishment of diffusion potential, Goldmann Equation, Measurement of membrane potential, resting potential, action potential.(6) Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode. (6) Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording.(6) Introduction to medical imaging, Radiography, Computerized tomography, X Ray,-CT, MRI.(8)						
Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, Introduction to Biomedical Engineering, Elsevier, 2012. 2. John G Webster, Medical Instrumentation, Application & Design, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, , Biomedical Instrumentation & Measurements, PHI, 2014 2. Arthur C Guyton, John E Hall, Textbook of Medical Physiology, Elsevier, 2006						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO642	RENEWABLE ENERGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+EA					
Course Outcomes	• CO1: To understand the basics of Energy System and overall energy resources • CO2: To design the solar and wind power plant • CO3: To understand the tidal, geothermal energy, biomass and other resources and principles • CO4: To understand the energy conservation opportunities and energy saving						
Topics Covered	Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification,						

	relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9) Solar photovoltaic: Introduction, solar radiation & its relation with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors:-materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8) Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6) Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4) Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects.(5) Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid.(5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)
Text Books, and/or reference material	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES651	ELECTRICAL MACHINES LABORATORY - II	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EES553 (ELECTRICAL MACHINES LABORATORY - I), EEC402 (ELECTRICAL MACHINES-I), EEC504 (ELECTRICAL MACHINES-II)		CT+EA					
Course Outcomes	• CO1:Ability to determine the equivalent circuit parameters of a single-phase Inductio Motor and also a three-phase Induction Motor. • CO2: Ability to calculate the parameters of a synchronous machine and evaluate th voltage regulation of an alternator						

	• CO3: Ability to synchronize two three-phase alternators and to observe sharing of load between them • CO4: Ability to obtain the V-curves of a synchronous motor • CO5: Ability to determine the efficiency of dc machines CO6: Ability to determine the efficiency and temperature rise of a transformer
Topics Covered	**List of Experiments:** 1. To perform no-load and blocked-rotor tests on a single-phase Induction Motor. 2. To perform no-load and blocked-rotor tests on a three-phase Induction Motor. 3. Voltage regulation of an alternator. 4. Parallel operation of two three-phase alternators. 5. To determine the V-curves of a synchronous motor. 6. Determination parameters of a salient pole synchronous machine. 7. Hopkinson's test on dc shunt machines 8. The Sumpner's test of transformer 9. Determination of positive, negative and zero sequence impedances of a synchronous machine.
Text Books, and/or reference material	Text Books: 1. A. S. Langsdorf, Theory of A. C. Machines, Tata McGraw Hill. 2. I. L. Kosow, Electric Machinery & Transformers, PHI Reference Books: 1. Laboratory manuals

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES652	POWER ELECTRONICS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EES553 (ELECTRICAL MACHINES LABORATORY - I), EEC402 (ELECTRICAL MACHINES-I), EEC501 (ELECTRICAL MACHINES-II)		CT+EA					
Course Outcomes	• CO1: To understandthe principal of power electronics devices • CO2: To understand the detail operation of the ac-dc/ dc-dc/ ac-ac/ dc-an components • CO3: To understand the implementation of the components for dc and ac machine control. • CO4: To develop the ability to design and implement different converters and gate driver circuits • CO5: To understand the control of the converters						
Topics Covered	**List of Experiments:** 1. Microprocessor Based Single Phase Firing Circuit (a) To study half wave converter circuit using Microprocessor (b) To study AC voltage regulator circuit using Microprocessor 2. Single Phase Bridge Inverter Using IGBT 3. Three Phase SCR Module (a) Three Phase Half Controlled Bridge Rectifier with R and R-L load (b) Three Phase Fully Controlled Bridge Rectifier R and R-L load (c) Three Phase AC Voltage Controller with R and R-L load 4. Speed Control of 3Ø AC Induction Motor Using IPM and MICRO–2407 (a) Open Loop Control of Three Phase Induction Motor by using V/F control.						

	(b) Closed Loop Control of Three Phase Induction Motor by using V/F control. 5. Speed Control of DC Motor by Using Single Phase Triggering and Device module 6. Four Quadrant Operation of DC-DC Chopper 7. Simulation of Gate Driver Circuits of Power Converters by Using PSpice 8. Simulation of Basic DC-DC Converters by Using Multisim 9. Modelling and control of Buck and Boost Converter by Using MATLAB Closed Loop Control of Boost Converter by Using Multisim
Text Books, and/or reference material	Text Books: 1.N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2.JosephVithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. Laboratory Manuals

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES653	POWER SYSTEMS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC401(POWERSYSTEMS-I) EEC503(POWER SYSTEMS–II)		CT+EA					
Course Outcomes	• CO1: Understand various types of relay implementation using static circuits. • CO2: Realization of characteristics for over current, distance and differential relays using test bench. • CO3: Realize the various dynamic characteristics of digital relays for protection of transmission lines, transformers. CO4: Identify the new developments in protective relaying and applications						
Topics Covered	**List of Experiments:** The Power system Laboratory includes the protection schemes and simulation related experiments. Facilities are available for over current, over voltage, directional, differential and distance relays including different numerical relays, Feeder Protection. Varieties of Power system Simulation packages like Load flow using MATLAB, EUROSTAG and MiPower are available. List of experiments: 1. Study of Inverse Definite Minimum Time over-current relay. 2. Study of Directional over-current relay (inverse) type CDD. 3. Study of Numerical Distance protection Relay MiCOM P442. 4. Parallel Feeder Protection. 5. Negative sequence protection of three-phase induction motor. 6. Study of over-voltage relay. 7. Study of Biased Differential Relay 8. Biased Differential Protection of a single phase Transformer 9. Restricted E/F Protection of 3-phase Transformer 10. Over-current and Earth fault protection scheme for three phase system. 11. To study load flow and different dynamic events of the given network using EUROSTAG / MiPower software 12. Study of Cable Fault Locator.						

Text Books, and/or reference material	Laboratory Manuals

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE710	RENEWABLE ENERGY SYSTEMS	PCL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+EA					
Course Outcomes	• CO1: To understand the basics of Energy System and overall energy resources • CO2: To design the solar and wind power plant • CO3: To understand the tidal, geothermal energy, biomass and other resources and principles • CO4: To understand the energy conservation opportunities and energy saving						
Topics Covered	Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification, relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission.(9) Solar photovoltaic: Introduction, solar radiation & its relation with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors:-materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments.(8) Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario.(6) Principles of tidal power generation, components of power plant, Single and two basinsystems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle.(4) Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects.(5) Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics.(5)						
Text Books, and/or	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003.						

reference material	2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE711</td><td>ADVANCED POWER CONVERTERS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC504(POWER ELECTRONICS), EEC502(CONTROL SYSTEMS)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To get an overview of Power Electronic Converters.
• CO2: Tolearn the operation of Switch-Mode DC-DC Converters and some advanced converters.
• CO3: To understand the concept of Switch Mode DC-AC Inverters, Multilevel Inverters& modulation techniques.
• CO4: To understand the operation of AC voltage controllers&Matrix converters.
• CO5: To familiarize with EMI & EMC issues in power electronic systems.
• CO6: To get acquainted with design of power electronic systems
• CO7: To get acquainted with practical applications,simulation and hands on training of power electronic converters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overview of basic power electronics converters. (2)

Switch-Mode DC-DC Converters: Introduction, Control of DC-DC converters, Buck, Boost, Buck-Boost, Cuk, Full bridge Converter, Some advanced converters: Tri-state, Interleaved, Multiphase & Higher order converters. (8)

Switch Mode DC-AC Inverters: Single Phase & Three-Phase Inverters, PWM switching schemes, space vector modulation, reduction of harmonics, output voltage control, Multilevel Inverters. (8)

AC voltage controllers: Single phase and three phase ac voltage controllers, Voltage control, Harmonic analysis, operation waveforms PWM, Matrix converters. (6)

Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Issues: EMI reduction At Source, EMI Filters, EMI Screening, EMI Measurement and Specifications. (4)

Design considerations: snubber circuit, driver circuit, temperature control and heat sink, materials, windings. Design of converter and chopper circuits. Triggering circuits for converter and choppers. MMF equations, magnetic. Design of transformers and inductors. (8)

Some practical applications, literature study, simulation and hands on training of power electronic converters. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons
2. H. W. Whittington, Switch Mode Power Supplies: Design and Construction, Research Studies Press.
3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995.</td></tr>
</table>

	Reference Books: 1. R. W. Erickson and D. Maksimovic, Fundamental of Power Electronics, Springer 2. E. Acha, V. G. Agelidis, O. Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes 3. L. Umanand, Power Electronics, Essential and Applications,Wiley India Pvt. Ltd.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE712	GENERALIZED THEORY OF ELECTRICAL MACHINES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC402 (ELECTRICAL MACHINES-1), EEC501 (ELECTRICAL MACHINES-II)		CT+EA					
Course Outcomes	• CO1: To understand the basic concept of Generalized theory of Electrical machines • CO2: To learn about Reference Frame theory • CO3: To transform 3-phase quantities to 2-phase quantities and vice-versa. • CO4: To model a 3-phase induction machine • CO5: To model a 3-phase synchronous machine • CO6: To perform both steady-stae and transient analysis of DC machines						
Topics Covered	Generalized Machines:Kron's primitive machine, Voltage, power and torque equations of Kron's primitive machine, Basic two-pole machine diagrams.(6) Reference Frame theory: Commonly used reference frames, Equations of transformation, 3-axis to 2-axis transformation, Park's transformation, Clarke's transformation. (4) Theory of symmetrical Induction machines:Dynamic modeling of three-phase induction machine, generalized model of three-phase induction machine in arbitrary reference frame, derivation of induction machine model in stator, rotor and synchronously rotating reference frames from the arbitrary reference frame model, Space-phasor model of induction machine, Normalized model of induction machine, Dynamic performance during sudden change in load torque. (12) Synchronous Machines:Stator and rotor flux linkages, Voltage and torque equations in machine variables, mathematical modeling of synchronous machine, Swing equation, state-space representation of Swing equation. (8) DC machines:DC generator: Steady-state analysis, transient analysis under different conditions. (6) DC motor: Steady-state analysis, transient analysis under different conditions. (6)						
Text Books, and/or reference material	Text Books: 1. Analysis of Electrical Machinery: P. C. Krause, McGraw-Hill. 2. Electric Motor Drives, Modelling Analysis and Control: R. Krishnan, Prentice-Hall Of India Pvt. Limited. Reference Books: 1. Modern Power Electronics and AC Drives: B. K. Bose, Prentice Hall. 2. Generalized Theory of Electrical Machines: P. S. Bimbhra, Khanna Publisher.						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE 713</td><td>ELECTRICAL DRIVES</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC402 (ELECTRICAL MACHINES-1), EEC504 (POWER ELECTRONICS), EEC502 (CONTROL SYSTEMS), EEC 501 (ELECTRICAL MACHINES-II)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire an idea general drives application in Industry
• CO2: To learn the detailoperation of the dc drives
• CO3: To learn the detailoperation of the ac drives
• CO4: To identify the drives and machine combinations for any particular application
• CO5: To develop a clear idea about the dynamic performance of the drives</td></tr>
<tr><td>Topics Covered</td><td colspan="7">DC drives: Braking of dc motors, speed control of dc motors, Single-phase half and full-controlled rectifier control of separately excited dc motor, three phase half and full-controlled and half controlled rectifier control of separately excited dc motor, chopper controlled dc drives, closed loop control of dc drives. (12)

AC drives: Braking of ac motors, speed control of ac motors, basic inverters circuits, variable voltage frequency control, VSI fed induction motor drives, AC voltage controller, cycloconverter, closed loop control of induction motor drives. (12)

Heating and selection of power rating of drive motors: Heating and temperature rise of motors, selection of motor power capacity, equivalent current, torque and power methods. (6)

Transients and Dynamics: Equation of motion, equivalent system, dynamics during dynamic braking of dc shunt motor, speed, time of braking and current during dynamic braking, dynamics during counter current braking of dc shunt motor, energy associated with transient process of dc shunt motor, dynamic response of induction motor, dynamics during starting and braking of induction motor. (8)

Industrial application of motors: Cement mill, paper mill, textile mills etc. (4)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001.
2. N. K. De and P. K. Sen, Electric Drives, PHI, 2001.
Reference Books:
1. V. Subrahmanyam, Electric Drives, Tata McGraw Hill..
2. S. K. Pillai, A first course in electrical drives, New Age international, 1989.</td></tr>
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<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE714</td><td>POWER SYSTEM PLANNING, OPERATION AND CONTROL</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC401(POWER SYSTEM- I), EEC503 (POWER SYSTEM- II)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Given specification leads to study of power system planning and operation. One will be able to find the best location as well as optimal capacity of proposed generating station.
● CO2: Given specification of stability analysis leads to modeling of power system equipment's like transmission line, generator and design system to obtain operating limits to satisfy the reliability criteria.
● CO3: Given specification leads to optimization of cost and the tariff to meet the load demand with having knowledge of choice of system.
● CO4: Given specification leads to knowledge of regulation of active, reactive power and frequency of any system and its application in optimal load flow and scheduling.
● CO5: Given specifications leads to complete knowledge of Scheduling of different power plants (Hydro and Thermal) for both stable and economic operation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Load flow studies: Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. Advantages and disadvantages. (7)

Power Factor Improvement: Introduction, Disadvantages of low power factor, causes of low power factor, power factor improvement, power factor correction by static capacitor. Economics of power factor improvement.(4)

Tariffs: Introduction, Types of Tariff-Flat demand tariff, straight line meter rate tariff, Block meter type tariff, Two part tariff, Power factor tariff, Peak load tariff, three part tariff (3)

Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, transmission loss as a function of plant generation, General loss formula, Optimum load dispatch considering transmission losses.(5)

Load frequency control: Necessity of keeping frequency constant, load frequency of single area, load frequency of single area model of speed governing system, load frequency control of two area system, block diagram representation of an isolated power system, steady state analysis, dynamic analysis, uncontrolled system, uncontrolled system, proportional plus integral control of single area and its block diagram, steady state response (proportional plus integral control), dynamic response (proportional plus integral control). (7)

Automatic Generation Control: Types of alternator exciters, exciter modelling, modelling of alternator, static and dynamic performances of AVR, compensation in AVR loop. (4)

Optimal Hydrothermal Scheduling: Classification of hydro plants, long range problem, short range problem, hydro model, equality and inequality constraints, transmission losses. (2)

Unit commitment: Definition, constraints in unit commitment, Methods available for unit</td></tr>
</table>

	commitment (priority list method & Dynamic programming). (5) Protection against over voltages: voltage surge, causes of over voltages, Internal causes of over voltages, lightning, protection against lightning, earthing screen, overhead ground wire, lightning arrester, surge absorber. (5)
Text Books, and/or reference material	Text Books: 1. P. M. Anderson & A. A. Fouad, Power system control and stability, Wiley Interscience 2. E.W. Kimbark, Power Systems Stability, Vol. I, II & III, Wiley Press Reference Books: 1. D.P. Kothari & I.J. Nagrath, Modern Power System Analysis, Tata Mc-Graw Hill 2. Subir Ray, Electrical Power Systems, PHI

Department of Electrical Engineering							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE715	EMBEDDED SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC602(MICROPROCESSOR & MICROCONTROLLER)		CT+EA					
Course Outcomes	• CO1: Comparing different microprocessor architectures and justifying their field of application. • CO2: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO3: Programming processor specific and processor independent software for different complex embedded system applications. • CO4: Developing software involving Real Time Operating System. • CO5: Knowledge of advanced microcontrollers and RTOS features.						
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP CISC and RISC - Instruction pipelining.General characteristics of embedded system, introduction to different components etc. (8) Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (7) Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (8) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc.(7) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (7) Basic design using a real time operating system: Overview. General principles. Design of an embedded system. Development Tool: Cross-Compiler, Cross-Assemblers, Linker/locator. PROM Programmers, ROM, Emulator, In-Circuit Emulators. Debugging Techniques. Instruction set simulators. The assert macro. (5)						

Text Books, and/or reference material	Text Books: 1. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. 2. An Embedded Software Primer, D.E. Simon. Pearson Education, 1999. 3. Design with PIC Microcontrollers, J.B. Peatman,Pearson Education, 1998 Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE716	FACTS DEVICE	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC401(POWERSYSTEMS-I), EEC504(POWER ELECTRONICS), EEC503(POWER SYSTEMS– II)		CT+EA					
Course Outcomes	• CO1: Understand the basic concept of FACTS devices. • CO2: Acquire knowledge about working principles of FACTS devices and their operatingcharacteristics of FACTS devices. • CO3:Acquire an idea about modelling of various FACTS devices and their interaction in power system. • CO4: Understand how FACTS devices improve various power system performances like power flow control, stability etc.						
Topics Covered	Introduction: Basics of Power Transmission Networks, Control of Power Flow in AC Transmission Line, Flexible AC Transmission, System Controllers, Concept and General System of Considerations, Checklist of possible benefits from FACTS technology, Application of FACTS Controllers in Distribution Systems. (2) Traditional Compensation: Analysis of Uncompensated AC Line, Passive Reactive Power Compensation, Compensation by a Series Capacitor Connected at the Mid-point of the Line, Shunt Compensation Connected at the Midpoint of the Line, Basics of Phase Shifting, Effects and Applications of different Compensators. (6) Static Var Compensator (SVC): Analysis of SVC, Configuration of SVC, Variable Impedance Type Static Var Generators, TCR, TSR, TSC, FC-TCR.SVC Controller, Harmonics and Filtering, Modeling and applications of SVC. (6) Static Synchronous Compensator (STATCOM): Switching Converter Type Var Generators, Basic concept and Principle of Operation of STATCOM, Basic converter configurations, Control of converters, modeling and applications of STATCOM. (5) Static Series Compensators: Basic Concepts of Controlled Series Compensation, Operation of TCSC, Analysis of TCSC, Control of TCSC,Modeling of TCSC for Stability Studies, Mitigation of Sub-synchronous, Applications of TCSC. (6) Static Synchronous Series Compensator: Operation of SSSC and the Control of Power Flow, Modeling and Control of SSSC, SSSC with an Energy Source, Analysis of SSR with a SSSC, Applications of SSSC. (5) Static Phase Shifting: Basic Principle of a PST, Configurations of SPST, Improvement of						

	Transient Stability Using SPST, Damping of Low Frequency Power Oscillations, Applications of SPST. (5) Combined Compensators:Unified Power Flow Controller (UPFC), Basic operating principles, Conventional transmission control capabilities, Functional control of shunt converter and series converter, Basic control systems for P and Q control, Interline Power Flow Controller. (7)
Text Books, and/or reference material	Text Books: 1. Yong Hua Song and Allan T Johns, "Flexible ac transmission systems (FACTS), the Institution of Electrical Engineers (UK), 2002. 2. N. G. Higorani& L. Gyugui, " Understanding FACTS", IEEE press, Standard Publishers Distributor, Delhi Reference Books: 1. K.R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New age International (P) Ltd. 2008 2. R. Mohan Mathur and Rajiv K. Varma, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", IEEE Press, John Wiley & Sons, 2002

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE717	GENERATION & UTILIZATION OF ELECTRICAL POWER	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: understand electrical power generation by thermal, hydro and nuclear power plant • CO2: understand the principle of operation of different types of lamps and selection of lamps for different applications. • CO3: understand different electric traction systems. • CO4: understand different heating methods and their applications. • CO5: create awareness of electrical energy conservation .						
Topics Covered	Generation: Importance of electrical energy; Generation of electrical energy by conventional methods; Thermal power plant - merits and demerits, selection of site, layout and working of the plant, components of the plant; Hydro power plant - merits and demerits, selection of site, layout and working principle, classification of the plant, Elements of the plant - water turbines, generator, etc.; Nuclear power plant - merits and demerits, selection of site, nuclear fission process, constituents of the plant, layout and working of the plant, nuclear reactor (15) Illumination: Nature of light; Concept of illumination, luminous intensity and luminance; polar curve, M.H.C.P., M.S.C.P, M.H.S.C.P; laws of illumination; photometer; Sources of light; Types of lighting scheme; Design of indoor and outdoor lighting system. (8) Electric Traction: Traction system; Duty cycle of traction drives; Calculations of traction drive ratings and energy consumption; Systems of track electrification; Traction motors; DC and AC traction drives. (8) Electric Heating: Advantages of electric heating; Classification of electric heating; Resistance heating; Electric arc furnace, Induction heating; Dielectric heating. (6) Economics Aspect of Power: Generation cost; Interest and depreciation; Load curve and						

	choice of generating stations, Tariff; Economics of power factor improvement plant. (5)
Text Books, and/or reference material	Text Books: 1. C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International (P) Limited. Reference Books: 1. S. C. Tripathy, Electric Energy Utilisation and Conservation, Tata McGraw Hill. 2. N.V. Suryanarayana, Utilisation of Electric Power, Wiley Eastern Ltd.

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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EEE718	ADVANCED CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
EEE502 (CONTROL SYSTEMS)		CE+EA					
Course Outcomes	• CO1: To understand discrete systems, sampling and hold process • CO2: To analyse LTI discrete systems in time domain • CO3: To understand the concept of stability in discrete time, correlation with s-plane • CO3: To learn the frequency domain analysis of discrete systems • CO4: To design controller system for digital control implementation • CO5: To understand nonlinear systems and to determine its stability • CO6: To design controller for nonlinear systems						
Topics Covered	Design of control systems by classical methods: Practical approaches of control system design, some practical Problems, hardware realization, Use of MATLAB in design practice (6) Sampled Data Control Systems:The sampling process, signal reconstruction, difference equations, Z-transform theory, Z-transfer functions (pulse transfer functions), inverse Z-transform and response of linear discrete systems, Z-transform analysis of sampled data control systems, Z and S domain relationship stability analysis in Z-plane (12) Root Locus analysis, Frequency domain Analysis of sampled data system, Compensator design, State space analysis of sampled data systems, MATLAB based Examples. (12) Non-linear Control Systems:Introduction, Classification of Non-linearities, Phenomena exhibited due to presence of non-linear element in control system, Phase plane analysis, singular points, Describing function method of analysis, Lyapunov Stability, Region of Attraction. (12)						
Text Books, and/or reference material	Text Books: 1. Digital control and state variable methods- M. Gopal 2. Discrete time control systems- K Ogata 3. Modern Control Engineering- K. Ogata 4. Digital Control of Dynamic systems. G.Franklin, J.Powell, M.L. Workman. 5. Nonlinear Systems – H. K. Khalil Reference Books: 1.Nonlinear System Analysis – M. Vidyasagar 2.Applied Nonlinear Control - Jean-Jacques E Slotine, Weiping Li						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE719</td><td>MICROPROCESSOR AND EMBEDDED SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC403 (DIGITAL ELECTRONICS)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller.
• CO2: Identify—and exercise—opportunities for hardware and software trade-offs.
• CO3: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor based system.
• CO4: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application.
• CO5: Programming processor specific and processor independent software for different complex embedded system applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP. CISC and RISC - Instruction pipelining.General characteristics of embedded system, introduction to different components etc. (5)

8085 Architectures, Organizations and Pin out details, Instruction sets, Assembly language programming, Micro operations of instructions. (6)

Memory Classification: ROM, EPROM, EEPROM, RAM, Memory Interfacing with 8085, Address decoding for Memory mapped I/O and I/O mapped I/O. (4)

Various types of Interrupts. (2)

Programmable Peripheral Devices and Interfacing with 8085: 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (6)

Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (5)

Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (5)

ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (4)

Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. The 8085 Microprocessor: Author : Ramesh Gaonkar, Pub: PRI
2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi & J. G. Mazidi.
3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd.</td></tr>
</table>

	4. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. Reference Books: 1.Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EEE720	DIGITAL SIGNAL PROCESSING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	• CO1: To understand the properties signals and systems. • CO2: To understand the concept of signal processing. • CO3: To analyzediscrete time signals and systems in time as well as frequency domain. • CO4: To design digital filters. • CO5: To get acquainted with digital processors recently used.						
Topics Covered	Introduction: Signals, systems and signal processing, concept of frequency in continuous and discrete time signal. (2) Discrete-time Signals and Systems: Discrete time signals and systems, analysis of LTI system and implementation correlation. (6) Z-transform: Review, Analysis of LTI system in z-domain. (4) Frequency Domain Analysis: Frequency analysis of continuous-time and discrete-time signals and LTI systems, LTI system as frequency selective filter, inverse system and de-convolution. (6) Discrete Fourier Transform: Properties and Applications, Analysis using DFT. (6) Fast Fourier Transform Algorithms: FFT algorithms and Applications, linear filtering approach to computation of DFT. (6) Implementation of Discrete-Time System: FIR system, IIR system, representation of numbers, quantization of filter coefficients, round-off effects. (2) Design of Digital Filters: Design of FIR and IIR filters. (6) DSP Processors. (2) Recent Developments. (2)						
Text Books, and/or reference material	Text Books: 1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles Algorithms and Applications, Pearson Education, 2005 2. A. V. Oppenheim, R. W. Schafer, Digital Signal Processing, Pearson Education, 2004 Reference Books: 1. S. K. Mitra - Digital Signal Processing: A computer based approach, TMH, 2001 2. L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Pearson Education,						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>EEO740</td><td>DIGITAL SIGNAL PROCESSING AND ITS APPLICATION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the properties signals and systems.
• CO2: To understand the concept of signal processing.
• CO3: To analyzediscrete time signals and systems in time as well as frequency domain.
• CO4: To design digital filters.
• CO5: To get acquainted with digital processors recently used.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Signals, systems and signal processing, concept of frequency in continuous and discrete time signal. (4)

Discrete-time Signals and Systems: Discrete time signals and systems, analysis of LTI system and implementation correlation. (6)

Z-transform: Review, Analysis of LTI system in z-domain. (4)

Frequency Domain Analysis: Frequency analysis of continuous-time and discrete-time signals and LTI systems, LTI system as frequency selective filter, inverse system and de-convolution. (6)

Discrete Fourier Transform: Properties and Applications, Analysis using DFT. (4)

Fast Fourier Transform Algorithms: FFT algorithms and Applications, linear filtering approach to computation of DFT. (6)

Implementation of Discrete-Time System: FIR system, IIR system, representation of numbers, quantization of filter coefficients, round-off effects. (2)

Design of Digital Filters: Design of FIR and IIR filters. (6)

DSP Processors. (2)

Recent Development. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles Algorithms and Applications, Pearson Education, 2005
2. A. V. Oppenheim, R. W. Schafer, Digital Signal Processing, Pearson Education, 2004
Reference Books:
1. S. K. Mitra - Digital Signal Processing: A computer based approach, TMH, 2001
2. L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Pearson Education,</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO741</td><td>UTILIZATION OF ELECTRICAL POWER</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of the course, the students will be able to :
• CO1: understand different electric traction systems.
• CO2: principle of operation of different types of lamps and selection of lamps for different applications.
• CO3: understand different heating methods and their applications.
• CO4: understand principle of electrolysis and its applications.
• CO5: create awareness of electrical energy conservation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Electric traction: Traction Systems, Electric traction, Tractive effort, Speed – time curve, Starting. (10)
Illumination: Production of light, Lighting schemes, Electric lamps: incandescent lamps, high pressure and low pressure gaseous discharge tubes. (8)
Electric heating: Resistance and inductance heating, Construction and fields of application, High frequency dielectric heating. (8)
Electric welding: Welding processes, Electric arc welding, Submerged arc welding, Spot welding, Seam welding. (7)
Electrolytic Processes: Basic principle of electrolysis, Application of electrolysis, Power supply for electrolytic processes. (5)
Economics in power utilization: Tariff, Power factor improvements. (4)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International (P) Limited.
Reference Books:
1. S. C. Tripathy, Electric Energy Utilisation and Conservation, Tata McGraw Hill.
2. N.V. Suryanarayana, Utilisation of Electric Power, Wiley Eastern Ltd.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO742</td><td>MACHINE LEARNING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites: NA</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand complexity of machine learning algorithms and their limitations
• CO2: Be capable of confidently applying common Machine Learning algorithms in practice and implementing their own
• CO3: Understand modern notions in data analysis oriented computing
• CO4: Be capable of performing experiments in machine learning using real-world data.</td></tr>
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Topics Covered	Introduction: Definition of learning systems. Goals and applications of machine learning. Aspects of developing a learning system (4) Inductive Classification: Concept learning. General-to-specific ordering of hypotheses. Finding maximally specific hypotheses. Version spaces and the candidate elimination algorithm. (6) Decision Tree Learning: Concepts as decision trees. Recursive induction of decision trees. Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Occam's razor. Overfitting, noisy data, and pruning. (5) Bayesian Learning: Probability theory and Bayes rule. Naive Bayes learning algorithm. Parameter smoothing. Generative vs. discriminative training. Logisitic regression. Bayes nets and Markov nets for representing dependencies. (5) Instance-Based Learning: Constructing explicit generalizations versus comparing to past specific examples. k-Nearest-neighbor algorithm. Case-based learning.Experimental (5) Rule Learning: Translating decision trees into rules. Heuristic rule induction using separate and conquer and information gain. First-order Horn-clause induction. (5) Evaluation of Learning Algorithms: Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing. (4) Artificial Neural Networks: Neurons and biological motivation. Linear threshold units. Perceptrons: representational limitation and gradient descent training. Multilayer networks and backpropagation. Hidden layers and constructing intermediate, distributed representations. Overfitting, learning network structure, recurrent networks. (4) Support Vector Machines: Maximum margin linear separators. Quadractic programming solution to finding maximum margin separators. Kernels for learning non-linear (4)
Text Books, and/or reference material	Text Books: 1. Tom M. Mitchell, Machine Learning 2. Christopher Bishop, Pattern Recognition and Machine Learning.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO743	DIGITAL IMAGE PROCESSING	PEL	3	0	0	3	3
Pre-requisites: NA		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Good understanding of several image enhancement techniques and their application to solve real life problem • CO2: Sufficient expertise in both theory and application of several image processing tasks such as image restoration, image compression, and image segmentation. • CO3: Expertise of several techniques for analysis of images • CO4: Develop basic problem solving skills as they apply to different situations as an engineer						
Topics Covered	Introduction: Image digitization, Pixel relationship, Distance transformation, Image transformation viz. 2-D DFT, 2-D discrete cosine transform (DCT) (8) Image Enhancement: Point and algebraic operations, edge detection and sharpening, Filtering in the spatial domain, Histogram equalization, Histogram specification, Sharpening filters and gradient operators, Introduction to frequency domain filtering using Fourier Transform; Basics of 2D Fourier Transform, Butterworth and Gaussian filters. (10)						

	Image Restoration: Degradation models, Mean Filters, Order Statistics, Adaptive filters, Band reject Filters, Band pass Filters, Notch Filters, Optimum Notch Filtering, Inverse Filtering, Wiener filtering. (6) Color Image Processing: Color image fundamentals - RGB, HSI and CMY models (8) Image Segmentation: Contour and shape dependent feature extraction, textural features, region-based and feature-based segmentation and level set method.(10)
Text Books, and/or reference material	Text Books: 1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods 2. Fundamentals of Digital Image Processing by Anil K Jain 3. Digital Image Processing by William K Pratt

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EES751	MICROPROCESSORS AND MICROCONTROLLERS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CE+EA					
Course Outcomes	• CO1: Programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Implementing key H/W and S/W attributes of microprocessors/microcontrollers. • CO3: Programming for various interfacing hardware • CO4: Programming in C/C++ language for typical microprocessor based system.						
Topics Covered	**List of Experiments** 1. 8085/8051/8086 assembly language programming practice 2. µP/µC controlled stepper motor drive 3. µP/µC controlled 7-segment display control 4. µP/µC controlled digital I/O 5. µP/µC controlled elevator simulator 6. µP/µC controlled DAC & ADC 7. µP/µC controlled traffic light simulation control 8. µP/µC controlled keyboard display control						
Text Books, and/or reference material	Suggested Text Books: 1. Douglas V. Hall, Microprocessors and interfacing: programming and hardware, Tata Mc-Graw Hill 2. Badri ram, Advanced Microprocessors and Interfacing, Tata McGraw-Hill Publishing Co. Ltd. 3. Ramesh Gaonkar, The 8085 Microprocessor, PHI						

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="3">Course Code</td><td rowspan="3">Title of the course</td><td rowspan="3">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="3">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td>EES752</td><td>ADVANCED POWER SYSTEM LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC401(POWERSYSTEMS-I)</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the Electric Field Distribution and concept of Dielectric strength of insulating material
• CO2: Able to measure and calibrate the high Voltage with sphere-sphere gap electrode combination.
• CO3: Able to conduct the destructive test i.e. high voltage test of gaseous, liquid and solid insulation and high Voltage power apparatus
• CO4: Able to conduct the non-destructive test of high Voltage power apparatus
• CO5: Able to characterize the magnetic field and lighting of any installation</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of experiments:
1. Analysis of Electrostatic Field in a Parallel Plate Capacitor Using Single & Multi Dielectrics
2. Calibration of Power frequency High Voltage and Measurement of Partial Discharge with sphere-sphere gap arrangement
3. Study the Characteristics of Impulse Voltage and the wave shape of Lighting impulse voltage
4. Study of Capacitance & Tan Delta of insulating material
5. Study the variation of Volume Resistivity of Transformer oil with temperature
6. Power Frequency Withstand Voltage test on 11 kV High voltage line materials
7. Measurement of BDV, Flash point and Fire point of Insulating oils
8. Study of Paschen’s Law and insulation resistance of paper
9. Survey of lighting in the classroom and spatial magnetic field in the vicinity of overhead power lines.
10. Survey of Magnetic field in 33KV power line and surrounding of 33/11KV and 11kV/415 V substation.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Laboratory Manuals</td></tr>
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<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="3">Course Code</td><td rowspan="3">Title of the course</td><td rowspan="3">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="3">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EES753</td><td>ELECTRICAL MACHINE DESIGN SESSIONAL</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC402 (ELECTRICAL MACHINES –I),EEC501 (ELECTRICAL MACHINES – II)</td><td colspan="5">CT+EA</td></tr>
</table>

Course Outcomes	• CO1: Students will be able to use standard methods to determine accurate modeling/simulation parameters for various general-purpose transformers and induction machines. • CO2: Students will be able to know the relationship between the design variables; current density, electric fields, flux density, weight etc.; and how their interaction effects the design performance. • CO3: Students will be able to choose appropriate materials for electrical machine design. • CO4: Students will be able to use modeling/simulation parameters with standard equivalent circuit models to predict correctly the expected performance of various general-purpose transformers and induction machines. • CO5: Students will be able use accepted national and international standards to select appropriate electrical machines to meet specified performance requirements.
Topics Covered	Design of Transformer: Output equation, Optimum design, Design of core, Design of yoke, Window dimensions, Design of windings, Design of insulation, Overall dimensions. (12) Transformer Design Details: Resistance of winding, Leakage reactance of winding, Regulation and Efficiency, Temperature rise, Cooling. (9) Design of Induction Motors: Output equation, Standard frame size, Stator core, Shape and number of stator slots, Stator winding, Length of air gap, Rotor core, Design of rotor bars and slots, Design of end rings, No load current, Losses and Efficiency, Temperature rise. (21)
Text Books, and/or reference material	Text Books: 1. A. K. Sawhney & A. Chakrabarti, Electrical Machine Design, Dhanpat Rai & Co. Reference Books: 1. S. K. Sen, Principles of Electrical Machine Design with Computer Programs, Oxford & IBH Publishing Company Pvt. Limited.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE810	POWER SYSTEM TRANSIENTS & POWER QUALITY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC301 (NETWORK ANALYSIS AND SYNTHESIS)		CT+EA					

Course Outcomes	• CO1: Get an idea about nature of power system transients and analyze the electrical transients in power systems. • CO2: Understand causes of the transients and how these can be reduced or eliminated. • CO3: Understand the concept of travelling waves. • CO4: Know various power quality problems like transients and harmonics etc, theirmitigation and measuring techniques.
Topics Covered	Fundamental Notions about Electrical Transients: Introduction, Circuit Parameters, Mathematical Statement of the Problem and its physical Interpretation, The Principle of Superposition. (2) Simple Switching Transients: The circuit closing Transient, The recovery Transient initiated by the removal of a short circuit, Double frequency transients. (3) Damping: Some observation on the RLC circuits, The generalized damping curves, Resistance Switching, Load Switching, Other forms of damping, Damping and

	frequency.(3) Abnormal Switching Transients: Normal and abnormal Switching Transients, Current suppression, Capacitance switching, Transformer Magnetizing Inrush Current, Ferroresonance. (4) Transients in DC circuits: Introduction, Interruption of Direct Current in low voltage circuits, Transients associated with HVDC circuit Breakers, Commutation Transients- The current Limiting static circuit breaker. (3) Travelling waves and other Transients on Transmission Lines: Circuit with distributed constants, The wave equation, Reflection and Refraction of travelling waves, Behaviour of Travelling waves at line termination, Lattice Diagram, Attenuation and Distortion of Travelling waves, Switching operation involving Transmission Lines. (4) Protection of systems and Equipments against Transient Overvoltages: Protection of Transmission Lines against Lightning, Lightning Shielding of substation, Surge Suppressors, Surge Capacitors and Reactors, Surge Protection of Rotating Machines. (7) Introduction to Power Quality: Definition of Power Quality, Power Quality Terminology, Power Quality Issues, Power Quality Progression. (2) Power Frequency Disturbance: Common Power Frequency Disturbances, Voltage Sags, Cure for Low-frequency Disturbances, Isolation Transformers, Voltage Regulators. (3) Harmonics: Definition, Harmonic Number, Odd and even harmonics, Harmonic Phase Rotation and Phase angle Relationship, Causes of voltage and current harmonics, Individual and Total Harmonic Distortion, Harmonic Signatures-Fluroscent Lighting, Adjustable Speed Drives, Personal Computer and Monitor, Effect of Harmonics on Power System Devices- Transformers, AC Motors, Capacitor Banks, Cables, Busways, Protective devices, Harmonic Current mitigation- Equipment Design, Harmonic Current Cancellation, Harmonic Filters. (6) Power Quality Measuring Devices and Measurement: Harmonic Analyzers, Transient-Disturbance Analyzers, Oscilloscopes, Data Loggers and Chart Recorders, True RMS Meters, Power Quality Measurement. (5)
Text Books, and/or reference material	Text Books: 1. “Electrical Transients in Power Systems”, by Allan Greenwood; John Wiley & Sons; 2nd edition, April 1991. 2. “Power Quality”, by C. Sankaran; First Indian reprint, CRC press; 2009. Reference Books: 1. “Power system transients: A Statistical approach”, by C. S. Indulkar and D. P. Kothari; PHI Learning Private Ltd., 2nd edition 2010. 2. “Understanding Power Quality Problems: Voltage Sags and Interruptions”, by Math H.J. Bollen; IEEE Press, 2001. 3. “Power System Quality Assessment”, by J. Arrillaga, N. R. Watson, S. Chen; John Wiley & Sons, 2000. 4. “Transients in power systems”, H.A.Peterson; Dover Publications, New York, 1963.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE811	ADVANCED POWER ELECTRONICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC 504 (POWER ELECTRONICS), EEC 502 (CONTROL SYSTEMS)		CT+EA					

Course Outcomes	• CO1: To review of basic Power Electronic Systems • CO2: Tolearn the operation of isolated and non-isolated type Switch-Mode DC-DC Converters • CO3: To understand the concept of Multilevel Converters and modulation techniques, Resonant Converters. • CO4: To understand converter dynamics and control, modelling techniques. • CO5: To familiarize with different Gate and Base Drive circuits for Power Devices • CO6: To get acquainted with the state of the art applications of power electronics in Industry and utility systems
Topics Covered	Review of Power Electronic Systems. Overview of Some Modern Power Semiconductor Devices. (2) Switch-Mode DC-DC Converters: Introduction, Control of DC-DC converters, Buck, Boost, Buck-Boost, Full bridge Converter. (4) Isolated Switching DC Power Supplies: Comparison between Linear & Switching Power Supply, Specification of SMPS, Different Topologies, Flyback, Forward, Push-Pull, Half and Full Bridge), Control Requirements & Techniques, Practical SMPS Design Consideration. (4) Multilevel Converters: Introduction, different topologies, Neutral Point Clamped (NPC), Flying Capacitor Converter, Cascaded Multilevel Converters. (4) Different PWM techniques for Inverters: Space Vector PWM technique, Carrier Based Modulation technique.(4) Resonant Converters: Introduction, Classification of Resonant Converters, Series-Loaded and Parallel-Loaded Resonant Converter Topology. (4) Converter Dynamics and Control: State Space Averaging, Converter transfer function, concept of controller design. (4) Gate and Base Drive circuits for Power Devices: Concept, different circuits applicable to converters. (2) Applications: DC Drives, AC Drives, Power Conditioners and Uninterruptible Power Supplies, Power Line Disturbances, Power Conditioners, UPS. (6) Other Residential and Industrial Applications: Electronic ballast, Induction Heating, Electrical Welding, Static Circuit Breakers, Solid State Relays, HVDC Transmission, Static Var Compensators. Integration of Renewable Energy in Electric Power Systems. (10)
Text Books, and/or reference material	Text Books: 1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. H. W. Whittington, Switch Mode Power Supplies: Design and Construction, Research Studies Press. 3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. R. W. Erickson and D. Maksimovic, Fundamental of Power Electronics, Springer

	2. E. Acha, V. G. Agelidis, O. Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes 3. L. Umanand, Power Electronics, Essential and Applications,Wiley India Pvt. Ltd.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE812	SMART GRID	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC601 (ADVANCED POWER SYSTEMS), EEE714(POWER SYSTEM PLANNING, OPERATION OF CONTROL SYSTEM AND STABILITY)		CT+EA					
Course Outcomes	• CO1: To understand various aspects of smart grid • CO2: To study various smart transmission and distribution technologies • CO3: To appreciate distribution generation and smart consumption and know the regulations and market models for smart grid • CO4: To realize the operation of various Systems and its Functions used in the smart grid. • CO5: To know about the initiative, present status, future aspects and development for smart gird.						
Topics Covered	Introduction: Smart Grid Concept, overview of Micro Grid, Green Grid, Intelligent Grid and Smart Grid, Necessity of Smart Grid. (2) Impact of Smart Grid: Business Value Chain Generation, Transmission and Distribution, Customer Services, Market, Original Equipment Manufacturer (OEM). (3) Fundamental Infrastructure: Concept of ElectrinetSM, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation, Attributes of Smart Grid, Complexity and Standard Organization.(4) Architecture of Smart Grid: Visualizing the Power System in Real Time, Framework of Smart Grid, Increasing System Capacity, Relieving Bottlenecks, Enabling a Self-Healing Grid, Enhanced Connectivity to Consumers, Fast Simulation and Modeling, Energy Resources in Advanced Automation.(7) Systems And Functions: Distributed Control System (DCS), Energy Management Systems (EMS), Supervisory Control And Data Acquisition (SCADA), Distribution Automation (DA), Power Electronics-Based Controllers, Power Market Tools Advanced Meter Infrastructure(AMI), Demand Response, Distributed Energy Resources (DERs), Distributed Generation (DG), Electric Vehicle (EV), Energy Storage (ES). (8) Electric Energy Efficiency: Power Plant Electricity Use, Electric Energy Efficiency in Power Production & Delivery, Efficiency in Power Delivery, Conservation Voltage Reduction. (4) Perfect Power System: Vision of Perfect Power System, Perfect Electric Energy Service System, Design Criteria, Perfect Power System Configurations, Fully Integrated Power System, Smart Grid Module With Core Factors, Graphical Representation of Smart Grid Features. (6) Smart Grid Progress: Status of Smart Grid in European Country, US, Present Power Scenario in India, Recent Initiatives, Strategy and Planning to Implement Smart Grid in Developed And Developing Countries . (6)						

Text Books, and/or reference material	Text Books: 1.Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, distributed & Efficient Energy", Academic Press (imprint of Elsevier), 2012. 2.Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving Sustainability", Artech House, Boston London, 2011 Reference Books: 1.Clark W. Gellings, "The smart grid: enabling energy efficiency and demand response", The Fairmont-CRC Press, 2010. 2.James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley-IEEE Press, 2012.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE813	SOFT COMPUTING THEORY AND APPLICATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEE610 (NUMERICAL ANALYSIS)		CT+EA					
Course Outcomes	• CO1: Learn about soft computing techniques and their applications • CO2. Analyze the genetic algorithms, PSO, DE and their applications • CO3: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossover, mutation and also understand the impact of different parent selection strategies. • CO4: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation. • CO5: For a given multi-objective problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique. • CO6: For a given problem, logically clarify the impact of hidden layers in artificial neuron network (ANN) and also stepwise explicate the back propagation algorithm of ANN. • CO7: For a given problem, describe fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification.						
Topics Covered	Introduction to soft-computing techniques and its necessity. (1) Fundamentals of genetic algorithm, Genetic algorithm, Encoding, Fitness function, Reproduction, Genetic modelling, Cross Over, Inversion and Deletion, Mutation operator, Bit-wise operators, examples. (7) Basic Steps in Particle Swarm Optimization algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, examples, new modifications of PSO, Parameter Selection in PSO; (7) Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. (8)						

	Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. (8) Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a back propagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory. (9) Applications of Soft Computing to various fields of engineering. (2)
Text Books, and/or reference material	Text Books: 1. Devendra K. Chaturvedi, "Soft Computing- techniques and its application in electrical engineering", Springer, 2008. 2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, "Evolutionary Algorithms for solving Multi-objective Problems", Second Edition, Springer, 2007. Reference Books: 1.Jyh-Shing Roger Jang, Chuen-Tsai Sun &EijiMizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2. S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3. L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO840	SOFT COMPUTING TECHNIQUE	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEE 610(NUMERICAL ANALYSIS)		CT+EA					
Course Outcomes	• CO1: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation. • CO2. Analyze the genetic algorithms, PSO, DE and their applications • CO3: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossover, mutation and also understand the impact of different parent selection strategies. • CO4: For a given multi-objective problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique. • CO5: For a given problem, describe fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification. • CO6: For a given problem, logically clarify the impact of hidden layers in artificial neuron network (ANN) and also stepwise explicate the back propagation algorithm of ANN.						
Topics Covered	Hard Computing and Soft-Computing techniques, Conventional & non-conventional approaches, limitations of hard computing techniques, merits & demerits of soft-computing						

	techniques, practical examples associated with soft-computing techniques. (3) Fundamental concept of optimization techniques and necessity of optimization techniques, types of optimization techniques, coding, fitness/objective function, algorithms. (2) Introduction of Particle Swarm Optimization (PSO) algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, Flowchart/algorithm, examples, new modifications of PSO, Parameter Selection in PSO. (6) Introduction of genetic algorithm, Binary coding & decoding, Genetic modelling, Reproduction, Crossover, Mutation, importance of crossover and mutation operators, parent selection strategy, parent selection methods, Flowchart/algorithm, drawback of binary coded genetic algorithm (BCGA), real coded genetic algorithm (RCGA), examples.(6) Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. (6) Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a back propagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory.(7) Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. (6) Applications of Soft Computing to various fields of engineering.(6)
Text Books, and/or reference material	Text Books: 1. Devendra K. Chaturvedi, "Soft Computing- techniques and its application in electrical engineering", Springer, 2008. 2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, "Evolutionary Algorithms for solving Multi-objective Problems", Second Edition, Springer, 2007. Reference Books: 1. Jyh-Shing Roger Jang, Chuen-Tsai Sun &EijiMizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2. S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3. L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO841	EMBEDDED SYSTEMS AND APPLICATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CT+EA					
Course Outcomes	• CO1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Identify—and exercise—opportunities for hardware and software trade-offs.						

	• CO3: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor based system. • CO4: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO5: Programming processor specific and processor independent software for different complex embedded system applications.
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP , CISC and RISC - Instruction pipelining.General characteristics of embedded system, introduction to different components etc. (3) Basic Microprocessor architectures, organizations and Instruction sets.(4) Memory Classification: ROM, EPROM, EEPROM, RAM. (4) Various types of Interrupts.(2) Programmable Peripheral Devices and Interfacing 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (4) Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (3) Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (4) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (6) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (6) Applications of Embedded systems in different field of engineering. (6)
Text Books, and/or reference material	Text Books: 1. The 8085 Microprocessor: Author : Ramesh Gaonkar, Pub: PRI 2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi & J. G. Mazidi. 3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO842	MICRO-ELECTRO-MECHANICAL SYSTEMS	PCR	3	0	0	3	3

Pre-requisites	Course assessment methods (continuous (CT) and end assessment (EA))
EE0842 (MICRO-ELECTRO-MECHANICAL SYSTEMS)	CT+EA

Course Outcomes	• CO1: Understanding the fundamentals of MEMS technology and its applications • CO2: To study and learn the different aspects of Microfabrication Procedures. • CO3: To learn about the Microfabrication Procedures. • CO4: To study about the Microsensors and Microactuators and their application. • CO5: Learn about the RF-MEMS and Bio-MEMS techniques and applications. • CO6: To learn the modelling and computer simulation techniques for MEMS designs.
Topics Covered	Introduction to MEMS: Introductionto MEMS technology, Why MEMS, Advantages, Applications, examples of MEMS devices, MEMS in Electronic Industries, VLSI Technology for fabrication of integrated circuitschips. (3) Fundamentals of Microfabrication Procedures: Introduction to Thin Film Technology, Clean rooms, Surface Micromachining, MEMS fabrications process flow (Deposition, Lithography and Etching), MEMS fabrication instruments, MEMS fabrication bench, Micromachining, Surface Modelling. (3) Thin Film Deposition Techniques: Substrate Materials, Silicon Wafer, Metal Polymer, Plastic substrate, Thin Film Deposition Process, Physical Deposition process, Chemical Vapour Deposition, Sputtering, Electrodeposition, Electroplating, Oxidation. (5). Fundamentals of Lithography: Introduction to Thin Film Technology, Different Lithography Technique, Mask and Mask Material, Photoresists, Positive Photoresists, Negative Photoresists, Lift-off, LIGA. (5) Etching Procedures: Need for etching process, different etching techniques, wet etching, dry etching, etching materials, Chemical Etching, Plasma Etching, precautions. (5) Microsensors and Microactuators: Accelerometers, Gyroscopes, Angle-Sensors, Pressure Sensor, Microphones and MEMS sensors. (3) Introduction to BioMEMS: MEMS technology in biomedical applications, Microelectrodes for Biomedical Engineering, Introduction to Microfluidics and its Applications. (4) RF MEMS: MEMS for telecommunications (RF MEMS), RF MEMS Components, RF-MEMS applications, Recent RF MEMS development, RF MEMS Limitations, RF MEMS Challenges. (3) Computational Modeling of MEMS and MEMS Devices: Overview of MEMS-CAD software; followed by tour of MEMS Design Centre, COMSOL, IntelliSuite. (4) Recent Development in Microtechnology: Introduction to Nanotechnology, Carbon Nanotube, Graphene, CNT Sensors Graphene Sensors. (3)
Text Books, and/or Reference Material	Text Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Artech House, 2000 2. Microsystem Technology: Wolfgang Menz, Jürgen Mohr, Oliver Paul, John Wiley & Sons, 2008. Reference Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Kirt Williams, Artech House, 2004. 2. Fundamentals of Microfabrication: The Science of Miniaturization, Marc J. Madou, CRC Press; 2nd Ed. 2002. 3. MEMS: A Practical Guide to Design, Analysis, and Applications: Jan Korvink Oliver Paul, William Andrew; 1 edition (November 14, 2005)