DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Periyar Nagar, Vallam, Thanjavur - 613 403, Tamil Nadu, India
Phone: + 91 - 4362 – 264600 Fax: + 91- 4362 - 264660
Email: headeee@pmu.edu Web: www. pmu.edu

PERIYAR MANIAMMAI UNIVERSITY
Under Sec. 3 of UGC Act, 1956

NAAC ACCREDITED

Curriculum and Syllabus

for

B.Tech

Electrical and Electronics Engineering

(Three and Half Year Part Time)

Regulation 2015

(Based on OBE)

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VISION

To become a leader in providing education and training in the field of Electrical and Electronics Engineering to the aspiring graduates to be competent in their profession.

MISSION

- To develop innovative, competent, efficient disciplined and quality electrical and electronics engineers.
- To enrich knowledge and encourage the students to become entrepreneurs.
- To produce Engineers who can participate in Technical Advancement and Social enlistment of the country and to meet the growing global challenges.
- To prosper in Academic Activities by continual improvement in Teaching methods, Laboratory facilities and Research activities.
- To develop consultancy for various industries.

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Our graduates are professionally competent and apply the concepts of mathematics, science and engineering to solve problems in Electrical and Electronics Engineering and related fields.
PEO2	Our graduates stay relevant in their chosen profession through lifelong learning and demonstrate social and ethical responsibility.
PEO3	Our graduates perform both independently and as a member of a team in executing projects.

Mapping of Mission (MS) with Program Educational Objectives (PEOs)

	PEO1	**PEO2**	**PEO3**
MS1	3	1	2
MS2	3	2	3
MS3	2	3	2
MS4	2	3	3
MS5	2	1	2

1- Slightly 2 – Supportive 3-Highly related

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GRADUATE ATTRIBUTES:

1. **Knowledge base for Engineering:** Demonstrate competence in mathematics, natural sciences, engineering fundamentals and specialized engineering knowledge appropriate to the programme.

2. **Analytical Skills:** Identify, formulate, analyze and solve diverse engineering problems.

3. **Design:** Solution for complicated open–ended engineering problems and design the components with appropriate standards to meet specified needs with proper attention to public health, safety, environment and society.

4. **Experimental Investigation:** Technical skills to conduct investigation, interpretation of observed data and provide solution for multifaceted problems.

5. **Modern Engineering tools usage**: Acquire, select, manipulate relevant techniques, resources and advanced engineering ICT tools to operate simple to complex engineering activities.

6. **Impact of engineering on society:** Provide a product / project for use by the public towards their health, welfare, safety and legal issues to serve the society effectively.

7. **Environment and Sustainability:** Design eco-friendly and sustainable products in demonstrating the technology development to meet present and future needs.

8. **High Ethical Standards:** Practice ethical codes and standards endorsed by professional engineers.

9. **Leadership and team work:** Perform as an individual and as a leader in diverse teams and in multi-disciplinary scenarios.

10. **Communication Skills:** Professional communication with the society to comprehend and formulate reports, documentation, effective delivery of presentation and responsible to clear instructions.

11. **Project management and Finance:** Appropriate in incorporating finance and business practices including project, risk and change management in the practice of engineering by understanding their limitations.

12. **Life-long learners:** Update the technical needs in a challenging world in equipping themselves to maintain their competence.

Mapping of Program Educational Objectives (PEOs) with Graduate Attributes (GAs)

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA 12
PEO1	3	3	2	3	2	1	1	2	1	2	2	2
PEO2	2	1	3	1	2	2	3	3	2	2	2	3
PEO3	2	2	3	2	2	1	2	2	3	2	3	2

1- Slightly 2 – Supportive 3 – Highly related

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PROGRAMME OUTCOMES (POs)

1. Apply the knowledge of mathematics, science, engineering fundamentals, to the solution of complex problems in Electrical and Electronics Engineering.
2. Identify, formulate, research literature and analyze complex Electrical and Electronics Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design solutions for complex Electrical and Electronics Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions, related to Electrical and Electronics Engineering.
5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex Electrical and Electronics Engineering activities with an understanding of the limitations.
6. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Mapping of Program Educational Objectives (PEOs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO 1	3	3	3	2	2	1	1	1	1	2	2	1
PEO 2	3	2	1	3	1	3	3	2	3	2	2	3
PEO 3	3	2	3	3	3	2	2	3	3	2	3	3

1- Slightly related **2 – Supportive** **3 - Highly**

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Mapping of Program Outcomes (POs) with Graduate Attributes (GAs)

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA 12
PO1	3	2	2	1	1	2	1	1	1	2	2	1
PO2	2	3	3	2	1	2	1	1	2	1	1	2
PO3	2	2	2	3	3	1	2	1	1	2	1	2
PO4	2	2	3	3	1	2	1	1	2	2	1	2
PO5	2	1	3	2	3	3	3	2	2	3	1	2
PO6	3	2	2	1	1	2	1	1	1	2	2	1
PO7	2	2	1	1	2	3	2	3	2	1	2	2
PO8	2	1	1	2	1	3	2	2	2	3	1	2
PO 9	2	1	1	2	3	3	2	2	3	3	1	3
PO10	2	2	1	1	2	3	2	3	2	1	2	2
PO11	2	1	2	3	2	3	1	3	3	2	1	3
PO12	2	2	2	3	3	1	2	1	1	2	1	2

1- Slightly related **2 – Supportive** **3 - Highly**

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CURRICULUM 2015

SEMESTER I

Code No.	Course Title	L	T	P	C
PMA101	Algebra, Differential Calculus and their Applications	3	1	0	4
PAP 102	Applied Physics	3	1	0	4
PAC103	Applied Chemistry	3	1	0	4
PEE 104	Electric Circuit Analysis	3	1	1	5
		12	**4**	**1**	**17**

SEMESTER II

Code No.	Course Title	L	T	P	C
PMA 201	Calculus and Laplace Transforms	3	1	0	4
PEE 202	Electromagnetic Field Theory	3	1	0	4
PEE 203	Electronic Devices and Circuits	3	1	0	4
PEE 204	Electrical Machines – I	3	1	1	5
		12	**4**	**1**	**17**

SEMESTER III

Code No.	Course Title	L	T	P	C
PEE301	Power Plant Engineering	3	0	0	3
PSC 302	Entrepreneurship Development	2	0	0	2
PEE303	Electrical Energy Utilization and Conservation	3	1	0	4
PEE304	Electrical Machines – II	3	1	1	5
		11	**2**	**1**	**14**

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SEMESTER IV

Code No.	Course Title	L	T	P	C
PEE 401	Transmission & Distribution of Electrical Power	3	0	0	3
*** 402	Environmental Studies	3	0	0	3
PEE 403	High Voltage Engineering	3	1	0	4
PEE 404	Control Systems Engineering	3	1	1	5
		12	**2**	**1**	**15**

SEMESTER V

Code No.	Course Title	L	T	P	C
PEE 501	Protection & Switchgear	3	0	0	3
PEE ***	Elective – 1 (Digital Logic Circuits)	3	0	0	3
PEE 503	Linear Integrated Circuits	3	1	0	4
PEE 504	Power Electronics	3	1	1	5
		12	**2**	**1**	**15**

SEMESTER VI

Code No.	Course Title	L	T	P	C
PEE ***	Elective – 2 (Microprocessors and Microcontrollers)	3	0	0	3
PEE 602	Power System Analysis	3	1	0	4
PEE 603	Solid State Drives	3	1	0	4
PEE 604	Measurements and Instrumentation	3	1	1	5
		12	**3**	**1**	**16**

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SEMESTER VII

Code No.	Course Title	L	T	P	C
PEE 701	Electric Vehicles and Power Management	3	0	0	3
PEE 702	Power System Operation andControl	3	0	0	3
PEE ***	Elective – 3 (Special Electrical Machines)	3	0	0	3
PEE 704	Major Project	0	0	12	12
		9	**0**	**12**	**21**

OVER ALL CREDITS = 115

ELECTIVE GROUP – 1 :

Code No.	Course Title	L	T	P	C
E11	Design of Electrical Apparatus	3	0	0	3
E12	Control and Maintenance of Electrical Machines	3	0	0	3
E13	Advanced Control System Engineering	3	0	0	3
E14	Digital Logic Circuits	3	0	0	3
E15	Total Quality Management	3	0	0	3
E16	Industrial Automation	3	0	0	3
E17	Bio-Medical Instrumentation	3	0	0	3
E18	Smart Grids	3	0	0	3

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ELECTIVE GROUP – 2 :

E21	Power Electronics for Renewable Energy Systems	3	0	0	3
E22	Wind Energy Conversion Systems	3	0	0	3
E23	Pollution performance Analysis of Electrical Systems	3	0	0	3
E24	Renewable Energy Technology	3	0	0	3
E25	Electrical Power Quality	3	0	0	3
E26	Microprocessors and Microcontrollers	3	0	0	3
E27	Micro Electro Mechanical Systems (MEMS)	3	0	0	3
E28	Disaster Management	3	0	0	3

ELECTIVE GROUP – 3 :

E31	Cyber Security	3	0	0	3
E32	Solar and Energy Storage System	3	0	0	3
E33	Sustainable Energy Utilization	3	0	0	3
E34	Special Electrical Machines	3	0	0	3
E35	Energy Management and Auditing	3	0	0	3
E36	Signals and Systems	3	0	0	3
E37	Digital Signal Processing	3	0	0	3
E38	HVDC Transmission	3	0	0	3

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ALGEBRA, DIFFERENTIAL CALCULUS AND APPLICATIONS

Course Outcomes(PMA 101):		**Domain**	**Level**
CO1	***Explain*** the Properties of eigen values and eigen vectors of the matrices, To ***Use*** orthogonal and similarity transformation and to ***Change*** the quadraticform to Canonical form	Cognitive	Understanding Understanding Understanding
CO2	***Define*** and ***Compute*** the radius and circle of curvature in cartesian and polar coordinates and to ***Explain*** evolutes and envelopes.	Cognitive	Remembering Understanding Understanding
CO3	***Explain*** the convergence of series of positive terms, alternating series, and power series using tests of convergence	Cognitive	Understanding
CO4	***Compute*** total and partial derivatives , Taylor series expansions of functions and the extremum of functions and their applications.	Cognitive	Understanding
CO5	***Solve*** the linear equations of second and higher order with constant and variable coefficients and simultaneous first order differential equations and to ***Apply*** Method of variation of parameters to ***Solve*** the differential equation.	Cognitive	Applying Applying Applying

SUBCODE	**SUB NAME**	**L**	**T**	**P**	**C**
PMA 101	**Algebra, Differential Calculus And Their Applications**	**3**	**1**	**0**	**4**
C:P:A = 3:0:0		**L**	**T**	**P**	**H**
		3	**2**	**0**	**5**

UNIT I MATRICES	**15**
Eigen values and Eigenvectors of a real matrix –Properties of Eigen values and Eigen vectors – Cayley-Hamilton theorem (excluding proof) - Similarity transformation (Concept only) – Orthogonal matrix - Orthogonal transformation of a symmetric matrix to diagonal form – Reduction of quadratic form to Canonical form by Orthogonal transformation.	
UNIT II GEOMETRICAL APPLICATIONS OF DIFFERENTIAL CALCULUS	**15**
Curvature – Cartesian and polar co-ordinates – Centre and radius of curvature – Circle of curvature – Involutes and evolutes – Envelopes – Properties of envelopes and evolutes.	

UNIT III INFINITE SERIES	**15**
Sequences – Convergence of series – General properties – Series of positive terms – Tests of convergence (Comparison test, Integral test, Comparison of ratios and D'Alembert's ratio test – Statement of theorems and problems only) – Alternating series – Series of positive and negative terms – Absolute and conditional convergence – Power Series – Convergence of exponential, logarithmic and Binomial Series (Simple problems only)	
UNIT IV FUNCTIONS OF SEVERAL VARIABLES	**15**
Functions of two variables – Partial derivatives – Total differentiation – Taylor's expansion – Maxima and Minima – Constrained maxima and minima – Lagrange's Multiplier method – Jacobian Determinants.	
UNIT V ORDINARY DIFFERENTIAL EQUATIONS AND APPLICATIONS	**15**
Linear equations of second and higher order with constant and variable coefficients (Euler's and Legendre's equations) – Simultaneous first order linear equations with constant coefficients – Method of variation of parameters - Applications to electrical circuit problems.	

LECTURE	**TUTORIAL**	**TOTAL**
45	**30**	**75**

TEXT BOOKS

1. Grewal, B.S. Higher Engineering Mathematics, 40th Edition, Khanna Publication, Delhi, 2007.
2. Kreyszig, E, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Son(Asia) Ltd, Singapore, 2001.

REFERENCE BOOKS

1. Bali N.P and Narayana lyengar, Engineering Mathematics, Laxmi Publications (P) Ltd, New Delhi, 2003.
2. Veerarajan T, Engineering Mathematics Fourth Edition, Tata – McGraw Hill Publishing Company Ltd, New Delhi, 2005.
3. Kandasamy P., Thilagavathy K, and Gunavathy K, Engineering Mathematics Volume I, II and III, S. Chand & Co, New Delhi, 2005.
4. Venkataraman M. K, Engineering Mathematics, Volume I and II Revised enlarge Fourth Edition, The National Publishing Company, Chennai, 2004.

E REFERENCE BOOKS

www.nptel.ac.in

Advanced Engineering Mathematics Prof. Pratima Panigrahi
Department of Mathematics Indian Institute of Technology, Kharagpur.

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COs versus GAs mapping

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
CO 1	3									1		1
CO 2	3									1		1
CO 3	3	2								1	1	2
CO 4	3	2			1					1	1	1
CO 5	3	2			1					1	1	1
	15	6	0	0	2	0	0	0	0	5	3	6

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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APPLIED PHYSICS

Course Outcomes(PAP102):		**Domain**	**Level**
CO1	***Identify*** the basics of mechanics, ***explain*** the principles of elasticity, viscosity and ***determine*** its significance in engineering systems and technological advances.	Cognitive Psychomotor	Applying Mechanism
CO2	***Describe*** the production, propagation, perception &***analysis*** of acoustical wave and ***locate*** basic acoustical problem encountered in constructed buildings.	Cognitive Affective	Analyze Receiving
CO3	***Understand*** the fundamental phenomena in optics by ***measurement*** and ***describe*** the working principle and ***application*** of various lasers and fibre optics.	Cognitive Psychomotor Affective	Understanding Mechanism Receiving
CO4	***Analyse*** different crystal structures, ***discuss*** and ***use*** physics principles of latest technology by ***visualizing.***	Cognitive Psychomotor Affective	Analyze Mechanism Receiving
CO5	***Develop Knowledge*** on engineering materials, its properties and ***application.***	Cognitive	Applying

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
PAP102	**APPLIED PHYSICS**	**3**	**1**	**0**	**4**
C:P:A = 2.8:0.8:0.4					
		L	**T**	**P**	**H**
		3	**1**	**0**	**4**

UNIT I MECHANICS AND PROPERTIES OF MATTER **9+6**

Mechanics: Force - Newton's laws of motion - work and energy - impulse and momentum - torque - law of conservation of energy and momentum - Friction.

Elasticity: Stress - Strain - Hooke's law - Stress strain diagram - Classification of elastic modulus - Moment, couple and torque - Torsion pendulum - Applications of torsion pendulum - Bending of beams - Experimental determination of Young's modulus: Uniform bending and non-uniform bending - I shape girders.**Viscosity:** Coefficient of viscosity - Laminar flow - streamline flow - turbulent flow - Reynold's number - Poiseuille's method.

UNIT II ACOUSTICS, ULTRASONICS AND SHOCK WAVES **9+6**

Acoustics: Classification of sound - Characteristics of musical sound - Loudness - Weber Fechner law - Decibel - Absorption coefficient - Reverberation - Reverberation time - Sabin's formula (growth and decay) - Factors affecting acoustics of buildings (reverberation time, loudness, focussing, echo, echelon effect - resonance and noise) and their remedies.**Ultrasonics**: Production: Magnetostriction and Piezoelectric methods - NDT: Ultrasonic flaw detector.**Shock waves**: Definition of Mach number - Description of a shock wave - Characteristics - Methods of creating shock waves.

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UNIT III OPTICS, LASERS AND FIBRE OPTICS	**9+6**

Optics: Dispersion - Optical instrument: Spectrometer - Determination of refractive index and dispersive power of a prism - Interference of light in thin films: air wedge - Diffraction: grating.
LASER: Introduction - Population inversion -Pumping - Laser action - Nd-YAG laser - CO_2 laser - Semiconductor Laser (homojunction) - Applications
Fibre Optics: Principle and propagation of light in optical fibre - Numerical aperture and acceptance angle - Types of optical fibre - Fibre optic communication system

UNIT IV SOLID STATE PHYSICS	**9+6**

Crystal Physics: Lattice - Unit cell - Lattice planes - Bravais lattice - Miller indices - Sketching a plane in a cubic lattice - Calculation of number of atoms per unit cell - Atomic radius - Coordination number - Packing density for SC, BCC, FCC and HCP structures.
Semiconductors: Semiconductor properties - Types of semiconductor - Intrinsic - Extrinsic: P-type and N-type semiconductor - PN junction diode - Biasing - Junction diode characteristics.

UNIT V NOVEL ENGINEERING MATERIALS AND BIOMETRICS	**9+6**

Novel Engineering Materials: Introduction - Metallic glasses: Melt spinning technique, properties, applications - Shape Memory Alloys: Transformation temperature, working of SMA, characteristics - Biomaterials: Properties, interaction of biomaterials with tissues, applications - Nano phase materials: Production, properties and applications.
Biometrics: Introduction - definition - instrumentation - devices -advantages

TEXT BOOKS

1. Avadhanulu M. N. and Kshirsagar P. G., "A Text Book of Engineering Physics", 7th Enlarged Revised Edition., S. Chand & Company Ltd., New Delhi, 2005.
2. Senthil Kumar G., " Engineering Physics", 2nd Enlarged Revised Edition, VRB Publishers, Chennai, 2003.
3. Mani P., "Engineering Physics", Dhanam Publications, Chennai, 2005.
4. Prabu P. and Gayathri P., " Applied Physics", PMU Press, Thanjavur, 2013

REFERENCE BOOKS

1. Gaur R.K. and Gupta S. L., "Engineering Physics", Dhanpat Rai Publishers, New Delhi, 2001.
2. Pillai S.O., "Solid State Physics", 5th Edition, New Age International Publication, New Delhi,2003.

E RESOURCES				
NPTEL , Engineering Physics, Prof. M. K. Srivastava, Department of Physics, IIT, Roorkee.				
REFERENCE BOOKS				
1. Srinivasan M. & others, "A text book of Practical Physics", Sultan Chand & Sons, 2001. 2. Shukla R.K., "Practical Physics", New Age International Publication, New Delhi, 2011. 3. Umayal Sundari AR., "Applied Physics Laboratory Manual", PMU Press, Thanjavur, 2012.				
	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL HOURS**
	45	**30**	**30**	**105**

Mapping of CO's with GA's:

	GA1	**GA2**	**GA3**	**GA4**	**GA5**	**GA6**	**GA7**	**GA8**	**GA9**	**GA10**	**GA11**	**GA12**
CO1	3	2	2	2	1	-	-	-	1	-	-	1
CO2	3		1		1	-	-	-		-	-	1
CO3	3	2	2	2	1	-	-	-	1	-	-	1
CO4	3	2	2	2	1	-	-	-	1	-	-	1
CO5	3		2			-	-	-		-	-	1
Total	**15**	**6**	**9**	**6**	**4**				**3**			**5**
Scaled to 0,1,2,3 scale	**3**	**2**	**2**	**2**	**1**				**1**			**1**

1 - Low, 2 – Medium, 3 – High

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APPLIED CHEMISTRY

Course Outcomes(PAC103):		**Domain**	**Level**
CO1	***Identify*** and ***describe*** the various water quality parameters and methods to purify water in contest with boilers and domestics usage.	Cognitive Psychomotor	Applying Keywords
CO2	***Explain*** the fundamental principles of electrochemical reactions, its applications in redox reactions and calculate the different electrochemical processes.	Cognitive Psychomotor	Evaluating Keywords
CO3	***Interpret*** thetypes of corrosion, ***use*** *and* ***measure*** its control by various methods including protective techniques.	Cognitive Affective Psychomotor	Understanding Receiving Mechanism
CO4	***Describe***, ***Illustrate*** and ***Discuss*** the generation of energy in batteries, nuclear reactors, solar cells, fuel cells and anaerobic digestion.	Cognitive Cognitive Affective	Remembering Understanding Responding
CO5	***Apply*** and ***measure*** the different types of spectral techniques for quantitative chemical analysis and ***list***nanomaterials for various engineering processes.	Cognitive Cognitive Psychomotor	Applying Evaluating Mechanism

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
PAC103	**APPLIED CHEMISTRY**	**3**	**1**	**0**	**4**
C:P:A = 2.8:0.8 :0.4		**L**	**T**	**P**	**H**
		3	**1**	**0**	**4**

Theory Part

UNIT I WATER TECHNOLOGY **7 + 8**

Sources and types of water – water quality parameters – BIS and ISO specifications- hardness: types and estimation of hardness (problems) - alkalinity: types and estimation (problems) – boiler feed water – requirements – disadvantages of using hard water in boilers – internal treatment, external treatment – demineralization process – desalination using reverse osmosis –domestic water treatment - Effluent treatment processes in industries

UNIT II ELECTROCHEMISTRY **8+5**

Basic concepts of conductance – Kohlraush's law and conductometric titrations –electrode potentials– Nernst equation: derivation and problems - reversible and irreversible cells – electrolytic and electrochemical cells– emf and its measurements - types of electrodes-reference electrodes - primary and secondary - glass electrode - determination of pH using quinhydrone and glass electrodes - electrochemical series and its applications - Galvanic cells and concentration cells - potentiometric titrations - redox titrations.

UNIT III CORROSION AND PROTECTIVE COATINGS	**9 + 4**

Corrosion- causes- types-chemical, electrochemical corrosion (galvanic, differential aeration), corrosion in electronic devices, corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method.

Protective coatings: paints- constituents and functions - electroplating of copper and gold, Electroless plating - Distinction between electroplating and electroless plating,
advantages of electroless plating, electroless plating of nickel and copper on PCB.

UNIT IV ENERGY STORAGE DEVICES AND NUCLEAR ENERGY	**12 + 7**

Energy storage devices – Batteries: Types – primary (dry cell, alkaline cells) and secondary (lead acid, Ni-Cd and Lithium ion batteries) - Supercapacitors – Fuel cells-Hydrogen-Oxygen fuel cell- Solar cells .

Nuclear energy: nuclear fission and fusion –chain reaction and its characteristics – nuclear energy and calculations (problems) – atom bomb –Nuclear reactor- light water nuclear power plant – breeder reactor- Weapon of mass destruction- nuclear, radiological, chemical and biological weapons. Disarmament - National and International Cooperation- Chemical Weapon Convention (CWC), Peaceful Uses of Chemistry. Bio fuels: biomethanation- anaerobic digestion process, biomass: sources and harness of energy.

UNIT V SPECTROSCOPY AND NANOCHEMISTRY	**9 +6**

Electromagnetic spectrum - Lambert law and Beer-Lambert's law (derivation and problems) – molecular spectroscopy -UV- visible spectroscopy: electronic transitions - chromophores and auxochromes – instrumentation (block diagram) - applications – IR spectroscopy: principle – fundamental modes of vibrations – calculations of vibrational frequency – IR spectrophotometer instrumentation (block diagram) – applications of IR spectroscopy.

Nanochemistry - Basics - distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Nanoparticles: Nanocluster, nanorod, nanotube and nanowire. Synthesis ; properties and applications of nano materials-Buckminister fullerenes, CNT"S(Single walled carbon nano tubes and Multi-walled carbon tubes)-Graphene- advantages and applications.

TEXT BOOKS

1. Jain and Jain , "A Text book of Engineering Chemistry", Dhanapatrai Publications,New Delhi, 2011.
2. Gadag and NityanandaShetty , "Engineering Chemistry", I.K International publishing House Pvt. Ltd, 2010.
3. P. Atkins, J.D. Paula , "Physical Chemistry" , Oxford University Press, 2009.
4. S. S. Dara, S. S. Umare, "A Text Book of Engineering Chemistry", S. Chand Publishing, 2011
5. C.P. Poole and F.J. Owens, " Introduction to Nanotechnology", , Wiley, New Delhi ,2007.

REFERENCE BOOKS

1. Puri B R Sharma L R and Madan S Pathania, " Principles of Physical Chemistry", Vishal publishing Co., Edition 2004
2. Kuriocose, J C and Rajaram, J, "Engineering Chemistry", Volume I/II, Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 2000

E Resources - MOOCs:

1. http://www.mooc-list.com/course/chemistry-minor-saylororg
2. https://www.canvas.net/courses/exploring-chemistry
3. http://freevideolectures.com/Course/2263/Engineering-Chemistry-I
4. http://freevideolectures.com/Course/3001/Chemistry-I
5. http://freevideolectures.com/Course/3167/Chemistry-II
6. http://ocw.mit.edu/courses/chemistry/

Mapping of CO's with GA's:

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
CO1	3	3	3			1	2	1	1	1		2
CO2	2	1	0			1		1	1			1
CO3	3	3	3	2	2	1	2		1	1		1
CO4	3	3	2	2	2	1	2		1	1		1
CO5	2	2	1	1	1	1	1	1	1			1
Total	**13**	**12**	**9**	**5**	**5**	**5**	**7**	**3**	**5**	**3**		**6**
Scaled to 0,1,2,3 scale	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**1**		**2**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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ELECTRIC CIRCUIT ANALYSIS

Course Outcomes(PEE 104):		**Domain**	**Level**
CO1	Able to ***define*** and ***recall*** the different fundamentalelectrical component, Laws and their applications.	Cognitive Cognitive	Remembering Remembering
CO2	***Relate***the concept of a phasor, and ***apply*** phasor analysismethods to analyze linear circuit operating under sinusoidal steady stateconditions.	Cognitive Cognitive	Understanding Applying
CO3	Able to ***Solve*** Thevenin and Norton equivalent circuit of a DC circuitand find the maximum power output using network theorems.	Cognitive	Applying
CO4	**Analyse** the transient response of a first and second ordercircuit consisting of RLC circuit. **Design** the sinusoidal steady state response of aDC and AC circuit consisting of RLC components.	Cognitive Cognitive	Analyzing Creating
CO5	**Create** and **Measure** different electrical parameters in acoupled single phase and three phase circuits.	Cognitive Cognitive	Creating Evaluating

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 104	**ELECTRIC CIRCUIT ANALYSIS**	3	1	1	5
C:P:A		**L**	**T**	**P**	**H**
3:0:0		3	2	2	7

UNIT -I	**BASIC CIRCUIT CONCEPTS**	**9 +9**
Terminologies and circuit elements (active and passive R,L,&C), ideal sources (independent and dependent), V-I relationship of circuit elements - AC and DC voltage and current - Ohm's Law and Kirchhoff's Laws - Analysis of series and parallel circuits - network reduction: voltage and current division, source transformation, star/delta transformation		
UNIT -II	**SINUSOIDAL STEADY STATE ANALYSIS**	**9 +9+10**
A.C. Fundamentals - Concept of phasor and complex Impedance / Admittance - Analysis of simple series and parallel circuits - active power, reactive power, apparent power (volt-ampere), power factor and energy associated with these circuits - resonance in series and parallel circuits - Q factor, half-power frequencies and bandwidth of resonant circuits.		
UNIT- III	**CIRCUIT ANALYSIS & NETWEORK THEOREMS**	**9 +6+10**
Mesh current analysis – Node-voltage analysis - Super position theorem - Thevenin's theorem - Norton's theorem - Reciprocity theorem - Compensation theorem - Tellegen's theorem - Millman's theorem - Maximum power transfer theorem		

UNIT- IV	**TRANSIENT RESPONSE ANDANALYSIS**	**9 +3+10**
Source free response of RL and RC circuits - forced (step) response of RL and RC circuits - source free response of RLC series circuit - forced (step) response of RLC series circuit - forced response of RL, RC and RLC series circuit to sinusoidal excitation - Time constant and natural frequency of oscillation of circuits - Laplace Transform application to the solution of RL, RC & RLC circuits.		
UNIT- V	**COUPLED CIRCUITS, NETWORKS AND THREE PHASE CIRCUITS**	**9 +3**
Coupled circuits - Mutual inductance - Coefficient of coupling - dot conversion - Analysis of simple coupled circuits. Network Topology - Two Port Network and its Parameters. Three phase circuits - Three Phase Connections - star/delta.		
Lecture = 45; Tutorial = 30; Lab = 30; Total = 105 Hours		

ELECTRICAL CIRCUITS LABORATORY

1. Verification of Kirchoff's voltage and current laws, Thevenin's and Norton's Theorems.
2. Study of oscilloscope and measurement of sinusoidal voltage, frequency and power factor.
3. Measurement of time constant of series R-C electric circuits.
4. Frequency response of RC and RL circuits.
5. Resonant frequency and frequency response of a series RLC circuit.
6. Study of the effect of Q on frequency response and bandwidth of series and parallel resonant circuits.
7. Study of low pass and high pass filters.
8. Measurement of real power, reactive power, power factor and impedance of RC, RL and RLC circuits using voltmeters and ammeters.
9. Power measurement in a three-phase circuit by two Wattmeter method.
10. Study of first and second order circuit transients by digital simulation.

TEXT BOOKS:

1.	William H.HaytJr, Jack E.Kemmerly, and Steven M.Durbin, "Engineering Circuit Analysis", Tata McGraw-Hill Publishing Co Ltd, New Delhi, 2002
2.	Joseph A.Edminister, MahmoodNahvi, "Electric Circuits", Schaum's Series, Tata McGraw-Hill, New Delhi 2001.
3.	B.R.Gupta and V.Singhal, "Fundamentals of Electric Networks", S.Chand & Co., New Delhi, 2006.
4.	A.Chakrabarti, "Circuit Theory (Analysis and Synthesis)", Dhanapatrai Publications, 2010.

REFERENCE BOOKS:	
1.	R.C. Dorf, "Introduction to Electric Circuits" John Wiley & Sons Inc, New York, Second Edition, 2010
2.	Charles K.Alexander, Mathew N.O. Sadiku, "Fundamentals of Electric Circuit", McGraw-Hill, N.Y, 2003.
3.	Van Valkenberg M.E, "Network Analysis", PHI Publications, 3rd Edition, New Delhi, 2006.
4.	Bell D A, "Fundamentals of Electric Circuits", Reston, USA
E-REFERENCES:	
1.	NPTEL :http://nptel.ac.in/courses/108102042/
2.	MOODLE : http://moodle.cecs.pdx.edu/course/view.php?id=16

COs versus PO, PSO mapping

CO/ PO/ PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	-	-	2	1	1	2	-	-	1	-	-	**1**	**1**
CO2	3	3	-	3	3	3	-	3	-	1	3	-	**1**	**1**
CO3	2	-	-	-	2	2	2	3	-	-	-	-	**2**	**2**
CO4	-	1	3	-	-	1	-	-	1	-	-	-	**2**	**2**
CO5	-	-	1	-	3	-	-	2	-	-	-	-	**1**	**2**
Total	**7**	**4**	**4**	**5**	**9**	**7**	**4**	**8**	**1**	**2**	**3**	**5**	**7**	**8**
Scaling	**2**	**1**	**1**	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**2**

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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CALCULUS AND LAPLACE TRANSFORMS

Course Outcomes(PMA 201):		**Domain**	**Level**
CO1	***Use*** standard results to ***estimate*** the Laplace transforms of derivatives andintegrals and to***solve*** differential equations.	Cognitive	Creating
CO2	***Apply*** *multiple integral concepts to****determine*** area, volume and to understandthe order of integration.	Cognitive	Applying
CO3	***Define*** the gradient, divergent curl of vectors. ***Compute*** directional derivative,unit vector normal to the surface. ***Apply*** corresponding theorems to find theline, surface and Volume integrals.	Cognitive	Applying
CO4	Construct and examine the analytic functions, and their the complexConjugate and to Explain the concept of conformal mapping and itsConstruction bilinear transformation.	Cognitive	Creating Applying
CO5	Compute the poles , singularities and residues of functions andto solve the problems using contour integration.	Cognitive	Creating Applying

SUBCODE	**SUB NAME**	**L**	**T**	**P**	**C**
PMA 201	**CALCULUS AND LAPLACE TRANSFORMS**	**3**	**1**	**0**	**4**
C:P:A = 3:0:0					
		L	**T**	**P**	**H**
		3	**2**	**0**	**5**

UNIT I LAPLACE TRANSFORMS **15**

Transforms of elementary functions – properties – derivatives and integrals of transforms- Transforms of derivatives and integrals - Transforms of unit step function and impulse function - Transform of periodic functions – Convolution Theorem – Inverse transforms – Solutions of differential and integral equations.

UNIT IIMULTIPLE INTEGRALS **15**

Double integration – Cartesian and polar coordinates – change of order of integration - area as a double integral – change of variables between Cartesian and polar coordinates - triple integration–– Simple applications (Finding area & volume of a certain region).

UNIT IIIVECTOR CALCULUS	**15**
Gradient, divergence and curl - directional derivative – normal and tangent to a given surface – angle between two surfaces – irrotational and solenoidal vector fields - Line, Surface and Volume Integral – Green's theorem in a plane, Gauss divergence theorem and Stoke's theorem (excluding proof).	
UNIT IV ANALYTIC FUNCTIONS	**15**
Function of a complex variable – analytic function – necessary and sufficient condition (excluding proof) – Cauchy Riemann equations – properties of analytic functions - harmonic conjugate - construction of an analytic function – Conformal mapping: w= z + c, cz, $\frac{1}{z}$, sinz, coshz, $z+\frac{k^2}{z}$ - Bilinear transformation.	
UNIT VCOMPLEX INTEGRATION	**15**
Statement and application of Cauchy's integral theorem and integral formula - Taylor's and Laurent's expansion - Residues – Cauchy's Residue Theorem - Contour integration over unit circle.	

	LECTURE	**TUTORIAL**	**TOTAL**
	45	**30**	**75**

TEXT BOOKS

1. Grewal, B.S. Higher Engineering Mathematics, 41st Edition, Khanna Publication, Delhi, 2011.
2. Kreyszig, E, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Son(Asia) Ltd, Singapore, 2001.

REFERENCE BOOKS

1. Bali N.P and Narayana lyengar, Engineering Mathematics, Laxmi Publications (P) Ltd, New Delhi, 2003.
2. Veerarajan T, Engineering Mathematics Fourth Edition, Tata – McGraw Hill Publishing Company Ltd, New Delhi, 2005.
3. Kandasamy P., Thilagavathy K, and Gunavathy K, Engineering Mathematics Volume I, II and III, S. Chand & Co, New Delhi, 2005.
4. Venkataraman M. K, Engineering Mathematics, Volume I and II Revised enlarge Fourth Edition, The National Publishing Company, Chennai, 2004.

E REFERENCES

www.nptel.ac.in

1. Advanced Engineering Mathematics Prof. Jitendra Kumar Department of Mathematics Indian Institute of Technology, Kharagpur

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COs versus GAs mapping

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
CO 1	3											1
CO 2	3											1
CO 3	3	2								1	1	2
CO 4	3	2			1					1	1	1
CO 5	3	2			1					1	1	1
	15	6	0	0	2	0	0	0	0	3	3	6

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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ELECTROMAGNETIC FIELD THEORY

Course Outcomes(PEE 202):		**Domain**	**Level**
CO1	**List and classify** the spatial variations of physical quantities by various coordinate systems using stokes and divergence theorem.	Cognitive	Remembering Understanding
CO2	**Define** the knowledge of electrostatics using gauss and Coulombs law and their applications and **Explain** boundary conditions,poissons,laplace equation.	Cognitive	Remembering Understanding
CO3	**Recall and outline** the magnetic field configuration using amperes Law, biot-savarts law,Lorentz law and boundary conditions.	Cognitive	Remembering Understanding
CO4	**State and Explain** electromagnetic fields generated by dynamic charge distributions using Maxwell's equation and faradays law	Cognitive	Remembering Understanding
CO5	**Define** and **outline** Electromagnetic wave propagation in different media.	Cognitive	Remembering Understanding

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 202	**ELECTROMAGNETIC FIELD THEORY**	**3**	**1**	**0**	**4**
C:P:A		**L**	**T**	**P**	**H**
2:0:0		**3**	**1**	**0**	**4**
UNIT- I	**INTRODUCTION**	**09+5**			
Sources and effects of electromagnetic fields - Vector fields - Different co-ordinate systems (brief description only) - Divergence theorem - Stoke's theorem.					
UNIT- II	**ELECTROSTATICS**	**09+5**			
Coulomb's Law – Electric field intensity - Field due to point and continuous charges - Gauss's law and application - Electrical potential - Electric field and equipotential plots - Electric field in free space, conductors, dielectric - Dielectric polarization, Electric field in multiple dielectrics - boundary conditions, Poisson's and Laplace's equation, Capacitance-energy density – Dielectric strength					
UNIT- III	**MAGNETOSTATICS**	**09+5**			
Lorentz Law of force, magnetic field intensity-permeability - Biot–savart's Law - Ampere's Law - Magnetic field due to straight conductors, solenoid - Magnetic flux density (B) - B in free space, conductor, Magnetic materials - Magnetization - Boundary conditions - Scalar and vector potential - Magnetic force - Torque - Inductance - Energy density - Magnetic circuits-permanent magnets..					
UNIT- IV	**ELECTRODYNAMICS FIEL**	**09+5**			
Faraday's law of induced emf, -Transformer and motional EMF, Maxwell's equations (differential and integral forms) - Conduction current, Displacement current - Relation between field theory and circuit theory.					

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UNIT- V	**ELECTROMAGNETIC WAVES**			**09+5**
Generation – Electro Magnetic Wave equations –Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, loss and lossless dielectrics, conductors-skin depth, Poynting vector – Plane wave reflection and refraction.				
		LECTURE	**TUTORIAL**	**TOTAL**
		45	**15**	**60**

TEXT BOOKS:	
1.	John.D.Kraus, 'Electromagnetics', McGraw Hill book Co., New York, Fourth Edition, 2002.
2.	William. H.Hayt, 'Engineering Electromagnetics', Tata McGraw Hill edition, 2001.
3.	Joseph. A.Edminister, 'Theory and Problems of Electromagnetics', Second edition, Schaum Series, Tata McGraw Hill, 1993.
REFERENCE BOOKS:	
1.	D.Sathaiah-M.Anitha, 'Electro magnetic fields' First edition-2007, SCITECH publications (India) Pvt Ltd., Chennai
2.	I.J. Nagrath, D.P. Kothari, 'Electric Machines', Tata McGraw Hill Publishing Co Ltd, Second Edition, 2000.
3.	Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 1999.
4.	Sadiku, 'Elements of Electromagnetics', Second edition, Oxford University Press, 2001.
E REFERENCES :	
1.	NPTEL - Electromagnetic Fields, Prof. Harishankar Ramachandran , IIT Madras
2.	NPTEL - Electromagnetic Fields, Prof. Prof. Ravindra Arora , IIT Kanpur.

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COs versus PO, PSO mapping

CO/ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	-	1	-	1	1	-	-	1	-	1	**1**	**1**
CO2	2	3	-	2	-	1	-	-	-	-	-	-	**1**	**1**
CO3	2	3	-	-	-	1	1	1	-	-	-	1	**-**	**2**
CO4	2	2	-	-	-	1	-	-	1	-	-	-	**1**	**2**
CO5	2	2	1	-	-	-	-	2	-	-	-	1	**1**	**1**
Total	**10**	**13**	**1**	**3**	**0**	**4**	**2**	**3**	**1**	**1**	**0**	**3**	**4**	**7**
Scaling	**2**	**3**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**2**

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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ELECTRONIC DEVICES AND CIRCUITS

Course Outcomes(PEE 203):		**Domain**	**Level**
CO1	***Classify*** and ***explain***semiconductor devices and ***show*** theinput output characteristics of basic semiconductor devices.	Cognitive	Understanding Understanding
CO2	***Explain***the construction, working and their characteristics of different types oftransistors.	Cognitive	Understanding
CO3	***Classify***the differenttypes of amplifiers and ***design***procedure of amplifiers and ***show*** the frequency response of an amplifier	Cognitive Psychomotor	Understanding Creating Set
CO4	***Classify***the differenttypes of amplifiers and ***show*** the designprocedure of amplifiers.	Cognitive Psychomotor	Understanding Set
CO5	***Explain*** the feedback amplifiers and oscillators.	Cognitive	Understanding

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 203	**ELECTRONIC DEVICES AND CIRCUITS**	3	1	0	4
C:P:A		**L**	**T**	**P**	**H**
3:1:0		3	1	0	4

UNIT- II	**PN JUNCTION DEVICES**	**10 + 20**
PN junction diode –structure, operation and V-I characteristics, diffusion and transient capacitance - Rectifiers – Half Wave and Full Wave Rectifier,– Display devices- LED, Laser diodes- Zener diode characteristics-Zener Reverse characteristics – Zener as regulator		
UNIT- II	**TRANSISTORS**	**8 + 9**
BJT, JFET, MOSFET- structure, operation, characteristics and Biasing UJT, Thyristor and IGBT - Structure and characteristics.		
UNIT- III	**AMPLIFIERS**	**9 + 5**
BJT small signal model – Analysis of CE, CB, CC amplifiers- Gain and frequency response –MOSFET small signal model– Analysis of CS and Source follower – Gain and frequency response- High frequency analysis.		
UNIT- IV	**MULTISTAGE AMPLIFIERS AND DIFFERENTIAL AMPLIFIER**	**9 + 5**
BIMOS cascade amplifier, Differential amplifier – Common mode and Difference mode analysis – FET input stages – Single tuned amplifiers – Gain and frequency response – Neutralization methods, power amplifiers –Types (Qualitative analysis).		
UNIT- V	**FEEDBACK AMPLIFIERS AND OSCILLATORS**	**9 + 3**
Advantages of negative feedback – voltage / current, series , Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.		

		Lecture	Tutorial	Lab	Total
		45	**30**	**0**	**75**

TEXT BOOKS:	
1.	Jacob. Millman, Christos C.Halkias, 'Electronic Devices and Circuits', Tata McGraw Hill Publishing Limited, New Delhi, 2003.
2.	David A.Bell, 'Electronic Devices and Circuits', Prentice Hall of India Private Limited, New Delhi, 2003.
3.	Principle of Electronics by V.K. Mehta , S.Chand
4.	Theodre. F. Boghert, 'Electronic Devices & Circuits', Pearson Education, VI Edition, 2003.
5.	Sedra and Smith, " Microelectronic circuits", Prentice Hall of India, 2004.
REFERENCE BOOKS:	
1.	Floyd, "Electronic Devices" Pearson Asia 5th edition 2001.
2.	Ben G. Streetman and Sanjay Banerjee, 'Solid State Electronic Devices', Pearson Education, 2002 / PHI
3.	Allen Mottershead, 'Electronic Devices and Circuits – An Introduction', Prentice Hall of India Private Limited, New Delhi, 2003.
4.	Electronic Devices and Circuits by Salivahanan – Tata Mcgraw – Hill Education private mited.
5.	Rashid, "Microelectronic circuits" Thomson Publication, 2000.
E-REFERENCES:	
1.	NPTEL, Electronic Devices and Circuits, Prof. T.S. Natarajan ,IIT Madras
2.	NPTEL, Electronic Devices and Circuits, Dr.S. Karmalkar , IIT Madras

COs versus POs mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	2	2	-	-	1	1	1	1	-	-	1	2	1
CO 2	2	3	3	-	-	1	0	1	-	-	-	2	2	1
CO 3	1	3	2	-	-	2	1	2	-	1	-	2	1	2
CO 4	2	2	2	-	-	1	2	1	1	-	1	1	1	2
CO 5	2	2	2	-	-	0	1	2	1	1	1	2	2	1
Total	10	12	11	-	-	5	5	7	3	2	2	8	8	7
Scaling	2	3	3	0	0	1	1	2	1	1	1	2	2	2

0 – No relation 1 – Low relation 2 – Medium relation 3 – High Relation

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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ELECTRICAL MACHINES - I

Course Outcomes(PEE 204):		**Domain**	**Level**
CO1	***Infer***the fundamentals concepts of rotating machine.	Cognitive	Understanding
CO2	***List***the parts of the DC machines and ***carry out*** thecomplete discussion about armature reaction and characteristic.	Cognitive Psychomotor	Remembering COR
CO3	***Define***the principle of operation of DC motor and uses of starter***show*** the speed control.	Cognitive Psychomotor	Remembering Set
CO4	***Illustrate*** the transformer construction and operation, equivalentcircuit and load condition. ***List*** the special type transformer.	Cognitive Cognitive	Understanding Understanding
CO5	***Recall***the knowledge in the testing of d.c. machinesand transformer. ***Show*** theperformance of machines like losses andefficiency.	Cognitive Psychomotor	Remembering Perception

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 204	**ELECTRICAL MACHINES I**	3	1	1	5
C:P:A		**L**	**T**	**P**	**H**
3:1:0		3	2	2	7

UNIT- I	**BASIC CONCEPTS OF ROTATING MACHINES**	**8+2+0**
Principles of electromechanical energy conversion - Energy in Magnetic System Field energy co-energy - Single and multiple excited systems - M.M.F of distributed A.C. windings - Rotating magnetic field - Magnetic saturation and leakage flux - Generated voltage		
UNIT- II	**DC GENERATORS**	**10+8+12**
Constructional details and components of D.C machine - Principles of Operation - Lap and Wave Winding - EMF equation - Methods of excitation - Self and separately excited generators - Armature reaction and commutation - Characteristics of series, shunt and compound generators - Parallel operation of DC shunt and compound generators.		
UNIT-III	**DC MOTORS**	**8+6+6**
Principles of operation - Types of D.C motors - Back EMF-Torque equation - Characteristics of series, shunt and compound motors - Speed control of DC series and shunt motors - Starting of DC motors - Types of starters.		

UNIT- IV	**TRANSFORMERS**	**10 +8+6**
Constructional details of core and shell type transformers - Types of windings - Principle of operation - EMF equation - Transformation ratio - Transformer on no-load - Parameters referred to HV / LV windings - Equivalent circuit - Transformer on load - Regulation and Efficiency - Parallel operation of single phase transformers - Auto transformer - Three phase transformers.		
UNIT-V	**TESTING OF DC MACHINES AND TRANSFORMERS**	**9+6+ 6**
Losses and efficiency in DC machines and transformers - Condition for maximum efficiency - Testing of DC machines - Brake test, Swinburne's test, Retardation test and Hopkinson's test - Testing of transformers - open circuit and short circuit tests - All day efficiency.		
1. Study of D.C. Motor Starters. 2. Open Circuit Characteristics (OCC) and load Characteristics of D.C self-excited generator. 3. Load characteristics of D.C shunt generator 4. Load characteristics of D.C. shuntmotor. 5. Load characteristics of D.C series motor. 6. Speed control of D.C shunt motor. 7. Load test on single-phase transformer. 8. Open circuit and short circuit tests on single phase transformer.		
Lecture = 45; Tutorial = 30; Lab = 30; Total = 105 Hours		

TEXT BOOKS:

1.	D.P. Kothari and I.J. Nagrath, 'Electric Machines', Tata McGraw Hill Publishing Company Ltd, 2002.
2.	P.S. Bimbhra, 'Electrical Machinery', Khanna Publishers, 2003.
3.	B.L.Theraja, "A Textbook of Electrical Technology "Vol. I&II, M/s S.Chand, Delhi,2013

REFERENCE BOOKS:

1.	A.E. Fitzgerald, Charles Kingsley, Stephen D.Umans, 'Electric Machinery', Tata McGraw Hill publishing Company Ltd, 2003.
2.	J.B. Gupta, 'Theory and Performance of Electrical Machines', S.K.Kataria and Sons, 2002.
3.	P.C. Sen, "Principles of Electrical Machines and Power Electronics" John Wiley & Sons, 1997.
4.	DeshPande M.V., "Electrical Machines" PHI Learning Pvt Ltd., New Delhi – 2011.

E-REFERENCES:

1.	NTPEL, Electrical Machines (Web Course), Prof. N. K. De, Prof. T. K. Bhattacharya and Prof. G. D. Roy, IIT Kharagpur.
2.	http://freevideolectures.com/Course/2335/Basic-Electrical-Technology/22-27Prof.L.Umanand , IISc Bangalore.
3.	http://nptel.ac.in/Onlinecourses/Nagendra/, Dr. Nagendra Krishnapura , IIT Madras.

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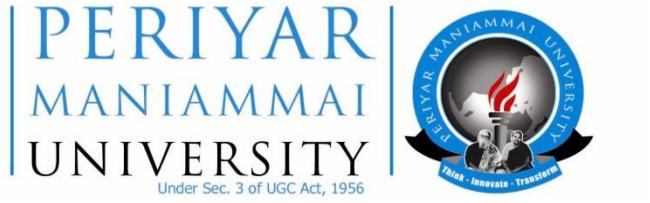

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COs versus POs mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	2	1	-	-	-	1	-	-	1	-	1
CO2	3	2	-	2	1	-	-	-	-	-	-	1	-	1
CO3	3	-	-	-	1	-	-	-	1	-	-	1	-	1
CO4	3	2	2	2	1	-	-	-	1	-	-	1	-	1
CO5	3	-	-	-	1	-	-	-	-	-	-	1	-	1
Total	15	6	4	6	5				3			5		5
Scaling	3	2	1	2	1				1			1		1

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POWER PLANT ENGINEERING

Course Outcomes(PEE 301):		**Domain**	**Level**
CO1	***Explain*** about the various types of the power generation and function of boilers	Cognitive	Understanding
CO2	***Choose***Various Measurements in power plants.	Cognitive	Remembering
CO3	***Illustrate*** Various *analyzers* in power plants, and ***identify*** the pollution monitoring instruments.	Cognitive	Understanding Applying
CO4	***Infer***all control loops in boiler , and interlocks in boiler operation-boiler trip protection.	Cognitive	Understanding
CO5	***Explain*** about turbine speed vibration – lubricant oil temperature control – cooling system and ***select*** the SCADA and other monitoring and control software	Cognitive	Understanding Remembering

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 301	**POWER PLANT ENGINEERING**	3	0	0	3
C:P:A		**L**	**T**	**P**	**H**
3:0:0		3	0	0	3

UNIT- I	**OVERVIEW OF POWER GENERATION**	**9**

Principle of Power Generation, Brief survey of methods of power generation – hydro, thermal, nuclear, solar, wind and tidal power – importance of instrumentation in power generation– Material handling of power plant equipment thermal power plants – building blocks – details of boiler processes UP&I diagram of boiler – cogeneration.

UNIT- II	**MEASUREMENTS IN POWER PLANTS**	**9**

Electrical measurements – current, voltage, power, frequency, power – factor etc. – non electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature – drum level measurement – radiation detector – smoke density measurement – dust monitor-emission measurements-performance measurements.

UNIT-III	**ANALYZERS IN POWER PLANTS**	**9**

Flue gas oxygen analyzer – Deminaral - Steam and Water Analysis System (SWAT) analysis of impurities in feed water and steam – dissolved oxygen analyzer – chromatography – PH meter – fuel analyzer – pollution monitoring instruments

UNIT-IV	**CONTROL LOOPS IN BOILER**	**9**

Combustion control – air/fuel ratio control – furnace draft control – drum level control –low and high protection- main steam and reheat steam temperature control – super heater control – at temperature – deaerator level control – distributed control system in power plants – interlocks in boiler operation-boiler trip protection

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UNIT- V	**TURBINE – MONITORING AND CONTROL SOFTWARE**	**9**
Speed, vibration, shell temperature monitoring and control – steam pressure control – lubricant oil temperature control – cooling system and application of SCADA and other monitoring and control software .		
Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours		

TEXT BOOKS:	
1.	Sam G. Dukelow, "The control of Boilers" Instrument Society of America, 2000.
2.	V.K. Mehta and Rohit Mehta "Principles of Power system" S. Chand & Company, New Delhi, 2003
3.	Er. R.K. Rajput, A text book of power plant engineering, Forth edition, 2015.
4.	Dr. P. C. Sharma's A Textbook of Power Plant Engineering, published by S. K. Kataria, 2013.
REFERENCE BOOKS:	
1.	Power station Engineering and Economy by Bernhardt G.A.Skrotzki and William A.Vopat-Tata McGraw Hill Publishing Company Ltd., New Delhi, 20th reprint 2002
2.	R.K.Jain, "Mechanical and Industrial Measurements" Khanna Publishers, New Delhi, 2002.
3.	Arora Domkundwar , A course in Power Plant engineering , Dhanpat Rai & Co,2001
E-REFERENCES:	
1	www.electrical4u.com

COs versus POs mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	-	-	-	1	-	-	1	3	2
CO2	3	1	-	2	1	-	-	-	1	-	-	1	1	2
CO3	3	-	1	-	1	-	-	-	1	-	-	1	2	1
CO4	3	2	2	2	1	-	-	-	1	-	-	1	3	1
CO5	3	1	-	-	1	-	-	-	-	-	-	1	2	1
Total	15	6	4	6	5				4			5	11	7
Scaling	3	2	1	2	1				1			1	3	2

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ENTREPRENEURSHIP DEVELOPMENT

Course Outcomes(PSC 302):		**Domain**	**Level**
CO1	***Recognise*** and ***describe*** the personal traits of an entrepreneur.	Affective Cognitive	Receiving Understanding
CO2	***Determine*** the new venture ideas and ***analyse*** the feasibility report.	Cognitive	Evaluating Analyzing
CO3	***Develop*** the business plan and ***analyse*** the plan as an individual or in team.	Cognitive	Applying Analyzing
CO4	***Describe*** various parameters to be taken into consideration for launching and managing small business.	Cognitive	Understanding
CO5	***Describe*** Technological management and Intellectual Property Rights	Cognitive	Understanding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
PSC 302	**ENTREPRENEURSHIP DEVELOPMENT**	**2**	**0**	**0**	**2**
C:P:A = 3:0:1					
		L	**T**	**P**	**H**
		2	**0**	**0**	**2**

UNIT- IENTREPRENEURIAL TRAITS AND FUNCTIONS	**6**
Definition of Entrepreneurship; competencies and traits of an entrepreneur; factors affecting Entrepreneurship Development; Role of Family and Society ; Achievement Motivation; Entrepreneurship as a career and national development;	
UNIT -II NEW PRODUCT DEVELOPMENT AND VENTURE CREATION	**6**
Ideation to Concept development; Sources and Criteria for Selection of Product; market assessment ; Feasibility Report ;Project Profile; processes involved in starting a new venture; legal formalities; Ownership; Case Study.	
UNIT –III ENTREPRENEURIAL FINANCE	**6**
Financial forecasting for a new venture; Finance mobilization; Business plan preparation; Sources of Financing, Angel Investors and Venture Capital; Government support in startup promotion.	
UNIT –IV LAUNCHING OF SMALL BUSINESS AND ITS MANGEMENT	**6**
Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units.	

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UNIT –V TECHNOLOGY MANAGEMENT, IPR PORTFOLIO FOR NEW PRODUCT VENTURE	**6**

Technology management; Impact of technology on society and business; Role of Government in supporting Technology Development and IPR protection; Entrepreneurship Development Training and Other Support Services.

	LECTURE	**TUTORIAL**	**TOTAL**
	30	**0**	**30**

TEXT BOOKS

1. Hisrich, 2016, *Entrepreneurship*, Tata McGraw Hill, New Delhi.
2. S.S.Khanka, 2013, *Entrepreneurial Development*, S.Chand and Company Limited, New Delhi.

REFERENCE BOOKS

1. Mathew Manimala, 2005, Entrepreneurship *Theory at the Crossroads, Paradigms & Praxis*, Biztrantra ,2nd Edition.
2. Prasanna Chandra, 2009, *Projects – Planning, Analysis, Selection, Implementation and Reviews*, Tata McGraw-Hill.
3. P.Saravanavel, 1997, *Entrepreneurial Development*, Ess Pee kay Publishing House, Chennai.
4. Arya Kumar,2012, *Entrepreneurship: Creating and Leading an Entrepreneurial Organisation*, Pearson Education India.
5. Donald F Kuratko, T.V Rao, 2012, *Entrepreneurship: A South Asian perspective*, Cengage Learning India.
6. Dinesh Awasthi, Raman Jaggi, V.Padmanand, *Suggested Reading / Reference Material*
   a. *for Entrepreneurship Development Programmes* (EDP/WEDP/TEDP), EDI Publication, Entrepreneurship Development Institute of India, Ahmedabad. Available from: http://www.ediindia.org/doc/EDP-TEDP.pdf

E RESOURCES

1. Jeff Hawkins, " Characteristics of a successful entrepreneur", ALISON Online entrepreneurship courses, "https://alison.com/learn/entrepreneurial-skills
2. Jeff Cornwall, "Entrepreneurship -- From Idea to Launch", Udemy online Education, https://www.udemy.com/entrepreneurship-from-idea-to-launch/

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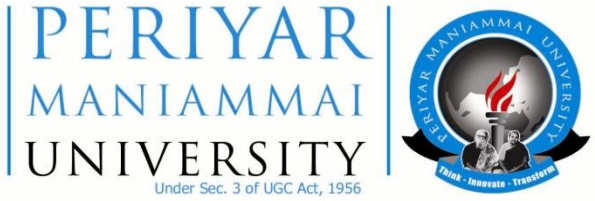

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MAPPING COURSE OUTCOME WITH GRADUATE ATTRIBUTES:

	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA1 0	GA1 1	GA1 2
CO1									3	3	3	1
CO2			1	2	3	2	1	1	1	2	3	
CO3						1		2	3	3		2
CO4						1	1	2	3		3	3
CO5						1	1	3				3
			1	2	3	5	3	8	10	8	9	9
			1	1	1	2	1	2	3	2	2	2

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ELECTRICAL ENERGY UTILIZATION AND CONSERVATION

Course Outcomes(PEE303):		**Domain**	**Level**
CO1	***Choose*** an industrial drive with relevant factors and ***develop*** electric traction system.	Cognitive	Remembering Applying
CO2	***Classify*** the lamps and lighting. ***Develop*** lighting scheme for residential, commercial and industrial applications.	Cognitive	Understanding Applying
CO3	***Explain*** electric heating and ***develop a*** heating system.	Cognitive	Understanding Applying
CO4	***Demonstrate*** the furnaces, welding and identify their applications.	Cognitive	Understanding
CO5	***Explain*** the application of electrolytic process and electroplating.	Cognitive	Understanding

SUBCODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE303	**ELECTRICAL ENERGY UTILIZATION AND CONSERVATION**	**3**	**1**	**0**	**4**
C:P:A		**L**	**T**	**P**	**H**
3:0:0		**3**	**1**	**0**	**4**

UNIT I ELECTRIC DRIVES AND TRACTION **10+5**

Fundamentals of electric drive - choice of an electric motor - application of motors for particular services - traction motors - characteristic features of traction motor - systems of railway electrification - electric braking - train movement and energy consumption - traction motor control - track equipment and collection gear.

UNIT II ELECTRIC LIGHTING **08+5**

Definition of terms – types of lamp – types of lighting –Lighting Scheme, methods of lighting calculation design of illumination – residential – commercial – industrial – energy saving measures.

UNIT III HEATING AND WELDING **09+5**

Advantages of electric heating – Models fo heat transfer – Methids of heating: Resistance heating, Induction heating, Dielectric heating – Requirement of heating material – design of heating element. Furnaces: Induction furnace, Arc furnace – Welding types: Resistance, Electric Arc, Welding generator, Welding transformer and its characteristics – plasma cutting.

UNIT IV	**ELECTRO-CHEMICAL PROCESSES**	**09+5**

Electrolysis – Electroplating – Electro deposition – Extraction of metals – Current, Efficiency - Batteries – types – Charging Methods.

UNIT V	**ENERGY CONSERVATION AND AUDIT**	**09+5**

Tariff – Need for electrical energy conservation – ways of energy conservation. Energy Auditing: Aim, Strategy, Periodic process review, energy audit of electrical system – Instruments for energy audit – Demand side management: Planning and implementation, load management, End use energy conservation.

LECTURE	**TUTORIAL**	**TOTAL**
60	**00**	**45**

TEXT BOOKS:

1. Wadhwa, C.L., 'Generation, Distribution and Utilization of electric energy, New age International Publications, 2006.
2. B. R. Gupta, “Generation of Electrical Energy”, Eurasia Publishing House Private Limited, New Delhi, 2003.

REFERENCE BOOKS:

1. S. L Uppal, “Electrical Power”, Khanna Publishers, 1988.
2. Suryanarayana, N.V., 'Utilisation of Electric Power', Wiley Eastern Ltd. 1993.

E REFERENCES

1. http://nptel.ac.in/courses/108105058/ Prof. S. Banerjee, IIT – Kharagpur.
2. https://www.youtube.com/watch?v=uy9lZCdkQIM Prof.D.P.Kothari, IIT Delhi

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Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	1	-	1	-	-	-	1	-
CO2	-	-	3	-	-	-	2	2	-	-	2	2	1	-
CO3	-	-	3	-	-	3	3	-	-	-	-	-	3	1
CO4	1	2	-	3		-	2	-	-	2	-	-	2	1
CO5	1	1	-	3	2	-	-	-	-	-	-	-	1	-
Total	4	5	7	6	2	3	8	2	1	2	2	2	8	2
Scaling	1	1	2	2	1	1	2	1	1	1	1	1	2	1

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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ELECTRICAL MACHINES II

Course Outcomes(PEE 304):		**Domain**	**Level**
CO1	***Explain*** the fundamentals concepts of alternator and***name*** the types of alternator. ***Demonstrate*** complete working of alternator and voltageregulation.	Cognitive Psychomotor	Understanding Remembering Set
CO2	**Summarise** the fundamentals concepts of synchronous motor and***perform***the starting, different torque and performance characteristics.	Cognitive Psychomotor	Understanding COR
CO3	***Define*** the operation of induction motor, equivalent circuitand slip – torque characteristic. ***Show*** the testing and performance of an inductionmotor.	Cognitive Psychomotor	Remembering Set
CO4	***Classify***the types of starters of induction motor and***List***the different methods of speed control.	Cognitive Cognitive	Understanding Remembering
CO5	***Define*** the concept of single phase induction motorand special machines. ***Perform*** the test like no load and blocked load test ofsingle phase induction motor.	Cognitive Psychomotor	Remembering COR

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 304	**ELECTRICAL MACHINES II**	3	1	1	5
C:P:A		**L**	**T**	**P**	**H**
3:0:0		3	2	2	7

UNIT- 1	**SYNCHRONOUS GENERATOR**	**10+12+12**
Constructional details – Types of rotors – Winding Factors– EMF equation – Synchronous reactance – Armature reaction – Voltage regulation – E.M.F, M.M.F and Z.P.F methods – Synchronizing and parallel operation – Synchronizing torque.		
UNIT- II	**SYNCHRONOUS MOTOR**	**9+2+2**
Principle of operation – Torque equation – Operation on infinite bus bars - V-curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed – Handing and Damper Winding.		
UNIT-III	**THREE PHASE INDUCTION MOTOR (IM)**	**10+8+8**
Constructional details – Types of rotors – Principle of operation – Slip – Cogging and Crawling - Equivalent circuit – Slip-torque characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Double cage rotors.		
UNIT- IV	**STARTING AND SPEED CONTROL OF THREE PHASE IM**	**7+2+2**
Need for starting – Types of starters – DOL Stator resistance, rotor resistance, autotransformer and star-delta starters – Speed control – Change of voltage, frequency, number of poles and slip – V/F Control .		

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UNIT- V	**SINGLE PHASE IM AND SPECIAL MACHINES**	**9+6+6**

Constructional details of single phase induction motor – Double revolving field theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors - Special machines - Shaded pole induction motor, reluctance motor, repulsion motor, hysteresis motor. A.C series motor, Stepper Motor – Introduction to Magnetic Levitation Systems.

1. OCC and Load Characteristics of three-phase alternator.
2. Regulation of three phase alternator by EMF /MMF methods.
3. Load test of a three phase alternator
4. V and Inverted V curves of Three Phase Synchronous Motor.
5. Load test on three-phase Squirrel Cage Induction motor.
6. Load test on Three-Phase Slip Ring Induction motor.
7. No load and blocked rotor test on three-phase induction motor.
8. Load test on single-phase induction motor
9. No load and blocked rotor test on single-phase induction motor.
10. Study of Induction motor starters

Lecture = 45; Tutorial = 30; Lab = 30; Total = 105 Hours

TEXT BOOKS:

1.	D.P. Kothari and I.J. Nagrath, ‘Electric Machines’, Tata McGraw Hill Publishing Company Ltd, 2002.
2.	P.S. Bimbhra, ‘Electrical Machinery’, Khanna Publishers, 2003.
3.	B.L.Theraja, “A Textbook of Electrical Technology,“Vol. I&II, M/s S.Chand, Delhi,2013

REFERENCE BOOKS:

1.	A.E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, ‘Electric Machinery’, Tata McGraw Hill publishing Company Ltd, 2003.
2.	J.B. Gupta, ‘Theory and Performance of Electrical Machines’, S.K.Kataria and Sons, 2002.
3.	P.C. Sen, “Principles of Electrical Machines and Power Electronics” John Wiley & Sons, 1997.
4.	DeshPande M.V., “Electrical Machines” PHI Learning Pvt Ltd., New Delhi – 2011.
5.	A. G. Warren, “Problems in Electrical Engineering”, Parker and Smith Solutions, Newyork, 1940.
6.	K. Murugesh Kumar, ‘Electric Machines’, Vikas publishing house Pvt Ltd, 2002.

E-REFERENCES:	
1.	http://freevideolectures.com/Course/2335/Basic-Electrical-Technology35-38,Prof.L.Umanand,IISc Bangalore.

COs versus POs mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	2	1	-	-	-	1	-	-	1	-	1
CO2	3	2	-	2	1	-	-	-	-	-	-	1	-	1
CO3	3	-	-	-	1	-	-	-	1	-	-	1	-	1
CO4	3	2	2	2	1	-	-	-	1	-	-	1	-	1
CO5	3	-	-	-	1	-	-	-	-	-	-	1	-	1
Total	15	6	4	6	5				3			5		5
Scaling	3	2	1	2	1				1			1		1

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TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER

Course Outcomes(PEE 401):		**Domain**	**Level**
CO1	***Explain*** the major components of Transmission and Distribution Systems (TDS). ***Classify*** different types of single and three phase transmission line parameters.	Cognitive	Understanding Understanding
CO2	***Outline*** the types of transmission line efficiency calculations and its performance	Cognitive	Understanding
CO3	***Explain*** the different types of insulators and ***solve*** for stress and sag in overhead lines.	Cognitive	Understanding Applying
CO4	***Interpret*** different types underground cables.	Cognitive	Understanding
CO5	***Sum*marize** the latest technologies in the field of distribution systems.	Cognitive	Understanding

SUBCODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE 401	**TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER**	**3**	**0**	**0**	**3**
3:0:0		**L**	**T**	**P**	**H**

UNIT I	**TRANSMISSION LINE PARAMETERS**	**09**
Structure of electric power system: Various levels such as generation, transmission and distribution; – Resistance, Inductance and Capacitance calculations – Single-phase and three-phase lines – double circuit lines – effect of earth on transmission line capacitance.		
UNIT II	**PERFORMANCE OF TRANSMISSION LINES**	**09**
Regulation and efficiency – Tuned power lines, Power flow through a transmission line – Power circle diagrams, Introduction to Transmission loss and Formation of corona – critical voltages – effect on line performance – travelling waveform phenomena.		
UNIT III	**MECHANICAL DESIGN OF OVERHEAD LINES**	**09**
Line supports – Insulators, Voltage distribution in suspension insulators – Testing of insulators – string efficiency – Stress and sag calculation – effects of wind and ice loading.		
UNIT IV	**UNDERGROUND CABLES**	**09**
Comparison with overhead line – Types of cables – insulation resistance – potential gradient – capacitance of single-core and three-core cables		

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UNIT V	**DISTRIBUTION SYSTEM**			**09**
General aspects – Kelvin's Law – A.C. distribution – Single-phase and three phase – Techniques of voltage control and power factor improvement – Introduction to Distribution loss – Recent trends in transmission and distribution systems				
	LECTURE	**TUTORIAL**	**TOTAL**	
	45	**0**	**45**	

TEXT BOOKS	
1.	D.P.Kothari and I.J. Nagrath, 'Power System Engineering', Tata McGraw–Hill, 2nd Edition, 2008.
2.	B.R.Gupta, 'Power System Analysis and Design', S.Chand, New Delhi, 2003.
3.	S.N. Singh, 'Electric Power Generation, Transmission and Distribution', Prentice Hall India Pvt. Ltd, 2002.
REFERENCE BOOKS	
1.	Luces M.Fualkenberry ,Walter Coffer, 'Electrical Power Distribution andTransmission', Pearson Education, 1996.
2.	Hadisaddak, 'Power System Analysis,' Tata McGraw Hill Publishing Company',2003
3.	Central Electricity Authority (CEA), 'Guidelines for Transmission System Planning', New Delhi
4.	Tamil Nadu Electricity Board Handbook', 2012.
E REFERENCES:	
1.	NPTEL, Power System Generation, Transmission and Distribution Prof. D. P. Kothari Center for Energy Studies Indian Institute of Technology, Delhi

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COs versus POs mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	1	3			1		3			1		2	2	3
CO 2	1	3	1									1	3	2
CO 3	1			1		1			1	1			2	3
CO 4	1	2						1			1	1	2	2
CO 5		2										1	2	3
Total	4	10	1	1	1	1	3	1	1	2	1	5	11	13
Scaling	1	2	1	1	1	1	1	1	1	1	1	1	3	3

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ENVIRONMENTAL STUDIES

Course Outcomes (PSC 402)		Domain	Level
CO1	***Describe*** the significance of natural resources and ***explain*** anthropogenic impacts.	Cognitive	Remembering Understanding
CO2	***Illustrate*** the significance of ecosystem and biodiversity for maintaining ecological balance	Cognitive	Understanding
CO3	***Identify*** the facts , consequences , preventive measures of major pollution and ***Recognize*** the disaster phenomenon	Cognitive Affective	Remembering Receiving
CO4	***Explain*** the socio- economics, policy dynamics and ***practice*** the control measures of global issues for sustainable development.	Cognitive	Understanding Analyzing
CO5	***Recognize*** the impact of population and ***apply*** the concept to develop various welfare programs.	Cognitive	Understanding Applying

SUB. CODE			SUB. NAME	L	T	P	C
PSC 402			Environmental Studies	3	0	0	3
C	P	A		L	T	P	H
2.5	0	0.5		3	0	0	3

UNIT I INTRODUCTION TO ENVIRONMENTAL STUDIES AND ENERGY **09**

Definition, scope and importance – Need for public awareness – Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – Role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles.

UNIT II ECOSYSTEMS AND BIODIVERSITY **09**

Concept of an ecosystem – Structure and function of an ecosystem – Producers, consumers and decomposers – Energy flow in the ecosystem – Ecological succession – Food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the (a) Forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to Biodiversity – Definition: genetic, species and ecosystem diversity - Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

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UNIT III	ENVIRONMENTAL POLLUTION	12

Definition – Causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards – Soil waste Management: Causes, effects and control measures of urban and industrial wastes – Role of an individual in prevention of pollution – Pollution case studies – Disaster management: flood, earthquake, cyclone and landslide.

UNIT IV	SOCIAL ISSUES AND THE ENVIRONMENT	09

Urban problems related to energy – Water conservation, rain water harvesting, watershed management – Resettlement and rehabilitation of people; its problems and concerns, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, Wasteland reclamation – Consumerism and waste products – Environment Production Act – Air (Prevention and Control of Pollution) Act – Water (Prevention and control of Pollution) Act – Wildlife Protection Act – Forest Conservation Act – Issues involved in enforcement of environmental legislation – Public awareness.

UNIT V	HUMAN POPULATION AND THE ENVIRONMENT	06

Population growth, variation among nations – Population explosion – Family Welfare Programme – Environment and human health – Human Rights – Value Education - HIV / AIDS – Women and Child Welfare – Role of Information Technology in Environment and human health – Case studies.

Lecture = 45; Tutorial = 00; Total = 45 Hours

TEXT BOOKS

5. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co, USA, 2000.
6. Townsend C., Harper J and Michael Begon, Essentials of Ecology, Blackwell Science, UK, 2003
7. Trivedi R.K and P.K.Goel, Introduction to Air pollution, Techno Science Publications, India, 2003.
8. Disaster mitigation, Preparedness, Recovery and Response, SBS Publishers & Distributors Pvt. Ltd, New Delhi, 2006.
9. Introduction to International disaster management, Butterworth Heinemann, 2006.
10. Gilbert M.Masters, Introduction to Environmental Engineering and Science, Pearson Education Pvt., Ltd., Second Edition, New Delhi, 2004.

REFERENCE BOOKS

1. Trivedi R.K., Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards, Vol. I and II, Enviro Media, India, 2009.
2. Cunningham, W.P.Cooper, T.H.Gorhani, Environmental Encyclopedia, Jaico Publ., House, Mumbai, 2001.
3. S.K.Dhameja, Environmental Engineering and Management, S.K.Kataria and Sons, New Delhi, 2012.
4. Sahni, Disaster Risk Reduction in South Asia, PHI Learning, New Delhi, 2003.
5. Sundar, Disaster Management, Sarup & Sons, New Delhi, 2007.
6. G.K.Ghosh, Disaster Management, A.P.H.Publishers, New Delhi, 2006.

E REFERENCE

1. Bharat Raj Singh , 2015,Global Warming: Causes, Impacts and Remedies , InTech.
2. Richard C. J. Somerville , The Forgiving Air: Understanding Environmental Change , 1998,
3. University of California Press
   Benny Joseph, Environmental Studies, 2005,Tata McGraw Hill.

Mapping of CO's with GA's:

	GA 1	GA 2	GA 3	GA 4	GA 5	GA 6	GA 7	GA 8	GA 9	GA 10	GA 11	GA 12
CO1	3											1
CO2	2					2	1			1		1
CO3	2	1	3			3	1		2	1		1
CO4	1	1	2			3	2	3				1
CO5	2	1	1			3						1
Total	**10**	**3**	**6**			**11**	**4**	**3**	**2**	**2**		**5**
Scaled to 0,1,2,3 scale	**2**	**1**	**2**			**3**	**1**	**1**	**1**	**1**	**1**	**1**

0 –No relation1 – Low relation2 – Medium relation3 – High Relation

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HIGH VOLTAGE ENGINEERING

Course Outcomes (PEE 403)		**Domain**	**Level**
CO1	***Explain*** the different causes of overvoltage and ***Illustrate*** overvoltage control due to switching. ***classify*** the various methods for protection of lightning overvoltage	Cognitive	Understanding
CO2	***Explain*** and ***Classify*** breakdown mechanisms in solid, liquid and gases dielectrics *and list out the application of insulating materials*	Cognitive	Understanding
CO3	**Able** to define **and *Classify*** the different methods to generate the various types of high voltages and high currents.	Cognitive	Understanding
CO4	***Classify*** and ***analyze*** the different techniques used to measure the various types of high voltages and high currents.	Cognitive	Understanding Analyzing
CO5	***Recall* and *Illustrate*** the different testing methods to test the various high voltage components of power System and ***define*** the International,Indian standards and insulation co-ordination.	Cognitive	Remembering Understanding

SUB CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 403			**High Voltage Engineering**	**3**	**1**	**0**	**4**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**1**	**0**	**4**

UNIT I	**OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS**	**09+05**
Natural Causes of overvoltage-Lightning phenomena and its effects on power system – Over voltage due to switching surge-power frequency overvoltage-control of overvoltage due to switching – protection of transmission lines against overvoltage – Becoleys lattice diagram.		
UNIT II	**ELECTRICAL BREAKDOWN IN GASES, SOLIDS AND LIQUIDS**	**09+05**
Gaseous breakdown in uniform and non-uniform fields - corona discharges - Vacuum breakdown - conduction and breakdown in pure and commercial liquids - Breakdown mechanisms in solid and composite dielectrics-Applications of insulating materials.		
UNIT III	**GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS**	**09+05**
Generation of High DC, AC, impulse voltages and currents. Tripping and control of impulse generators.		
UNIT IV	**MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS**	**09+05**
Measurement of High direct current voltages – measurement of voltages: alternating and impulse voltages- Measurement of High currents: direct, alternating and impulse currents. Digital techniques in high voltage measurement.		

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UNIT V	**HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS**	**09+05**

High voltage testing of electrical power apparatus – power frequency, impulse voltage and DC testing – International and Indian standards-Insulation co-ordination.

Lecture = 45; Tutorial = 30; Total = 75 Hours

TEXT BOOKS

1. E. Kuffel and M. Abdullah, 'High Voltage Engineering', Pergamon press, Oxford,2010.
2. M.S. Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill,4th Edition, 2004.
3. E. Kuffel and W.S. Zaengl, 'High Voltage Engineering Fundamentals', Pergamon Press, Oxford, London, 2012
4. August F.Metraux. "Some problems and actual limits of test techniques at extra high voltages",Haefely publications EIS 14.

REFERENCE BOOKS

1. C.L.Wadhwa, 'High Voltage Engineering', New Age International (P) Ltd, 2nd Edition2006.
2. Ravindra Arora, Wolfgang Mosch, "High Voltage Insulation Engineering", New Age International (P) Limited, 2011.
3. Chinnappa ,K.M., Need for next higher voltage level in India", National seminar on high voltage AC and Dc Transmission,New delhi.

E REFERENCES

1. Web Content - http://www.library.dce.edu/e-resources/books/ee/
2. NPTEL-High Voltage Engineering, C.L. Wadhwa -IIT Madras.

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COs versus PO, PSO mapping

CO/ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	-	-	1	-	1	-	-	-	2	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	1	1	2
CO3	2	2	-	-	1	1	-	1	-	-	-	1	1	1
CO4	2	2	-	-	-	-	1	-	-	-	-	1	2	2
CO5	2	2	-	2	-	1	-	-	-	-	-	2	2	2
Total	12	10	2	2	1	3	1	2	0	0	0	7	8	9
Scaling	3	2	1	1	1	1	1	2	0	0	0	2	2	2

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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CONTROL SYSTEMS ENGINEERING

Course Outcomes (PEE 404)		**Domain**	**Level**
CO1	**Identify** the basic elements, derive the transfer function and **Construct** the transfer function of DC motors and DC generators	Cognitive	Applying Applying
CO2	**Explain** the performance of I and II system with static and dynamic error coefficients.	Cognitive	Understanding
CO3	**Describe** Time domain & Frequency domain and **shows** the response of time and frequency domain	Cognitive	Remembering Understanding
CO4	***Explain*** State space model and ***construc***t ***and verify*** the canonical state model and kalmans test for controllability and observability.	Cognitive	Understanding Applying
CO5	***Describe*** State transition matrix	Cognitive	Remembering

SUB CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 404			**Control System Engineering**	**3**	**1**	**1**	**5**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**1**	**0**		**3**	**2**	**2**	**7**

UNIT I SYSTEMS AND THEIR REPRESENTATION	**10 + 09 + 20**
Basic elements in control systems – Open and closed loop systems – Principles of feedback, Transfer function Block diagram reduction techniques – Signal flow graphs. Mason gain formula, Modeling of electric systems translation and rotational mechanical systems.	
UNIT II TIME RESPONSE	**08 + 09**
Time response – Time domain specifications – Types of test input – I and II order system response – Error coefficients – Generalized error series – Steady state error	
UNIT III FREQUENCY RESPONSE	**09 + 03 + 05**
Frequency domain specification – Bode plot – Polar plot – Determination of closed loop response from open loop response – Correlation between frequency domain and time domain specifications series, parallel, series-parallel compensators, Lead, Lag and Lead Lag Compensators.	
UNIT IV STABILITY OF CONTROL SYSTEM	**09 + 06 + 05**
Characteristics equation – Location of roots in S plane for stability – Routh Hurwitz criterion – Root locus construction – Effect of pole, zero addition – Gain margin and phase margin – Nyquist stability criterion	

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UNIT V STATE VARIABLE ANALYSIS & DIGITAL CONTRO SYSTEMS	**09 + 03**

Introduction to state Space Analysis – Physical Variable phase variable and canonical variable forms State Space representation of continuous time system. Transfer function from state variable representation – solutions of the state equations – concepts of controllability and observability

1. Transfer function and modeling of separately excited DC Generator.
2. Transfer function and modeling of Armature & field controlled DC Motor.
3. Transfer function of AC Servomotor.
4. Frequency response of Lag, Lead & Lag – Lead networks.
5. Analysis of Synchro Transmitter and Receiver.
6. Performance of DC Stepper Motor
7. Transfer function and modeling of Ward – Leonard speed control system applied to DC motor.
8. DC Position using feedback Control system.
9. Digital simulation of I order and II order system by using Scilab.
10. Determination of Phase margin and Gain margin of the Bode plot using Scilab.

Lecture = 45; Tutorial = 30; Lab = 30; Total = 105 Hours

TEXT BOOKS:

1. I.J. Nagrath& M. Gopal, ‘Control Systems Engineering’, New Age International Publishers, 2003
2. Norman S. Nise, "Control System Engineering” fifteh edition, John Wiley &Sons, inc, 2007.
3. M. Gopal, ‘Control Systems, Principles & Design’, Tata McGraw Hill, New Delhi, 2002.
4. Richard C. Dorf & Robert H. Bishop, “ Modern Control Systems”, Addidon – Wesley, 2012.

REFERENCE BOOKS:

1. B.C. Kuo, ‘Automatic Control Systems’, Prentice Hall of India Ltd., New Delhi, 2014.
2. K. Ogata, ‘Modern Control Engineering’, 4th edition, Pearson Education, New Delhi, 2003 / PHI.
3. N. Bandyopadhyay, ‘Control Engineering Theory and Practice’, Prentice Hall of India, 2009
4. John J.D’azzo & Constantine H.Houpis, ’Linear control system analysis and design’, Tata McGrow-Hill, Inc., 2013.

E-REFERENCES:

1. NTPEL, Control sytems Engineering (Web Course), Prof. M. Gopal, IIT Kharagpur.

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Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	3	2	1	-	-	1	1	1	-	-	1	-	-
CO2	2	3	1		2	1	1	1	1	1	-	2	2	1
CO3	3	3	3	2	-	-	1	-	3	-	-	-	2	2
CO4	1	2	2	3	1	2	1	1	2	1	1	2	1	2
CO5	2	1	1	1	1	1	1	1	2	1	-	1	2	1
Total	10	13	9	7	4	4	5	4	9	3	1	6	7	6
Scaling	2	2	2	2	1	1	1	1	2	1	1	2	2	2

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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PEE 501 PROTECTION AND SWITCHGEAR

Course Outcomes (PEE 501)		**Domain**	**Level**
CO1	To ***Illustrate*** and ***recall*** the principle, characteristics and working of different types of relay.	Cognitive	Understanding Remembering
CO2	To ***choose*** relevant protection systems for the Generator and Transformers.	Cognitive	Applying Evaluating
CO3	**To *compare*** the concepts of arc quenching techniques of different equipments.	Cognitive	Analyzing
CO4	**To *classify*** the different type of Circuit breakers and its selection criteria.	Cognitive	Analyzing
CO5	**To *select*** of different type of equipments used for over voltage protection and Lightning arrestors.	Cognitive	Applying

SUB CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 501			**Protection and Switchgear**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**0**	**0**	**3**

UNIT- I	**RELAYS**	**09**
General classification, Principle of operation, types, characteristics, Torque equation, Relaying Schemes, Relay Co- ordination. Requirement of relays, Primary & backup protection, Desirable qualities of relays, Terminology used in protective relay, Over current relays directional, distance and differential, under frequency, negative sequence relays.		
UNIT- II	**APPARATUS PROTECTION**	**09**
Protection of Generator: Earth Fault, percentage, differential, Loss of excitation, Prime mover failure, over current, Negative phase sequence, heating, Reverse power protection schemes .Protection of Transformers: Internal and external fault protection, Differential, Earth fault, Over Current, Overheating. Transformer Protection - Incipient fault.		
UNIT-III	**THEORY OF CIRCUIT INTERRUPTION**	**09**
Physics of arc phenomena and interruption- rate of rise of recovery voltage. Elementary principle of arc quenching, Recovery and re-striking voltage, arc quenching devices, current chopping, capacitive current, resistance switching, interruption of capacitive current.		
UNIT- IV	**CIRCUIT BREAKERS**	**09**
Switchgear, fault clearing, description and operation of Bulk oil, Minimum oil, Air break, Air blast, SF6, Vacuum circuit breakers and DC circuit breakers, LT Switch gear, HRC fuses, current limiting reactor & influence of reactors in CB ratings, selection of circuit breakers, Testing of circuit breaker, Intelligent circuit breakers.		

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UNIT- V	**PROTECTION AGAINST OVERVOLTAGES**	**09**

Switching surges, Phenomena of Lightning, over voltage due to lightning, Protection against lightning, Lightning arrestors, selection of lightning arrestors, Surge absorbers, and diverters, Rod gap, Horn gap expulsion type & valve type lightning arrestors, solid resistance and reactance earthing, Arc suppression coil, Earthing transformers, Earthwires, insulation co-ordination.

Lecture = 45; Tutorial = 00; Total = 45 Hours

TEXT BOOKS

1. Badri Ram, Vishwakarma D N., "Power System Protection and Switchgear" Tata McGraw Hill Publishing House Limited, New Delhi, 2005.
2. Soni, M.L., Gupta, P.V., Bhatnagar, U.S. and Chakrabarti, A., "A Text Book on Power Systems Engineering", Dhanpat Rai & Sons Company Limited, New Delhi, 2008.
3. Sunil, S.Rao, "Switchgear Protection and Power Systems (Theory, Practice & Solved Problems", Khanna Publishers Limited, New Delhi, 12th Edition, 2008.
4. B.Ravindranath, and N.Chander, 'Power System Protection and Switchgear',WileyEastern Ltd., 2000.

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1. Paithankar Y. G., Bhide S. R., "Fundamentals of Power System Protection" Prentice Hall of India Limited, New Delhi, 2nd Edition, 2010.
2. Wadhwa, C.L., "Electrical Power Systems", New Age International Publishers Limited, 2006, New Delhi,6th Edition, 2010
3. Patra, S.P., Basu, S.K. and Chowduri, S., 'Power systems Protection', Oxford and International Book House Publishing Co, 2000.

E-REFERENCES

1. NTPEL, Power System Generation, Transmission and Distribution ,Prof. D. P. Kothari Center for Energy Studies ,Indian Institute of Technology, Delhi

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COs versus POs mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	-	-	-	1	-	-	-	1	1
CO2	2	2	-	2	1	-	-	-	-	-	-	-	1	1
CO3	2	-	-	-	1	-	-	-	1	-	-	-	1	1
CO4	2	2	2	2	1	-	-	-	1	-	-	-	1	1
CO5	2	-	-	-	1	-	-	-	-	-	-	-	1	1
Total	10	6	4	6	5				3				1	5
Scaling	2	1	1	1	1				1				1	1

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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LINEAR INTEGRATED CIRCUITS

Course Outcomes(PEE503):		**Domain**	**Level**
CO1	***Illustrate andclassify***the different manufacturing process of ICs.	Cognitive	Understanding Understanding
CO2	***Explains***the terminal characteristics of op – amps.	Cognitive	Understanding
CO3	***Illustrate*** and ***design*** the various application of op – amps.	Cognitive	Understanding Creating
CO4	***Illustrate*** the various functional block, characteristics and applicationsof special ICs.	Cognitive	Understanding
CO5	***Classify*** and ***explain*** the different techniques of data converters.	Cognitive	Understanding Understanding

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
PEE503	**LINEAR INTEGRATED CIRCUITS**	**3**	**1**	**0**	**4**
C:P:A		**L**	**T**	**P**	**H**
2:0:0		**3**	**2**	**0**	**5**

UNIT- I	**IC FABRICATION**	**9 + 6**
Introduction of IC fabrication, Advantages & Limitation of ICs, Scale of integration, classification of ICs; IC Terminology; Fundamentals of monolithic IC technology, Crystal growth and wafer preparation, Epitaxial growth, Oxidation, Photolithography, etching, Diffusion, Ion implantation, Metallization, packaging of ICs.		
UNIT- II	**CHARACTERISTICS OF OP – AMP**	**9 + 6**
Basics of Op – amp, Ideal Op – amp characteristics, DC characteristics, AC characteristics, Open Loop and Closed Loop configuration of Op – amp, Packages of Op – amp, Inverting & Non – inverting amplifier, Voltage follower, Differential amplifier; Frequency response of Op – amp; Basic applications of op – amp – summer, Differentiator and Integrator.		
UNIT- III	**APPLICATION OF OP – AMP**	**9 + 6**
Instrumentation amplifier, First and second order active filters, V / I and I / V converters, Comparators- Regenerative comparator (Schmitt Trigger), Multi vibrators Astable & Monostable; Waveform generators- RC phase shift oscillator; Wien bridge oscillator; Triangular wave generator; Clippers, Clampers.		
UNIT- IV	**SPECIAL ICs**	**9 + 6**
555 Timer circuit – Functional block, Characteristics and applications; 566 – Voltage controlled oscillator circuit; 565 – Phase lock loop circuit functioning and applications.		

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UNIT- V	**ANA LOG TO DIGITAL AND DIGITAL TO ANA LOG CONVERTERS; SPECIAL FUNCTION ICS.**	**9 + 6**

Introduction of A/D and D/A converters, Sample & Hold circuit, D /A converter (R – 2R ladder and weighted resistor types), A / D converter – Dual slope, Successive approximation and Flash types. ICL 8038 function generator IC. Isolation Amplifiers.

		LECTURE	**TUTORIAL**	**TOTAL**
		45	**30**	**75**

TEXT BOOKS:	
1.	Ramakant . A. Gayakwad ‘Op – Amps and Linear Integrated Circuits’, Prentice Hall of India 3rd Edition, 2001.
2.	Linear Integrated Circuits by D. Roy Choudhury and Shail B. Jain, New Age International Publishers.
REFERENCE BOOKS:	
1.	S.M. Sze, ‘VLSI Technology, 2nd Edition, Tata McGraw Hill,2000.
2.	Sergio Franco, ‘Design with Operational Amplifiers and Analog and Integrated Circuits’, 2nd Edition, McGraw Hill,2002.
3.	National Semiconductor/Texas – TTL/MOS/VLSI Data Manuals.
E REFERENCES :	
1.	NPTEL, Linear Integrated Circuits, Prof. Clark Tu – Cuong Nguyen, IIT Madras.
2.	NPTEL,Linear Integrated Circuits, Prof. TS. Natarajan, IIT Madras.

COs versus PO, PSO mapping

CO/ PO/PSO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	3	-	2	3	-	-	-	-	-	-	-	2	2
CO2	2	1	1	2	2	-	-	-	-	-	-	-	1	1
CO3	1	2	-	3	2	-	-	-	1	-	1	-	1	1
CO4	1	2	-	2	2	-	-	-	-	-	-	-	2	1
CO5	3	2	-	2	2	-	-	-	-	-	-	-	1	2
Total	09	10	01	11	11	0	0	0	01	0	01	0	07	07
Scaling	2	2	1	3	3	0	0	0	1	0	1	0	2	2

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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PEE 504 POWER ELECTRONICS

Course Outcomes (PEE 504)		**Domain**	**Level**
CO1	***Describe*** the structure, operation and characteristics of power semiconductor devices.	Cognitive Psychomotor	Understanding Set
CO2	***Determine*** the operation, characteristics and performance parameter of controlled rectifiers	Cognitive Psychomotor	Understanding Set
CO3	***Illustrate*** the chopper circuits, Switching techniques and basic topologies of DC-DC switching regulators	Cognitive Psychomotor	Applying Set
CO4	***Analysis*** the operations of various inverters and infer the suitable PWM techniques	Cognitive Psychomotor	Analyzing Set
CO5	***Classify*** the 1ϕ, 3ϕ voltage controllers and cyclo-converter.	Cognitive Psychomotor	Understanding Set

Sub.code			**Sub. Name**	**L**	**T**	**P**	**C**
PEE504				**3**	**1**	**1**	**5**
C	**P**	**A**	**Power Electronics**	**L**	**T**	**P**	**H**
3	**1**	**0**		**3**	**2**	**2**	**7**

UNIT I POWER SEMI-CONDUCTOR DEVICES	**09 +06+09**
Review on Semiconductor devices - characteristics and modeling of power diodes, SCR, TRIAC, power BJT, power MOSFET and IGBT. Triggering and Commutation Circuits.	
UNIT II PHASE CONTROLLED CONVERTERS	**09+06+03**
2 pulse, 3 phase converters- effect of freewheeling diode, performance parameters and effect of source inductance - firing circuits, Dual converters.	
UNIT III DC TO DC CHOPPERS	**09+06+06**
Types of Choppers, Class A to E, step up chopper - Analysis of Voltage, Current and load-commutated choppers –Introduction to Resonant converters.	
UNIT IV INVERTERS	**09+06+06**
Single phase, Three Phase voltage source inverters (Both 120º and 180º mode of conductions) - PWM techniques: Sinusoidal PWM, Multiple PWM, space vector PWM - Current source inverters - Concepts of UPS.	
UNIT V AC VOLTAGE CONTROLLERS	**09+06+06**
Single-phase and 3 phase AC voltage controllers -. Multi stage sequence control - step up and step down cyclo-converters – Single phase to single phase and Single phase to Three phase cyclo-converters- Introduction to matrix converters.	

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PEE 504 – Power Electronics Laboratory

Name of the Experiments:

1. Characteristics of SCR
2. Characteristics of MOSFET
3. Characteristics of IGBT
4. 1Φ fully Controlled rectifier with R, RL load.
5. BUCK- BOOST Converter using MOSFET.
6. IGBT based choppers.
7. 1Φ IGBT PWM inverter.
8. Parallel Inverter.
9. 1Φ AC voltage controller using SCR / TRIAC.
10. Mini Project (Related to above experiments).

Lecture = 45; Tutorial = 30; Lab = 30; Total = 105 Hours

TEXT BOOKS :

1. Rashid, M.H., 'Power Electronics - Circuits Devices and Applications', Prentice Hall of India,2004.
2. Singh.M.D and Kanchandani , 'Power Electronics'-Tata McGraw Hill & Hill publication Company Ltd New Delhi-2009.
3. BimbhraP.S , "Power Electronics" Khanna Publishers; 2007
4. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics:* Converters, Applications and Design, New Jersey, John Wiley and Sons, 2006.

REFERENCE BOOKS:

1. Dubey, G.K., Doradia, S.R., Joshi, A. and Sinha, R.M., 'Thyristorised Power Controllers', Wiley Eastern Limited, 1986.
2. Lander,W., 'Power Electronics', McGraw Hill and Company, Third Edition, 2009.
3. Sen.P.C "Power Electronics" Tata McGraw-Hill Publishing Co. Ltd., New Delhi 2005
4. Joseph Vithayathil "Power Electronics" McGraw-Hill New York – 1996.

E REFERENCES:

1. ***Lecture*** Series on ***Power Electronics*** by Prof. B.G. Fernandes, Department of Electrical Engineering, IIT Bombay.
2. http://www.nptel.ac.in/courses/108105066/PDF/L-1(SSG)(PE)%20((EE)NPTEL).pdf

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COs versus PO, PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	2	1	0	0	1	3	0	0	0	0	1	3	1
CO 2	2	1	2	1	0	0	1	0	0	0	0	0	2	2
CO 3	3	1	1	0	0	0	0	0	0	0	0	0	1	2
CO 4	1	3	2	0	0	1	0	0	0	0	0	0	2	1
CO 5	1	2	3	1	3	0	1	1	0	0	0	0	3	2
Total	10	9	9	2	3	2	5	1	0	0	0	1	11	6
Scaling	2	2	2	1	1	1	1	1	0	0	0	1	3	2

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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Course Outcomes (PEE 602)		**Domain**	**Level**
CO1	***Demonstrate*** the per phase analysis of power system.	Cognitive	Understanding
CO2	***Develop*** the model of various components of power system and ***Construct*** the Y Bus and Z Bus for a power system.	Cognitive	Applying
CO3	***Analyze*** the power system network with symmetrical and unsymmetrical faults. ***Calibrate*** the fault current in a power system.	Cognitive Psychomotor	Analyzing Complex
CO4	***Summarize*** the power flow equation. ***Assess*** the voltage profile of a power system by performing the load flow analysis and ***Identify*** the line loss and line flow.	Cognitive Psychomotor	Understanding Evaluating Perception
CO5	***Classify*** and ***determine*** the stability of power system. ***Detect*** the transient behaviour of power system when it is subjected to a fault.	Cognitive psychomotor	Understanding Evaluating Perception

SUB.CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 602			**Power System Analysis**	**3**	**1**	**0**	**4**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**1**	**0**		**3**	**2**	**0**	**5**

UNIT I	**INTRODUCTION**	**08+07**
Need for system analysis in planning and operation of modern power system – per phase analysis - Single line diagram - Per unit representation and Per unit calculations – Change of base – Introduction to Electricity Deregulation.		
UNIT II	**MODELLING OF POWER SYSTEM COMPONENTS**	**09+09**
Primitive network and its matrices – bus incidence matrix – bus admittance and bus impedance matrix formation – Z – Bus building algorithm - Modelling of generator, load, transformer, transmission line for different power system studies.		
UNIT III	**FAULT ANALYSIS-UNSYMMETRICAL FAULTS**	**09+05**
Need for short circuit study - basic assumptions in fault analysis of power systems. Symmetrical (or) balanced three phase faults – problem formulation – fault analysis using Z-bus matrix – algorithm and flow chart. Computations of short circuit capacity, post fault voltage and currents. Introduction to symmetrical components – sequence impedances – sequence networks Unsymmetrical fault analysis: L-G, L-L and L-L-G faults.		
UNIT IV	**POWER FLOW ANALYSIS**	**10+06**
Need for Power Flow Analysis – bus classification – derivation of power flow equation – solution by Gauss–Seidel, Newton–Raphson and Fast Decoupled Power Flow methods – comparison of three methods.		

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UNIT V	**STABILITY ANALYSIS**	**09+03**

Types of stability - Swing equation in state space form - equal area criterion - stability analysis of single machine connected to infinite bus by modified Euler's method using classical machine model – critical clearing angle and time. Causes of voltage instability – voltage stability proximity indices for two-bus system – methods of improving power system stability.

Lecture = 45; Tutorial = 30; Lab = 0; Total = 75 Hours

TEXT BOOKS

1. Hadi Sadaat, "Power System Analysis", Tata McGraw Hill Publishing Company, 2002.
2. Nagarath, I.J., and Kothari, D.P., 'Modern Power System Analysis', Tata McGraw Hill Publishing Company, 2009.
3. John J. Grainger and Stevenson Jr. W.D., "Power System Analysis", McGraw Hill International Edition, 1994.
4. Pai. M.A "Computer techniques in Power System Analysis" Tata McGraw Hill Publishing Company, 3rd edition 2014.

REFERENCE BOOKS

1. Stagg, G.W. and El-Abaid, A. H. "Computer Methods in Power System Analysis", McGraw-Hill International Book Company, 2000.
2. Wadhwa C.L. "Electric Power Systems" Willey Eastern, 2007.

E-REFERENCES

1. http://nptel.ac.in/courses/108105067/ Prof. A. K. Sinha, IITechnology, Kharagpur.
2. http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/power-system/ui/TOC.htm Prof. Arindam Ghosh, IIT Kanpur

COs versus POs mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO 1	3	2		2			1				1		2	
CO 2	3	2	2	2			1				1		2	1
CO 3	3	2	2	2	3		1				1		2	1
CO 4	3	3	2	3			1				1		2	1
CO 5		2	1	1							1		3	1
Total	12	11	7	10	3	0	4	0	0	0	5	0	11	4
Scaled to 0,1,2,3 scale	3	3	2	2	1	0	1	0	0	0	1	0	3	1

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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SOLID STATE DRIVES

Course Outcomes(PEE 603):		**Domain**	**Level**
CO1	***Outline***the fundamentals of Electric Drives and their ratings.	Cognitive	Understanding
CO2	***List*** the various control techniques of DC Drives.	Cognitive	Remembering
CO3	***Categorize*** the different speed control methods for an Induction motor drive	Cognitive	Analyzing
CO4	***Illustrate*** the solid state converters based controllers for Rotor control of an Induction motor drive	Cognitive	Understanding
CO5	***Make use of***the assorted control strategies of synchronous motor drive.	Cognitive	Applying

Sub.code	**Sub. Name**	**L**	**T**	**P**	**C**
PEE 603		3	1	0	4
C:P:A	**SOLID STATE DRIVES**	**L**	**T**	**P**	**H**
3:0:0		3	2	0	5

UNIT-I	**DRIVE CHARACTERISTICS**	**10+5**
Fundamentals of Electric Drives-Advantage of Electric Drives-selection of Motor power rating-Thermal model of motor for heating and cooling - Classes of duty cycle Determination of motor rating - Control of Electric drives- modes of operation - speed control and drive classifications.		
UNIT-II	**SOLID STATE CONTROL OF DC DRIVES**	**10+5**
DC motor and their performance - Transient analysis - Ward Leonard drives - Steady state analysis of the single and three phase fully controlled converter fed separately excited DC motor drive – continuous and discontinuous mode Chopper controlled DC drives - Time ratio control and current limit control.		
UNIT-III	**STATOR CONTROLLED INDUCTION MOTORDRIVES**	**8+5**
Induction Motor Drives-Stator control-Stator voltage and frequency control – VSI,CSI and cyclo converter fed induction motor drives –open loop and closed VVVF control.		
UNIT-IV	**ROTOR CONTROLLED INDUCTION MOTORDRIVES**	**8+5**
Rotor resistance control – Slip power recovery schemes –Sub synchronous and super synchronous operations – Power factor improvement – Closed loop control.		
UNIT-V	**SYNCHRONOUS MOTOR DRIVES**	**9+5**
Separate controlled mode - Self controlled mode of synchronous motor – Constant marginal angle control and motor power factor control – Cyclo converter fed		

synchronous motors- Digital Control and Drive Applications.
Lecture = 45; Tutorial = 30; Lab = 0; Total = 75 Hours

TEXT BOOKS:	
1.	Dubey.G.K. "Fundamentals of Electrical drives", Narora publications, 2008
2.	R. Krishnan, "Electricmotor& Drives; Modelling, Analysis and Control", Prentice Hall of India, 2001.
3.	Gopal K. Dubey, Fundamentals of Electrical Drives, New Delhi, 2nd Edition, Narosa Publishing House, 2001.
4.	B. K. Bose, 'Power Electronics and AC Drives', Prentice Hall Onglewood cliffs, New Jersey, 1998.
REFERENCE BOOKS:	
1.	Murphy, J.M.D and TurnbullF.G. , 'Thyristor control of AC Motors', Pergamon Press,1990.
2.	Sen. P.C., 'Thyristor D.C. Drives', John Wiley and Sons, 1981.
3.	Vedam Subrahmaniyam, 'Electric Drives Concepts and Applications', Tata McGraw HillPublishing company Ltd., 2011.
4.	Gaekward, "Analog and Digital control systems", Wiley Eastern Ltd, 1989.
E REFERENCES:	
1.	***Lecture*** Series on Solid state devices by Prof. S.Karmalkar, Department of Electrical Engineering, IIT Madras.
2.	*http://nptel.ac.in/courses/108108077/*

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PS O 1**	**PS O 2**
CO 1	3	2	1	0	2	0	1	0	0	0	0	0	0	3
CO 2	3	1	0	0	2	0	1	0	0	0	0	0	3	2
CO 3	1	2	3	0	2	0	0	1	0	0	0	0	1	2
CO 4	0	2	0	0	3	0	1	0	0	0	0	0	2	2
CO 5	3	1	1	0	0	1	1	1	0	0	0	1	1	2
Total	10	8	5	0	9	1	4	2	0	0	0	1	7	11
Scalin g	2	2	1	0	2	1	1	1	0	0	0	1	2	3

3–High Relation, 2–Medium Relation, 1–Low Relation, 0–No Relation

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PEE 604 MEASUREMENTS AND INSTRUMENTATION

Course Outcomes (PEE 604)		**Domain**	**Level**
CO1	***Describe*** functional elements of measuring Instruments. ***Design*** of bridge circuits for the measurement of unknown parameters.	Cognitive	Remembering
CO2	***Explain*** the construction and working of different types of indicating and integrating instruments.	Cognitive	Understanding
CO3	***Describe*** the operation of A/D and D/A converters and to ***perform*** its characteristics..	Cognitive	Remembering
CO4	***Explain*** the construction and operation of recording Instruments. **Carryout** calibration test for measuring instruments.	Cognitive	Understanding
CO5	***Explain*** the different types of transducers.	Cognitive	Remembering

SUB.CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 604			**Measurements and Instrumentation**	**3**	**1**	**1**	**5**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**1**	**0**		**3**	**2**	**2**	**7**

UNIT I	**INTRODUCTION**	**09+05 +06**
Functional elements of an instrument - errors in measurement - static and dynamic characteristics statistical evaluation of measurement data - standard and calibration		
UNIT 2	**ELECTRICAL AND ELECTRONIC INSTRUMENTS**	**09+05**
DC Ammeter – Multirange ammeter – Extension of ammeter range – RF ammeter – Voltmeter – Analog Electromechanical instruments-Galvanometer- multirange voltmeter – Extending Voltmeter range – Transistor voltmeter – Dual slope integrating type DVM — instrument transformer –Magnetic measurement- instruments for measurement of frequency and phase.		
UNIT 3	**SIGNAL CONDITIONING CIRCUITS**	**09+05 +18**
Bridge circuits – Wheatstone's bridge – Maxwell's Bridge - Wien's bridge, Resonance Bridge – Hay's Bridge – Schering Bridge –De saulty bridge- differential ampflier – instrumentation amplifier – filter circuits, data acquisition system –Spectrum analyzer-Wagner's Earth (Ground) connection- Earthing techniques.		
UNIT 4	**STORAGE AND DISPLAY DEVICES**	**09+05 +06**
CRO – introduction – Block diagrams of Oscilloscope – simple CRO – circuit displays – storage oscilloscope – digital CRO – X-Y recorder – magnetic recorder – strip chart recorder – printers – LED, LCD and Dot matrix displays – Data logger-Virtual Instruments		

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UNIT 5	TRANSDUCERS	09+05

Classification of transducers – selection of transducers – resistive, capacitive and inductive transducers – piezo electric transducers – optical and digital transducers. pH electrodes – Load cell-transducers for measurement of displacement, temperature, level, flow, pressure, velocity, acceleration, torque, speed, Smart Sensors.

1. Study of Voltmeter , Ammeter and Wattmeter Range Extension.
2. Characteristics of Thermal Transducers (Thermocouples).
3. Measurement of Pressure using LVDT.
4. AC Bridges:
   a) Maxwell Inductance Bridge
   b) Anderson Bridge
5. Wheatstone bridge.
6. Instrumentation Amplifiers.
7. A/D and D/A converters.
8. Calibration of Single phase and Three phase Energy meter.
9. Calibration of Current Transformer and potential transformer.
10. Measurement of Three phase power and power factor by two watt meter method.

Lecture = 45; Tutorial = 30;Practical = 30; Total = 105 Hours

TEXT BOOKS

1. Sawhney A.K ‘A Course in Electrical & Electronic Measurements and Instrumentation’ Dhanpat Rai and Sons,2007.
2. Doebeling, E.O., 'Measurement Systems – Application and Design', McGraw Hill Publishing Company.
3. H.S. Kalsi, ‘Electronic Instrumentation’, Tata Mc Graw Hill Co., 1995.
4. B Gupta, ’A course in Electronic and Electrical Measurement’, S.K.Kataria & sons,Delhi-2003

REFERENCES BOOKS

1. Golding E.W and Wills F.E ‘Measurements and Measuring Instruments’ Sir Isaac Pitman and Sons(P) Ltd, 1997.
2. Moorthy, D.V.S., 'Transducers and Instrumentation', Prentice Hall of India Pvt. Ltd., 1995
3. Dalley, J.W., Riley, W.F. and Meconnel, K.G., 'Instrumentation for Engineering Measurement', John Wiley & Sons, 1993

E REFERENCES

1. NPTEL, Measurements and Instruments, Prof.T.Anjaneyulu, Department of EEE, Indian Institute of Technology, Delhi.

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COs versus POs mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	1			1		1	1			3			2	3
CO 2	1	1										1	2	3
CO 3	1		1		1			2		1			2	2
CO 4	1	2										1	2	2
CO 5									1		1	1	2	3
Total	4	3	1	1	1	1	1	2	1	4	1	3	10	13
Scaling	1	3	1	1	1	1	1	1	1	1	1	1	2	3

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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PEE 701 ELECTRIC VEHICLES AND POWER MANAGEMENT

Course Outcomes (PEE 701)		**Domain**	**Level**
CO1	**Specify** the key components of a vehicle propulsion system and their functions	Cognitive	Understanding
CO2	**Select** appropriate hybrid electric power-train architecture **Determine** appropriate type and size of hybrid electric power-train components and ESS	Cognitive	Understanding
CO3	**Identify** fundamental aspects of reactive power and its effect on system voltage and **Select** the suitable voltage control method for the system operating condition.	Cognitive	Understanding
CO4	**Discuss** battery and energy storage system	Cognitive	Understanding
CO5	**Identify** Alternative Energy Storage Systems	Cognitive	Understanding

SUB. CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 701			**Electric Vehicles and Power Management**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**0**	**0**	**3**
UNIT I			**ELECTRIC VEHICLES AND VEHICLE MECHANICS**			**09**	
Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics							
UNIT II			**ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS**			**09**	
Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes							
UNIT III			**CONTROL OF DC AND AC DRIVES**			**09**	
DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives							

UNIT IV	**BATTERY ENERGY STORAGE SYSTEM**	**09**
Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries		
UNIT V	**ALTERNATIVE ENERGY STORAGE SYSTEMS**	**09**
Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors		
Lecture = 45; Tutorial = 0; Lab = 0; Total =45 Hours		

TEXT BOOKS

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid
3. Chris Mi, M. Abul Masrur and David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley and Sons, 2011

REFERENCE BOOKS:

1. Ali Emadi, Mehrdad Ehsani, John M.Miller Vehicular Electric Power Systems, Marcel dekker, 2004
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. L. E. Carmichael, Hybrid and Electric Vehicles, ABDO Publishing Company, 2013

E-REFERENCES:

1. NPTEL : https://nptel.ac.in/downloads/108103009/

COs versus PO, PSO mapping

CO/ PO/PSO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	1	1	2	-	-	-	-	1	-	-	**2**	**1**
CO2	2	3	2	2	2	-	-	-	1	1	1	-	**2**	**-**
CO3	2	2	2	2	3	-	-	-	-	-	1	1	**2**	**-**
CO4	2	2	3	3	2	-	-	-	-	1	-	-	**1**	**-**
CO5	1	2	2	2	2	-	-	-	-	-	-	1	**1**	**1**

Total	**10**	**12**	**10**	**10**	**11**	**0**	**0**	**0**	**1**	**3**	**2**	**2**	**8**	**2**
Scaling	**2**	**3**	**2**	**1**	**3**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**2**	**1**

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PEE 702 POWER SYSTEM OPERATION AND CONTROL

Course Outcomes (PEE 702)		**Domain**	**Level**
CO1	**Explain** power system load characteristics and generation reserve requirements.	Cognitive	Understanding
CO2	**Demonstrate** and **Apply** the mathematical knowledge to model and analysis of power system for frequency control.	Cognitive Cognitive	Understanding Applying
CO3	**Identify** fundamental aspects of reactive power and its effect on system voltage and **Select** the suitable voltage control method for the system operating condition.	Cognitive	Applying
CO4	**Formulate** economic dispatch and unit commitment problem and its solution.	Cognitive	Creating
CO5	**Apply** computer control methods for power system operation and control	Cognitive	Applying

SUB CODE			**SUB NAME**	**L**	**T**	**P**	**C**
PEE 702			**Power System Operation and Control**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**0**	**0**	**3**
Unit- 1			**INTRODUCTION**				**09**
An overview of power system operation and control - system load variation - load characteristics - load curves and load-duration curve - load factor - diversity factor - Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves - Importance of load forecasting - quadratic and exponential curve fitting techniques for forecasting – plant level and system level controls.							
Unit- 2			**REAL POWER - FREQUENCY CONTROL**				**09**
Basics of speed governing mechanism and modeling - speed-load characteristics – load sharingbetween two synchronous machines in parallel - concept of control area - LFC control of a single-area system: static and dynamic analysis of uncontrolled and controlled cases - two-areasystem: modeling - static analysis of uncontrolled case - tie line with frequency bias control - state variable model							
Unit- 3			**REACTIVE POWER–VOLTAGE CONTROL**				**09**
Generation and absorption of reactive power - basics of reactive power control - excitation systems – modeling - static and dynamic analysis - stability compensation - methods of voltage control: tap-changing transformer, injection reactive power - SVC (TCR + TSC) and STATCOM – secondary voltage control.							

Unit- 4	**UNIT COMMITMENT AND ECONOMIC DISPATCH**	**09**
Formulation of economic dispatch problem – I/O cost characterization – incremental cost curve - coordination equations without and with loss (No derivation of loss coefficients) - solution by direct method and λ-iteration method - statement of unit commitment problem – priority-listmethod - forward dynamic programming.		
Unit- 5	**COMPUTER CONTROL OF POWER SYSTEMS**	**09**
Need for computer control of power systems - concept of energy control centre – functions - system monitoring - data acquisition and control - system hardware configuration – SCADA and EMS functions - network topology - state estimation – WLSE - Contingency Analysis - state transition diagram showing various state transitions and control strategies.		
Lecture = 45; Tutorial = 0; Lab = 00; Total =45 Hours		

TEXT BOOKS:

1. Olle.I.Elgerd, 'Electric Energy Systems theory - An introduction', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 34th reprint, 2010.
2. Allen. J. Wood and Bruce F. Wollenberg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 2003.
3. Kundur P., 'Power System Stability and Control, Tata McGraw Hill, New Delhi, 5th reprint, 2008.

REFERENCE BOOKS:

1. Nagrath I.J. and Kothari D.P., 'Modern Power System Analysis', Tata McGraw-Hill, Fourth Edition,2011.
2. Hadi Saadat, 'Power System Analysis', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.
3. Abhijit Chakrabarti, Sunita Halder, 'Power System Analysis Operation and Control', PHI learning Pvt. Ltd., New Delhi, Third Edition, 2010.

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COs versus PO, PSO mapping

CO/ PO/PSO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	1	1	2	-	-	-	-	1	-	-	**2**	**1**
CO2	2	3	2	2	2	-	-	-	1	1	1	-	**2**	**-**
CO3	2	2	2	2	3	-	-	-	-	-	1	1	**2**	**-**
CO4	2	2	3	3	2	-	-	-	-	1	-	-	**1**	**-**
CO5	1	2	2	2	2	-	-	-	-	-	-	1	**1**	**1**
Total	**10**	**12**	**10**	**10**	**11**	**0**	**0**	**0**	**1**	**3**	**2**	**2**	**8**	**2**
Scaling	**2**	**3**	**2**	**1**	**3**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**2**	**1**

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E 11 DESIGN OF ELECTRICAL APPARATUS

Course Outcomes (E 11)		Domain	Level
CO1	Able to ***define*** and ***recall*** the different fundamental concepts of electrical and magnetic circuit parameters, Laws, MMF calculations, and their applications.	Cognitive	Remembering Remembering
CO2	**Compare** the main dimensions of different machines, and **relate** its impact on the **design** of various parts of AC and DC machines.	Cognitive	Understanding Understanding Creating
CO3	Categorize different types of Transformer based on its design. **Understand** about single phase and three phase transformer parameters and its efficiency calculation.	Cognitive	Understanding
CO4	**Classify** types of three phase Induction motor. **Analyze** the design procedure of each part of the motor.	Cognitive	Understanding Analyzing
CO5	**Classify** types of three phase Synchronous motor. **Analyze** the design procedure of each part of the motor	Cognitive	Understanding Analyzing

SUB CODE			SUB NAME	L	T	P	C
E 11			Design of Electrical Apparatus	3	0	0	3
C	P	A		L	T	P	H
3	0	0		3	0	0	3

UNIT I	**BASIC CONSIDERATIONS IN MACHINES DESIGN**	**06**
Concept of magnetic circuit – MMF calculation for various types of electrical machines – real and apparent flux density of rotating machines – magnetic leakage.		
UNIT II	**D.C. MACHINES**	**06**
Constructional details – output equation – main dimensions - choice of specific loadings – choice of number of poles – armature design – design of field poles and field coil – design of commutator and brushes.		
UNITIII	**TRANSFORMERS**	**06**
Constructional details of core and shell type transformers – output rating of single phase and three phase transformers – optimum design of transformers – design of core, yoke and windings for core and shell type transformers.		
UNIT IV	**THREE PHASE INDUCTION MOTOR**	**06**
Constructional details of squirrel cage and slip ring motors – output equation – main dimensions – choice of specific loadings – design of stator – design of squirrel cage and slip ring rotor.		

UNIT V	**SYNCHRONOUS MACHINES**	**06**

Constructional details of cylindrical pole and salient pole alternators – output equation – choice of specific loadings – main dimensions – short circuit ratio – design of stator and rotor of cylindrical pole and salient pole machines - design of field coil.

Lecture = 45; Tutorial = 00; Total = 45 Hours

TEXT BOOKS:

1. A.K. Sawhney, 'A Course in Electrical Machine Design', DhanpatRai and Sons, New Delhi, 1984.
2. S.K. Sen, 'Principles of Electrical Machine Design with Computer Programmes', Oxford and International Book House Publishing Company Pvt Ltd., New Delhi, 1987.
3. G Warren, "Problems in Electrical Engineering", Parker and Smith Solutions, Newyork, 1940.
4. J. G. Jamnani, "Elements of electrical design' 2nd Edition, Mahajan publishing house.

REFERENCE BOOKS:

1. R.K. Agarwal, 'Principles of Electrical Machine Design', S.K.Kataria and Sons, Delhi, 2002.
2. V.N. Mittle and A. Mittle, 'Design of Electrical Machines', Standard Publications and Distributors, Delhi, 2002.
3. T. Stolarski, Y. Nakasone and S. Yoshimoto, "Engineering analysis with ANSYS software", Butterworth – Heinemann Publisher, 2006.
4. K.G.Upadhyay, "Design of Electrical Machines", New age international publishers.

E REFERENCES :

1. Web Content - http://www.library.dce.edu/e-resources/books/ee/
2. Web Course - http://elearning.vtu.ac.in/

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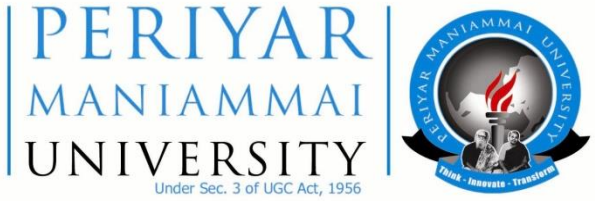

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COs versus PO, PSO mapping

CO/ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	-	-	2	1	1	2	-	-	1	-	-	**1**	**1**
CO2	3	3	-	3	3	3	-	3	-	1	3	-	**1**	**1**
CO3	2	-	-	-	2	2	2	3	-	-	-	-	**2**	**2**
CO4	-	1	3	-	-	1	-	-	1	-	-	-	**2**	**2**
CO5	-	-	1	-	3	-	-	2	-	-	-	-	**1**	**2**
Total	**7**	**4**	**4**	**5**	**9**	**7**	**4**	**8**	**1**	**2**	**3**	**0**	**7**	**8**
Scaling	**2**	**1**	**1**	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**0**	**2**	**2**

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CONTROL AND MAINTENANCE OF ELECTRICAL MACHINES

Course Outcomes(E12):		**Domain**	**Level**
CO1	***Recall***the functions and concepts of electrical maintenance department.***Name***the tools required.	Cognitive	Remembering
CO2	***List*** the various types of losses and ***compare*** with heatproduced and its dissipationin the rotating machine.	Cognitive	Remembering Understanding
CO3	***Name***the various types of lubrication and lubricators and ***choose***the correct lubrication for various operations of rotating machines.	Cognitive	Remembering Remembering
CO4	***Select*** the motor for particular application and ***demonstrate*** thedifferent types of installation and trouble shootings.	Cognitive	Applying Understanding
CO5	***Recall*** the methods andprocedure for domestic installation.***Compare*** the faults and ensure the precautionsto avoid mishaps.	Cognitive	Remembering Understanding

SUB CODE	**SUB NAME**	**3**	**0**	**0**	**3**
E12	**CONTROL AND MAINTENANCE OF ELECTRICAL MACHINES**	**L**	**T**	**P**	**H**
C:P:A		**3**	**0**	**0**	**3**
2:0:0					

UNIT- I	**PRINCIPLES AND PLANNING OF MAINTENANCE**	**6**
Introduction, Essentials of preventive maintenance programme, Functions of electrical maintenance department. Tools required, loading and unloading of electrical machinery		
UNIT- II	**HEATING AND COOLING OF ELECTRICAL MACHINES**	**6**
Introduction, , Energy losses in electrical conductors, Energy losses in magnetic conductors, Energy losses in insulating materials, Efficiency in electrical machines, Modes of heat dissipation, Radiation, Convection, Conduction, Causes of overheating, Ventilation of electrical machines, transformer cooling, Cooling of, Synchronous machines		
UNIT-III	**LUBRICATION**	**6**
Introduction, Purpose of lubrication, Classification of lubricants, liquid lubricants, Semi-liquid lubricants, Solid lubricants. Characteristics of lubricants, Viscosity, Viscosity index, Oiliness, Specific gravity-flash point, fire point, freezing point or pour point, Volatility. Methods of lubrication Ring oiling, Needle lubricator, Wick lubrication.		
UNIT-IV	**MOTORS**	**6**
Selection of motors, Storage pre installation check, Installation, Alignment, Connecting and starting, Pre commissioning checks, Drying out, Commissioning, Overhauling of motors, Preventive maintenance, Trouble shooting in electric motors, Maintenance schedule of synchronous machine		

UNIT-V	**DOMESTIC INSTALLATIONS**	**6**
Introduction, Testing the electrical installation of a building-testing of insulation resistance to earth, testing of insulation resistance between conductors, Continuity or open circuit test, Short circuit test, Testing of earth continuity path, polarity test, Localization of fault, IE Rules for domestic installations. Electric Fire, Precautions to avoid fire,		
Lecture = 45; Tutorial = 00; Lab = 00; Total = 45 Hours		
TEXT BOOKS:		
1.	SK Bhattacharya,"Electrical Machines", Tata Mc Graw Hill, New Delhi, 1998.	
2.	Kenneth B. Rexford, "Electrical Control for Machnines", Delmar cengage leaning, November 22, 1996.	
3.	Frank D. Petruzella, "Electric Motors Control systems", McGraw Hill Education, May 2009.	
REFERENCE BOOKS:		
1.	Nagrath and Kothari,"Electrical Machines", Tata McGraw Hill, New Delhi, 2010	
2.	Diane Lobsiger, Peter Giuliani & Kenneth Rexford, "Electrical Control for Machines", 7th edition, Delmar Cengage Learning, January 2015.	
3.	JB Gupta, "Electrical and Electronics Engineering", S.K. Kataria&Sons, New Delhi, 2009.	
4.	Philip Kiameh "Electrical Equipment Handbook: Troubleshooting and Maintenance" McGraw Hill Inc., New Delhi, 2003, ISBN: 9780071396035	
E-REFERENCES:		
1.	https://accessengineeringlibrary.com/browse/electrical-equipment-handbook-troubleshooting-and-maintenance	

Table 1: COs versus POs mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	-	1	-	-	-	1	-	-	1	-	1
CO2	3	1	-	1	1	-	-	-	-	-	-	1	-	1
CO3	3	1	-	1	1	-	-	-	1	-	-	1	-	1
CO4	3	1	2	1	1	-	-	-	1	-	-	1	-	1
CO5	3	1	-	-	1	-	-	-	-	-	-	1	-	1
Total	15	5	4	3	5				3			5		5
Scaling	3	1	1	1	1				1			1		1

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E13 ADVANCED CONTROL SYSTEM ENGINEERING

Course Outcomes (E13)		**Domain**	**Level**
CO1	**Discuss** to represent State space model and **Describes** Controllability & Observability of the systems.	Cognitive	Remembering
CO2	**Design** the Non linear systems approach to system stability using Liapunov's and Popov's stability criteria	Cognitive	Creating
CO3	**Distinguish** the time-optimal control problem and infinite time regulator problem.	Cognitive	Analyzing
CO4	**Choose** appropriate dynamics for data extrapolation by using Z- Transfrom	Cognitive	Perception
CO5	**Describe** the applications of non linear systems and their real-time implementation challenges	Cognitive	Remembering

SUB.CODE			**SUB NAME**	**L**	**T**	**P**	**C**
E 13			**Advanced Control System Engineering**	3	0	0	3
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		3	0	0	3

UNIT I	**STATE VARIABLE ANALYSIS AND DESIGN**	**09**
State models – solution of state equations- controllability and observability – pole assignment by state feedback – full and reduced order observers. Mathematical model of Electrical and mechanical system.		
UNIT II	**NONLINEAR SYSTEMS**	**09**
Common types of non-linear phenomena – construction of phase trajectories – system analysis by phase plane method – describing function method – describing function of nonlinear elements – stability analysis by describing function method – Liapunov's and Popov's stability criteria.		
UNIT III	**OPTIMAL CONTROL**	**09**
Problem formulation – necessary conditions of optimality – state regulator problem – Matrix Riccati equation – infinite time regulator problem – output regulator and tracking problems – time-optimal control problem.		
UNIT IV	**DIGITAL CONTROL SYSTEM**	**09**
haracteristics of sampling - Data extrapolation – Review of Z transform theory - characteristic response of a sample and ZOH combination – stability analysis by mathematical tests and root locus diagrams – design using Root loci. Frequency response of DT system.		

UNIT V	ALGORITHM AND STRATEGY FOR COMPUTER CONTROL	09

Scaling data - linearization of input data - arithmetical operations and functions - integration - control law algorithm - PID control law - self-tuning strategy.

Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours

TEXT BOOKS

1. M. Goal, 'Digital Control and State Variable Methods', Tata McGraw-Hill, 1997.
2. Chessman, Wilson and Leila, 'Advanced Control System Technology', Viva-low priced edition, 1998.
3. Benjamin C. Kuo, "Digital Control Systems". Oxford University Press, 1992.
4. S. Majhi,Advanced Control Theory-Relay Feedback Approach, Cengage Asia/India Pvt.Ltd, 2009.

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1. R.C.Dorf and R.H.Bishop, 'Modern Control Systems', Addison-Wesley, 1995. (MATLAB Reference)
2. Nagrath, I.J. and Gopal, M., 'Control System Engineering', Wiley Eastern, Reprint 1995
3. K. Ogata, "Modern Control Engineering" 2nd Edition, Prentice Hall India, New Delhi, 1992.
4. A. Johnson and H. Moradi, New Identifications and Design Methods, Springer -Verlag, 2005.

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1. NTPEL, Advanced Control Systems by Prof. Somanath Majhi, Department of Electronics & Electrical Engineering, IIT Guwahati.

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Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	-	-	-	1	-	-	-	-	
CO2	2	1	2	2	-	-	-	-	-	1	-	2	-	-
CO3	1	3	-	3	1	-	2	3	-	1	1	-	2	1
CO4	2	2	-	1	1	1	-	-	2	2	-	1	1	-
CO5	2	1	1	1	-	-	-	-	-	-	2	-	1	1
Total	9	8	3	7	2	1	2	3	3	4	3	3	4	2
Scaling	2	2	1	2	1	1	1	1	1	1	1	1	1	1

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E14 DIGITAL LOGIC CIRCUITS

Course Outcomes (E14)		**Domain**	**Level**
CO1	***Name*** numerical values in various number systems and ***show*** number conversions between different number systems.	Cognitive Psycomotor	Remembering Set
CO2	**Explain** Boolean functions and minimization techniques using k –maps and postulates and theorems of Boolean Algebra, minimization of Boolean functions using basic laws.	Cognitive	Understanding
CO3	***Explain*** logic gates and their applications and ***construc***t and ***verify*** the logic gates and construct simple adders and sub tractors using logic gates. Able to ***design*** digital combinational circuits.	Cognitive Psycomotor Cognitive	Understanding Set Creating
CO4	***Explain*** sequential digital circuits like flip-flops, registers, counters and ***verify*** the state tables of flip-flops using NAND and NOR gates.	Cognitive Psycomotor	Understanding Set
CO5	***Explain*** the synchronous sequential circuits and programmable logic devices.	Cognitive	Understanding

SUB CODE			**SUB NAME**	**L**	**T**	**P**	**C**
E14			**Digital Logic Circuits**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**0**	**0**	**3**

UNIT I	**NUMBER SYSTEM AND CODES**	**10**
Number systems- base-2, 8, 10, 16 – Radix conversion – Alphanumeric codes – various codes – error detection and correction.		
UNIT II	**BOOLEAN ALGEBRA AND MINIMIZATION TECHNIQUES**	**08**
Basic Boolean functions – AND, OR NOT operations – postulates and theorems of Boolean Algebra – De-Morgan's laws – minimization of Boolean functions using basic laws – sum of product and product of sum forms – Minterms and Maxterms – K- map of switching functions – minimization using K-map method and Quine –Mc Clusky method.		
UNIT III	**LOGIC CIRCUITS LOGIC FAMILIES AND COMBINATIONAL**	**09**
Digital Logic Families – introduction to RTL, DTL, TTL, ECL and MOS families and their characteristics – internal circuits of basic gates AND, OR, NOT and XOR using Bipolar, MOS and CMOS families – Combinational logic and representation of logic functions – simplification and implementation of combinational logic circuits - multiplexer and demultiplexer – encoder and decoder –adder– subtractor and magnitude comparators.		

UNIT IV	**SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**09**
Sequential Logic - Flipflops SR, JK, D and T flip-flops – Analysis of synchronous sequential circuits – Memories. Counters — state diagram – state reduction and Assignment – Morre and Mealy model.		
UNIT V	**AS SYNCHRONOUS SEQUENTIAL CIRCUITS AND PROGRAMMABLE LOGIC DEVICES**	**09**
As synchronous sequential logic circuits-transition table, flow table-race condition, hazard and error in digital circuits, analysis of As synchronous sequential logic circuits- Introduction to programmable logic devices, PROM-PLA-PAL. Application of gates by SAMA standards.		
Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours		

TEXT BOOKS:

1. Malvino and Leach, ‘Digital Principles and Applications', McGraw Hill, 2001.
2. Moris Mano, ‘Digital Design’, Prentice Hall of India, 2000.
3. Rajakamal,“Digital system-Principle & Design”,Pearson education 2nd edition 2007
4. Comer “ Digital Logic & State Machine Design” , Oxford 2012.

REFERENCE BOOKS:

1. Taub and Schilling, 'Digital Integrated Circuits', McGraw Hill, 2002.
2. Millman, J. andHalkias, C.C., 'Integrated Electronics: Analog and Digital Circuits and Systems', McGraw Hill, Kogakusha Ltd., Tokyo, 2001.
3. Samuel C. Lee “Digital Circuits and Logic Designs” Prentice Hall of India; 2000
4. Fletcher, W.I., 'An Engineering Approach to Digital Design', Prentice Hall of India, 2002.
5. Anand kumar, Fundamental of Digital circuits, PHI 2003.

E-REFERENCES:

1. NPTEL, Digital Logic Circuits, Prof. S.Srinivasan, IIT Madras.
2. NPTEL, Digital Logic Circuits, Prof. D. Roychoudhury, IIT Kharagpur

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COs versus POs mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	2	1	3	-	-	1	1	1	-	1	-	2	2	1
CO 2	3	2	1	-	-	2	0	2	1	-	-	2	1	2
CO 3	2	2	1	-	-	1	2	2	1	1	-	1	2	2
CO 4	2	3	3	-	-	1	1	1	-	-	1	1	1	2
CO 5	3	2	2	-	-	0	1	1	1	1	1	2	2	2
Total	12	10	10	-	-	5	5	7	3	3	2	8	8	9
Scale value	3	2	2	0	0	1	1	2	1	1	1	2	2	2

0 – No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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E16 INDUSTRIAL AUTOMATION

Course Outcomes (E16)		Domain	Level
CO1	Able to ***define*** and **Explain** the fundamentals of Pneumatics, hydraulics and electrical drives. ***List*** out the advantages, disadvantages and its application	Cognitive	Remembering Understanding
CO2	**Apply** the knowledge of electrical ladder diagrams for hydraulic and pneumatic system and able to ***define*** pressure, proximity switches and intelligent Relays.	Cognitive	Applying Remembering
CO3	**Explain** and **Categorize** different types of Sensors and their application.***List*** out timer,counter and their application.	Cognitive	Understanding Analyzing Remembering
CO4	**Illustrat**e the knowledge in the PLC logic, Architecture and **design** the industrial automated system for specific applications and **Apply** the knowledge of PLC programming to interface pneumatics.	Cognitive	Understanding Creating Applying
CO5	**Outline** the overview of robotics and their application. **Apply** the knowledge of robotics programming	Cognitive	Understanding Applying

SUB.CODE			SUB NAME	L	T	P	C
E16			Industrial Automation	3	0	0	3
C	P	A		L	T	P	H
2	0	0		3	0	0	3

UNIT I	INTRODUCTION TO PNEUMATICS AUTOMATION	09
Introduction to Pneumatics- Overall structure- Electro pneumatic –hydraulics- Overall –structure – **Advantages and disadvantages – Application**-Electrical drives.		
UNIT II	**APPLICATIONS OF RELAYS**	**09**
Essential qualities of relays- NO & NC contacts- **Electrical signal storage – Electrical Ladder diagram-Pneumatic system- Hydraulic system**-pressure and proximity switches- Intelligent Relays.		
UNIT III	**SMART SENSORS AND TIMERS IN CONTROLLERS**	**09**
Introduction to sensors- characteristics- types of sensors-resistive - inductive-capacitive- magnetic-ultrasonic - photoelectric- nano sensors- timers-counters-types-applications.		
UNIT IV	**PROGRAMMABLE LOGIC CONTROLLERS**	**09**
Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – PLC interface to pneumatics.		
UNIT V	**ROBOTICS**	**09**
Introduction and overviews of Robotics – Terms and Definition, Historical development of robotics, classification and configuration of robots, Basic components - Drives, controller gripper, application-programming in Robotics.		
Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours		

TEXT BOOKS

1. James Dally, W., "Instrumentation for Engineering Measurements", John Wiley & sons
2. Patranabis, D., "Sensors and Transducers", Wheeler Publishing, 2000.
3. Harry Colestock, Industrial Robotics, McGraw Hill Book Co., New Delhi, 2005.
4. Harry Colestock, Industrial Robotics, McGraw Hill Book Co., New Delhi, 2005.

REFERENCE BOOKS

1. Anthony Esposito, Fluid Power with Applications, Pearson Education, 5th Edition, New Delhi, 2000.
2. Stuart A. Boyer., SCADA: Supervisory Control and Data Acquisition, 3rd Edition, The instrumentation systems and Automation Society, 2009.
3. Micro-sensors;principles and applications-J.W.Gardner.
4. Semiconductor sensors and its application-S.M.Sze.

E REFERENCES

1. NPTEL- Industrial automation, Prof. S. Mukhopadhyay - IIT Kharagpur.
2. Web Course - http://elearning.vtu.ac.in/

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COs versus PO, PSO mapping

CO/ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	2	1	1	1	-	-	1	1	-	**2**	**1**
CO2	3	2	-	-	1	1	-	1	-	1	3	2	**2**	**1**
CO3	2	3	-	-	1	1	1	-	-	-	-	1	**2**	**1**
CO4	2	1	3	-	-	1	-	1	1	-	-	1	**-**	**2**
CO5	2	2		-	1	-	-	2	-	-	-	1	**-**	**2**
Total	**12**	**10**	**3**	**2**	**4**	**4**	**2**	**4**	**1**	**2**	**4**	**5**	**6**	**7**
Scaling	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**2**	**2**

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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BIO MEDICAL INSTRUMENTATION

Course Outcomes(E17):		**Domain**	**Level**
CO1	***Identify*** the origin of bio-potentials and various bioelectric signals that are recorded routinely in modern clinical practice .	Cognitive	Applying
CO2	***Explain*** the various techniques of measuring blood flow, pressure & volume.	Cognitive	Understanding
CO3	***Describe*** and apply the safety issues, safe design, and safe use of medical instrumentation, specifically electrical safety.	Cognitive	Remembering
CO4	***Choose*** the appropriate amplifier and fileters for medical instrumentation.	Cognitive	Applying
CO5	***Describe*** the parameters constraining the resolution of CT, MRI & Ultrasound image.	Cognitive	Remembering

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
E17	**BIO MEDICAL INSTRUMENTATION**	3	0	0	3
C:P:A		**L**	**T**	**P**	**H**
3:0:0		3	0	0	3

UNIT-I	**HUMAN SYSTEM AND BIO POTENTIAL ELECTRODES**	**9**
Different types of human system, origin of bio-potential and its propagation. Electrode-electrolyte interface, electrode-skin interface, half cell potential, Types of electrode, PH electrode, Recording problems, measurement with two electrodes - human cell structure.		
UNIT-II	**ELECTRODE CONFIGURATION**	**9**
Bio signals characteristics – frequency & amplitude ranges. ECG – Enthoven's triangle, standard 12 load system, PQPs waveform. EEG – 10-20 electrode system, brain waves, recording setup of EEG, EMG, ERG, and EOG – unipolar and bipolar mode.		
UNIT-III	**BIO AMPLIFIER AND TRANSDUCER**	**9**
Need for Bio –amplifier, power amplifier, isolation amplifier, feedback amplifier. Resistive, Inductive, Capacitive transducer and application, Fibre optic, photoelectric transducer – description, features applicable for biomedical instrumentation		
UNIT-IV	**CARDIAC MEASUREMENTS**	**9**
Blood pressure measurement – blood flow measurement – phonocardiography – vector cardiography. Heart lung machine –ventilator – Anesthetic machine – cardiac pacemaker - defibrillator patient safety - electrical shock hazards.		

UNIT-V	**MEDICAL DIAGNOSTICS INSTRUMENTS AND SYSTEMS**	**9**
CT scanner – MRI Scan and Ultrasonic scanner –X Ray – Laser Equipment and application- bio-telemetry Kidney dialysis machine – electron microscope – blood cell counter- Endoscopy		
Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours		

TEXT BOOKS:

1.	Khandpur, R.S., 'Handbook of Biomedical Instrumentation', Tata McGraw Hill, 2007.
2.	ArumugamM.,'Bio Medical Instrumentation', Anuradha agencies Pub., 2012.
3.	C.Rajarao and S.K. Guha, 'Principles of Medical Electronics and Bio-medical Instrumentation', Universities press (India) Ltd, Orient Longman ltd, 2008.
4.	J. Webster, 'Medical Instrumentation', John Wiley & Sons, 2003.

REFERENCE BOOKS:

1.	Geddes L.A., and Baker, L.E., 'Principles of Applied Bio-medical Instrumentation', 3rd Edition, John Wiley and Sons, 2011.
2.	Cromwell, Weibell and Pfeiffer, 'Biomedical Instrumentation and Measurements', 2nd Edition, Prentice Hall of India, 2014.
3.	Tompkins W.J., Biomedical Digital Signal Processing, Prentice Hall of India, 2008.
4.	J. Wilson, J.F.B. Hawkes, 'Laser Principles and Applications',.(Prentice-Hall, New York), (2006)

E-REFERENCES:

1.	http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Bio medical instrumentation

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO 1	2			2	1							2	1	1
CO 2	3	2	2	2	2							1	1	1
CO 3	2		2			2						1	1	1
CO 4	2	2		2		2						1	1	2
CO 5	2	2				2						1	1	2
Total	11	6	4	6	3	6	0	0	0	0	0	6	5	7
Scaled to 0,1,2,3 scale	3	2	1	2	1	2	0	0	0	0	0	2	1	1

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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E18 SMART GRIDS

Course Outcomes (E18)		Domain	Level
CO1	***Explain*** the paradigm shift between traditional power transmission and distribution and smart power grids verbally and in writing.	Cognitive	understanding
CO2	***List*** and ***illustrate*** drivers, challenges and benefits to the integration of renewable and distributed generation into large power grids.	Cognitive	Remembering Understanding
CO3	Describe and ***assess*** smart grid technologies that enhance transmission and distribution systems.	Cognitive	Evaluating
CO4	***Appraise*** current implementations of smart grid technologies and/or policies using regional data sources.	Cognitive	Evaluating
CO5	***Take part in*** project teams using appropriate communication skills in order to present information about smart grid industry practices and community engagement.	Cognitive	Analyzing

SUB.CODE			SUB NAME	L	T	P	C
EE 18			Smart Grids	3	0	0	3
C	P	A		L	T	P	H
3	0	0		3	0	0	3

UNIT I	INTRODUCTION TO SMART GRID	09

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives

UNIT II	SMART GRID TECHNOLOGIES	09

Smart energy resources,Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control,Fault Detection, Isolation and service restoration, Outage management,High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV)..

UNIT III	SMART METERS AND ADVANCED METERING INFRASTRUCTURE	09

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

UNIT IV	POWER QUALITY MANAGEMENT IN SMART GRID	09

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT V	HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS	09

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

Lecture = 45; Tutorial = 0; Total = 45 Hours

TEXT BOOKS

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
2. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”,CRC Press 2012.
3. Yang Xiao, Communication and Networking in Smart Grids, CRC press, 2012

REFERENCE BOOKS

1. NouredineHadjsaïd and Jean-Claude SabonnadièreSmart, SmartGrids, ISTE Ltd. 2012.
2. Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
3. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey” , IEEE Transaction on Smart Grids.

E REFERENCES

1. https://iit.edu/news/iittoday/?tag=smart-grid
2. https://www.smartgrid.gov/the_smart_grid/

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COs versus PO, PSO mapping

CO/ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	1	1	2	-	2	-	3	-	1	1	-	-	1	1
CO2	-	-	-	1	-	-	-	-	2	1	2	-	1	1
CO3	1	-	-	-	1	-	-	-	-	-	-	-	1	2
CO4	-	-	2	2	-	-	-	-	2	1	2	-	1	1
CO5	-	-	-	-	-	-	3	-	3	2	1	-	1	2
Total	2	1	4	3	3	0	6	0	8	5	5	0	5	7
Scaling	1	1	1	1	1	0	2	0	2	1	1	0	1	2

0 –No relation1 – Low relation2 – Medium relation3 – High Relation

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POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Course Outcomes(E21):		**Domain**	**Level**
CO1	Explain the fundamentals of renewable energy systems and government support on developing new technology for Renewable Energy Systems.	Cognitive	Understanding
CO2	Illustrate the operation of various electrical machines onrenewable energy conversion system.	Cognitive	Understanding
CO3	Categorize the different types of power converters used for renewable energy conversion .	Cognitive	Analyzing
CO4	Construct the Grid connected solar and wind power generation systems.	Cognitive	Applying
CO5	Find the need of hybrid system and Recall the power conversion and storage systems.	Cognitive	Remembering

Sub. Code	**Sub. Name**	**L**	**T**	**P**	**C**
E21		3	0	0	3
C:P:A	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	**L**	**T**	**P**	**H**
3:0:0		3	0	0	3

UNIT- I	**INTRODUCTION TO ENERGY**	**10**
Trends in energy consumption - World energy scenario - Energy source and their availability – Conventional and renewable sources - Need to develop new energy technologies- MNRE Rules and Regulations-TEDA-Wind and solar survey in India and World.		
UNIT-II	**ELECTRICAL MACHINES FOR RENEWABL EENERGY CONVERSION**	**8**
Review of reference theory fundamentals-principle of operation and analysis :Induction Generator (IG),Permanent Magnet Synchronous Generator (PMSG), squirrel cage induction generator (SCIG) and Doubly Fed Induction Generator (DFIG).		
UNIT- III	**POWER CONVERTERS**	**10**
Solar: Block diagram of solar photo voltaic system, line commutated converters (inversion-mode) - Maximum power point tracking – Applications – Water pumping – Street lighting, battery sizing, array sizing. Wind: three phase AC voltage controllers-AC-DC-AC converters, Grid Interactive Inverters-matrix converters.		
UNIT-IV	**ANALYSIS OF WIND AND PV SYSTEMS**	**8**
Standalone operation affixed and variable speed wind energy conversion systems and solar energy conversion system based on PV system -Inter connections with Grid - Power conditioning schemes.		

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UNIT-V	**HYBRID RENEWABLE ENERGY SYSTEMS**	**9**
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV- Power converters for distributed power systems- Storage - Reliability evolution		
Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours		

TEXT BOOKS:	
1.	S. Rao and Parulekar, Energy Technology – Non Conventional, Renewable and Conventional, New Delhi, Khanna Publishers, 1999.
2.	Mukund R. Patel, Wind and Solar Power System, New York, CRC Press LLC, 1999.
3.	Ned Mohan, Tore M. Undeland and William P.Robbins, Power Electronics: Converters, Applications and Design, New Jersey, John Wiley and Sons, 2003.
4.	S.N.Bhadra,D.Kastha,&S.Banerjee "WindElectrical systems",OxfordUniversity Press,2009
REFERENCE BOOKS:	
1.	Rashid.M.H "power electronicsHandbook",Academicpress, 2001.
2.	Rai.G.D,"Nonconventional energysources",Khannapublishes, 1993
3.	Gray,L.Johnson,"Windenergysystem",prenticehall linc, 1995.
E REFERENCES:	
1.	***Lecture*** Series on *Energy Resources & Technology*by Prof. S.Banerjee, Department of Electrical Engineering, IIT Kharagpur
2.	Principles and Performance of Solar Energy Thermal Systems: A Web Course by V.V.Satyamurty Professor of Mechanical Engineering, IIT Kharagpur.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO 1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO 1	2	3	1	0	2	0	1	0	0	0	0	0	3	0
CO 2	3	1	0	0	2	0	1	0	0	0	0	0	1	1
CO 3	1	2	3	0	1	0	0	1	0	0	0	0	3	2
CO 4	0	2	0	0	3	0	1	0	0	0	0	0	2	2
CO 5	3	1	1	0	0	2	1	1	0	0	0	1	2	1
Total	9	9	5	0	8	2	4	2	0	0	0	1	11	6
Scaling	2	2	1	0	2	1	1	1	0	0	0	1	3	2

3–High Relation, 2–Medium Relation, 1–Low Relation, 0–No Relation

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WIND ENERGY CONVERSION SYSTEMS

Course Outcomes(E22):		**Domain**	**Level**
CO1	***Illustrate*** the components, schemes, power obtained and power Coefficient of wind turbine.	Cognitive	Understanding
CO2	***Explain***and***design*** the different methods of wind turbines.	Cognitive	Understanding Creating
CO3	***Classify*** types of fixed speed systems and ***design*** procedure of each part of the fixed speed systems.	Cognitive	Understanding Creating
CO4	***Explain***the variable speed systems and the power – wind speed characteristics of variable speed system.	Cognitive	Understanding
CO5	***Classify*** and ***explain***the different techniques ofgridnected systems.	Cognitive	Understanding Understanding

SUB CODE	**SUB NAME**	**L**	**T**	**P**	**C**
EE 22	**WIND ENERGY CONVERSION SYSTEMS**	**3**	**0**	**0**	**3**
C:P:A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I	**INTRODUCTION**	**9**
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.		
UNIT- II	**WIND TURBINES**	**9**
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.		
UNIT-III	**FIXED SPEED SYSTEMS**	**9**
Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed-Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.		
UNIT-IV	**VARIABLE SPEED SYSTEMS**	**9**
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling-Variable speed variable frequency schemes.		

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UNIT- V	**GRID CONNECTED SYSTEMS**	**9**
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impaction steady-state and dynamic performance of the power system including modellingissue.		

		LECTURE	**TUTORIAL**	**TOTAL**
		45	**0**	**45**

TEXT BOOKS:	
1.	L.L.Freris"WindEnergyconversionSystems",PrenticeHall,2000
2.	S.N.Bhadra, D.Kastha,S.Banerjee, "Wind Electrical Sytems",Oxford University Press,2010.
REFERENCE BOOKS:	
1.	IonBoldea,"Variablespeedgenerators",Taylor &Francisgroup,2006.
2.	E.W.Golding "Thegeneration of Electricity by windpower",Redwoodburn Ltd., Trowbridge,2001.
3.	N.Jenkins,"Wind Energy Technology" JohnWiley&Sons,2001
4.	S.Heir "Grid Integration of WECS",Wiley 2001.
E REFERENCES :	
1.	NPTEL, Wind energy conversion, Prof. Shireesh. B, Kedre, IIT Bombay
2.	NPTEL, Wind energy conversion , Prof. S. Banerjee, IIT Kharagpur

COs versus PO, PSO mapping

CO/ PO/PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	2	-	1	1	-	-	-	-	-	-	-	2	1
CO2	3	2	1	2	2	-	-	-	-	-	-	-	2	1
CO3	2	1	-	1	2	-	-	-	1	-	1	-	1	1
CO4	2	2	1	2	1	-	-	-	-	-	-	-	2	1
CO5	2	2	-	1	2	-	-	-	-	-	-	-	1	2
Total	11	09	02	7	8	0	0	0	01	0	01	0	09	06
Scaling	3	2	1	2	2	0	0	0	1	0	1	0	2	2

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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POLLUTION PERFORMANCE ANALYSIS OF ELECTRICAL SYSTEMS

Course Outcomes(E23):		**Domain**	**Level**
CO1	***Explain*** the different pollution testing mechanism and causes for insulators failures.	Cognitive	Understanding
CO2	***Explain*** the performance of insulator, surge diverter and indoor ***Explain*** the performance of insulator, surge diverter and indoor.	Cognitive	Understanding
CO3	***Show*** the effect of pollution and the protective characteristics of gap and gapless arresters.	Cognitive	Remembering
CO4	***Outline*** protective characteristics of gap and gapless arresters. ***Develop*** the modeling of surge diverter.	Cognitive	Understanding Applying
CO5	***Show*** the pollution performance of the indoor switchgear, organic insulator.	Cognitive	Understanding

SUBCODE	**SUB NAME**	**L**	**T**	**P**	**C**
E23	**Pollution performance analysis of Electrical Systems**	3	0	0	3
C:P:A		**L**	**T**	**P**	**H**
3:0:0		3	0	0	3

UNIT- I	**INTRODUCTION**	**09**
Fundamental process of pollution flashover– Causes of failure in insulators-development and effect of contamination layer – creepage distance–pollution conductivity–mechanism of pollution flashover–analytical determination of flash over voltage.		
UNIT-II	**POLLUTIONTESTING**	**09**
Artificial pollution testing – salt – fog method – solid layer method–monitoring of parameters–measurement of layer conductivity–field testing methods.		
UNIT-III	**POLLUTIONPERFORMANCEOFINSULATORS**	**09**
Ceramic and non-ceramic insulators–mitigation of pollution induced flash over-design of shed profiles–rib factor effect in AC and DC insulators–modeling.		
UNIT-IV	**POLLUTIONPERFORMANCEOFSURGEDIVERTERS**	**09**
External insulation–effect of pollution on the protective characteristic so gap and gapless arresters–modeling of surge diverters under polluted conditions.		

UNIT-V	**POLLUTION PERFORMANCE OF INDOOR EQUIPMENT**	**09**
Condensation and contamination of indoor switch gear – performance of organic insulator under polluted conditions – accelerated testing techniques.		

	45	**0**	**45**

TEXTBOOKS

1. Kuffel,E.,Zaengl,W.S.andKuffelJ.,"HighVoltageEngineeringFundamentals",Elsvier IndiaPvt.Ltd,2005.
2. Ragaller,"SurgesinHighKlaus VoltageNetworks", PlenumPress,New York,1980.
3. Looms,J.S.T.,"Insulatorsfor HighVoltages",Peter Peregrinus.Ltd., London,1988.

REFERENCE BOOKS

1. DieterKindandKurtFeser,"HighVoltageTestTechniques",SecondEdition,SBAElectrical EngineeringSeries,New Delhi,1999.
2. 2. Ravi S.Gorur,"Outdoor Insulators",Inc.Phoenix,Arizona85044,USA,1999

E-REFERENCES

1. E-learning course on Design and Testing on power apparatus , Dr.R.Sarathi, IIT-Chennai

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO 1	1	3		1				2		1		2	2	3
CO 2	1				1						1	1	2	3
CO 3	1		1				1			1		1	2	1
CO 4	1	2										1	2	3
Total	4	5				1			1	2		6	10	10
Scaling	1	1	1	1	1	1	1	2	1	1	1	2	2	2

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E24 RENEWABLE ENERGY TECHNOLOGY

Course Outcomes (E24)		Domain	Level
CO1	***Infers*** the Power Demand and ***identifies*** the various renewable energy systems to meet out the demand.	Cognitive	Understanding Applying
CO2	***Explains*** about the Performance of various solar collectors and ***apply*** the recent advancement in PV systems to improve the efficiency.	Cognitive	Understanding Applying
CO3	***Explain about*** the performance characteristics of wind energy and its application in hybrid systems.	Cognitive	Understanding
CO4	***Apply*** the Bio-energy in various conversion technologies and processes, for sustainable development.	Cognitive	Applying
CO5	***Compares*** the role-play of various energy resources.	Cognitive	Understanding

SUB.CODE			**SUB NAME**	**L**	**T**	**P**	**C**
E24			**Renewable Energy Technology**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**0**	**0**		**3**	**0**	**0**	**3**

UNIT I	**INTRODUCTION**	**09**
Primary energy sources, Renewable Vs non-renewable primary energy sources, Renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.		
UNIT II	**SOLAR ENERGY**	**09**
Solar Radiation and its measurements, Solar Thermal Energy Conversion from Flat- plate Solar Collectors, Concentrating Collectors and its Types , Efficiency and performance of collectors, Direct Solar Electricity Conversion from Photovoltaics- types of solar cells and its application of battery charger, Recent Advances in PV Applications- Building Integrated PV, Grid Connected PV Systems.		
UNIT III	**WIND ENERGY**	**09**
Wind energy principles, wind site and its resource assessment, wind assessment, Factors influencing wind, wind turbine components, wind energy conversion systems(WECS), Classification of WECS devices, Hybrid systems - safety and environmental aspects, economic aspects.		

UNIT IV	**BIO-ENERGY**	**09**

Energy from biomass, Principle of biomass conversion technologies process and their classification, Bio gas generation, types of biogas plants, selection of site for biogas plant, classification of biogas plants, Advantage and disadvantages of biogas generation, biomass gasifies, Application of biomass and biogas plants and their economics.

UNIT V	**OTHER TYPES OF ENERGY**	**09**

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, Potential in India. Tidal and wave energy.

Lecture = 45; Tutorial = 00; Total = 45 Hours

TEXT BOOKS

1. G.D. Rai, Non-Conventional Energy Sources- Khanna Publishers.
2. Twidell & Wier, Renewable Energy Resources –CRC Press (Taylor & Francis).
3. D.P.Kothari, K.C.Singha , Renewable energy sources and emerging technologies - P.H.I
4. Mukund R.Patel, 1999.Wind And Solar Power Systems- CRC Press ,Florida,

REFERENCE BOOKS

1. Tiwari and Ghosal Narosa- Renewable energy resources,
2. Ramesh & Kumar ,Narosa -Renewable Energy Technologies ,
3. K Mittal ,Wheeler, Non-Conventional Energy Systems ,
4. Volker Quaschning , 2005-Understanding the Renewable Energy Systems,- Earth Scan,London,UK,

E-REFERENCES

1. http://www.nptelvideos.in/2012/11/energy-resources-and-technology.html
   NPTEL, Lecture Series on Energy Resources and Technology, Prof.S.Banerjee,Department of Electrical Engineering, IIT Kharagpur.
2. http://freevideolectures.com/Course/2352/Power-System-Generation-Transmission-and-Distribution/6
   NPTEL, Renewable Energy Technology, Prof. D.P.Kothari IIT Delhi Course.
3. http://textofvideo.nptel.iitm.ac.in/112105051/lec43.pdfNPTEL, Renewable Energy Technology,Prof. V. V. Satyamurty Department of Mechanical Engineering Indian Institute of Technology, Kharagpur.

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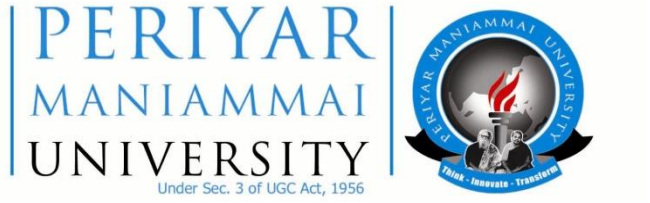

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COs versus PO, PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	2	2			1		3	1	1	1	0	1	2	3
CO 2	2	2	2	2			2	1	1	1	2	1	2	3
CO 3	3	3												3
CO 4	3	2	2		3		3	1	1	1		1	2	3
CO 5		2											2	3
Total	10	11	4	2	4	0	8	3	3	3	2	3	8	15
Scaled to 0,1,2,3 scale	2	3	1	1	2	0	2	1	1	1	1	1	2	3

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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E25 ELECTRICAL POWER QUALITY

Course Outcomes (E25)		Domain	Level
CO1	***Infer*** the electrical power quality terms, power quality events and causes for reduction in power quality.	Cognitive	Understanding
CO2	***Analyse*** the voltage sag performance, mitigation of sag and effects on drives	Cognitive	Analyzing
CO3	***Find*** the harmonics sources from commercial and industrial load. ***Interpret*** the Effect of harmonics and controlling harmonic distortion.	Cognitive	Remembering Understanding
CO4	***Construct*** a Filter circuit for harmonics and power factor improvement. ***Compare*** the VAR compensators-SVC and STATCOM	Cognitive	Applying Understanding
CO5	***Inference a*** mathematical simulation tools for monitoring and diagnostic techniques for various power quality power quality problems and Quality measurement equipment.	Cognitive	Analyzing

SUB.CODE			SUB NAME	L	T	P	C
E25			Electrical Power Quality	3	0	0	3
C	P	A		L	T	P	H
3	0	0		3	0	0	3

UNIT I	INTRODUCTION	09

Definition of Electric Power Quality- Description of poor power quality events. Power Quality phenomena – Basic terminologies – various events in Power Quality – Causes for reduction in Power Quality — Power Quality Standards and power quality strategy.

UNIT II	VOLTAGE SAG	09

Sources of sags – estimating voltage sag performance, sag severities – voltage sag due to induction motor starting - mitigation of voltage sags - effect on adjustable AC Drives, DC drives, computers and consumer electronics

UNIT III	HARMONICS	09

Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics - Harmonics Vs transients. Effect of harmonics - evaluation of Harmonic distortion - devices for controlling harmonic distortion

UNIT IV	FILTERING AND POWER FACTOR IMPROVEMENT	09

Power factor improvement- Passive Compensation. Passive Filtering Active Harmonic Filtering- Shunt Injection Filter for single phase, three-phase three-wire and three-phase four-wire systems static VAR compensators-SVC and STATCOM

UNIT V	POWER QUALITY MONITORING	09

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyzer – Quality measurement equipment - harmonic / flicker meters - disturbance analyzer. Applications of expert systems for power quality monitoring

Lecture = 45; Tutorial = 0; Lab = 0; Total = 45 Hours

TEXT BOOKS

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty, “Electrical Power Systems Quality” McGraw Hill,2003
2. C. Sankaran, “Power Quality” CRC Press, 2002.
3. Alexander Kusko “Power Quality in Electrical Systems” The McGraw-Hill Companies, Inc, 2007.
4. Ewald F. Fuchs and Mohammad A.S. Masoum” Power Quality in Power Systems and Electrical Machines”, 2011

REFERENCE BOOKS

1. Silvester and Ferrari, “Finite for Electrical Engineers”, Cambridge University Press, 1983
2. S.R.H.Hoole, Computer – Aided, Analysis and Design of Electromagnetic Devices, Elsevier, New York, Amsterdam, London, 1989
3. D.A.Lowther and P.P Silvester, “Computer Aided Design in Magnetics”, Springer Verlag, New York, 1956

E-REFERENCES

1. http://www.copper.org/applications/electrical/pq/issues.html

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COs versus POs mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	3	1	1	-	1	-	1	1	-	1	3	2
CO2	3	3	1	2	1	-	1	-	-	1	-	1	1	-
CO3	3	2	1	1	1	-	1	-	1	-	-	1	2	1
CO4	3	2	1	2	1	-	1	-	1	-	-	1	1	1
CO5	2	1	1	-	1	-	1	-	-	-	-	1	2	1
Total	14	9	7	6	5	-	5		3	2		5	9	5
Scaling	3	2	2	2	1		1		1	1		1	2	1

0 –No relation 1 – Low relation 2 – Medium relation 3 – High Relation

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MICRO PROCESSORS AND MICROCONTROLLERS

Course Outcomes (E 26)		**Domain**	**Level**
CO1	To ***understand*** the architecture and basic concepts of 8085 microprocessor.	Cognitive	Understanding
CO2	To ***understand*** the memory organization, flags, stack, and special function registers, I/O ports, connecting external memory, counters and timers, serial data I/O, Interrupts present in 8051 microcontroller.	Cognitive	Understanding
CO3	To ***understand*** the 8051 Microcontroller instructions to ***develop*** *and* ***show*** assembly language programs for basic logical and arithmetic operations, by using jump and call instructions.	Cognitive Psychomotor	Understanding Applying Set
CO4	To ***identify*** timer and counter programming, Interrupt programming and ***show*** the I/O interfacing techniques with 8051 microcontroller.	Cognitive Psychomotor	Applying Set
CO5	To **d*esign*** and ***test*** assembly language program in 8051 microcontroller for ***displaying*** Waveform generation, speed control of DC motor, Stepper motor control, seven segments LED display	Cognitive Psychomotor	Creating Mechanism

SUB. CODE			**SUB NAME**	**L**	**T**	**P**	**C**
E 26			**Micro Processors and Microcontrollers**	**3**	**0**	**0**	**3**
C	**P**	**A**		**L**	**T**	**P**	**H**
3	**1**	**0**		**3**	**0**	**0**	**3**

UNIT I	**INTEL 8085 PROCESSOR**	**09**
Architecture – Instruction format addressing modes – Basic timing diagram – input/output – 8085 based simple programs.		
UNIT II	**8051 MICROCONTROLLER ARCHITECTURE**	**09**
8051 architecture, memory organization, flags, stack, and special function registers, I/O ports - connecting external memory, counters and timers, serial data I/O, Interrupts		
UNIT III	**8051 MICROCONTROLLER INSTRUCTIONS AND ADDRESSING MODES**	**09**
Microcontroller instructions - addressing modes, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns.		
UNIT IV	**MICROCONTROLLER PROGRAMMING AND INTERFACING BASICS**	**09**
Microcontroller programming - Assembly Language Programming, timer and counter programming, connection to RS 232 and RS 485, Interrupt programming		

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UNIT V	**INTERFACING PERIPHERALS AND MICROCONTROLLER APPLICATIONS**	**09**

Serial and parallel I/O (8251 and 8255), Programmable DMA controller, Programmable interrupt controller, ADC/DAC interfacing. Programming concepts Regarding Waveform generation, speed control of DC motor, Stepper motor control, seven segments LED display.

Lecture = 45; Lab = 0; Total = 45 Hours

TEXT BOOKS

1. Ramesh .S. Gaonkar, 'Microprocessor architecture, Programming and its applications with the 8085' Penram International Publications (India), 4thEdition,2000
2. N.Senthilkumar, M.Saravanan, S.Jeevananthan'Microprocessors and microcontroller', Oxford university press, 2010
3. Kenneth Ayala, 'The 8051 Microcontroller', Cengage Learning Publications, 3rd Edition, 2007.
4. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay 'The 8051 Microcontroller and Embedded Systems using Assembly and C', Prentice Hall Publications, 2nd Edition, 2008.

REFERENCE BOOKS

1. Ray A. K., Bhurchandi K. M., 'Advanced Microprocessor and Peripherals', Tata McGraw-Hill Publications, 3 r d E d i t i o n , 2013.
2. Sencer Yeralan, Helen Emery, 'Programming and interfacing the 8051 Microcontroller', Addison-Wesley Publications, 1st Edition, 2000.
3. Krishna Kant, 'Microprocessors and Microcontrollers, Architecture, Programming and System Design-8085, 8086, 8051, 8096', Prentice Hall India Ltd Publications, 1st Edition, 2010.
4. Douglas. V. Hall - Microprocessors and Interfacing - Tata McGraw Hill- Revised 2nd edition, 2006

E-REFERENCES:

1. NTPEL, Microprocessor (Web Course), Prof. S.P.Da,IIT Kharagpur.

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COs versus POs mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	2	-	-	-	-	-	-	1	1	-	1	1
CO2	1	2	1	3	1	-	-	-	2	1	2	1	1	1
CO3	-	-	-	-	-	1	2	-	1	2	-	-	1	1
CO4	1	1	2	2	1	-	-	-	2	1	2	1	-	1
CO5	1	2	2	1	-	-	3	-	3	2	1	-	-	1
Total	4	5	5	6	2	1	5	-	8	7	6	2	3	5
Scaling	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**1**	**1**	**1**	**1**	**1**

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E 27	**Sub. Name**	**Micro Electro Mechanical Systems (MEMS)**
Year	IV	**Semester**	VII	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Credit**			**Hours/ Week**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 0; P = 0;**			**Total = 45 hrs**

Objective (s)	•To understand the properties of materials ,microstructure and fabrication methods •To Describe the design and modeling of Electrostatic sensors and actuators. •To give exposure to different MEMS and NEMS devices	
Unit- 1	**MEMS:MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS**	**09 hours**
	Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.	
Unit- 2	**ELECTROSTATIC SENSORS AND ACTUATION**	**09 hours**
	Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications.	
Unit- 3	**THERMAL SENSING AND ACTUATION**	**09 hours**
	Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.	
Unit- 4	**PIEZOELECTRIC SENSING AND ACTUATION**	**09 hours**
	Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.	
Unit- 5	**CASE STUDIES**	**09 hours**
	Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices	
Text Books:		
1.	Maluf, Nadim “An introduction to Micro Electro-mechanical Systems Engineering “AR Techhouse, Boston 2000.	
2.	Marc F madou “ Fundamentals of micro fabrication” CRC Press 2002 2nd Edition	
3.	Tai Ran Hsu, “MEMS & Micro systems Design and Manufacture” Tata McGraw Hill, New Delhi, 2002.	
4.	Julian w. Gardner, Vijay k. varadan, Osama O.Awadelkarim,micro sensors mems and smart devices, John Wiley & son LTD,2002	

Reference Books:	
1.	Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2.	Boston , "Micromachined Transducers Sourcebook",WCB McGraw Hill, 1998.
3.	M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.
4.	Mohamed Gad – el – Hak "MEMS Handbook" Edited CRC Press 2002

E27 –Micro Electro Mechanical Systems (MEMS) **Course Outcomes (COs)**
At the end of the course, the students will be able to
1. Integrate the knowledge of semiconductors and solid mechanics to fabricate MEMSdevices **2. Apply** the rudiments of Micro fabrication techniques. **3. Identify** and **Apply** the various sensors and actuators. **4. Analyse** different materials used for MEMS

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E28	**Sub. Name**	**Disaster Management**
Year	IV	**Semester**	VIII	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Hours/ Week**			**Credit**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P = 00;**			**Total = 45 hrs**

Objective (s)	To increase the knowledge and understanding of the disaster phenomenon, its different contextual aspects, impacts and public health consequences. To ensure skills and abilities to analyze potential effects of disasters and of the strategies and methods to deliver public health response to avert these effects.	
Unit- 1	**INTRODUCTION TO DISASTERS**	**08 hours**
	Concepts, and definitions (Disaster, Hazard, Vulnerability, Resilience, Risks)	
Unit- 2	**DISASTERS**	**12 hours**
	Classification Causes, Impacts (including social, economic, political, environmental, health, psychosocial, etc.) Differential impacts- in terms of caste, class, gender, age, location, disability Global trends in urban disasters, pandemics, complex emergencies, Climate change.	
Unit- 3	**APPROACHES TO DISASTER RISK REDUCTION**	**09 hours**
	Disaster cycle - its analysis, Phases, Culture of safety, prevention, mitigation and preparedness community based DRR, Structural- nonstructural nesures, roles and responsibilities of - community, Panchayati Raj Institutions/Urban Local Bodies (PRIs/ULBs), states, Centre, and other stake-holders.	
Unit- 4	**INTER-RELATIONSHIP BETWEEN DISASTERS AND DEVELOPMENT**	**10 hours**
	Factors affecting Vulnerabilities, differential impacts, impact of Development projects such as dams, embankments, changes in Land-use etc. Climate Change Adaptation. Relevance of indigenous knowledge, appropriate technology and local resources.	
Unit- 5	**DISASTER RISK MANAGEMENT IN INDIA**	**06 hours**
	Hazard and Vulnerability profile of India Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management Institutional arrangements (Mitigation, Response and Preparedness, DM Act and Policy, Other related policies, plans, programmes and legislation)	

Text Books:	
1.	Kapur, Anu& others, 2005: Disasters in India Studies of grim reality, Rawat Publishers, Jaipur.
2.	Environment Engineering and Disaster Management, Sanjay K. Sharma,2011
3.	Disaster Management,Dr. MrinaliniPandey,WILEY INDIA PVT. LTD,2010.
Reference Books:	
1.	Alexander David, Introduction in 'Confronting Catastrophe', Oxford University Press, 2000.
2.	Andharia J. Vulnerability in Disaster Discourse, JTCDM, Tata Institute of Social Sciences Working Paper no. 8, 2008.
3.	Govt. of India: Disaster Management Act 2005, Government of India, New Delhi.
4.	Government of India, 2009. National Disaster Management Policy.
5.	Gupta Anil K, Sreeja S. Nair. 2011Environmental Knowledge for Disaster Risk Management, NIDM, New Delhi.

E28 Disaster Management
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Analyze, evaluate** and manage the different public health aspects of disaster events at local and global levels, even when limited information is available.
2. **Describe, analyze** and **evaluate** the environmental, social, cultural, economic, legal and organisational aspects influencing vulnerabilities and capacities to facedisasters.
3. Obtain, **analyze**andcommunicate information on risks, relief needs and lessons learned from earlier disasters in order to formulate strategies for mitigation in future scenarios with the ability to clearly present and discuss their conclusions and the knowledge and arguments behind them.
4. **Design** and perform research on the different aspects of the emergencies and disaster events while demonstrating insight into the potential and limitations of science, its role in society and people's responsibility for how it is used.
5. **Analyze** and **evaluate** research work on the field of emergencies and disaster while demonstrating insight into the potential and limitations of science, its role in society and people's responsibility for how it is used.

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Department	Electrical & Electronics Engineering	**Course Code**		014	**Sub. Code**	E32	**Sub. Name**	**Solar and Energy Storage System**
Year	IV	**Semester**		VIII	**Regulation**	2015	**Max Mark**	100
MODE OF EVALUATION & WEIGHTAGE (%)					**Hours/ Week**			**Credit**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P = 00;**			**Total = 45 hrs**

Objective (s)	To impart the Basic knowledge ofsemiconductors, cell properties and their interconnection. To understand the concept of solar modules and design of standalone PV system. To Deal with grid connected PV systems. To Discuss about different energy storage systems.To give exposure to different applications of PV systems and its storage systems.	
Unit- 1	**INTRODUCTION**	**09 Hours**
	Characteristics of sunlight – Semiconductors and PN junctions – Behavior of solar cells – Cell properties – PV cell interconnection.	
Unit- 2	**STANDALONE PV SYSTEM**	**09 Hours**
	Solar modules – Storage systems – Power conditioning and regulation - Protection – Stand alone PV systems design – Sizing.	
Unit- 3	**GRID CONNECTED PV SYSTEMS**	**09 Hours**
	PV Systems in buildings – Design issues for central power stations – Safety – Economic aspect – Efficiency and performance - International PV programs.	
Unit- 4	**ENERGY STORAGE SYSTEMS**	**09 Hours**
	Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries - Impact of intermittent generation – Energy storage in battery – Solar thermal energy storage – Pumped hydroelectric energy storage	
Unit- 5	**APPLICATIONS**	**09 Hours**
	Water pumping – Battery chargers – Solar car – Direct-drive applications –Space – Telecommunications.	
Text Books:		
1.	Eduardo Lorenzo G. Araujo, 1994. Solar ElectricityEngineering of Photovoltaic Systems, Progensa.	
2.	Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, 2007. AppliedPhotovoltaics, Earthscan, UK.	

Reference Books:	
1.	Frank S. Barnes and Jonah G. Levine, 2011. Large Energy Storage Systems Handbook, CRC Press.
2.	McNeils, Frenkel and Desai, 1990. Solar & Wind energy Technologies, Wiley Eastern.
3.	Sukhatme, S.P., 1987. Solar Energy, New Delhi: Tata McGraw-Hill.

E32 –Solar and Energy Storage System
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Recognize and reproduce** Basic knowledge of semiconductors, cell properties and their interconnection.
2. Gain theknowledgein the solar modules & system and **design** the standalone PV system for specific applications.
3. **Classify** the various PV systems in buildings and manage the issues for central power stations.
4. **Define** the various types of energy storage systems.
5. **Employ** different applications of PV systems and its storage systems.

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E33	**Sub. Name**	**Sustainable Energy Utilization**
Year	IV	**Semester**	VII	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Credit**			**Hours/ Week**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 0; P = 0;**			**Total = 45 hrs**

Objective (s)	To discuss the utilization of energy in the present day society, taking into account sustainability and environmental aspects. To focus on the technologies used to meet a wide spectrum of energy demands needed for cooling, heating, and ventilation in the built environment.	
Unit- 1	**HEAT FLOW CALCULATIONS IN BUILDINGS**	**09 hours**
	Unsteady heat flows through walls, roof, windows etc. Direct heat gains through windows. Convective gains/losses, air exchange rates. Gains from people, appliances etc. Air conditioning load calculations	
Unit- 2	**NEED OF ENERGY IN BUILDINGS**	**09 hours**
	Role of building design and building services to evaluate the energy performance in buildings. Study of Climate and its influence in building design for energy requirement - Environmental science of buildings - Study of Thermal environment and visual environment - Heat gain and heal loss phenomenon of buildings - Role of building enclosures, openings and materials in thermal environment -Energy efficient light design of buildings - Design for visual Environment. Energy rating of buildings.	
Unit- 3	**PASSIVE COOLING / HEATING CONCEPTS**	**09 hours**
	Building form and orientation, internal and external shading devices, ventilation, passive concepts for composite climates, evaporative and nocturnal cooling, earth–air tunnel, sky-thermal system, and solar chimney-based hybrid system.Introduction and use of different building simulation software such as TRNSYS, ECOTECT etc. Case studies of non-air conditioned and air conditioned buildings.	
Unit- 4	**ENERGY EFFICIENT BUILDINGS**	**09 hours**
	Introduction - Definition and concepts, Energy and Water as a resource,- Criticality of resources and needs of modern living - Envelop heat loss and heat gain and its evaluation, Thermal Comport improvement methods, Optimum performance, other building comports, IAQ requirements.	
Unit- 5	**ELECTRICAL ENERY CONSERVATION**	**09 hours**
	Opportunities and Techniques for energy conservation in Buildings - Adoption to sustainable resources, process and Technologies. Green Buildings, Intelligent Buildings, Rating of Buildings, Efficient Use of Buildings, Solar Passive Architecture, Eco-housing concepts and National and International norms.	

Text Books:	
1.	Koenigsberger, et.al Manual of Tropical housing and Building Longman Group Ltd London (now published by Orient Longman Ltd, Madras, India),1974.
2.	Oliver and Daniel, D Chiras Natural Resource Conservation Management for a sustainable future, Prentice Hall International Ltd, London, 1992.
3.	USAID International resource book, Energy Conservation Building design Tip Sheet - Building Lighting Design.
4.	MS Sodha, NK Bansal, PK Bansal, A Kumar and MAS Malik, Solar Passive Building, Science and Design, Pergamon Press, 1986.
5.	JR Williams, Passive Solar Heating, Ann Arbar Science, 1983.
Reference Books:	
1.	RWJones, JD Balcomb, CE Kosiewiez, GS Lazarus, RD McFarland and WOWray, Passive Solar Design Handbook, Vol 3, Report of US Department of Energy (DOE/CS-0127/3), 1982.
2.	J Krieder and A Rabi, Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill, 1994.
3.	RD Brown, TJ Gillespie, Microclimatic Landscape Design, John Wiley and Sons, New York, 1990.
4.	TA Markus, EN Morris, Building, Climate and Energy, SpottwoodeBallantype Ltd, London, 1980.

E33 – Sustainable Energy Utilization
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Understand** and explain the physics that govern an indoor climate, and assess the changes needed to improve the indoor climate in existing buildings.
2. **Perform** heating/cooling load calculations for a single family residence.
3. **Understand** and describe different types of heating systems, and assess their applicability.
4. **Understand** and describe the function of passive systems and **discuss** about alternative cooling processes.
5. **Recognize** need of energy in building and various conservation techniques to use energy in sustainable manner.

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E34	**Sub. Name**	**Special Electrical Machines**
Year	IV	**Semester**	VII	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Hours/ Week**			**Credit**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P = 00;**			**Total = 45hrs**

Objective (s)	To impart the Basic knowledge of synchronous reluctance motor. To understand the concepts of working principles and construction of stepping motors and switched reluctance motor. To impart the knowledge of permanent magnet brushless AC and DC motor.	
Unit – 1	**SYNCHRONOUS RELUCTANCE MOTORS**	**09 hours**
	Constructional features – types – axial and radial air gap motors – operating principle – reluctance – phasordiagram - characteristics – Vernier motor.	
Unit –2	**STEPPING MOTORS**	**09 hours**
	Constructional features – principle of operation – variable reluctance motor – Hybrid motor – single and Multi stack configurations – theory of torque predictions – linear and non-linear analysis – characteristics –closed loop control - drive circuits.	
Unit –3	**SWITCHED RELUCTANCE MOTORS**	**09 hours**
	Constructional features – principle of operation – torque prediction – power controllers – Nonlinear analysis – Microprocessor based control –closed loop control - characteristics.	
Unit –4	**PERMANENT MAGNET BRUSHLESS DC MOTORS**	**09 hours**
	Principle of operation –EMF and Torque equations – Types of Power Controllers – Torque Speed characteristics – Commutation logic - Control.	
Unit –5	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**09 hours**
	Principle of operation – EMF and torque equations – reactance – phasor diagram – power controllers - converter - volt-ampere requirements – torque speed characteristics - microprocessor based control.	

Text Books:	
1.	Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1989.
2.	Aearnley, P.P., 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus, London, 1982.
3.	P.P. Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus, London, 1982.
4.	R.Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design andApplication', CRC Press, New York, 2001.
Reference Books:	
1.	Kenjo, T., 'Stepping Motors and their Microprocessor Controls', Clarendon Press London, 1984.
2.	Kenjo, T., and Nagamori, S., 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.
3.	K. Dhayalini, 'Special Electrical Machines', Anuradha Publications.
4.	S.AlbertAlexander,J.Gnanavadivel, "Special Electrical Machines",Anuradha Publications.

E34–Special Electrical Machines
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Able** to know the construction and working of synchronous motor.
2. **Describe** the construction and working of stepping motor.
3. **Analyze** the control and performance of stepping motor.
4. **Understand** the construction, working and performance of switched reluctance motor.
5. **Illustrate** the different types of power controllers of switched reluctance motor
6. **Explain** the construction and working of permanent magnet dc and synchronous motor
7. **Handle** the microprocessors based control using Permanent magnet synchronous motor.

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E35	**Sub. Name**	**Energy Management and Auditing**
Year	IV	**Semester**	VII	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Hours/ Week**			**Credit**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P =00;**			**Total = 45 hrs**

Objective (s)	Tostudytheconceptsbehindeconomicanalysis andLoadmanagement.Toemphasize theenergymanagementonvariouselectricalequipments and metering.Toillustratetheconcept oflightingsystemsandcogeneration.	
Unit- 1	**INTRODUCTION**	**09 hours**
	Need for energy management - energy basics- designing and starting an energy managementprogram–energyaccounting-energymonitoring,targetingandreporting-energyauditprocess.	
Unit- 2	**ENERGYCOSTAND LOADMANAGEMENT**	**09 hours**
	Importantconceptsinaneconomicanalysis-Economicmodels-Timevalueofmoney-Utilityratestructures- cost of electricity-Lossevaluation Loadmanagement:Demandcontroltechniques-Utilitymonitoringandcontrolsystem-HVAC andenergymanagement.	
Unit- 3	**ENERGYMANAGEMENTFOR MOTORS, SYSTEMS,AND ELECTRICAL EQUIPMENT**	**09 hours**
	Systems andequipment- Electric motors-Transformers and reactors-Capacitors and synchronousmachines-Energy management in industrial drive.	
Unit- 4	**METERINGFOR ENERGYMANAGEMENT**	**09 hours**
	Relationshipsbetweenparameters-Unitsofmeasure-Typical costfactors- Utilitymeters-Timingofmeterdiscforkilowattmeasurement-Demandmeters-Parallelingofcurrent transformers-Instrumenttransformer burdens-Multitaskingsolid-statemeters-Metering locationvs.requirements.	
Unit- 5	**LIGHTINGSYSTEMS**	**09 hours**
	Conceptoflightingsystems-Thetaskandtheworkingspace-Lightsources-Ballasts-Luminaries-Lightingcontrols-Optimizinglightingenergy-Powerfactorandeffectof harmonicsonpower quality- Cost analysistechniques-Lightingandenergystandards-BEE standards.	

Text Books:	
1.	BarneyL.Capehart,WayneC.Turner,andWilliamJ.Kennedy, 'GuidetoEnergy Management',FifthEdition,TheFairmontPress,Inc.,2006
2.	EastopT.D &Croft D.R, Energy Efficiency for Engineers and Technologists,. LogmanScientific&Technical,ISBN-0-582-03184,1990.
Reference Books:	
1.	ReayD.A, 'Industrial EnergyConservation',1Stedition,PergamonPress,1977.
2.	IEEERecommendedPracticefor EnergyManagementinIndustrialand Commercial Facilities,IEEE,196.
3.	Amit K.Tyagi, 'HandbookonEnergyAuditsandManagement',TERI, 2003.

E 35 Energy Management and Auditing
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Understand** the need and necessity of energy audit and energy conservation.
2. **Analyze** different phase of energy audit and to implement the techniques.
3. **Study** the operation of different energy audit instruments.
4. **Designing** and implementing energy audit methodology in a plant.
5. Locationof proper energy audit instrument in the plant to minimize the energy consumption
6. **Operate** the equipment to minimize the energy consumption and peak demand.
7. **Optimal** utilizing of lighting in domestic and industrial area and improvement of power factor in a system.

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<table>
<tr><td>Department</td><td>EEE</td><td>Course Code</td><td>014</td><td>Sub. Code</td><td>E36</td><td>Sub. Name</td><td>Signals and Systems</td></tr>
<tr><td>Year</td><td>III</td><td>Semester</td><td>V</td><td>Regulation</td><td>2015</td><td>Max Mark</td><td>100</td></tr>
<tr><td colspan="4">MODE OF EVALUATION & WEIGHTAGE (%)</td><td colspan="3">Credit</td><td>Hours/ Week</td></tr>
<tr><td rowspan="2">CA 1</td><td rowspan="2">CA 2</td><td rowspan="2">CA 3</td><td rowspan="2">CA 4</td><td rowspan="2">Total</td><td>L</td><td>T</td><td>P</td><td rowspan="2">3</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td>15%</td><td>15%</td><td>20%</td><td>50%</td><td>100%</td><td colspan="3">L = 45; T = 00; P =00;</td><td>Total = 45hrs</td></tr>
<tr><td>Objective (s)</td><td colspan="7">To study and analyze the characteristics,properties and representationof continuous, discrete signals and systems.To Understand the analysis and synthesis of discrete time systems.To execute the sampling process and analysis of discrete systems using z-transformsand exploit them.</td></tr>
<tr><td>Unit- 1</td><td colspan="6">CLASSIFICATION OF SIGNALS AND SYSTEMS</td><td>09 hours</td></tr>
<tr><td></td><td colspan="7">Continuous time signals (CT signals), discrete time signals (DT signals) - Step, Ramp, Pulse, Impulse, Exponential, Classification of CT and DT signals - periodic and periodic, random signals, CT systems and DT systems, Basic properties of systems.</td></tr>
<tr><td>Unit- 2</td><td colspan="6">ANALYSIS OF CONTINUOUS TIME SIGNALS</td><td>09 hours</td></tr>
<tr><td></td><td colspan="7">Fourier series analysis, Spectrum of C.T. signals, Fourier Transform and LaplaceTransform in Signal Analysis.</td></tr>
<tr><td>Unit- 3</td><td colspan="6">LINEAR TIME INVARIANT - DISCRETE TIME SYSTEMS</td><td>09 hours</td></tr>
<tr><td></td><td colspan="7">Differential equation, Block diagram representation, Impulse response, Convolution and Correlation concept, frequency response, Fourier and Laplace transforms in analysis.</td></tr>
<tr><td>Unit- 4</td><td colspan="6">ANALYSIS OF DISCRETE TIME SIGNALS</td><td>09 hours</td></tr>
<tr><td></td><td colspan="7">Sampling of CT signals and antialiasing Filter design, DTFT and properties, Z-transform and properties ofZ-transform.</td></tr>
<tr><td>Unit- 5</td><td colspan="6">LINEAR TIME INVARIANT - DISCRETE TIME SYSTEMS</td><td>09 hours</td></tr>
<tr><td></td><td colspan="7">Difference equations, Block diagram representation, Impulse response, Convolutionsum,LTI systems analysis using DTFT, State variable equations andmatrix representation of systems.</td></tr>
</table>

Text Books:	
1.	Allan V.Oppenheim, S.Wilsky and S.H.Nawab -2007, -Signals and Systems, Pearson Education,.
2.	Edward W Kamen& Bonnie's Heck2007, -Fundamentals of Signals and Systems, Pearson Education.
3.	Simon Haykins and Barry Van Veen,2004- Signals and Systems John Wiley & sons , Inc.
4.	Rodger E. Ziemer, William H. Tranter, D. Ronald Fannin. 2002-Signals and Systems, fourth Edition, Pearson Education,.
Reference Books:	
1.	H P Hsu, Rakesh Ranjan,2007 - Signals and Systems, Schaum's Outlines, Tata McGraw Hill, Indian Reprint,
2.	S.Salivahanan, A. Vallavaraj, C. Gnanapriya,2007, -Digital Signal Processing, McGraw HillInternational ,TMH,
3.	Robert A. Gabel and Richard A.Roberts, 1987 -Signals and Linear Systems, John Wiley, III edition.
4.	J.G.Prokiis and D.G. Manolakies, 1989-Introduction to Digital Signal Processing ,MacMillan Publishing company.

E36 –Signals and Systems
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Calculate** Fourier transforms for continuous-time and discrete-time signals (or) impulse-response functions.
2. **Interpret** the sampling theorem and how it links continuous-time signals to discrete-time signals.
3. **Investigate**—the Laplace and Z transforms—to treat a class of signals broader than what the Fourier transform can handle.
4. **Evaluate** the reasonably-accurate mathematical models for physical systems and **recognize** the LTI approximations to the models.
5. Learn to develop and **analyze** state-space models of linear and nonlinear systems.

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Department	Electrical & Electronics Engineering	**Course Code**		014	**Sub. Code**	E37	**Sub. Name**	**Digital Signal Processing**
Year	III	**Semester**		V	**Regulation**	2015	**Max Mark**	100
MODE OF EVALUATION & WEIGHTAGE (%)					**Credit**			**Hours/ Week**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P = 00;**			**Total = 45hrs**

Objective (s)	This course will treat a broad range of Digital Signal Processing (DSP) topics. It will strengthen the student's understanding of the foundations of DSP, introduce the students to three major application areas: speech processing image processing and array signal processing, and provide extensive hands-on design experience	
Unit- 1	**INTRODUCTION**	**09 hours**
	Characterization and classification of signals - examples of signals – multichannel –multi-dimensional - continuous versus discrete - analog versus digital - concept of frequency. Concepts of signal processing - typical applications - advantages of digital signal processing compared with analog processing	
Unit- 2	**DISCRETE TIME SYSTEMS ANALYSIS**	**09 hours**
	Representations-classifications - time domain and frequency domain characterization - transfer functions – Convolution - Z-transform and Inverse Z- transform applications.	
Unit- 3	**FREQUENCY ANALYSIS OF SIGNAL**	**09 hours**
	Analysis of analog and discrete signals-using Fourier series, Fourier transform, computation of DFT. Fourier transform of discrete sequence and discrete Fourier transform-properties of transforms-computation of DIT and DIF-computation of discrete Fourier transforms-Radix 2. FFT algorithms - circular convolution	
Unit- 4	**DESIGN ANALOG AND DIGITAL FILTERS**	**09 hours**
	Sampling of continuous signals-analog filter design-anti aliasing filters-sample and hold circuit-reconstructing filters-Block diagram representation – IIR and FIR structures	
Unit- 5	**DIGITAL SIGNAL PROCESSORS**	**09 hours**
	Introduction - Block diagram and construction. Instruction and addressing of Texas commercial processors (TMS 302 C 54X processors) Techniques of ‘C54X’ Internal memory organization, program memory addressing. Comparison b/w DSP processors and general purpose processor	

Text Books:	
1.	S.K. Mitra, 'Digital signal processing-A Computer based approach', Tata McGraw-Hill Edition, 1998
2.	Alan V Oppenheim, Ronald W.Schafer, “Digital Signal Processing”, Prentice Hall, 1975.
3.	S. Salivahanan, A. Vallavaraj and C. Gnanapriya., “Digital Signal Processing” Tata McGraw-Hill Edition, 2006.
4.	E.C. Ifeachor and B.W. Jervis, " Digital signal processing - A practicalapproach",Second edition, Pearson, 2002..
Reference Books:	
1.	Lonnie C. Lumen, 'Fundamentals of Digital Signal Processing', John Wily and Sons, 1987
2.	J.G. Prookis and D.G. Manolakis, 'Introduction to Digital Signal Processing', Macmillan. Publishing company, 1989.
3.	R.G.Lyons, 'Understanding Digital Signal Processing', Addison Wesley, 1997
4.	Johny R. Johnson, Introduction to Digital Signal Processing, PHI, 2006.

E37 – Digital Signal Processing
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Discuss** to represent real world signals in digital format and understand transform-domain (Fourier and z-transforms) representation of the signals.
2. **Design** the linear systems approach to signal processing problems using high-level programming language.
3. **Understand** the basic architecture of microprocessors and digital signal processors.
4. **Develop** to linearfilters in real-time DSP chips.
5. **Describe** the applications of linear filters and their real-time implementation challenges

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Department	Electrical & Electronics Engineering	**Course Code**	014	**Sub. Code**	E38	**Sub. Name**	**HVDC Transmission**
Year	III	**Semester**	V	**Regulation**	2015	**Max Mark**	100

MODE OF EVALUATION & WEIGHTAGE (%)					**Credit**			**Hours/ Week**
CA 1	**CA 2**	**CA 3**	**CA 4**	**Total**	**L**	**T**	**P**	**3**
					3	0	0	
15%	15%	20%	50%	100%	**L = 45; T = 00; P = 00;**			**Total = 45hrs**

Objective (s)	To impart knowledge on operation, modelling and control of HVDC link.• To perform steady state analysis of AC/DC system.• To expose various HVDC simulators.•	
Unit- 1	**DC POWER TRANSMISSION TECHNOLOGY**	**06 hours**
	Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.	
Unit- 2	**ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL**	**12 hours**
	Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters- General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.	
Unit- 3	**MULTITERMINAL DC SYSTEMS**	**09 hours**
	Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.	
Unit- 4	**POWER FLOW ANALYSIS IN AC/DC SYSTEMS**	**09 hours**
	Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method.	
Unit- 5	**SIMULATION OF HVDC SYSTEMS**	**09 hours**
	Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFFline simulators — Dynamic interactions between DC and AC systems	

Reference Books:	
1.	P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993
2.	K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
3.	J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
4.	Erich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2004.
5.	V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

E38 – HVDC Transmission
Course Outcomes (COs)

At the end of the course, the students will be able to

1. **Discuss** to represent real world signals in digital format and understand transform-domain (Fourier and z-transforms) representation of the signals.
2. **Design** the linear systems approach to signal processing problems using high-level programming language.
3. **Understand** the basic architecture of microprocessors and digital signal processors.
4. **Develop** to linearfilters in real-time DSP chips.
5. **Describe** the applications of linear filters and their real-time implementation challenges

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Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

E11 –Design of Electrical Apparatus

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	2	1	1	2	-	-	1	-	-
CO2	3	3	-	3	3	3	-	3	-	1	3	-
CO3	2	-	-	-	2	2	2	3	-	-	-	-
CO4	-	1	3	-	-	1	-	-	1	-	-	-
CO5	-	-	1	-	3	-	-	2	-	-	-	-

E 12 – Control and Maintenance of Electrical Machines

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	1	-	1	1	-	-	1	-	-
CO2	2	1	1	1	-	3	-	-	1	1	-	-
CO3	1	-	-	-	1	3	1	-	1	1	-	-
CO4	1	1	2	2	-	2	-	-	1	1	-	-
CO5	1	1	-	-	-	3	3	-	1	2	-	-
CO6	1	1	1	1	2	2	2	-	1	2	-	-
CO7	2	-	1	-	-	1	1	1	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E13 – Advanced Control System Engineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	1	-	-	-
CO2	3	1	2	3	-	-	-	-	-	-	-	-
CO3	3	1	-	3	1	-	-	-	-	-	-	-
CO4	3	3	-	1	1	-	-	-	-	3	-	2
CO5	3	2	1	3	-	-	-	-	1	1	-	-

1- Slightly 2 – Supportive 3 – Highly related

E14 - Digital Logic Circuits

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	3	3	-	-	-	3	2	3	1
CO2	3	3	1	3	3	-	-	-	2	3	3	3
CO3	3	3	2	3	3	-	-	1	3	3	3	2
CO4	-	-	-	-	-	-	-	-	1	-	-	-
CO5	2	2	1	2	2	-	-	-	2	2	2	2

1- Slightly 2 – Supportive 3 – Highly related

E16 – Industrial Automation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			2	2	-		-			-	-
CO2	-	2	2	3	-	-	1	-			1	-
CO3		1	1	-		-	-	-	-	-	1	2
CO4	-	1		2	3	-	-	-			1	-
CO5	-	2	-	1	1	2		-				-
CO6		2	-	1	3	-	2	-				-

1- Slightly 2 – Supportive 3 – Highly related

E17 – Bio Medical Instrumentation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	-	-	-	-	3	1	-	-	-
CO2	2	2	2	1	-	-	-	-	-	-	-	-
CO3	2	2	-	1	2	-	-	-	-	-	-	-
CO4	2	3	-	1	-	-	-	-	-	-	-	-
CO5	2	2	1	1	-	-	1	-	1	-	-	-
CO6	-	-	3	-	-	-	2	2	-	-	2	2
CO7	-	-	3	-	-	3	3	-	-	-	-	-
CO8	1	2	-	3		-	2	-	-	2	-	-
CO9	1	1	-	3	2	-	-	-	-	-	-	-
CO10	2	2	1	3	3	-	-	-	-	-	-	2

1- Slightly 2 – Supportive 3 – Highly related

EE 18 – Smart Grids

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	-	2	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	-	-	1	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	-	-	3	-	3	2	1	-

1- Slightly 2 – Supportive 3 – Highly related

E21– Power Electronics for Renewable Energy Systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	-	2	-	3	-	2	1	-	-
CO2	2	2	-	1	1	2	3	-	-	-	2	-
CO3	1	3	-	3	-	2	2	-	2	-	1	1
CO4	-	3	-	1	2	1	-	2	-	-	2	-
CO5	-	3	-	-	1	-	-	1	1	1	1	-
CO6	1	-	3	3	-	-	2	-	-	-	-	-
CO7	1	2	3	1	-	-	-	1	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E 22 – Wind EnergyConversionSystems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	2	3	-	-	-	3	2	3	1
CO 2	3	2	1	1	2	-	-	-	2	3	3	3
CO 3	3	3	2	3	2	-	-	1	3	3	3	2
CO 4	-	-	-	1	-	-	-	-	1	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E23 -Pollution Performance of Power Apparatus and Systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	-	2	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	-	-	1	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	-	-	3	-	3	2	1	-
CO6	1	-	-	1	2	-	2	-	1	2	3	-
CO7	-	-	-	-	-	-	1	1	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E24 - Renewable Energy Technology

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	-	1	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	1	-	-	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	-	-	3	-	3	2	1	-

1- Slightly 2 – Supportive **3** – Highly related

E 25 – Electrical Power Quality

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	2	1	2	-	-	-	-	-
CO2	1	1	2	3	2	1	1	-	-	-	-	-
CO3	2	1	1	2	1	1	1	-	-	-	-	-
CO4	1	2	2	2	1	-	1	-	-	-	-	-
CO5	1	1	1	1	1	1	-	-	-	-	-	-
CO6	1	1	3	1	1	-	1	-	-	-	-	-
CO7	1	1	2	2	-	-	1	-	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E 26 – Microprocessors and Microcontrollers

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	2	-	-	-	-	-	-	1	1	-
CO2	1	2	1	3	1	-	-	-	2	1	2	1
CO3	-	-	-	-	-	1	2	-	1	2	-	-
CO4	1	1	2	2	1	-	-	-	2	1	2	1
CO5	1	2	2	1	-	-	3	-	3	2	1	-

1- Slightly 2 – Supportive 3 – Highly related

E 27 –Micro Electro Mechanical Systems (MEMS)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	2	-	-	-	-	-	-	1	1	-
CO2	1	2	1	3	1	-	-	-	2	1	2	1
CO3	-	-	-	-	-	1	2	-	1	2	-	-
CO4	1	1	2	2	1	-	-	-	2	1	2	1

1- Slightly 2 – Supportive 3 – Highly related

E 28Disaster Management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	-	1	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	1	-	1	-	2	-	-	1	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	2	-	3	-	3	2	1	-

1- Slightly 2 – Supportive 3 – Highly related

E32 –Solar and Energy Storage System

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	2	1	2	-	-	-	-	-
CO2	1	1	2	3	2	1	1	-	-	-	-	-
CO3	2	1	1	2	1	1	1	-	-	-	-	-
CO4	1	2	2	2	1	-	1	-	-	-	-	-
CO5	1	1	1	1	1	1	-	-	-	-	-	-

1- Slightly 2 – Supportive **3** – Highly related

E33 – Sustainable Energy Utilization

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	1	2	1	-	-	-	-	-	-
CO2	2	3	-	1	-	-	2	1	-	-	-	-
CO3	-	-	3	-	2	1	1	1	2	-	-	-
CO4	1	2	2	-	-	3	1	-	-	1	-	-
CO5	-	2	3	2	3	1	-	1	-	-	-	-

1- Slightly 2 – Supportive **3** – Highly related

E34 –Special Electrical Machines

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	2	-	-	-	-	-	-	1	1	-
CO2	1	2	1	3	1	-	-	-	2	1	2	1
CO3	-	-	-	-	-	1	2	-	1	2	-	-
CO4	1	1	2	2	1	-	-	-	2	1	2	1
CO5	1	-	2	-	-	-	-	-	-	1	1	-
CO6	1	2	1	3	1	-	-	-	2	1	2	1
CO7	-	-	-	-	-	1	2	-	1	2	-	-

1- Slightly 2 – Supportive **3** – Highly related

E35 - Energy Management and Auditing

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	-	1	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	1	-	-	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	-	-	3	-	3	2	1	-
CO6	1	-	-	1	2	-	2	-	1	2	3	-
CO7	-	-	-	-	-	-	1	1	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

E36 - Signals and Systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	-	1	-	3	-	2	1	-	-
CO2	-	-	-	1	-	-	-	-	2	1	2	-
CO3	1	-	1	-	-	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	2	1	2	-
CO5	-	-	-	-	-	-	3	-	3	2	1	-

1- Slightly 2 – Supportive **3** – Highly related

E 37 – Digital Signal Processing

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	-	-	-	-	-	-
CO2	2	3	2	3	-	-	-	-	-	-	-	-
CO3	1	3	-	3	1	-	-	-	-	-	-	-
CO4	2	2	-	1	1	-	-	-	-	-	-	-
CO5	2	1	1	3	-	-	-	-	-	-	-	-

1- Slightly 2 – Supportive 3 – Highly related

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E 38 – HVDC Transmission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	-	-	-	-	-	-
CO2	2	3	2	3	-	-	-	-	-	-	-	-
CO3	1	3	-	3	1	-	-	-	-	-	-	-
CO4	2	2	-	1	1	-	-	-	-	-	-	-
CO5	2	1	1	3	-	-	-	-	-	-	-	-

1- Slightly 2 – Supportive **3** – Highly related