DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
Periyar Nagar, Vallam, Thanjavur - 613 403, Tamil Nadu, India
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Curriculum and Syllabus

for

B.Tech.

Electrical and Electronics Engineering

(Four Year Full Time)

Regulation 2018
(Based on OBE)

HoD/ EEE	Dean FET	Dean Academics
(Dr. N. Muruganantham)	(Dr. R. Jayanthi)	(Dr. P. K. Srividhya)

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INSTITUTE VISION & MISSION

VISION	To be a Institution of global dynamism with excellence in knowledge and innovation ensuring social responsibility for creating an egalitarian society.	
MISSION	**IM1**	Offering well balanced Programmes with scholarly faculty and state-of-art facilities to impart high level of knowledge.
	IM2	Providing student - centred education and foster their growth in critical thinking, creativity, entrepreneurship, problem solving and collaborative work.
	IM3	Involving progressive and meaningful research with concern for sustainable development.
	IM4	Enabling the students to acquire the skills for global competencies.
	IM5	Inculcating Universal values, Self-respect, Gender equality, Dignity and Ethics.

CORE VALUES

- Student – centric vocation
- Academic excellence
- Social Justice, equity, equality, diversity, empowerment, sustainability
- Skills and use of technology for global competency.
- Continual improvement
- Leadership qualities.
- Societal needs
- Learning, a life – long process
- Team work
- Entrepreneurship for men and women
- Rural development
- Basic, Societal, and applied research on Energy, Environment, and Empowerment.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION	To become a leader in providing education, training and research in the field of Electrical and Electronics Engineering to the aspiring graduates to be competent in their profession and render best service to the society.	
MISSION	**DM1**	To provide affordable, quality undergraduate and graduate education in the areas of electrical engineering.
	DM2	To provide service to the profession, the university, the community, and society
	DM3	To conduct scholarly research at the frontiers of electrical engineering.
	DM4	To instil our graduates the need for life-long learning
	DM5	To promote personal and intellectual growth to reinforce a commitment to ethical and professional practices.

TABLE 1: MAPPING OF INSTITUTION MISSION (IMs) AND DEPARTMENT MISSION (DMs)

	DM1	DM2	DM3	DM4	DM5
IM1	**3**	**1**	**1**	**0**	**0**
IM2	**1**	**3**	**1**	**0**	**0**
IM3	**0**	**2**	**3**	**2**	**0**
IM4	**0**	**0**	**2**	**3**	**1**
IM5	**0**	**1**	**0**	**1**	**3**

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

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PROGRAMME EDUCATIONAL OBJECTIVES

Based on the Mission of the Department, the Programme Educational Objectives are formulated as

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.

TABLE 2: MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) WITH DEPARTMENT MISSION (DMs)

	DM 1	**DM 2**	**DM3**	**DM 4**	**DM 5**
PEO 1	2	0	1	1	1
PEO 2	1	3	1	3	3
	3	**3**	**2**	**4**	**4**

1- Low 2 – Medium 3-High

GRADUATE ATTRIBUTES (GAs)

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, analyse 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.

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 analyse 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.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	Ability to design and answer the problems in the field of Power Engineering by applying the knowledge acquired from Electrical Machines, Power Electronics, Electric Circuit Analysis, Power Systems & other related topics.
PSO2	Graduates will be able to develop and support Renewable based systems.

TABLE 3: GAs VERSUS POs and PSOs MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
GA1	3	2	2	2	2	3	2	2	2	2	2	2	3	3
GA2	2	3	2	2	1	2	2	1	1	2	1	2	3	3
GA3	2	3	2	3	3	2	1	1	1	1	2	2	3	3
GA4	1	2	3	3	2	1	1	2	2	1	3	3	3	3
GA5	1	1	3	1	3	1	2	1	3	2	2	3	2	2
GA6	2	2	1	2	3	2	3	3	3	3	3	1	3	3
GA7	1	1	2	1	3	1	2	2	2	2	1	2	3	3
GA8	1	1	1	1	2	1	3	2	2	3	3	1	3	3
GA9	1	2	1	2	2	1	2	2	3	2	3	1	2	2
GA10	2	1	2	2	3	2	1	3	3	1	2	2	3	3

GA11	2	1	1	1	1	2	2	1	1	2	1	1	2	2
GA12	1	2	2	2	2	1	2	2	3	2	3	2	3	3

TABLE 4: MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) WITH PROGRAMME 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

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

DISTRIBUTION OF SUBJECTS TO BE INCLUDED AS PER UGC AND NAAC

S.No.	**Category**	**Symbol**
1.	Humanities and Social Sciences (HS), including Management;	HS
2.	Basic Sciences (BS) including Mathematics, Physics, Chemistry, Biology;	BS
3.	Engineering Sciences (ES), including Materials, Workshop, Drawing, Basics of Electrical/Electronics/Mechanical/Computer Engineering, Instrumentation;	ES
4.	Professional Subjects-Core (PC), relevant to the chosen specialization/branch;	PC
5.	Professional Subjects – Electives (PE), relevant to the chosen specialization/ branch;	PE
6.	Open Subjects- Electives (OE), from other technical and/or emerging subject areas;	OE
7.	Project Work, Seminar and/or Internship in Industry or elsewhere	PW/PI
8.	Mandatory Courses (UGC Mandatory)	MC
9.	Non-credit Course	ELS
10.	NCC/NSS/YRC/RRC/Sports	

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STRUCTURE OF B.Tech.
ELECTRICAL AND ELECTRONICS ENGINEERING PROGRAMME

S.No.	Category	Suggested by AICTE Breakup of Credits	Implementation in Curriculum 2018
1.	Humanities and Social Sciences including Management courses	12	12
2.	Basic Science courses	26	23
3.	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	20	16
4.	Professional core courses	53	55
5.	Professional Elective courses relevant to chosen specialization/branch	18	20
6.	Open subjects – Electives from other technical and /or emerging subjects	18	19
7.	Project work, seminar and internship in industry or elsewhere and minor courses	11	13
8.	Mandatory Courses [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)	(non-credit)
	Total	**158**	**158**

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HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

S.No.	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1.	English	2:0:1	3	II
2.	Industrial Economics and Foreign Trade	3:0:0	3	V
3.	E-Waste Management	3:0:0	3	VI
4..	Professional Ethics and Human Values	3:0:0	3	VII
Total			**12**	

BASIC SCIENCE COURSES

S. No.	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1.	Calculus and Linear Algebra	3:1:0	4	I
2.	Applied Physics for Engineers	3:1:2	6	I
3.	Calculus, Ordinary Differential Equations and Complex Variable	3:1:0	4	II
4.	Applied Chemistry for Engineers	3:1:1	5	II
5.	Mathematics – III (Probability and Statistics)	3:1:0	4	IV
Total			**23**	

ENGINEERING SCIENCE COURSES

S.No.	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1.	Programming for Problem Solving	3:0:4	5	II
2.	Electrical and Electronics Engineering Systems	3:1:1	5	I
3.	Workshop Practices	1:0:2	3	II
4.	Engineering Graphics	2:0:1	3	I
Total			**16**	

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PROFESSIONAL CORE COURSES TRACKS-
ELECTRICAL AND ELECTRONICS ENGINEERING [PEC-EE]

S.No.	Course Title	Hrs. /Week L: T: P	Credits	Semester
1.	Electrical Circuit Analysis	3:1:2	5	III
2.	Analog Electronics	3:0:2	4	
3.	Electrical Machines-I	3:1:2	5	
4.	Electromagnetic Fields	3:1:0	4	
5.	Transmission and Distribution	3:0:0	3	
6.	Digital Electronics	3:0:2	4	IV
7.	Power Electronics	3:0:2	4	
8.	Electrical Machines-II	3:1:2	5	
9.	Signals and Systems	2:1:0	3	
10.	Power Systems – I (Apparatus and Modelling)	3:1:2	5	V
11.	Control Systems	3:0:2	4	
12.	Microprocessors and Microcontrollers	3:0:2	4	
13.	Power Systems –II (Operation and Control)	3:1:2	5	VI
Total			**55**	

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PROFESSIONAL ELECTIVE COURSE TRACKS- ELECTRICAL AND ELECTRONICSENGINEERING [PEC-EE]

S.No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1.	XEE E11	Protection and Switchgear	3:0:0	3	V onwards
2.	XEE E12	Electrical Machine Design	3:0:0	3	V onwards
3.	XEE E42	Embedded System	3:0:0	3	V onwards
4.	XEE E13	Electrical safety, operations and Regulations	3:0:0	3	V onwards
5.	XEE E31	Industrial Automation	3:0:2	5	V onwards
6.	XEE E43	Power system Restructuring	3:0:0	3	V onwards
7.	XEE E44	Line Commutated and Active Rectifiers	3:0:0	3	VI onwards
8.	XEE E51	Electrical Drives	3:0:0	3	VI onwards
9.	XEE E41	High Voltage Engineering	3:0:0	3	VI onwards
10.	XEE E33	Electrical Energy, Conservation and Auditing	3:0:0	3	VI onwards
11.	XEE E34	Industrial Electrical Systems	3:0:0	3	VI onwards
12.	XEE E24	Digital Control Systems	3:0:0	3	VI onwards
13.	XEE E32	Digital Signal Processing	3:0:0	3	VI onwards
14.	XEE E14	Computer Architecture	3:0:0	3	V onwards
15.	XEE E22	Electromagnetic Waves	3:0:0	3	VI onwards
16.	XEE E23	Computational Electromagnetics	3:0:0	3	VI onwards
17.	XEE E21	Measurement and Instrumentation	3:0:2	5	VI onwards
18.	XEE E52	Power System Dynamics and Control	3:0:0	3	VII onwards
19.	XEE E53	HVDC Transmission Systems	3:0:0	3	VII onwards
20.	XEE E54	Power Quality and FACTS	3:0:0	3	VII onwards
21.	XEE E62	Wind and Solar Energy Systems	3:0:0	3	VII onwards
22.	XEE E61	Electrical and Hybrid Vehicles	3:0:0	3	VII onwards
23.	XEE E63	Power System Protection	3:0:0	3	VII onwards

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24.	OC*	Minor Course	3:0:0	1	VII onwards
25.	XEE E64	Advanced Electric Drives	3:0:0	3	VIII

PROJECT WORK & INTERNSHIP IN INDUSTRY

S.No.	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1.	In-plant Training	0:0:0	1	V
2.	Project Phase-I	0:0:6	3	VII
3.	Summer Internship (45 to 60 days duration during summer vacation of III year)	0:0:0	1	VII
4.	Project Phase-II	0:0:16	8	VIII
Total			**13**	

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SEMESTER-WISE STRUCTURE OF CURRICULUM
REGULATIONS – 2018
(Applicable to the students admitted from the Academic year 2018-19)

CURRICULUM 2018

SEMESTER I

Code No.	Course Title	L	T	P	C	TCH
XMA 101	Calculus and Linear Algebra	3	1	0	4	4
XES 102	Environmental Sciences	3	0	0	0	3
XBE 103	Electrical and Electronics Engineering Systems	3	1	1	5	6
XAP 104	Applied Physics for Engineers	3	1	2	6	8
XEG 105	Engineering Graphics	2	0	1	3	4
	TOTAL	**14**	**3**	**4**	**18**	**25**

SEMESTER II

Code No.	Course Title	L	T	P	C	TCH
XMA 201	Calculus, Ordinary Differential Equations and Complex Variable	3	1	0	4	4
XCP 202	Programming for Problem Solving	3	0	2	5	7
XGS 203	English	2	0	1	3	4
XAC 204	Applied Chemistry for Engineers	3	1	1	5	6
XWP 205	Workshop Practices	1	0	2	3	5
	TOTAL	**12**	**2**	**6**	**20**	**26**

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SEMESTER III

Code No.	Course Title	L	T	P	C	TCH
XEE 301	Electrical Circuit Analysis	3	1	1	5	6
XEE 302	Analog Electronics	3	0	1	4	5
XEE 303	Electrical Machines - I	3	1	1	5	6
XEE 304	Electromagnetic Fields	3	1	0	4	4
XEE 305	Transmission and Distribution	3	0	0	3	3
XEE 306	In-plant Training - I	0	0	0	0	0
	TOTAL	**15**	**3**	**3**	**21**	**24**

SEMESTER IV

Code No.	Course Title	L	T	P	C	TCH
XPS 401	Probability and Statistics	3	1	0	4	4
XEE 402	Digital Electronics	3	0	1	4	5
XEE 403	Power Electronics	3	0	1	4	5
XEE 404	Electrical Machines - II	3	1	1	5	6
XUM 405	Entrepreneurship Development	3	0	0	3	3
XEE 406	Signals and Systems	2	1	0	3	3
	TOTAL	**17**	**3**	**3**	**23**	**26**

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SEMESTER V

Code No.	Course Title	L	T	P	C	TCH
XEE 501	Power Systems - I (Apparatus and Modelling)	3	1	1	5	6
XEE 502	Control Systems	3	0	1	4	5
XEE 503	Microprocessors and Microcontrollers	3	0	1	4	5
XEE E1*	Professional Elective - 1	3	0	0	3	3
X** OE*	Open Elective - 1	3	0	0	3	3
XUM 506	Constitution of India	3	0	0	3	3
XEE 507	In-plant Training - II	0	0	0	0	0
XEE M01	Minor Course - I	0	0	0	0	2
TOTAL		**18**	**1**	**3**	**22**	**27**

SEMESTER VI

Code No.	Course Title	L	T	P	C	TCH
XUM 601	Economics for Engineers	3	0	0	3	3
XEE 602	Power Systems - II (Operation and Control)	3	1	1	5	6
XEE E2*	Professional Elective - 2	3	0	1	4	5
XEE E3*	Professional Elective - 3	3	0	1	4	5
X** OE*	Open Elective - 2	3	0	0	3	3
XUM 606	Disaster Management	3	0	0	P/F*	3
XEE M02	Minor Course - II	0	0	0	0	2
TOTAL		**18**	**1**	**3**	**19**	**27**

*Pass / Fail course

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SEMESTER VII

Code No.	Course Title	L	T	P	C	TCH
XEE E4*	Professional Elective - 4	3	0	0	3	3
XEE E5*	Professional Elective - 5	3	0	0	3	3
XUM 703	Human Ethics, Values, Rights and Gender Equality	3	0	0	3	3
X** OE*	Open Elective - 3	3	0	0	3	3
X** OE*	Open Elective - 4	3	0	0	3	3
XEE 706	Project Phase - I	0	0	8	4	6
XEE 707	In-plant Training - III	-	-	4	2	-
XEE M03	Minor Course - III	0	0	0	0	2
TOTAL		**15**	**0**	**12**	**21**	**23**

SEMESTER VIII

Code No.	Course Title	L	T	P	C	TCH
XUM 801	Cyber Security	0	0	0	P/F	3
XEE E6*	Professional Elective - 6	3	0	0	3	3
X** OE*	Open Elective -5	3	0	0	3	3
XEE 804	Project Phase - II	0	0	12	6	16
TOTAL		**6**	**0**	**12**	**12**	**25**

OVER ALL CREDITS = 156 CREDITS

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MINOR (ONE CREDIT) COURSES:

Code No.	Course Title	L	T	P	C
OC1	Electrical Safety	1	0	0	1
OC2	Micro-grid	1	0	0	1
OC3	PLC programming	1	0	0	1
OC4	Energy Auditing	1	0	0	1
OC5	Programming with Arduino	1	0	0	1
OC6	Online MOOC Course	1	0	0	1

VALUE ADDED COURSES:

Code No.	Course Title
VAC1	Electrical System Design Using ETAP
VAC2	Electrical System Design Using HMI
VAC3	Auto CAD - Electrical
VAC4	Electrical System Design using PLC & SCADA
VAC5	Electrical System Design Using VFD
VAC6	Electrical System Design Using Internet of Things

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LIST OF ELECTIVES

ELECTIVE GROUP –1: (5th Sem)

Code No.	Course Title	L	T	P	C
E11	Protection and Switchgear	3	0	0	3
E12	Electrical Machine Design	3	0	0	3
E13	Electrical Safety, Operations and Regulations	3	0	0	3
E14	Computer Architecture	3	0	0	3

ELECTIVE GROUP – 2: (6th Sem)

Code No.	Course Title	L	T	P	C
E21	Measurements and Instrumentation	3	0	1	4
E22	Electromagnetic Waves	3	0	0	3
E23	Computational Electromagnetics	3	0	0	3
E24	Digital Control Systems	3	0	0	3

ELECTIVE GROUP –3: (6th Sem)

Code No.	Course Title	L	T	P	C
E31	Industrial Automation	3	0	1	4
E32	Digital Signal Processing	3	0	0	3
E33	Electrical Energy Conservation and Auditing	3	0	0	3
E34	Industrial Electrical Systems	3	0	0	3

ELECTIVE GROUP –4: (7th Sem)

Code No.	Course Title	L	T	P	C
E41	High Voltage Engineering	3	0	0	3
E42	Embedded System	3	0	0	3
E43	Power System Restructuring	3	0	0	3
E44	Line Commutated and Active Rectifiers	3	0	0	3

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ELECTIVE GROUP –5:(7th Sem)

Code No.	Course Title	L	T	P	C
E51	Electrical Drives	3	0	0	3
E52	Power System Dynamics and Control	3	0	0	3
E53	HVDC Transmission Systems	3	0	0	3
E54	Power Quality and FACTS	3	0	0	3

ELECTIVE GROUP - 6:(8th Sem)

Code No.	Course Title	L	T	P	C
E61	Electrical and Hybrid Vehicles	3	0	0	3
E62	Wind and Solar Systems	3	0	0	3
E63	Power System Protection	3	0	0	3
E64	Advanced Electric Drives	3	0	0	3

OPEN ELECTIVES:

Code No.	Course Title	L	T	P	C
OE1	Industrial Automation	3	0	0	3
OE2	Energy Management and Auditing	3	0	0	3
OE3	Renewable Energy Technology	3	0	0	3

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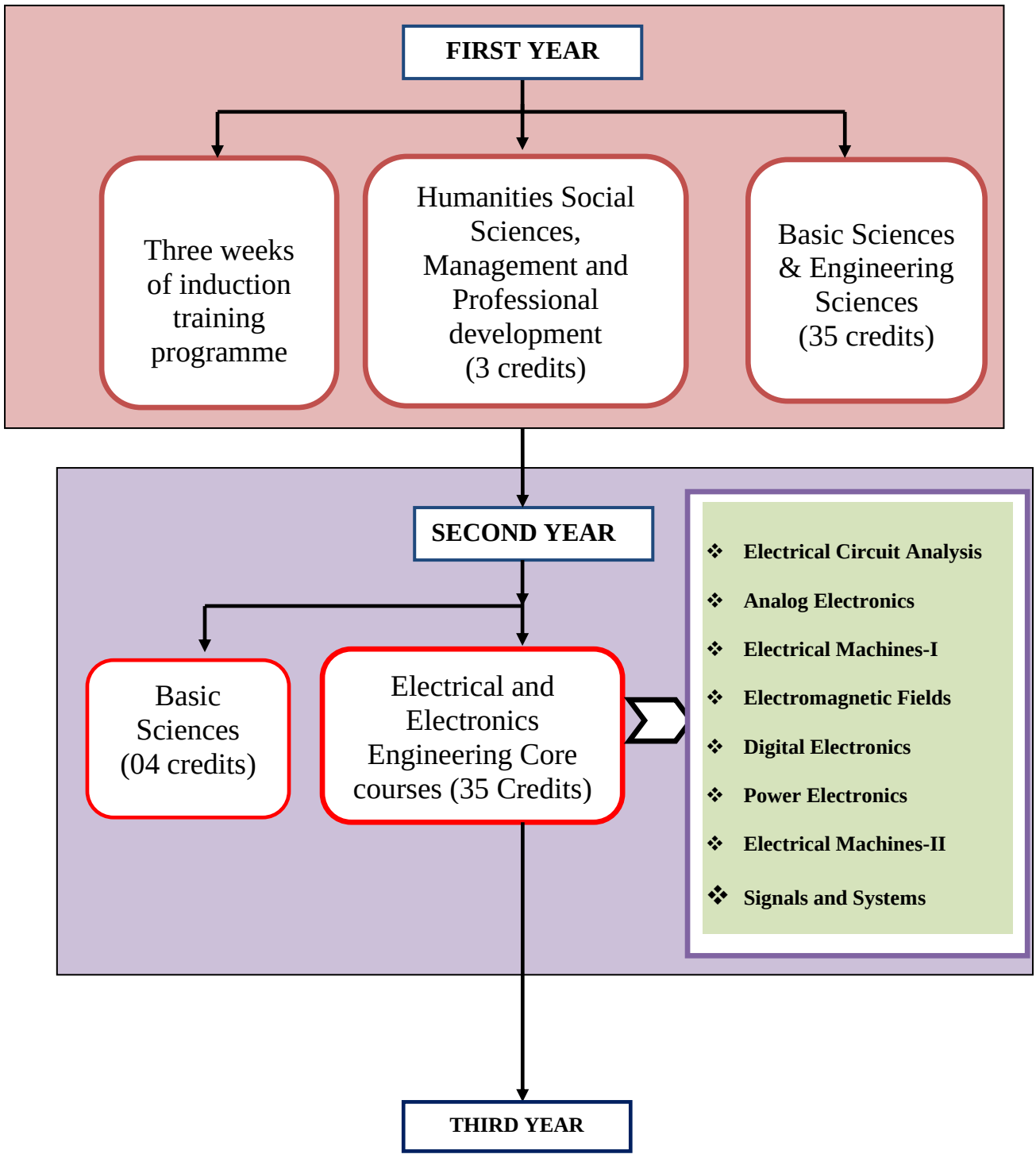
FLOW CHART FOR THE ENTIRE PROGRAMME



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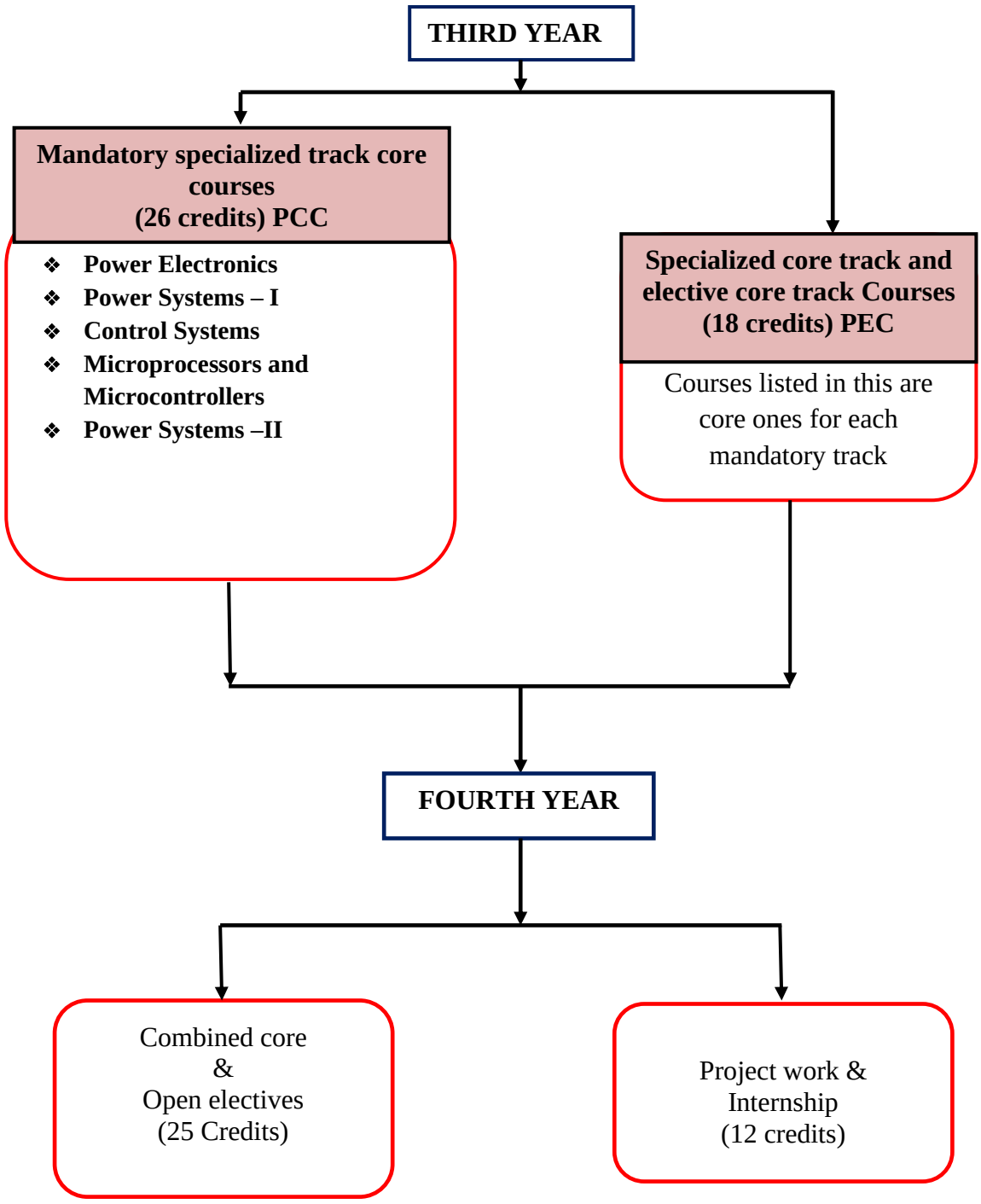

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SYLLABUS 2018

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SEMESTER I
CALCULUS AND LINEAR ALGEBRA

COURSE CODE			COURSE NAME	L	T	P	C
XMA101			CALCULUS AND LINEAR ALGEBRA	3	1	0	4
C	P	A		L	T	P	H
3	0.5	0.5		3	1	0	4

PREREQUISITE: Differentiation and Integration

Course Outcomes (XMA 101):		Domain	Level
CO1	**Apply** orthogonal transformation to reduce quadratic form to canonical forms.	Cognitive	Remembering Applying
CO2	**Apply** power series to tests the convergence of the sequences and series. Half range Fourier sine and cosine series.	Cognitive Psychomotor	Applying Remembering Guided Response
CO3	**Find** the derivative of composite functions and implicit functions. Euler's theorem and Jacobian	Cognitive Psychomotor	Remembering Guided Response
CO4	**Explain** the functions of two variables by Taylors expansion, by finding maxima and minima with and without constraints using Lagrangian Method. Directional derivatives, Gradient, Curl and Divergence.	Cognitive Affective	Remembering Understanding Receiving
CO5	**Apply** Differential and Integral calculus to notions of Curvature and to improper integrals.	Cognitive	Applying

UNIT -I: MATRICES	**9+3**
Linear Transformation - Eigen values and Eigen vectors -Properties of Eigen values and Eigen vectors - Cayley-Hamilton Theorem – Diagonalisation of Matrices – Real Matrices: Symmetric - Skew-Symmetric and Orthogonal Quadratic form – canonical form - Nature of Quadratic form and Transformation of Quadratic form to Canonical form (Orthogonal only).	
UNIT- II: SEQUENCES AND SERIES	**9+3**
Sequences: Definition and examples-Series: Types and convergence- Series of positive terms – Tests of convergence: Comparison test, Integral test and D'Alembert's ratio test-. Fourier series: Half range sine and cosine series- Parseval's Theorem.	
UNIT- III: MULTIVARIABLE CALCULUS: PARTIAL DIFFERENTIATION	**9+3**
Limit and continuity –Partial differentiation – Total Derivative – Partial differentiation of Composite Functions: Change of Variables – Differentiation of an Implicit Function - Euler's Theorem- Jacobian.	

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UNIT-IV: MULTIVARIABLE CALCULUS: MAXIMA AND MINIMA AND VECTOR CALCULUS	**9+3**
Taylor's theorem for function of Two variables- Maxima, Minima of functions of two variables: with and without constraints - Lagrange's Method of Undetermined Multipliers – Directional Derivatives - Gradient, Divergence and Curl.	
UNIT-V: DIFFERENTIAL AND INTEGRAL CALCULUS	**9+3**
Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.	

	LECTURE	**TUTORIAL**	**TOTAL**
	45	**15**	**60**

TEXT BOOKS

1. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill New Delhi, 11th Reprint, 2015**. (Unit-1, Unit-3 and Unit-4).**
2. N.P. Bali and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, Reprint, 2014. **(Unit-2).**
3. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 40th Edition,2010. **(Unit-5).**

REFERENCE BOOKS

1. G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", 9th Edition, Pearson Reprint, 2002.
2. Veerarajan T., "Engineering Mathematics for first year", Tata McGraw-Hill, New Delhi,2008.
3. D. Poole, "Linear Algebra: A Modern Introduction", 2nd Edition, Brooks/Cole, 2005.
4. Erwin kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons,2006.

Mapping of COs with GAs

	GA1	**GA2**	**GA3**	**GA4**	**GA5**	**GA6**	**GA7**	**GA8**	**GA9**	**GA10**	**GA11**	**GA12**
CO 1	3	2			2					1		2
CO 2	3	2								1		1
CO 3	3	2								1		1
CO 4	3	2								1		1
CO 5	3	2			1					1		2
Total	15	10	0	0	3	0	0	0	0	5	0	7
Scaled Value	3	2			1					1		2

$1 – 5 \rightarrow 1$, $6 – 10 \rightarrow 2$, $11 – 15 \rightarrow 3$

0 - No Relation 1 - Low Relation 2- Medium Relation 3- High Relation

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ENVIRONMENTAL SCIENCES

COURSE CODE	COURSE NAME	L	T	SS	P	C
XES 102	ENVIRONMENTAL SCIENCES	0	0	0	0	0
C:P: A		L	T	SS	P	H
1.4: 0.3: 0.3		3	0	0	0	3

Course Outcomes (XES102):		Domain	Level
CO1	**Describe** the significance of natural resources and **explain** anthropogenic impacts.	Cognitive	Remember Understand
CO2	**Illustrate** the significance of ecosystem, biodiversity and natural geo bio chemical cycles for maintaining ecological balance.	Cognitive	Understand
CO3	**Identify** the facts, consequences, preventive measures of major pollutions and **recognize** the disaster phenomenon	Cognitive Affective	Remember Receive
CO4	**Explain** the socio-economic, policy dynamics and **practice** the control measures of global issues for sustainable development.	Cognitive	Understand Apply
CO5	**Recognize** the impact of population and the concept of various welfare programs, and **apply** the modern technology towards environmental protection.	Cognitive	Understand Analysis

UNIT – I: INTRODUCTION TO ENVIRONMENTAL STUDIES AND ENERGY	**12**
Definition, scope and importance – Need for public awareness – Forest resources: Use, deforestation, case studies. – Water resources: Use and over-utilization of surface and ground water, dams-benefits and problems – Mineral resources: Uses, environmental effects of mining, case studies-iron mining(Goa), bauxite mining(Odisha) – Food resources: 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 – Role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles.	
UNIT – II: ECOSYSTEMS AND BIODIVERSITY	**7**
Concept of an ecosystem – Structure and function of an ecosystem – Producers, consumers and decomposers – Biogeochemical cycles – 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 ecosystem (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.	
UNIT – III: ENVIRONMENTAL POLLUTION	**10**
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 – Solid waste management– Role of an individual in prevention of pollution – Pollution case studies – Disaster management: flood, earthquake, cyclone and landslide.	

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UNIT –IV: SOCIAL ISSUES AND THE ENVIRONMENT	10
Rain water harvesting – Resettlement and rehabilitation of people; its problems and concerns, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents – Consumerism and waste products – Environment Protection Act – Air (Prevention and Control of Pollution) Act – Water (Prevention and control of Pollution) Act – Wildlife Protection Act – Forest Conservation Act – Public awareness.	
UNIT –V: HUMAN POPULATION AND THE ENVIRONMENT	**6**
Population growth, variation among nations – Population explosion– Environment and human health – HIV / AIDS– Role of Information Technology in Environment and human health.	

	LECTURE	TUTORIAL	PRACTICAL	SELF STUDY	TOTAL
	45	0	0	0	45

TEXT BOOKS

1. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co, USA, 2000.
2. Townsend C., Harper J and Michael Begon, Essentials of Ecology, Blackwell Science, UK, 2003
3. Trivedi R.K and P.K.Goel, Introduction to Air pollution, Techno Science Publications, India, 2003.
4. Disaster mitigation, Preparedness, Recovery and Response, SBS Publishers & Distributors Pvt. Ltd, New Delhi, 2006.
5. Introduction to International disaster management, Butterworth Heinemann, 2006.
6. 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 RESOURCES

1. http://www.e-booksdirectory.com/details.php?ebook=10526
2. https://www.free-ebooks.net/ebook/Introduction-to-Environmental-Science
3. https://www.free-ebooks.net/ebook/What-is-Biodiversity
4. https://www.learner.org/courses/envsci/unit/unit_vis.php?unit=4
5. http://bookboon.com/en/pollution-prevention-and-control-ebook
6. http://www.e-booksdirectory.com/details.php?ebook=8557
7. http://www.e-booksdirectory.com/details.php?ebook=6804
8. http://bookboon.com/en/atmospheric-pollution-ebook
9. http://www.e-booksdirectory.com/details.php?ebook=3749
10. http://www.e-booksdirectory.com/details.php?ebook=2604
11. http://www.e-booksdirectory.com/details.php?ebook=2116

12. http://www.e-booksdirectory.com/details.php?ebook=1026
13. http://www.faadooengineers.com/threads/7894-Environmental-Science

Mapping of COs with POs

	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
CO 1	3	3	3	2	1	1	1	1	1	0	0	1	2	2
CO 2	2	1	1	1	1	1	1	1	1	0	0	1	1	1
CO 3	2	1	3			3	1		2	1		1		
CO 4	1	1	2			3	2	3				1	1	1
CO 5	2	1	1			3						1		
Total	**10**	**3**	**6**	3	2	**11**	**4**	**3**	**2**	**2**	0	**5**	4	4
Scaled	2	1	2	1	1	3	1	1	1	1	0	1	1	1

1-5 → 1, 6-10 → 2, 11-15 → 3

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

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ELECTRICAL AND ELECTRONICS ENGINEERING SYSTEMS

COURSE CODE	COURSE NAME	L	T	P	C
XBE 103	ELECTRICAL AND ELECTRONICS ENGINEERING SYSTEMS	3	1	1	5
Prerequisites	**Physics**	**L**	**T**	**P**	**H**
C:P: A 3:1:0		3	1	2	6

Course Outcomes (XBE 103):		Domain	Level
CO1	**Define and Relate** the fundamentals of electrical parameters and **build** and **explain** AC, DC circuits by Using measuring devices	Cognitive Psychomotor	Remember Understand Mechanism
CO2	**Define and Explain** the operation of DC and AC machines.	Cognitive	Remember Understand
CO3	**Recall and Illustrate** various semiconductor devices and their applications and displays the input output characteristics of basic semiconductor devices.	Cognitive Psychomotor	Remember Understand Mechanism
CO4	**Relate and Explain the** number systems and logic gates. **Construc**t the different digital circuit.	Cognitive Psychomotor	Remember Understand Origination
CO5	**Label and Outline the** different types of microprocessors and their applications.	Cognitive	Remember Understand

UNIT-I: FUNDAMENTALS OF DC AND AC CIRCUITS, MEASUREMENTS	9+9+12

Fundamentals of DC– Ohm's Law – Kirchhoff's Laws - Sources - Voltage and Current Relations – Star/Delta Transformation - Fundamentals of AC – Average Value, RMS Value, Form Factor - AC power and Power Factor, Phasor Representation of sinusoidal quantities - Simple Series, Parallel, Series Parallel Circuit - Operating Principles of Moving coil and Moving Iron Instruments (Ammeter, Voltmeter) and Dynamometer type meters (Watt meter and Energy meter).

List of Experiments

1. Study of Electrical Symbols, Tools and Safety Precautions, Power Supplies.
2. Study of Active and Passive elements – Resistors, Inductors and Capacitors, Bread Board.
3. Verification of AC Voltage, Current and Power in Series and Parallel connection.
4. Testing of DC Voltage and Current in series and parallel resistors which are connected in breadboard by using Voltmeter, Ammeter and Multimeter.
5. Fluorescent lamp connection with choke.
6. Staircase Wiring.

UNIT -II: ELECTRICAL MACHINES	**9 + 6+0**
Construction, Principle of Operation, Basic Equations, Types and Application of DC Generators, DC motors - Basics of Single-Phase Induction Motor and Three Phase Induction Motor- Construction, Principle of Operation of Single-Phase Transformer, Three phase transformers, Auto transformer.	

UNIT- III: SEMICONDUCTOR DEVICES	**9 + 3+8**
Classification of Semiconductors, Construction, Operation and Characteristics: PN Junction Diode – Zener Diode, PNP, NPN Transistors, Field Effect Transistors and Silicon Controlled Rectifier – Applications. **List of Experiments** 5. Forward and Reverse bias characteristics of PN junction diode. 6. Forward and Reverse bias characteristics of zener diode. 7. Input and Output Characteristics of NPN transistor.	
UNIT- IV: DIGITAL ELECTRONICS	**9 + 6+10**
Basic of Concepts of Number Systems, Logic Gates, Boolean Algebra, Adders, Subtractors, multiplexer, demultiplexer, encoder, decoder, Flipflops, Up/Down counters, Shift Registers. **List of Experiments** 8. Construction and verification of simple logic gates. 9. Construction and verification of adders. 10. Construction and verification of subtractor.	
UNIT- V: MICROPROCESSORS	**9+ 6+0**
Architecture, 8085, 8086 - Interfacing Basics: Data transfer concepts – Simple Programming concepts	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

TEXT BOOKS

1. Metha V.K., 2008. Principles of Electronics. Chand and Company.
2. Malvino, A. P., 2006. Electronics Principles. 7th ed. New Delhi: Tata McGraw-Hill.
3. Rajakamal, 2007. Digital System-Principle & Design. 2nd ed. Pearson education.
4. Morris Mano, 1999. Digital Design. Prentice Hall of India.
5. Ramesh, S. Gaonkar, 2000, Microprocessor Architecture, Programming and its Applications with the 8085, 4th ed, India: Penram International Publications.

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1. Corton, H.,2004 Electrical Technology. CBS Publishers & Distributors.
2. Syed, A. Nasar, 1998, Electrical Circuits. Schaum Series.
3. Jacob Millman and Christos, C. Halkias, 1967, Electronics Devices, New Delhi: McGraw-Hill.
4. Millman, J. and Halkias, C. C., 1972. Integrated Electronics: Analog and Digital Circuits and Systems, Tokyo: McGraw-Hill, Kogakusha Ltd.
5. Mohammed Rafiquzzaman, 1999. Microprocessors - Theory and Applications: Intel and Motorola. Prentice Hall International.

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E-REFERENCES

1. NTPEL, Basic Electrical Technology (Web Course), Prof. N. K. De, Prof. T. K. Bhattacharya and Prof. G.D. Roy, IIT Kharagpur.
2. Prof.L.Umanand, http://freevideolectures.com/Course/2335/Basic-Electrical-Technology#, IISc Bangalore.
3. http://nptel.ac.in/Onlinecourses/Nagendra/, Dr. Nagendra Krishnapura, IIT Madras.
4.Dr.L.Umanand, http://www.nptelvideos.in/2012/11/basic-electrical-technology.html, IISC Bangalore.

Mapping of COs with POs

	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
CO 1	3	3	1	1	1	1			1	1	1		3	3
CO 2	3	3	1	1	1	1			1	1	1		3	3
CO 3	2	2	2	1	2	2	1	1	1	1	1		3	3
CO 4	2	2	1	1	1	1	1	1	1	1	1		3	3
CO 5	2	2	1	1	1	1	1	1	1	1	1		3	3
Total	12	12	6	5	6	6	3	3	5	5	5		15	15
Scaled	3	3	2	1	2	2	1	1	1	1	1		5	5

1-5 → 1, 6-10 → 2, 11-15 → 3

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

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APPLIED PHYSICS FOR ENGINEERS

COURSE CODE	COURSE NAME	L	T	P	C
XAP 104	APPLIED PHYSICS FOR ENGINEERS	3	1	2	6
C:P: A 2.8:0.8:0.4		L	T	P	H
PREREQUISITE:	Basic Physics in HSC level	3	1	4	8

Course Outcomes (XAP104):		Domain	Level
CO1	**Identify** the basics of mechanics, **explain** the principles of elasticity and **determine** its significance in engineering systems and technological advances.	Cognitive Psychomotor	Remember, Understand Mechanism
CO2	**Illustrate** the laws of electrostatics, magneto-statics and electromagnetic induction; **use** and **locate** basic applications of electromagnetic induction to technology.	Cognitive Psychomotor Affective	Remember, Analyze, Mechanism Respond
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	Understand, Apply Mechanism Receive
CO4	**Analyze** energy bands in solids, **discuss** and **use** physics principles of latest technology using semiconductor devices.	Cognitive Psychomotor Affective	Understand, Analyze Mechanism Receive
CO5	**Develop** Knowledge on particle duality and **solve** Schrodinger equation for simple potential.	Cognitive	Understand, Apply

UNIT - I: MECHANICS OF SOLIDS	**9+3+9**
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.	
UNIT -II: ELECTROMAGNETIC THEORY	**9+3+3**
Laws of electrostatics - Electrostatic field and potential of a dipole; Dielectric Polarization, Dielectric constant, internal field - Clausius Mossotti Equation - Laws of magnetism - Ampere's Faraday's law; Lenz's law - Maxwell's equation - Plane electromagnetic waves; their transverse nature - expression for plane, circularly and elliptically polarized light - quarter and half wave plates - production and detection of plane, circularly and elliptically polarized light.	
UNIT –III: OPTICS, LASERS AND FIBRE OPTICS	**9+3+12**
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.	

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LASER: Introduction - Population inversion -Pumping - Laser action - Nd-YAG laser - CO_2 laser – Applications **Fiber Optics:** Principle and propagation of light in optical fiber - Numerical aperture and acceptance angle - Types of optical fiber - Fiber optic communication system (Block diagram).

UNIT –IV: SEMICONDUCTOR PHYSICS	**9+3+6**

Semiconductors: Energy bands in solids - Energy band diagram of good conductors, insulators and semiconductors - Concept of Fermi level - Intrinsic semiconductors - Concept of holes - doping - Extrinsic semiconductors - P type and N type semiconductors - Hall effect.

Diodes and Transistors: P-N junction diode - Forward bias and reverse bias - Rectification action of diode - Working of full wave rectifier using P N junction diodes - PNP and NPN transistors - Three different configurations - Advantages of common emitter configuration - working of NPN transistor as an amplifier in common emitter configuration.

UNIT –V: QUANTUM PHYSICS	**9+3+0**

Introduction to quantum physics, black body radiation, Compton effect, de Broglie hypothesis, wave – particle duality, uncertainty principle, Schrodinger wave equation (Time dependent and Time independent), particle in a box, Extension to three dimension - Degeneracy.

TEXT BOOKS

1. Gaur R. K. and Gupta S. L., "Engineering Physics", Dhanpat Rai Publications, 2009.
2. Avadhanulu M. N. "Engineering Physics" (Volume I and II), S. Chand & Company Ltd., New Delhi, 2010.

REFERENCE BOOKS

1. Palanisamy P. K., "Engineering Physics", Scitech Publications (India) Pvt. Ltd, Chennai.
2. Arumugam M., "Engineering Physics" (Volume I and II), Anuradha Publishers, 2010.
3. Senthil Kumar G., "Engineering Physics", 2nd Enlarged Revised Edition, VRB Publishers, Chennai, 2011.
4. Mani P., "Engineering Physics", Dhanam Publications, Chennai, 2007.

E RESOURCES

NPTEL, Engineering Physics, Prof. M. K. Srivastava, Department of Physics, IIT, Roorkee.

LABORATORY

1.	Torsional Pendulum - determination of moment of inertia and rigidity modulus of the given material of the wire.
2.	Uniform Bending - Determination of the Young's Modulus of the material of the beam.
3.	Non-Uniform Bending - Determination of the Young's Modulus of the material of the beam.
4.	Meter Bridge - Determination of specific resistance of the material of the wire.
5.	Spectrometer - Determination of dispersive power of the give prism.
6.	Spectrometer - Determination of wavelength of various colours in Hg source using grating.
7.	Air wedge - Determination of thickness of a given thin wire.
8.	Laser - Determination of wavelength of given laser source and size of the given micro particle using Laser grating.

9.	Post office Box - Determination of band gap of a given semiconductor.
10.	PN Junction Diode - Determination of V-I characteristics of the given diode.

REFERENCE BOOKS

1. Samir Kumar Ghosh, "A text book of Advanced Practical Physics", New Central Agency (P) Ltd, 2008.
2. Arora C.L., "Practical Physics", S. Chand & Company Ltd., New Delhi, 2013.
3. Umayal Sundari AR., "Applied Physics Laboratory Manual", PMU Press, Thanjavur, 2012.

	LECTURE	TUTORIAL	PRACTICAL	TOTAL
	45	15	30	90

Mapping of COs with POs

	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
CO 1	3	2	2	1					1			1	3	2
CO 2	3		1		1							1	3	3
CO 3	3	2	2	2	1				1			1		
CO 4	3	2	2	2	1				1			1	2	3
CO 5	3		2									1		
Total	15	6	9	6	4				3			5	8	8
Scaled	3	2	2	2	1				1			1	2	2

1-5 → 1, 6-10 → 2, 11-15 → 3

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

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ENGINEERING GRAPHICS

COURSE CODE			COURSE NAME	L	T	P	C
XEG 105			ENGINEERING GRAPHICS	2	0	1	3
C	P	A		L	T	P	H
1.75	1	0.25		2	0	2	4

PREREQUISITE: NIL

Course outcomes:		Domain	Level
CO1	Apply the national and international standards, construct and practice various curves	Cognitive, Psychomotor Affective	Applying, Guided response and Responds to Phenomena
CO2	Interpret, construct and practice orthographic projections of points, straight lines and planes.	Cognitive Psychomotor Affective	Understanding, Mechanism and Responds to Phenomena
CO3	Construct Sketch and Practice projection of solids in various positions and true shape of sectioned solids.	Cognitive Psychomotor Affective	Applying, Complex Overt Response and Responds to Phenomena
CO4	Interpret, Sketch and Practice the development of lateral surfaces of simple and truncated solids, intersection of solids.	Cognitive Psychomotor Affective	Understanding, Complex Overt Response and Responds to Phenomena
CO5	Construct sketch and practice isometric and perspective views of simple and truncated solids.	Cognitive Psychomotor Affective	Applying, Complex Overt Response and Responds to Phenomena

UNIT-I: INTRODUCTION, FREE HAND SKETCHING OF ENGG. OBJECTS AND CONSTRUCTION OF PLANE CURVE	**6+6**

Importance of graphics in engineering applications – use of drafting instruments – BIS specifications and conventions as per SP 46-2003.Pictorial representation of engineering objects – representation of three-dimensional objects in two-dimensional media – need for multiple views – developing visualization skills through free hand sketching of three-dimensional objects. Polygons & curves used in engineering practice – methods of construction – construction of ellipse, parabola and hyperbola by eccentricity method – cycloidal and involute curves – construction – drawing of tangents to the above curves.

UNIT –II: PROJECTION OF POINTS, LINES AND PLANE SURFACES	**6+6**

General principles of orthographic projection – first angle projection – layout of views – projections of points, straight lines located in the first quadrant – determination of true lengths

of lines and their inclinations to the planes of projection – traces – projection of polygonal surfaces and circular lamina inclined to both the planes of projection.
UNIT-III: PROJECTION OF SOLIDS AND SECTIONS OF SOLIDS **6+6**
projection of simple solids like prism, pyramid, cylinder and cone when the axis is inclined to one plane of projection – change of position & auxiliary projection methods – sectioning of above solids in simple vertical positions by cutting plane inclined to one reference plane and perpendicular to the other and above solids in inclined position with cutting planes parallel to one reference plane – true shapes of sections.

UNIT –IV: DEVELOPMENT OF SURFACES AND INTERSECTION OF SOLIDS **6+6**
Need for development of surfaces – development of lateral surfaces of simple and truncated solids – prisms, pyramids, cylinders and cones – development of lateral surfaces of the above solids with square and circular cutouts perpendicular to their axes – intersection of solids and curves of intersection –prism with cylinder, cylinder & cylinder, cone & cylinder with normal intersection of axes and with no offset
UNIT -V: ISOMETRIC AND PERSPECTIVE PROJECTIONS **6+6**
Principles of isometric projection – isometric scale – isometric projections of simple solids, truncated prisms, pyramids, cylinders and cones – principles of perspective projections – projection of prisms, pyramids and cylinders by visual ray and vanishing point methods.

	THEORY	PRACTICAL	TOTAL
	30	30	60

TEXT BOOKS

1. Bhatt,N.D, “Engineering Drawing”, Charotar Publishing House, 46th Edition-2003.
2. Natarajan,K.V, “ A Textbook of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2006 .
3. Dr. P.K. Srividhya, P. Pandiyaraj, “Engineering Graphics”, PMU Publications, Vallam, 2013

REFERENCES

1. Luzadder and Duff, “Fundamentals of Engineering Drawing” Prentice Hall of India PvtLtd, XI Edition - 2001.
2. Venugopal,K. and Prabhu Raja, V., “Engineering Graphics”, New Age International(P) Ltd., 2008.
3. Gopalakrishnan.K.R,. “Engineering Drawing, I & II”, SUBJECThas Publications, 1998.
4. Shah,M.B and Rana,B.C.,”Engineering Drawing”, Pearson Education,2005.

E RESOURCES

1. http://periyarnet/Econtent
2. http://nptel.ac.in/courses/112103019/

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Mapping of COs with POs

	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
CO 1	3	2	3	1	1	0	0	0	0	0	0	1	3	2
CO 2	3	2	1	1	1	0	0	0	0	0	0	1	3	3
CO 3	3	2	1	1	1	0	0	0	0	0	0	1	3	3
CO 4	3	2	1	1	1	0	0	0	0	0	0	1	3	3
CO 5	3	2	1	1	1	0	0	0	0	0	0	1	3	3
Total	15	10	7	5	5	0	0	0	0	0	0	5	15	15
Scaled value	3	2	2	1	1	0	0	0	0	0	0	1	3	3

1-5 → 1, 6-10 → 2, 11-15 → 3

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

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SEMESTER II
CALCULUS, ORDINARY DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLE

COURSE CODE	COURSE NAME	L	T	P	C
XMA 201	CALCULUS, ORDINARY DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLE	3	1	0	4

C	P	A		L	T	P	H
3	0	0		3	1	0	4

PREREQUISITE: Mathematics I (Calculus and Linear Algebra)

Course outcomes:		Domain	Level
CO1	**Find** double and triple integrals and to find line, surface and volume of an integral by **Applying** Greens, Gauss divergence and Stokes theorem.	Cognitive	Applying Remembering
CO2	**Solve** first order differential equations of different types which are solvable for p, y, x and Clairaut's type.	Cognitive	Applying
CO3	**Solve** Second order ordinary differential equations with variable coefficients using various methods.	Cognitive	Remembering
CO4	**Use** CR equations to verify analytic functions and to find harmonic functions and harmonic conjugate. Conformal mapping of translation and rotation. Mobius transformation.	Cognitive Psychomotor	Understanding Remembering Guided Response
CO5	**Apply** Cauchy residue theorem to evaluate contour integrals involving sine and cosine function and to state Cauchy integral formula, Liouvilles theorem. Taylor's series, zeros of analytic functions, singularities, Laurent's series.	Cognitive Affective	Applying Receiving

UNIT -I: MULTIVARIABLE CALCULUS (INTEGRATION)	**12**
Multiple Integration: Double integrals (Cartesian) - change of order of integration in double integrals - Change of variables (Cartesian to polar) - Triple integrals (Cartesian), Scalar line integrals - vector line integrals - scalar surface integrals - vector surface integrals - Theorems of Green, Gauss and Stokes.	
UNIT-II: FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS	**12**
Exact - linear and Bernoulli's equations - Euler's equations - Equations not of first degree: equations solvable for p - equations solvable for y- equations solvable for x and Clairaut's type.	
UNIT-III: ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDERS	**12**
Second order linear differential equations with variable coefficients- method of variation of parameters - Cauchy-Euler equation- Power series solutions- Legendre polynomials- Bessel functions of the first kind and their properties.	

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UNIT-IV: COMPLEX VARIABLE – DIFFERENTIATION	**12**
Differentiation-Cauchy-Riemann equations- analytic functions-harmonic functions-finding harmonic conjugate- elementary analytic functions (exponential, trigonometric, logarithm) and their properties- Conformal mappings- Mobius transformations and their properties.	
UNIT-V: COMPLEX VARIABLE – INTEGRATION	**12**
Contour integrals - Cauchy-Goursat theorem (without proof) - Cauchy Integral formula (without proof)- Liouville's theorem (without proof)- Taylor's series- zeros of analytic functions- singularities- Laurent's series – Residues- Cauchy Residue theorem (without proof)- Evaluation of definite integral involving sine and cosine- Evaluation of certain improper integrals using the Bromwich contour.	

	LECTURE	**TUTORIAL**	**TOTAL**
	45	**15**	**60**

TEXT BOOKS

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 40thth Edition, 2008.

REFERENCE BOOKS

1.G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", 9th Edition, Pearson, Reprint, 2002.
2. Erwin kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2006.
3.W. E. Boyce and R. C. DiPrima, "Elementary Differential Equations and Boundary Value Problems", 9thEdn. Wiley India, 2009.
4. S. L. Ross, "Differential Equations", 3rd Ed., Wiley India, 1984.
5.E. A. Coddington, "An Introduction to Ordinary Differential Equations", Prentice Hall India, 1995.
6. E. L. Ince, "Ordinary Differential Equations", Dover Publications, 1958.
7.J. W. Brown and R. V. Churchill, "Complex Variables and Applications", 7th Ed., McGraw Hill, 2004.
8. N.P. Bali and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, Reprint, 2008.

Mapping of COs with GAs

	GA1	**GA2**	**GA3**	**GA4**	**GA5**	**GA6**	**GA7**	**GA8**	**GA9**	**GA10**	**GA11**	**GA12**
CO 1	3	2			2					1		2
CO 2	3	1								1		1
CO 3	3	1								1		1
CO 4	3	2								1		1
CO 5	3	2			1					1		2
Total	15	8	0	0	3	0	0	0	0	5	0	7
Scaled	3	2			1					1		

$1 – 5 \rightarrow 1$, $6 – 10 \rightarrow 2$, $11 – 15 \rightarrow 3$

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

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PROGRAMMING FOR PROBLEM SOLVING

COURSE CODE	COURSE NAME	L	T	P	C
XCP 202	PROGRAMMING FOR PROBLEM SOLVING	3	0	2	5
PREREQUISITES		**L**	**T**	**P**	**H**
C:P: A 3:1:1		3	0	4	7

Course Outcomes		Domain	Level
CO1	**Define** programming fundamentals and **Solve** simple programs using I/O statements	Cognitive Psychomotor	Remember Understand Apply
CO2	**Define** syntax and **write simple programs** using control structures and arrays	Cognitive Psychomotor	Remember Understand Apply
CO3	**Explain** and **write simple programs** using functions and pointers	Cognitive Psychomotor	Understand Apply
CO4	**Explain** and **write simple programs** using structures and unions	Cognitive Psychomotor	Understand Apply Analyze
CO5	**Explain** and **write simple programs** using files and **Build** simple projects	Cognitive Psychomotor	Remember Understand Create

UNIT- I: PROGRAMMING FUNDAMENTALS AND INPUT/ OUTPUT STATEMENTS — 9+6

Theory

Introduction to components of a computer system, Program–Flowchart– Pseudocode–Software– Introduction to C language–Character set–Tokens: Identifiers, Keywords, Constants, and Operators– sample program structure-Header files – Data Types-Variables- Output statements –Input statements.

Practical

1.Program to display a simple picture using dots.
2.Program for addition of two numbers
3.Program to swap two numbers
4.Program to solve any mathematical formula.

UNIT- II: CONTROL STRUCTURE AND ARRAYS — 9+6

Theory

Control Structures–Conditional Control statements: Branching, Looping-Unconditional control structures: switch, break, continue, goto statements– Arrays: One Dimensional Array–Declaration–Initialization–Accessing Array Elements–Searching–Sorting–Two Dimensional Arrays-Declaration –

Initialization– Matrix Operations – Multi Dimensional Arrays-Declaration– Initialization. Storage classes: auto–extern–static. Strings: Basic operations on strings.

Practical

1. Program to find greatest of 3 numbers using Branching Statements
2. Program to display divisible numbers between n1and n2 using looping Statement
3. Program to remove duplicate element in an array.
4. Program to perform string operations.

Performing basic sorting algorithms

UNIT- III: FUNCTIONS AND POINTERS	**9+6**

Theory

Functions: Built in functions–User Defined Functions-Parameter passing methods-Passing arrays to functions–Recursion-Programs using arrays and functions. Pointers-Pointer Declaration-Address Operator-Pointer expressions & pointer arithmetic-Pointers and function-Call by value-Call by Reference-Pointer to arrays-Use of Pointers in self-referential structures-Notion of linked list (no implementation).

Practical

1.Program to find factorial of a given number using four function types.
2.Programs using Recursion such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort
3.Programs using Pointers

UNIT -IV: STRUCTURES AND UNION	**9+6**

Theory

Structures and Unions -Giving values to members-Initializing Structure-Functions and structures-Passing structure to elements to functions- Passing entire function to functions- Arrays of structure - Structure within a structure and Union.

Practical

1.Program to read and display student mark sheet Structures with variables
2.Program to read and display student marks of a class using Structures with arrays
3.Program to create linked list using Structures with pointers

UNIT- V: FILES	**9+6**

Theory

File management in C-File operation functions in C-Defining and opening a file- Closing a file-The getw and putw functions- The fprintf & fscanf functions - fseek function– Files and Structures.

Practical

1.Program for copying contents of one file to another file.
2.Program using files using structure with pointer

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**30**	**75**

TEXT BOOKS/ REFERENCES

1.ByronGottfried,"ProgrammingwithC", III Edition, (Indian Adapted Edition), TMH publications, 2010
2. Yeshwant Kanethker, "Let us C", BPB Publications, 2008

3. Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language", Pearson Education Inc. 2005
4. Behrouz A. Forouzan and Richard. F. Gilberg,"A Structured Programming Approach Using C", II Edition, Brooks–Cole Thomson Learning Publications, 2001
5. Johnsonbaugh R. and Kalin M., "Applications Programming in ANSIC", III Edition, Pearson Education India, 2003
6. E. Balaguruswamy, Programming in ANSIC, Tata McGraw-Hill

Mapping of COs with POs

	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
CO 1	2	2	2	2	1								1	0
CO 2	2	-	2	1								1		1
CO 3	2							1						1
CO 4	2	2	2		1	1	1			1				
CO 5	2							1		1				
Total	10	4	6	3	2	1	1	2		2		1	1	2
Scaled	2	1	2	1	1	1	1	1	0	1	0	1	1	1

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

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ENGLISH

COURSE CODE	COURSE NAME	L	T	P	SS	C
XGS 203	ENGLISH	2	0	1	0	3
Pre-requisites (if any)		L	T	P	SS	H
C: P: A 2.6:0.4:0		2	0	2	0	4

Course Outcomes (XGS 203):		Domain	Level
CO1	**Ability** to recall the meaning for proper usage	Cognitive	Remember
CO2	**Apply** the techniques in sentence patterns	Cognitive	Apply
CO3	**Identify** the common errors in sentences	Cognitive	Remember
CO4	**Construct** the Nature and Style of sensible Writing	Cognitive	Create
CO5	**Practicing** the writing skills	Psychomotor	Guided Response
CO6	**Grasping** the techniques in learning sounds and etiquettes	Psychomotor	Adapting

UNIT -I: VOCABULARY BUILDING	**9**
1.1 The concept of Word Formation 1.2 Root words from foreign languages and their use in English 1.3 Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives 1.4 Synonyms, antonyms, and standard abbreviations.	
UNIT -II: BASIC WRITING SKILLS	**9**
2.1 Sentence Structures 2.2 Use of phrases and clauses in sentences 2.3 Importance of proper punctuation 2.4 Creating coherence 2.5 Organizing principles of paragraphs in documents 2.6 Techniques for writing precisely	
UNIT -III: IDENTIFYING COMMON ERRORS IN WRITING	**9**
3.1 subject-verb agreement 3.2 Noun-pronoun agreement 3.3 Misplaced modifiers 3.4 Articles 3.5 Prepositions 3.6 Redundancies 3.7 Clichés	
UNIT -IV: NATURE AND STYLE OF SENSIBLE WRITING	**9**
4.1 Describing 4.2 Defining 4.3 Classifying 4.4 Providing examples or evidence 4.5 Writing introduction and conclusion	

UNIT -V: WRITING PRACTICES	**9**
5.1 Comprehension 5.2 Précis Writing 5.3 Essay Writing	
UNIT VI - ORAL COMMUNICATION (This unit involves interactive practice sessions in Language Lab) • Listening Comprehension • Pronunciation, Intonation, Stress and Rhythm • Common Everyday Situations: Conversations and Dialogues • Communication at Workplace • Interviews • Formal Presentations	

	LECTURE	**PRACTICAL**	**TOTAL**
	30	**30**	**60**

Suggested Readings:

(i) Practical English Usage. Michael Swan. OUP. 1995
(ii) Remedial English Grammar. F.T. Wood. Macmillan.2007
(iii) On Writing Well. William Zinsser. Harper Resource Book. 2001
(iv) Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006
(v) Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011
(vi) Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Mapping of COs with POs

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O 1**	**PSO 2**
CO1	2	0	0	0	0	0	2	0	1	0	0	0	0	0
CO2	2	0	0	0	0	0	2	0	1	0	0	0	0	0
CO3	1	0	0	0	0	0	1	0	1	0	0	0	0	0
CO4	2	0	0	0	0	0	1	0	1	0	0	0	0	0
CO5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7	0	0	0	0	0	6	0	4	0	0	0	0	0
Scaled	2	0	0	0	0	0	2	0	1	0	0	0	0	0

1-5= 1, 6-10 = 2, 11-15= 3

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

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APPLIED CHEMISTRY FOR ENGINEERS

COURSE CODE	COURSE NAME	L	T	P	C
XAC 204	APPLIED CHEMISTRY FOR ENGINEERS	3	1	1	5
PREREQUISITES	Nil	L	T	P	H
C:P: A		3	1	2	6
3.5:1.0:0.5					

Course Outcomes (XAC 204):		Domain	Level
CO1	**Identify**the periodic properties such as ionization energy, electron affinity, oxidation states and electro negativity. **Describe** the various water quality parameters like hardness and alkalinity.	Cognitive Psychomotor	Remember Perception
CO2	**Explain** and **Measure** microscopic chemistry in terms of atomic, molecular orbitals and intermolecular forces.	Cognitive Psychomotor	Understand Set
CO3	**Interpret** bulk properties and processes using thermodynamic and kinetic considerations.	Cognitive Psychomotor Affective	Apply Mechanism Receive
CO4	**Describe, Illustrate** and **Discuss** the chemical reactions that are used in the synthesis of molecules.	Cognitive Psychomotor Affective	Remember Analyze Perception Respond
CO5	**Apply, Measure** and **Distinguish** the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques	Cognitive Psychomotor	Remember Apply Mechanism

UNIT – I: PERIODIC PROPERTIES AND WATER CHEMISTRY	8+3+6
Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries. **Water Chemistry**-Water quality parameters-Definition and explanation of hardness, determination of hardness by EDTA method-Introduction to alkalinity.	
UNIT–II: USE OF FREE ENERGY IN CHEMICAL EQUILIBRIA	**12+3+6**
Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Corrosion-Types, factors affecting corrosion rate and Control methods. Use of free energy considerations in metallurgy through Ellingham diagrams. Advantages of electroless plating, electroless plating of nickel and copper on Printed Circuit Board (PCB).	

UNIT–III: ATOMIC AND MOLECULAR STRUCTURE	**10+3+6**

Schrodinger equation. Particle in a box solution and their applications for conjugated molecules and nanoparticles. Molecular orbitals of diatomic molecules and plots of the multicenter orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic molecules. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Intermolecular forces and potential energy surfaces

Ionic, dipolar and Vander waals interactions. Equations of state of real es and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

UNIT-IV: SPECTROSCOPIC TECHNIQUES AND APPLICATIONS	**7+3+6**

Principles of spectroscopy and selection rules. Electronic spectroscopy-chromophore, auxochromes, types of electronic transition and application. Fluorescence and its applications in medicine. Vibrational spectroscopy-types of vibrations, Instrumentation and applications. Rotational spectroscopy of diatomic molecules. Nuclear magnetic resonance spectroscopy-concept of chemical shift and applications-magnetic resonance imaging. Diffraction and scattering.

UNIT–V: STEREOCHEMISTRY AND ORGANIC REACTIONS	**8+3+6**

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

Organic reactions and synthesis of a drug molecule

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization reactions and ring opening reactions. Synthesis of a commonly used drug molecule- Aspirin and paracetamol.

	LECTURE	TUTORIAL	PRACTICAL	TOTAL
	45	15	30	90

TEXT BOOKS

1. Puri B.R. Sharma, L.R., Kalia K.K. Principles of Inorganic Chemistry, (23rd edition), New Delhi, Shoban Lal Nagin Chand & Co., 1993
2. Lee. J.D. Concise Inorganic Chemistry, UK, Black well science, 2006.
3. Trapp. C, Cady, M. Giunta. C, Atkins's Physical Chemistry, 10th Edition, Oxford publishers, 2014.
4. Glasstone S., Lewis D., Elements of Physical Chemistry, London, Mac Millan & Co. Ltd, 1983.
5. Morrison R.T. and Boyd R.N. Organic Chemistry (6th edition), New York, Allyn & Bacon Ltd., 1976.
6. Banwell. C.N, Fundamentals of Molecular Spectroscopy, (3th Edition), McGraw-Hill Book Company, Europe 1983.
7. Bahl B.S. and Arun Bahl, Advanced Organic Chemistry, (4th edition), S./ Chand & Company Ltd. New Delhi, 1977.
8. P. S. Kalsi, Stereochemistry: Conformation and mechanism, (9th Edition), New Age International Publishers, 2017.

REFERENCE BOOKS

1. Puri B R Sharma L R and Madan S Pathania, "Principles of Physical Chemistry", Vishal publishing Co., Edition 2004

2. Kurioe, 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 COs with POs

	PO1	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	0	0	0	0	0	2	3	3	0	0	0	1	2
CO2	2	0	0	0	0	0	1	2	2	0	0	0	1	1
CO3	3	0	0	0	0	0	2	3	3	0	0	0	0	0
CO4	3	0	0	0	0	0	3	3	3	0	0	0	0	0
CO5	3	0	0	0	0	0	2	2	3	0	0	0	0	0
Total	14	0	0	0	0	0	10	13	14	0	0	0	2	3
Scaled	3	0	0	0	0	0	2	3	3	0	0	0	1	1

1 – 5 →1, 6 – 10→ 2, 11 – 15→ 3

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

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WORKSHOP PRACTICES

COURSE CODE			COURSE NAME	L	T	P	C
XWP 205			WORKSHOP PRACTICES	1	0	2	3
C	P	A		L	T	P	H
1	2	0		1	0	4	5

PREREQUISITE:

Course outcomes:		Domain	Level
CO1	**Summarize** the machining methods and **Practice** machining operation.	Cognitive Psychomotor	Understanding Guided response
CO2	**Defining** metal casting process, moulding methods and **relates** Casting and Smithy applications.	Cognitive Psychomotor	Remembering Perception
CO:	**Plan** basic carpentry and fitting operation and **Practice** carpentry and fitting operations.	Cognitive Psychomotor	Applying Guided response
CO4	**Summarize** metal joining operation and **Practice** welding operation.	Cognitive Psychomotor	Understanding Guided response
CO5	**Illustrate** the, electrical and electronics basics and **Makes** appropriate connections**.**	Cognitive Psychomotor	Understanding Origination

COURSE CONTENT

EXP.NO.	TITLE	CO RELATION
1	Introduction to machining process	CO1
2	Plain turning using lathe operation	CO1
3	Introduction to CNC	CO1
4	Demonstration of plain turning using CNC	CO1
5	Study of metal casting operation	CO2
6	Demonstration of moulding process	CO2
7	Study of smithy operation	CO2
8	Study of carpentry tools	CO3
9	Half lap joint – Carpentry	CO3
10	Mortise and Tenon joint – Carpentry	CO3
11	Study of fitting tools	CO3
12	Square fitting	CO3
13	Triangular fitting	CO3
14	Study of welding tools	CO4
15	Square butt joint - welding	CO4
16	Tee joint – Welding	CO4
17	Introduction to house wiring	CO5

18	One lamp controlled by one switch		CO5
19	Two lamps controlled by single switch		CO5
20	Staircase wiring		CO5
	LECTURE	**PRACTICAL**	**TOTAL**
	15	**60**	**75**

TEXT BOOKS

1. Workshop Technology I, II, III, by S K Hajra, Choudhary and A K Chaoudhary. Media Promoters and Publishers Pvt. Ltd., Bombay
2. Workshop Technology by Manchanda Vol. I, II, III India Publishing House, Jalandhar.

REFERENCES

1. Manual on Workshop Practice by K Venkata Reddy, KL Narayana et al; MacMillan India Ltd.
2. Basic Workshop Practice Manual by T Jeyapoovan; Vikas Publishing House (P) Ltd.,New Delhi
3. Workshop Technology by B.S. Raghuwanshi, Dhanpat Rai and Co., New Delhi.
4. Workshop Technology by HS Bawa, Tata McGraw Hill Publishers, New Delhi.

E RESOURCES

1. **http://nptel.ac.in/courses/112107145/**

Mapping of COs with POs

	PO1	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	3	0	2	3	0	0	0	0	0	0	0	2	2
CO2	2	1	1	2	2	0	0	0	0	0	0	0	1	1
CO3	1	2	0	3	2	0	0	0	1	0	1	0	1	1
CO4	1	2	0	2	2	0	0	0	0	0	0	0	2	1
CO5	2	2	0	2	2	0	0	0	0	0	0	0	1	2
Total	9	10	1	11	11	0	0	0	14	0	1	0	7	7
Scaled	2	2	1	3	0	0	0	0	3	0	1	0	2	2

1 – 5 →1, 6 – 10→ 2, 11 – 15→ 3

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

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SEMESTER III
ELECTRICAL CIRCUIT ANALYSIS

Course Outcomes (XEE 301):		Domain	Level
CO1	Apply network theorems for the analysis of electrical circuits. Respond network theorems for the analysis of electrical circuits.	Cognitive Psychomotor	Apply Guided Response
CO2	Comparing the transient and steady-state response of R, RL and RLC electrical circuits. Describe the transient and steady-state response of RL and RC electrical circuits.	Cognitive Psychomotor	Understand Perception
CO3	Analyze circuits in the sinusoidal steady-state (single-phase and three-phase). Construct and analyze of Single-phase transformer for its Sinusoidal response	Cognitive Psychomotor	Analyze Mechanism
CO4	Laplace transforms analysis of ac circuits. Construct and analyze of RLC Series and parallel resonance circuits.	Cognitive Psychomotor	Analyze Mechanism
CO5	To Understand the concept of one port and two port network functions.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE 301	ELECTRICAL CIRCUIT ANALYSIS	3	1	1	5
C:P: A		L	T	P	CH
3:1:0		3	1	2	6

UNIT- I: NETWORK THEOREMS **09+03**

Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks.

List of Experiments

1.Verification of KVL and KCL
2.Verification of Thevenin theorem
3.Verification of Norton theorem
4.Verification of Maximum power transfer theorem

UNIT- II: SOLUTION OF FIRST AND SECOND ORDER NETWORKS **08+03**

Solution of first and second order differential equations for Series and parallel R-L, R-C, RL-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

List of Experiments

5.Transient analysis of Series RL, RC circuits
6.Sinusoidal analysis of Series RL, RC circuits

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UNIT- III: SINUSOIDAL STEADY STATE ANALYSIS	**08+03**
Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer. **List of Experiments** 7.Measurement of active power for star and delta connected balanced loads 8.Verification of self, mutual inductance and coefficient of coupling	

UNIT- IV: ELECTRICAL CIRCUIT ANALYSIS USING LAPLACE TRANSFORMS	**08+03**
Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances **List of Experiments** 9.RLC Series and parallel Resonance	

UNIT- V: NETWORK FUNCTIONS AND TWO PORT NETWORKS	**12+03**
Concepts of complex frequency, Transform impedance, Networks function of one port and two port networks, concepts of poles and zeros, property of driving point and transfer function. Two Port Networks, terminal pairs, Relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

TEXTBOOKS

1. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
2. D. Roy Choudhury, “Networks and Systems”, New Age International Publications, 1998.
3. W. H. Hayt and J. E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.

REFERENCES

1. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004.
2. K. V. V. Murthy and M. S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.

E REFERENCES

1. NPTEL: http://nptel.ac.in/courses/108102042/
2. MOODLE: http://moodle.cecs.pdx.edu/course/view.php?id=16

REFERENCES

1. Department Lab Manual
2. Sudhakar.A and Shyam Mohan.S.P, “Circuits and Networks Analysis and Synthesis”, Fourth edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3									1		1	1	1
CO 2	3									1		1	2	1
CO 3	3	2								1	1	2	3	1
CO 4	3	2			1					1	1	1	3	3
CO 5	3	2			1					1	1	1	2	2
Total	15	6	0	0	2	0	0	0	0	5	3	6	11	8
Scaled	3	2	0	0	1	0	0	0	0	1	1	2	3	2

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

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ANALOG ELECTRONICS

Course Outcomes (XEE 302):		**Domain**	**Level**
CO1	Understand the characteristics of diode and analyze the rectifier circuits.	Cognitive Psychomotor	Understand Analyze Guided Response
CO2	Understand the characteristics of transistor.	Cognitive Psychomotor	Understand Mechanism
CO3	Understand the concept of MOSFET and analyze the circuits and its characteristics	Cognitive Psychomotor	Understand Analyze Mechanism
CO4	Classify and explain different types of amplifier	Cognitive Psychomotor	Understand Mechanism
CO5	Recall and explain linear and non-linear application of OP-AMP	Cognitive Psychomotor	Understand Mechanism

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE 302	**ANALOG ELECTRONICS**	**3**	**0**	**1**	**4**
C:P: A = 3:1:0		**L**	**T**	**P**	**H**
		3	**0**	**2**	**5**

UNIT- I: DIODE CIRCUITS **9+9**

P-N junction diode, I-V characteristics of a diode; review of half-wave and full-wave rectifiers, Zener diodes, Special diodes, clamping and clipping circuits.

List of Experiments

1. Design of full wave rectifier with and without filter.
2. Design of bridge rectifier circuits using with and without filter.
3. Conduct an experiment to test clipping and clamping circuits.

UNIT- II: BJT CIRCUITS **8+3**

Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror; common-emitter, common-base and common collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits.

List of Experiments

4. Design of BJT common emitter amplifier using voltage divider bias with and without feedback.

UNIT- III: MOSFET CIRCUITS **8+3**

MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, transconductance, high frequency equivalent circuit.

List of Experiments

5.Plot the drain and transfer characteristics of MOSFET.

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UNIT- IV: DIFFERENTIAL, MULTI-STAGE AND OPERATIONAL AMPLIFIERS	**8+3**
Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product) **List of Experiments** 6. Conduct experiment on differential amplifier	
UNIT -V: LINEAR AND NONLINEAR APPLICATIONS OF OP-AMP	**9+15**
Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wien bridge and phase shift). Analog to Digital Conversion. Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector, Monoshot. **List of Experiments** 7.Design of Phase shift and Wien bridge oscillators using OP-AMP. 8.Conduct experiment on Inverting, Non inverting amplifier using OP-AMP. 9.Conduct experiment on astable and monostable multivibrator using OP-AMP. 10.Conduct experiment on integrator and differentiator circuit using OP-AMP. 11.Conduct experiment on Schmitt trigger circuit using OP-AMP.	

	LECTURE	**PRACTICAL**	**TOTAL**
	45	**30**	**75**

TEXTBOOKS

1. A. S. Sedra and K. C. Smith, “Microelectronic Circuits”, New York, Oxford University Press, 1998.
2. J. V. Wait, L. P. Huelsman and G. A. Korn, “Introduction to Operational Amplifier theory and applications”, McGraw Hill U. S., 1992.
3. J. Millman and A. Grabel, “Microelectronics”, McGraw Hill Education, 1988.

REFERENCES

1. P. Horowitz and W. Hill, “The Art of Electronics”, Cambridge University Press, 1989.
2. P. R. Gray, R. G. Meyer and S. Lewis, “Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons, 2001.
3. Department Lab Manual.

E REFERENCES

1. www.nptel.ac.in.

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3									1		1	2	2
CO 2	3									1		1	2	2
CO 3	3	2								1	1	2	2	2
CO 4	2	2			1					1	1	1	2	2
CO 5	3	1			2					1	1	1	2	2
Total	14	5	0	0	3	0	0	0	0	5	3	6	10	10
Scaled	3	1	0	0	1	0	0	0	0	1	1	2	2	2

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

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ELECTRICAL MACHINES-I

Course Outcomes (XEE 303):		Domain	Level
CO1	Understand the operation of DC machines.	Cognitive Psychomotor	Understand Perception
CO2	Understand the winding concepts of DC machine.	Cognitive Psychomotor	Understand Complex Overt Response
CO3	Understand the motoring and generating concepts of DC machine.	Cognitive Psychomotor	Understand Set
CO4	Analyse single phase and three phase transformers circuits.	Cognitive Psychomotor	Analyse Set
CO5	Understand the various loss in magnetic circuits	Cognitive Psychomotor	Understand Set

COURSE CODE	COURSE NAME	L	T	P	C
XEE 303	ELECTRICAL MACHINES - I	3	1	1	5
C:P: A = 3:1:0		L	T	P	H
		3	1	2	6

UNIT -I: INTRODUCTION TO DC MACHINES **9+3+6**

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil.

List of Experiments

1. Study of D.C. Motor Starters.

UNIT- II: DC MACHINES – ARMATURE AND WINDING **9+3+6**

Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

UNIT- III: DC MACHINE - MOTORING AND GENERATION **8+3+6**

Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

List of Experiments

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. shunt motor.
5. Load characteristics of D.C series motor.
6. Speed control of D.C shunt motor.

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UNIT -IV: TRANSFORMERS AND TEST	**10+3+6**
Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test- separation of hysteresis and eddy current losses **List of Experiments** 7.Load test on single-phase transformer. 8. Open circuit and short circuit tests on single phase transformer.	
UNIT -V: AUTOTRANSFORMERS	**9+3+6**
Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current.	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

TEXTBOOKS

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.

REFERENCES

1. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
2. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

Mapping of COs with POs

	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**
CO 1	3	2	2	2	1				1			1	1	0
CO 2	3	-	2	1				1				1		1
CO 3	3			1				1			1			1
CO 4	3	2	2	2	1		1			1		1		1
CO 5	3			1						1				1
Total	15	4	6	7	2	0	1	2	1	2	1	3	1	4
Scaled	3	1	2	2	1	0	1	1	1	1	1	1	1	1

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

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ELECTROMAGNETIC FIELDS

Course Outcomes (XEE 304):		Domain	Level
CO1	To understand the basics of vector and outline different coordinate system.	Cognitive	Remembering Understanding
CO2	To understand the concept of static electric field for simple configuration using gauss and Coulombs law.	Cognitive	Understanding
CO3	Define the knowledge of electrostatics using, boundary conditions, Poissons and Laplace equation.	Cognitive	Understanding
CO4	Recall the magnetic field configuration using Different laws and outline time varying electric and magnetic fields using Maxwell's equation.	Cognitive	Remembering Understanding
CO5	Recall the concept of magnetization and magnetic field configuration using boundary condition.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE 304	ELECTROMAGNETIC FIELDS	3	1	0	4
C:P: A = 3:0:0		L	T	P	H
		3	1	0	4

UNIT- I: REVIEW OF VECTOR CALCULUS	**9+3**
Vector algebra-addition, subject traction, components of vectors, scalar and vector multiplications, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus differentiation, partial differentiation, integration, vector operator del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.	
UNIT- II: STATIC ELECTRIC FIELD	**9+3**
Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density.	
UNIT -III: CONDUCTORS, DIELECTRICS AND CAPACITANCE	**9+3**
Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two-wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.	
UNIT -IV: STATIC MAGNETIC FIELDS, TIME VARYING FIELDS AND MAXWELL'S EQUATIONS	**9+3**

Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors. Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Condit ions. Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic circuits, inductances and mutual inductances.
UNIT -V: ELECTROMAGNETIC WAVES **9+3**
Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

LECTURE	TUTORIAL	TOTAL
45	15	60

TEXTBOOKS

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
4. G. W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.

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2. W. J. Duffin, "Advanced Electricity and Magnetism", McGraw Hill, 1968.
3. E. G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press,1966.
4. B. D. Popovic, "Introductory Engineering Electromagnetics", Addison-Wesley Educational Publishers, International Edition, 1971.
5. W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.

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1. NPTEL: http://nptel.ac.in/courses

Mapping of COs with POs

	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	-	1	1	1
CO2	1	2	-	1	-	-	-	-	-	-	1	-	2	1
CO3	1	2	-	-	-	-	-	-	-	-	-	1	1	2
CO4	1	3	-	-	-	-	-	-	-	-	-	-	2	2
CO5	1	2	1	-	-	-	-		-	-	-	1	1	1
Total	6	11	1	3	0	0	0	0	0	1	1	3	7	7
Scaled	2	3	1	1	0	0	0	0	0	1	1	1	2	2

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

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Course Outcomes (XEE 305):		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 type's underground cables.	Cognitive	Understanding
CO5	**Summarize** the latest technologies in the field of distribution systems.	Cognitive	Understanding

TRANSMISSION AND DISTRIBUTION

COURSE CODE	COURSE NAME	L	T	P	C
XEE 305	TRANSMISSION AND DISTRIBUTION	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

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.	
UNIT- V: DISTRIBUTION SYSTEM	**09**

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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

TEXTBOOKS

1.D.P. Kothari and I.J. Nagrath, 'Power System Engineering', Tata McGraw–Hill,2 nd 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.

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1. Luces M.Fualkenberry ,Walter Coffer, 'Electrical Power Distribution and Transmission', 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.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3								1		2	2	1
CO2	1	3	1		1							1	3	1
CO3	1			1	1					1			2	1
CO4	1	2									1	1	2	1
CO5	1	2										1	2	1
Total	5	10	1	1	2	0	0	0	0	2	1	5	11	5
Scaling	2	3	1	1	1	0	0	0	0	1	1	2	3	2

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

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PROBABILITY AND STATISTICS

Course Outcomes (XPS 401):		Domain	Level
CO1	**Explain** conditional probability, independent events; **find** expected values and Moments of Discrete random variables with their properties.	Cognitive	Understanding Remembering
CO2	**Find** distribution function, Marginal density function, conditional density function and to **define** density function of conditional distribution functions normal, exponential and gamma distributions.	Cognitive	Remembering
CO3	**Determine** the statistical parameters of Binomial, Poisson and Normal and to find correlation, regression and Rank Correlation coefficient of two variables. Moments, skewness and Kurtosis.	Cognitive Psychomotor	Understanding Guided Response
CO4	**Explain** large sample test for single proportion, difference of proportion, single mean, difference of means and difference of standard deviations with simple problems.	Cognitive	Understanding
CO5	**Explain** small sample test for single mean, difference of mean and correlation coefficients, variance test, chi square test with simple problems.	Cognitive Affective	Understanding Receiving

Learning Objectives

1. Appreciate the importance of probability and statistics in computing and research
2. Develop skills in presenting quantitative data using appropriate diagrams, tabulations and summaries
3. Use appropriate statistical method in the analysis of simple datasets.
4. Interpret and clearly present output from statistical analyses in a clear concise and understandable manner
5. The main objective of this course is to provide students with the foundations of probabilities and statistical analysis mostly used in varied applications in engineering and science like disease modeling, climate prediction and computer networks etc.

COURSE CODE	COURSE NAME	L	T	P	C
XEE 401	MATHEMATICS – III	3	1	0	4
C:P: A = 3.5:2.5:2.5	(PROBABILITY AND STATISTICS)	L	T	P	CH
		3	1	0	4

UNIT - I: BASIC PROBABILITY	12
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality	

UNIT-II: CONTINUOUS PROBABILITY DISTRIBUTIONS & BIVARIATE DISTRIBUTIONS	**12**
Continuous random variables and their properties, distribution functions and densities, normal, exponential and gamma densities. Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.	
UNIT - III: BASIC STATISTICS	**12**
Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation	
UNIT- IV: APPLIED STATISTICS	**12**
Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.	
UNIT-V: SMALL SAMPLES	**12**
Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes	

	LECTURE	**TUTORIAL**	**TOTAL**
	45	**15**	**60**

TEXTBOOKS

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2015.
2. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2010.
3. Veerarajan T., "Probability, Statistics and Random processes", Tata McGraw-Hill, New Delhi, 2010.

REFERENCES

1. P. G. Hoel, S. C. Port and C. J. Stone, "Introduction to Probability Theory", Universal Book Stall, 2003.
2. S. Ross, "A First Course in Probability", Pearson Education India, 2002.
3. W. Feller, "An Introduction to Probability Theory and its Applications", Vol. 1, Wiley, 1968.
4. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2006.

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Probability and Statistics by Prof.Somesh kumar, Department of Mathematics, IIT Kharagpur. (http://nptel.ac.in/noc/noc_courselist.php)

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Mapping of COs Vs GAs

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
CO 1	3	2	1						1	1		1
CO 2	3	2	1						1	1		1
CO 3	3	2	1	1					1	1		1
CO 4	3	2	1	1	1	1			1	1	1	1
CO 5	3	2	1	1	1	1	1		1	1	1	1
Total	15	10	5	3	2	2	1		5	5	2	5
Scaled	3	2	1	1	1	1	1		1	1	1	1

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

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DIGITAL ELECTRONICS

Course Outcomes (XEE 402):		**Domain**	**Level**
CO1	To Understand numerical values in various number systems and show number conversions between different number Systems.	Cognitive Psychomotor	Understanding Guided Response
CO2	To Analyze Boolean functions and minimization techniques using k –maps and postulates and theorems of Boolean Algebra, minimization of Boolean functions using basic laws.	Cognitive Psychomotor	Analyze Perception
CO3	To Apply Logic gates and their applications and construct the simple adders and subtractors using logic gates.	Cognitive Psychomotor	Apply Mechanism
CO4	To Understand the process of Analog to Digital conversion and its applications.	Cognitive Psychomotor	Understanding Mechanism
CO5	To Understand the process of Digital to Analog conversion and its applications.	Cognitive Psychomotor	Understanding Mechanism

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE 402	**DIGITAL ELECTRONICS**	**3**	**0**	**1**	**4**
C:P: A		**L**	**T**	**P**	**CH**
2:1:0		**3**	**0**	**2**	**5**

UNIT - I: FUNDAMENTALS OF DIGITAL SYSTEMS AND LOGIC FAMILIES **9+9**

Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital ICs, digital logic families.

List of Experiments

1.Verification and study of logic gates.
2. Binary to Gray and Gray to binary code converters.
3.Excess -3 to BCD and vice-versa code converters.

UNIT - II: COMBINATIONAL DIGITAL CIRCUITS **9+6**

Standard representation for logic functions, K-map representation, and simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Multiplexer, De-Multiplexer/Decoders, Adders, Subtractors, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders Q-M method of function realization.

List of Experiments

3. Implementation and verification of Multiplexers and Demultiplexer using logic gates.
4. Implementation and verification of Encoders and Decoders using logic gates.

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UNIT - III: SEQUENTIAL CIRCUITS AND SYSTEMS	**9+6**
A 1-bit memory, the circuit properties of Bistable latch, JK, SR, D and T types flip-flops, applications of flip-flops, shift registers, applications of shift registers, Asynchronous counters, synchronous counters design using flip flops, special counter IC's, applications of counters. **List of Experiments** 5.Design and verify operation of Half / Full adder. 6.Design and verify operation of Half/Full Subtractor.	
UNIT- IV: A/D AND D/A CONVERTERS	**9+6**
Digital to analog converters: weighted resistor/converter, R-2R Ladder DAC, specifications for D/A converters, examples of DAC ICs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator ADC, successive approximation ADC, specifications of ADC, example of ADC ICs. **List of Experiments** 8.Verification of state tables of RS, JK, T and D flip flops using NAND and NOR gates.	
UNIT-V: SEMICONDUCTOR MEMORIES AND PROGRAMMABLE LOGIC DEVICES	**9+3**
Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, ROM, RAM, content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, PLA, PAL, CPLDS, and FPGA. **List of Experiments** 9. Shift registers and Counters**.**	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**30**	**75**

TEXTBOOKS

1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

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5. Taub and Schilling, 'Digital Integrated Circuits', McGraw Hill, 2002.
6. Samuel C. Lee "Digital Circuits and Logic Designs" Prentice Hall of India; 2000.
7. Fletcher, W.I., 'An Engineering Approach to Digital Design', Prentice Hall of India, 2002.
8. Anand Kumar, Fundamental of Digital circuits, PHI 2003.

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

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Mapping of COs with POs

	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
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	2	3	-	-	1	1	1	-	-	1	1	1	2
CO 5	3	2	2	-	-	0	1	1	1	1	1	2	2	2
Total	12	9	10	-	-	5	5	7	3	3	2	8	8	9
Scaled	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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POWER ELECTRONICS

Course Outcomes (XEE 403):		Domain	Level
CO1	To Understand the structure, operation and characteristics of power switching devices.	Cognitive Psychomotor	Understanding Response
CO2	Determine the operation, characteristics and performance parameters of controlled rectifiers.	Cognitive Psychomotor	Understanding Mechanism
CO3	Analysis the operation of DC - DC choppers.	Cognitive Psychomotor	Analyzing Mechanism
CO4	Analysis the operation of various inverters and infer the suitable PWM techniques.	Cognitive Psychomotor	Analyzing Mechanism
CO5	To Understand the concept of various types of AC voltage controllers.	Cognitive Psychomotor	Understanding Mechanism

COURSE CODE	COURSE NAME	L	T	P	C
XEE 403	POWER ELECTRONICS	3	0	1	4
C:P: A		L	T	P	H
2:1:0		3	0	2	5

UNIT – I: POWER SWITCHING DEVICES **9+9**

Review on Semiconductor devices – I-V characteristics and Switching Characteristics of power Diodes, SCR, TRIAC, power BJT, power MOSFET and IGBT. Triggering and Commutation Circuits.

List of Experiments

1.Characteristics of SCR
2.Characteristics of MOSFET
3.Characteristics of IGBT

UNIT – II: THYRISTOR RECTIFIERS **9+3**

Single phase half-wave and full-wave thyristor rectifiers – Single phase full-bridge thyristor rectifier with R-load and highly inductive load – Three phase full-bridge thyristor rectifier with R-load and highly inductive load.

List of Experiments

4. Single phase fully controlled rectifier with R, RL load

UNIT – III: DC TO DC CHOPPERS **9+6**

Types of Choppers, Class A to E, step-up and step-down choppers – Analysis of Voltage, Current and Load commutated choppers –Introduction to Resonant converters

List of Experiments

5.BUCK- BOOST converter using MOSFET.
6.IGBT based choppers.

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UNIT – IV: INVERTERS	**9+6**
Single phase, Three phase voltage source inverters (Both 120º and 180º mode of conductions) – Bipolar sinusoidal modulation and unipolar sinusoidal modulation, Modulation Index - PWM Techniques- Current Source Inverters. **List of Experiments** 7.Single phase IGBT PWM inverter. 8.Series Inverter/ Parallel Inverter	
UNIT – V:AC VOLTAGE CONTROLLERS	**9+6**
Single-phase and three phase AC voltage controllers -. Multi-stage sequence control – step-up and step-down cycloconverter – Single phase to single phase and Single phase to Three phase cycloconverters. **List of Experiments** 9.Single phase AC voltage controller using SCR / TRIAC. 10.Single phase cycloconverter. 11.Mini project: Design of basic power converter circuits**.**	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**30**	**75**

TEXTBOOKS

1. Rashid, M.H., ‘Power Electronics: Circuits, Devices and Applications’, Pearson Education India, 2009.
2. Singh, M.D and Kanchandani, ‘Power Electronics’, Tata McGraw Hill & Hill publication Company Ltd New Delhi, 2009.
3. Bimbhra, P.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, 2007.

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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.
5. Erickson, R.W and Maksimovic, D., 'Fundamentals of Power Electronics', Springer Science & Business Media, 2007.
6. Umanand, L., 'Power Electronics: Essentials and Applications', Wiley India, 2009.
7. Department Laboratory Manual

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

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
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	8
Scaled	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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ELECTRICAL MACHINES – II

Course Outcomes (XEE 404):		Domain	Level
CO1	To Understand the fundamentals of different types of slots and windings used for AC machines.	Cognitive Psychomotor	Understanding Mechanism
CO2	To Understand the concepts of pulsating and revolving magnetic fields.	Cognitive Psychomotor	Understanding Mechanism
CO3	To Understand the operation of induction machines, ttorque slip characteristics, equivalent circuit and its phasor diagram.	Cognitive Psychomotor	Understanding Mechanism
CO4	To Understand the different typesof starting, braking and speed control for induction motors. React the generator operation, self-excitation and doubly-fed Induction machines.	Cognitive Psychomotor	Understanding Mechanism
CO5	To Understand the operation of single-phase induction motors and its performance parameters.	Cognitive Psychomotor	Understanding Mechanism

COURSE CODE	COURSE NAME	L	T	P	C
XEE 404	ELECTRICAL MACHINES – II	3	1	1	5
C:P: A = 2:1:0		L	T	P	H
		3	1	2	6

UNIT – I: FUNDAMENTALS OF AC MACHINE WINDINGS **9+3+12**

Physical arrangement of windings in stator and cylindrical rotor–Slots for windings –Single-turn coil – Active portion and overhang –Full-pitch coils–Types of windings– 3D visualization of the above winding types– Air-gap MMF distribution with fixed current through winding –Winding distribution factor.

List of Experiments

1.Load test on three phase squirrel cage induction motor.
2.Load test on three phase slip ring induction motor.
3.Load test of a three-phase alternator.
4.Load test on single-phase induction motor.

UNIT – II: PULSATING AND REVOLVING MAGNETIC FIELDS **9+3+6**

Types of magnetic fields –Alternating current in windings with spatial displacement – Magnetic field produced by a single winding – Fixed current and alternating current. Pulsating fields produced by spatially displaced windings– Windings spatially shifted by 90° – Three windings spatially shifted by 120° (carrying three-phase balanced currents) – Revolving magnetic field.

List of Experiments

5.No load and blocked rotor test on three phase induction motor.
6.No load and blocked rotor test on single phase induction motor.

UNIT – III: INDUCTION MACHINES **12+3+3**

Constructional details –Types of rotors (squirrel cage and slip-ring) – Torque Slip Characteristics – Equivalent circuit – Phasor Diagram– Effect of parameter variation on torque speed characteristics –Methods

of starting, braking and speed control for induction motors–Generator operation –Self-excitation– Doubly-Fed Induction Machines.

List of Experiments

7.Regulation of three phase alternator by EMF /MMF methods.

UNIT – IV: SINGLE PHASE INDUCTION MOTORS	**6+3+6**

Constructional details of single-phase induction motor – Double revolving field theory and operation – Equivalent circuit – Determination of parameters – Split-phase starting methods and applications.

List of Experiments

8.OCC and load characteristics of three phase alternator

9.V and inverted V curves of three phase synchronous motor.

UNIT – V: SYNCHRONOUS MACHINES	**9+3+3**

Constructional details – Cylindrical rotor synchronous machine– EMF equation –Equivalent circuit – Phasor diagram–Armature reaction–Voltage regulation– V-curves. Salient pole machine – Two reaction theory – Phasor diagram –Power angle characteristics. Synchronizing and parallel operation.
(Basic operation of synchronous motors)

List of Experiments

10.Study of induction motor starters.

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

TEXTBOOKS

1. I. J. Nagrath and D. P. Kothari, ‘Electric Machines’, Tata McGraw Hill Publishing Company Ltd, 2010.
2. M. G. Say, ‘Performance and Design of AC Machines’, CBS Publishers, 2002.
3. P. S. Bimbhra, ‘Electrical Machinery’, Khanna Publishers, 2011.
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2. A. S. Langsdorf, ‘Alternating Current Machines’, Tata McGraw Hill publishing Company Ltd, 1984.
3. P. C. Sen, “Principles of Electric Machines and Power Electronics”, John Wiley & Sons, 2007.
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5. DeshPande M.V., ‘Electrical Machines’, PHI Learning Pvt Ltd., New Delhi – 2011.
6. A. G. Warren, ‘Problems in Electrical Engineering’, Parker and Smith Solutions, Newyork, 1940.
7. K. Murugesh Kumar, ‘Electric Machines’, Vikas Publishing House Pvt Ltd, 2002.
8. Department Laboratory Manual.

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

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO 1	3	2	2	2	1	0	0	0	0	0	0	2	2	1
CO 2	3	2	2	2	1	0	0	0	0	0	0	1	2	1
CO 3	3	2	2	2	1	0	0	0	0	0	0	1	1	1
CO 4	2	2	1	3	2	0	0	0	0	0	0	1	1	1
CO 5	3	0	0	0	1	0	0	0	0	0	0	1	1	1
Total	14	8	7	9	6	0	0	0	0	0	0	6	7	5

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

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ENTREPRENEURSHIP DEVELOPMENT

Course Outcomes (XUM 405):		Domain	Level
CO1	***Recognise*** and ***describe*** the personal traits of an entrepreneur.	Cognitive Affective	Understand Receiving
CO2	***Determine*** the new venture ideas and ***analyze*** the feasibility report.	Cognitive	Understand Analyze
CO3	***Develop*** the business plan and ***analyze*** the plan as an individual or in team.	Cognitive Affective	Receiving Analyze
CO4	***Describe*** various parameters to be taken into consideration for launching and managing small business.	Cognitive	Understand
CO5	***Describe*** Technological management and Intellectual Property Rights	Cognitive	Understand

COURSE CODE	COURSE NAME	L	T	P	C
XUM 405	ENTREPRENEURSHIP DEVELOPMENT	3	0	0	3
C:P: A = 2:0:1		L	T	P	H
		3	0	0	3

UNIT – I: ENTREPRENEURIAL TRAITS AND FUNCTIONS	**9**
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	**9**
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	**9**
Financial forecasting for a new venture; Finance mobilization; Business plan preparation; Sources of Financing, Angel Investors and Venture Capital; Government support in start-up promotion.	
UNIT – IV: LAUNCHING OF SMALL BUSINESS AND ITS MANGEMENT	**9**
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	**9**
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**	**PRACTICAL**	**TOTAL**
	45	**0**	**0**	**45**

TEXTBOOKS

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

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1. Mathew Manimala, 2005, Entrepreneurship Theory at the Crossroads, Paradigms & Praxis,
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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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Mapping of COs with POs

	GA 1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
CO 1	0	0	0	0	0	0	0	0	3	3	3	1
CO 2	0	0	1	2	3	2	1	1	1	2	3	0
CO 3	0	0	0	0	0	1	0	2	3	3	0	2
CO 4	0	0	0	0	0	1	1	2	3	0	3	3
CO 5	0	0	0	0	0	1	1	3	0	0	0	3
Total	0	0	1	2	3	5	3	8	10	8	9	9
Scaled	0	0	1	1	1	2	1	2	3	2	2	2

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

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SIGNALS AND SYSTEMS

Course Outcomes (XEE 406):		Domain	Level
CO1	Understand the concepts of continuous time and discrete time systems.	Cognitive	Understand
CO2	Analyse systems in complex frequency domain.	Cognitive	Analyse
CO3	Learn about Fourier transformation techniques	Cognitive	Remembering
CO4	Learn about Laplace transformation techniques	Cognitive	Remembering
CO5	Learn about Z- transformation techniques	Cognitive	Remembering

COURSE CODE	COURSE NAME	L	T	P	C
XEE 406	SIGNALS AND SYSTEMS	2	1	0	3
C:P: A		L	T	P	H
3:0:0		2	1	0	3

UNIT -I: INTRODUCTION TO SIGNALS AND SYSTEMS — **09**

Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, reliability. Examples.

UNIT- II: BEHAVIOUR OF CONTINUOUS AND DISCRETE-TIME LTI SYSTEMS — **09**

Impulse response and step response, convolution, input-output behaviour with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its Relation to the impulse response.

UNIT -III: FOURIER TRANSFORMS — **09**

Fourier series representation of periodic signals, Waveform Symmetries, Fourier Coefficients, harmonic spectrum and THD. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete- Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Application to simple circuits.

UNIT- IV: LAPLACE TRANSFORMS — **06**

Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behaviour. Application to simple circuits.

UNIT -V: Z- TRANSFORMS AND SAMPLING RECONSTRUCTION — **12**

The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis. The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

	LECTURE	TUTORIAL	TOTAL
	30	15	45

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TEXTBOOKS

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.
3. H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
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2. M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.
3. B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2	2	2	1				1			1	1	0
CO 2	3	3	2	1		3		1				2		1
CO 3	3			1		3		1			1			1
CO 4	3	2	2	2	1		1			2		2		1
CO 5	3			1						2				1
Total	15	7	6	7	2	6	1	2	1	4	1	5	1	4
Scaled	3	2	2	2	1	2	1	1	1	1	1	1	1	1

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

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SEMESTER V
POWER SYSTEMS-I
(APPARATUS AND MODELLING)

Course Outcomes (XEE 501):		**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	**Analyse** the power system network with symmetrical and unsymmetrical faults. **Calibrate** the fault current in a power system.	Cognitive psychomotor	Analysing 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

Learning Objectives:

Establish and use power system models based on nodal admittance and impedance matrices for the analysis of large-scale power networks. Model generators, transformers, lines and cables in the positive, negative and zero sequence systems as basis for the analysis of symmetrical and unsymmetrical faults. Perform analysis of power systems subject to symmetrical and unsymmetrical faults.

Use simulation tools to perform comprehensive short circuit studies, load flow studies, and optimal power flow studies.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE 501	**POWER SYSTEMS-I (APPARATUS AND MODELLING)**	**3**	**1**	**1**	**5**
C:P: A		**L**	**T**	**P**	**H**
3:1:0		**3**	**1**	**2**	**6**

UNIT - I: INTRODUCTION	**9+3**
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	**12+3+6**
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.	

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List of Experiments

1. Formation of Bus Admittance Matrix.
2. Formation of Bus Impedance Matrix using building Algorithm

UNIT - III: FAULT ANALYSIS-UNSYMMETRICAL FAULTS	**12+3+6**

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.

List of Experiments

3. Symmetrical Fault Analysis.
4. Unsymmetrical Fault Analysis.

UNIT- IV: POWER FLOW ANALYSIS	**9+3+9**

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

List of Experiments

5. Solution of power flow using Gauss-Seidel Method.
6. Solution of power flow using Newton Raphson Method.
7. Solution of power flow using Fast Decoupled Power Flow Method.

UNIT -V: STABILITY ANALYSIS	**9+3+3**

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.

List of Experiments

9. Transient Stability Analysis of Single-Machine Infinite Bus System

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

TEXT BOOKS

1. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw-Hill Education; 2nd edition (December 28, 2015)
2. O. I. Elgerd, "Electric Energy Systems Theory", McGraw Hill Education, 1st July 2017.
3. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson Education Inc., 2nd Edition, 2009.

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1. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education, 4th Edition (29 June 2011)
2. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 5 **edition** (December 26, 2012)

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3									1		1	3	2
CO 2	3									1		1	3	2
CO 3	3	2								1	1	2	3	2
CO 4	3	2			1					1	1	1	3	2
CO 5	3	2			1					1	1	1	3	2
Total	15	6	0	0	2	0	0	0	0	5	3	6	15	10
Scaled	3	1	0	0	0	0	0	0	0	1	1	1	3	2

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

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CONTROL SYSTEMS

Course Outcomes (XEE 502):		Domain	Level
CO1	**Identify** the basic elements, derive the transfer function and **Compute** the overall gain of the control system and **Construct** the transfer function of DC motors and DC generators.	Cognitive Psychomotor	Understanding
CO2	**Explain** the performance of First and Second order system with static and dynamic error coefficients.	Cognitive Psychomotor	Understanding Set
CO3	**Describe** the frequency domain specifications and show the response of frequency response.	Cognitive Psychomotor	Remembering Understanding Set
CO4	**Determine** the stability of the systems and **Design** the suitable compensator and controller for the given performance criteria of the control system	Cognitive Psychomotor	Understanding Design Perception
CO5	**Describe** State transition matrix. **Explain** State space model **and construct** and **verify** the canonical state model and Kalman's test for controllability and observability.	Cognitive	Remembering

Learning Objectives: Control Systems is the engineering discipline that applies control theory to design systems with desired behaviours. To make students understand the concept of system representation for stability analysis and state –space analysis, to design the compensator in time and frequency domain, to design the PID compensator

COURSE CODE	COURSE NAME	L	T	P	C
XEE 502	CONTROL SYSTEMS	3	0	1	4
C:P: A		L	T	P	H
3:1:0		3	0	2	5

UNIT - I: SYSTEMS AND THEIR REPRESENTATION **9+9**

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, Modelling of electric systems translation and rotational mechanical systems.

List of Experiments

1. Transfer function and modelling of separately excited DC Generator.
2. Transfer function and modelling of Armature & field-controlled DC Motor.
3. Transfer function of AC Servomotor

UNIT – II: TIME RESPONSE ANALYSIS **9+9**

Time response – Time domain specifications - Standard test signals. Time response of first and second order systems for standard test inputs. Error coefficients – Generalized error series – Steady state error

List of Experiments

4. Analysis of Synchro Transmitter and Receiver.
5. Performance of DC Stepper Motor

6. Digital simulation of I order and II order system by using Scilab.

UNIT - III: FREQUENCY-RESPONSE ANALYSIS	**9+6**

Frequency domain specification – Bode plot – Polar plot – Determination of closed loop response from open loop response – CorRelation between frequency domain and time domain specifications

List of Experiments

7. Frequency response of Lag, Lead & Lag – Lead networks.
8. Determination of Phase margin and Gain margin of the Bode plot using Scilab.

UNIT – IV: STABILITY ANALYSIS AND CONTROLLER DESIGN	**9**

Characteristics equation – Location of roots in S plane for stability –Routh Hurwitz criterion – Root locus construction – Effect of pole, zero addition –Nyquist stability criterion. Introduction to design of Proportional, Integral and Derivative Controllers- Lead and Lag compensator- Analog and Digital implementation of controllers.

UNIT – V: STATE VARIABLE ANALYSIS	**9+6**

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Physical variable phase variable and canonical variable forms State Space representation of continuous time system. Transfer function from state variable representation –. Concept of controllability and observability.

List of Experiments

9. Transfer function and modeling of Ward – Leonard speed control system applied to DC motor.
10. DC Position using feedback Control system.

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**30**	**75**

TEXTBOOKS

1. I.J. Nagrath & M. Gopal, 'Control Systems Engineering', New Age International Publishers Pvt Ltd; Sixth edition (1 September, 2018)
2. Norman S. Nise, "Control System Engineering" Seventh edition, John Wiley &Sons, Inc, 2015.
3. M. Gopal, "Control Systems, Principles & Design", Tata McGraw Hill, New Delhi, 2002.
4. Richard C. Dorf & Robert H. Bishop, "Modern Control Systems", Addison– Wesley, 2012.

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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 Systems Engineering (Web Course), Prof. M. Gopal, IIT Kharagpur.

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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	2	2	1	1	2	1	1	2	1	2
CO5	2	1	1	1	2	1	1	1	2	1		1	2	2
Total	10	10	9	7	4	4	5	4	9	3	1	6	7	7
Scaled	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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MICROPROCESSORS AND MICROCONTROLLERS

Course Outcomes (XEE 503):		**Domain**	**Level**
CO1	To understand the fundamentals of microprocessors, microcontrollers and embedded systems	Cognitive	Understanding
CO2	To understand the architecture, Timing diagrams and Execution cycles of 8051	Cognitive	Understanding
CO3	To understand the types of addressing modes, Instruction types and to understand the basic concepts of programming	Cognitive Psychomotor Affective	Understanding Set Responding
CO4	To understand interfacing design of peripherals like I/O, A/D, D/A, timer etc.	Cognitive Psychomotor Affective	Understanding Set Responding
CO5	To understand communication protocols and interfacing with external devices	Cognitive Psychomotor Affective	Understanding Set Responding

Learning Outcomes: Able to do assembly language programming, do interfacing design of peripherals like I/O, A/D, D/A, timer etc. and to develop systems using different microcontrollers.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE 503	**MICROPROCESSORS AND MICROCONTROLLERS**	**3**	**0**	**1**	**4**
C:P: A		**L**	**T**	**P**	**H**
3:1:0		**3**	**0**	**2**	**5**

UNIT- I: FUNDAMENTALS OF MICROPROCESSORS	**9**
Fundamentals of Microprocessor Architecture. 8-bit Microprocessor and Microcontroller architecture, Comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family.	
UNIT -II: THE 8051 ARCHITECTURE	**9**
Internal Block Diagram, CPU, ALU, address, data and control bus, working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory, Timing diagrams and Execution Cycles.	
UNIT- III: INSTRUCTION SET AND PROGRAMMING	**9+12**
Addressing modes: Introduction, Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, indexed addressing, Bit inherent addressing, bit direct addressing. 8051 Instruction set, Instruction timings. Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction. Assembly language programs, C language programs. Assemblers and compilers. Programming and Debugging tools.	

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List of Experiments

1. Simple arithmetic operations with 8085 Microprocessors: Multi precision addition / subtraction / multiplication / division.
2. Programming with control instructions: Increment / Decrement, Ascending / Descending order, Maximum / Minimum of numbers, Rotate instructions.
3. Demonstration of basic instructions with 8051 Micro controller execution, including: a. Conditional jumps, looping b. Calling subroutines. c. Stack parameter testing
4. Design program for code conversions.

UNIT -IV: MEMORY AND I/O INTERFACING	**9+3**

Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, ADC, DAC, timers, counters, memory devices.

List of Experiments

5. Interfacing Converters of 8-bit D/A and A/D.

UNIT -V: EXTERNAL COMMUNICATION INTERFACE AND APPLICATIONS	**9+15**

Synchronous and Asynchronous Communication. RS232, SPI, I2C.Introduction and interfacing to protocols like Blue-tooth and Zig-bee LED, LCD and keyboard interfacing. Stepper motor interfacing, DC Motor interfacing, sensor interfacing.

List of Experiments

6. Interfacing of Keyboard with 8085
7. Interfacing of seven segment display with 8085.
8. Serial communication, I/O Port operations.
9. Design and implementation of Traffic Light control.
10. Design and implementation of Stepper motor control

	LECTURE	**PRACTICAL**	**TOTAL**
	45	**30**	**75**

TEXTBOOKS

1. M.A.Mazidi, J.G.Mazidi and R.D.McKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, Pearson Education, 2007.
2. K.J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning, 2004.
3. R. Kamal, “Embedded System”, McGraw Hill Education, Third Edition, 2017.
4. R.S. Gaonkar, “Microprocessor Architecture: Programming and Applications with the 8085”, Penram International Publishing, 6th Edition, 2013

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1. D.A.Patterson and J.H.Hennessy, “Computer Organization and Design: The Hardware /Software interface”, Morgan Kaufman Publishers, 5th Edition, 2013.
2. D.V.Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education,2005.

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https://nptel.ac.in/courses/Webcourse-contents/IISc BANG/notused/Microprocessors%20and%20Microcontrollers-/Learning%20Material%20-%20Microprocessors%20and%20microcontrollers.pdf

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	1	0	2	0	0	0	0	0	0	1	1	0	1	1
CO 2	1	2	1	3	1	0	0	0	2	1	2	1	1	1
CO 3	0	0	0	0	0	1	2	0	1	2	0	0	1	1
CO 4	1	1	2	2	1	0	0	0	2	1	2	1	0	1
CO 5	1	2	2	1	0	0	3	0	3	2	1	0	0	1
Total	4	5	7	6	2	1	5	0	8	7	6	2	3	5
Scaled	1	1	2	1	1	1	1	0	2	2	1	1	1	1

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

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CONSTITUTION OF INDIA

Course Outcomes:		Domain	Level
CO1	***Understand*** the Constitutional History	Cognitive	Understanding
CO2	***Understand*** the Powers and Functions	Cognitive	Understanding
CO3	***Understand*** the Legislature	Affective	Remembering
CO4	***Understand*** the Judiciary	Affective	Remembering
CO5	***Understand*** the Centre State relations	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XUM 506	CONSTITUTION OF INDIA	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I:	**9**
Constitutional History- The Constitutional Rights- Preamble- Fundamental Rights- Fundamental Duties- Directive principles of State Policy.	
UNIT- II:	**9**
The Union Executive- The President of India (powers and functions)- Vice-President of India- The Council of Ministers-Prime Minister- Powers and Functions.	
UNIT- III:	**9**
Union Legislature- Structure and Functions of Lok Sabha- Structure and Functions of Rajya Sabha- Legislative Procedure in India- Important Committees of Lok Sabha- Speaker of the Lok Sabha.	
UNIT- IV:	**9**
The Union Judiciary- Powers of the Supreme Court- Original Jurisdiction- Appellate jurisdictions- Advisory Jurisdiction- Judicial review.	
UNIT- V:	**9**
Centre State relations- Political Parties- Role of governor, powers and functions of Chief Minister-Legislative Assembly- State Judiciary- Powers and Functions of the High Courts.	

LECTURE	TUTORIAL	TOTAL
45	0	45

REFERENCES

1. W.H.Morris Shores- Government and politics of India, NewDelhi,B.1.Publishers,1974.
2. M.V.Pylee- Constitutional Government in India, Bombay, Asia Publishing House, 1977.
3. R.Thanker- The Government and politics of India, London:Macmillon, 1995.

4. A.C.Kapur- Select Constitutions S,Chand & Co.,NewDelhi, 1995
5. V.D.Mahajan- Select Modern Governments,S,Chand &Co, NewDelhi,1995.
6. B.C.Rout- Democractic Constitution of India.
7. Gopal K.Puri- Constitution of India, India 2005.

COs versus POs mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	0	0	1	0	0	0	0	0	0	0	0	0	0
CO 2	2	0	0	1	0	0	0	0	0	0	0	0	0	0
CO 3	2	0	0	1	0	0	0	0	1	0	0	0	0	0
CO 4	2	0	0	1	0	0	0	1	1	0	0	0	0	0
CO 5	2	2	0	1	0	0	0	1	1	0	0	0	0	0
Total	10	2	0	5	0	0	0	2	3	0	0	0	0	0
Scaled	2	1	0	1	0	0	0	1	1	0	0	0	0	0

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

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SEMESTER VI

ECONOMICS FOR ENGINEERS

Course Outcomes:		**Domain**	**Level**
CO1	***Understand*** the concepts of economics in engineering.	Cognitive	Remembering
CO2	***Interpret*** Break-even analysis.	Cognitive	Understanding
CO3	***Illustrate*** value engineering procedure.	Cognitive	Understanding
CO4	***Understand*** *and* ***analyze*** replacement problem.	Cognitive	Understanding
CO5	***Explain*** depreciation.	Cognitive	Understanding

Learning Objectives:

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XUM 601	**ECONOMICS FOR ENGINEERS**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**
UNIT- I: INTRODUCTION TO ECONOMICS					**8**
Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics- types of costing, element of costs, preparation of cost sheet and estimation, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost					
UNIT- II: BREAK-EVEN ANALYSIS & SOCIAL COST BENEFIT ANALYSIS					**12**
Margin of Safety, Profit, Cost & Quantity Analysis-Product Mix decisions and CVP analysis, Profit/Volume Ratio (P/V Ratio), Application of Marginal costing, Limitations **Social Cost Benefit Analysis**: compare different project alternatives, Calculate direct, indirect and external effects; Monetizing effects; Result of a social cost benefit analysis.					
UNIT- III: VALUE ENGINEERING & COST ACCOUNTING					**10**
Value engineering – Function, aims, Value engineering procedure - Make or buy decision Business operating costs, Business overhead costs, Equipment operating costs					
UNIT- IV: REPLACEMENT ANALYSIS					**7**
Replacement analysis –Types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset.					
UNIT- V: DEPRECIATION					**8**

Depreciation- Introduction, Straight line method of depreciation, declining balance method of depreciation-Sum of the years digits method of depreciation, sinking fund method of depreciation, Annuity method of depreciation, service output method of depreciation.

	LECTURE	TUTORIAL	TOTAL
	45	0	45

TEXTBOOKS

1. 1 Sp Gupta, Ajay Sharma & Satish Ahuja, "Cost Accounting", V K Global Publications, Faridabad, Haryana, 2012
2. S.P.Jain & Narang, "Cost accounting – Principles and Practice", Kalyani Publishers, Calcutta, 2012
3. Panneer Selvam, R, "Engineering Economics", Prentice Hall of India Ltd, New Delhi, 2001.
4. William G.Sullivan, James A.Bontadelli & Elin M.Wicks, "Engineering Economy", Prentice Hall International, New York, 2001.

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1. Luke M Froeb / Brian T Mccann, "Managerial Economics – A problem solving approach" Thomson learning 2007
2. Truett & Truett, "Managerial economics- Analysis, problems & cases "Wiley India 8th edition 2004.
3. Chan S.Park, "Contemporary Engineering Economics", Prentice Hall of India, 2002.
4. Donald.G. Newman, Jerome.P.Lavelle, "Engineering Economics and analysis" Engg. Press, Texas, 2002

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POWER SYSTEMS-II (OPERATION AND CONTROL)

Course Outcomes (XEE 602):		**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	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

Learning Objectives: To provide the knowledge of optimization techniques used in the power system and Load Frequency Control (LFC). To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in Turbine models. To provide the knowledge of Hydrothermal scheduling, reactive power control.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE 602	**POWER SYSTEMS-II (OPERATION AND CONTROL)**	**3**	**1**	**1**	**5**
C:P: A = 3:1:0		**L**	**T**	**P**	**H**
		3	**1**	**2**	**6**

UNIT - I: INTRODUCTION	**9+3**
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 - II: REAL POWER - FREQUENCY CONTROL	**12+3+9**
Basics of speed governing mechanism and modelling - speed-load characteristics – load sharing between 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-area system: modelling - static analysis of uncontrolled case - tie line with frequency bias control - state variable model.	

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List of Experiments

1. Simulink model of single area load frequency control with PI controller.
2. Simulink model of single area load frequency control without PI controller.
3. Simulink model for two area load frequency control.

UNIT - III: REACTIVE POWER–VOLTAGE CONTROL	**9+3+6**

Generation and absorption of reactive power - basics of reactive power control - excitation systems– modelling - static and dynamic analysis - stability compensation - methods of voltage control: tap-changing transformer, injection reactive power - SVC (TCR + TSC) and STATCOM – secondary voltage control.

List of Experiments

4. Modelling of reactive power compensation using STATCOM in MATLAB.
5. Modelling of reactive power compensation using SVC in MATLAB.

UNIT -IV: UNIT COMMITMENT AND ECONOMIC DISPATCH	**12+3+9**

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-list method - forward dynamic programming.

List of Experiments

6. MATLAB program to find optimum loading of generators with penalty factor.
7. MATLAB program to find optimum loading of generators neglecting transmission losses.
8. MATLAB program to find economic load dispatch problem.

UNIT- V: COMPUTER CONTROL OF POWER SYSTEMS	**9 +3**

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	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**15**	**30**	**90**

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., 3rd Edition ,2013.
3. Kundur P., 'Power System Stability and Control, Tata McGraw Hill, New Delhi, 5th reprint, 2014.

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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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1. www.nptel.ac.in
2. NPTEL : http://nptel.ac.in/courses/108104052/

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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
Scaled	2	3	2	1	3	0	0	0	1	1	1	1	2	1

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

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DISASTER MANAGEMENT

Course Outcomes:		**Domain**	**Level**
CO1	Understanding the concepts of application of types of disaster preparedness	Cognitive	Application
CO2	On completion of this course the students will be able to understand planning essentials of disaster.	Cognitive	Analyze
CO3	Have a good understanding of importance of seismic waves occurring globally	Cognitive	Analyze
CO4	On completion of this course, the students will be able to perform drill essential for disaster mitigation	Cognitive	Application
CO5	Have a keen knowledge on essentials of risk reduction	Cognitive	Application

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XUM 606	**DISASTER MANAGEMENT**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION	**9**
Introduction – Disaster preparedness – Goals and objectives of ISDR Programme- Risk identification – Risk sharing – Disaster and development: Development plans and disaster management –Alternative to dominant approach– disaster-development linkages -Principle of risk partnership	
UNIT- II: APPLICATION OF TECHNOLOGY IN DISASTER RISK REDUCTION	**9**
Application of various technologies: Data bases – RDBMS – Management Information systems – Decision support system and other systems – Geographic information systems – Intranets and extranets – video teleconferencing. Trigger mechanism – Remote sensing-an insight – contribution of remote sensing and GIS - Case study	
UNIT- III: AWARENESS OF RISK REDUCTION	**9**
Trigger mechanism – constitution of trigger mechanism – risk reduction by education – disaster information network – risk reduction by public awareness	
UNIT- IV: DEVELOPMENT PLANNING ON DISASTER	**9**
Implication of development planning – Financial arrangements – Areas of improvement – Disaster preparedness – Community based disaster management– Emergency response.	
UNIT- V: SEISMICITY	**9**
Seismic waves – Earthquakes and faults – measures of an earthquake, magnitude and intensity – ground damage – Tsunamis and earthquakes	

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	LECTURE	TUTORIAL	TOTAL
	45	0	45

TEXTBOOKS

1. Siddhartha Gautam and K Leelakrishna Rao, "Disaster Management Programmes and Policies", Vista International Pub House, 2012,
2. Arun Kumar, "Global Disaster Management", SBS Publishers, 2008

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1. Encyclopaedia of Disaster Management, Neha Publishers & Distributors, 2008
2. Pradeep Sahni, Madhavi Malalgoda and Ariyabandu, "Disaster risk reduction in South Asia", PHI, 2002
3. Amita Sinvhal, "Understanding earthquake disasters" TMH, 2010.
4. Pardeep Sahni, Alka Dhameja and Uma Medury, "Disaster mitigation: Experiences and reflections", PHI, 2000

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1		1	1					1			1	1	2	2
CO 2			2		3						2	2	2	2
CO 3						2	2				1	1		1
CO 4		2	2		1	1	1	2	1	1	3	1	1	
CO 5						2	3	3		2	1	1	2	2
Total	0	3	5	0	4	5	6	6	1	3	8	6	7	7
Scaled	0	1	1	0	1	1	1	1	1	1	2	1	2	2

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

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SEMESTER VII
HUMAN ETHICS, VALUES, RIGHTS AND GENDER

Course Outcomes:		**Domain**	**Level**
CO1	Adapt the human values and Social Justice.	Cognitive Affective	Knowledge and Responding
CO2	Discuss and accept Gender Equality, empowerment and feminism.	Cognitive Affective	Comprehension and Valuing
CO3	Recognize the status of women and analyse the issues related to women.	Cognitive Affective	Comprehension and Valuing
CO4	Demonstrate the human rights and good governance.	Cognitive Affective	Comprehension Responding
CO5	Adapt the human values and Social Justice.	Cognitive Affective	Apply Responding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XUM 703	**HUMAN ETHICS, VALUES, RIGHTS AND GENDER**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**
UNIT- I: Human Values					**9**
Human Ethics and values - Understanding of oneself and others- Basic instincts, motives and needs- Social service, Social Justice, Dignity and worth, Harmony in human relationship: Family and Society, Integrity and Competence, Caring and Sharing, Honesty and Courage, Valuing Time, Co-operation, Commitment, Sympathy and Empathy, Self-Confidence and Personality- Living in harmony at various levels.					
UNIT- II: Gender Equality					**9**
Gender Equality - Gender Vs Sex -, Concepts, definition, Gender equity, equality, and empowerment. Status of Women in India Social, Economic, Education, Health, Employment, HDI, GDI, GEM. Contributions of Dr.B.R. Ambethkar, Thanthai Periyar and Phule to Women Empowerment.					
UNIT- III: Women issues and Challenges					**9**

Women Issues and Challenges- Female Infanticide, Female feticide, Violence against women, Domestic violence, Sexual Harassment, Trafficking, Access to education, Marriage. Remedial Measures – Acts related to women: Political Right, Property Rights, and Rights to Education, Medical Termination of Pregnancy Act, and Dowry Prohibition Act.		
UNIT- IV: Human Rights		**9**
Human Rights Movement in India – The preamble to the Constitution of India, Human Rights and Duties Universal Declaration of Human Rights (UDHR), Civil, Political, Economic, Social and Cultural Rights, Rights against torture, Discrimination and forced Labour, Rights of Children.		
UNIT- V: Good Governance		**9**
Good Governance - Democracy, People's Participation, Guaranteed Freedoms, Open and Transparency governance, Combating corruption, Fairness in criminal justice administration, Government system of Redressal, Judiciary, National Human Rights Commission and other statutory Commissions, Creation of Human Rights Literacy and Awareness.		

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

TEXTBOOKS

1. Alam, Aftab ed., Human Rights in India: 1999Issues and Challenges (New Delhi: Raj Publications,)
2. Bajwa, G.S. and D.K. Bajwa, 1996 Human Rights in India: Implementation and Violations (New Delhi: D.K. Publications,)
3. Chatrath, K. J. S., (ed.), 1998) Education for Human Rights and Democracy (Shimala: Indian Institute of Advanced Studies,).
4.Jagadeesan.P., 1990. Marriage and Social legislations in Tamil Nadu, Elachiapen pub, Chennai,
5. Kaushal, Rachna, 2000 Women and Human Rights in India (New Delhi: Kaveri Books,)
6. Mani. V. S., 1998)Human Rights in India: An Overview (New Delhi: Institute for the World Congress on Human Rights,)
7. Singh Sehgal, B. P. 1999 (ed) Human Rights in India: Problems and Perspectives (New Delhi: Deep and Deep,)
8. Veeramani K. (1996), Periyar on Women Right, Emerald Publishers, Chennai , India.
9..Veeramani.K (2010) (ed) Periyar Feminism.Periyar ManiammaiUniversity,Vallam, Thanjavur.
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Mapping of COs with POs

	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
CO 1			3		3	2		2						
CO 2			3		1	2		3						
CO 3			2		2	2		3						
CO 4			3		3	3		3						
CO 5			1		1	1		1						
Total			12		10	10		12						
Scaled			3		2	2		3						

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

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SEMESTER VIII
CYBER SECURITY

Course Outcomes:		**Domain**	**Level**
CO1	Able to **understand** the Cyber Security Policy, Laws and Regulations	Cognitive	Remember
CO2	Able to **discuss** the Cyber Security Management Concepts	Cognitive	Understand
CO3	Able to **understand** the Cyber Crime and Cyber welfare	Cognitive	Understand
CO4	Able to **discuss** on issues related to Information Security Concepts	Cognitive	Understand
CO5	Able to **understand** various security threats	Cognitive	Understand

Learning Objectives:

To understand key terms and concepts in cyber law, intellectual property and cybercrimes, trademarks and domain theft. Able to examine secure software development practices. The learner will be able to incorporate approaches for risk management and best practices. To understand the basic knowledge of information security and security threats.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XUM 801	**CYBER SECURITY**	**0**	**0**	**0**	**0**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**0**	**0**	**0**	**3**

UNIT-I: INTRODUCTION **9**

Cyber Security – Cyber Security policy – Domain of Cyber Security Policy – Laws and Regulations – Enterprise Policy – Technology Operations – Technology Configuration - Strategy Versus Policy – Cyber Security Evolution – Productivity – Internet – E commerce – Counter Measures – Challenges

UNIT-II: CYBER SECURITY OBJECTIVES AND GUIDANCE **9**

Cyber Security Metrics – Security Management Goals – Counting Vulnerabilities – Security Frameworks – E Commerce Systems – Industrial Control Systems – Personal Mobile Devices – Security Policy Objectives – Guidance for Decision Makers – Tone at the Top – Policy as a Project– Cyber Security Management – Arriving at Goals – Cyber Security Documentation – The Catalog Approach – Catalog Format – Cyber Security Policy Taxonomy

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UNIT- III: CYBER SECURITY POLICY CATALOG	**9**
Cyber Governance Issues – Net Neutrality – Internet Names and Numbers – Copyright and Trademarks – Email and Messaging - Cyber User Issues - Malvertising - Impersonation – Appropriate Use – Cyber Crime – Geo location – Privacy - Cyber Conflict Issues – Intellectual property Theft – Cyber Espionage – Cyber Sabotage – Cyber Welfare	
UNIT-IV: INFORMATION SECURITY CONCEPTS	**9**
Information Security Overview: Background and Current Scenario - Types of Attacks - Goals for Security - E-commerce Security - Computer Forensics – Steganography	
UNIT-V: SECURITY THREATS AND VULNERABILITIES	**15**
Overview of Security threats -Weak / Strong Passwords and Password Cracking - Insecure Network connections - Malicious Code - Programming Bugs - Cyber-crime and Cyber terrorism - Information Warfare and Surveillance	

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

TEXTBOOKS

1. Jennifer L. Bayuk, J. Healey, P. Rohmeyer, Marcus Sachs, Jeffrey Schmidt, Joseph Weiss "Cyber Security Policy Guidebook" John Wiley & Sons 2012.

REFERENCES

1. Rick Howard "Cyber Security Essentials" Auerbach Publications 2011.
2. Richard A. Clarke, Robert Knake "Cyberwar: The Next Threat to National Security & What to Do About It" Ecco 2010.
3. Dan Shoemaker Cyber security The Essential Body Of Knowledge, 1st ed. Cengage Learning 2011.
4. Rhodes-Ousley, Mark, "Information Security: The Complete Reference", Second Edition, McGraw-Hill, 2013.

E REFERENCES

1. https://www.coursera.org/specializations/cyber-security
2. www. nptel.ac.in
3. http://professional.mit.edu/programs/short-programs/applied-cybersecurity

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	0	0	2	3	3	1	2	2	1	0	1	1	2	2
CO 2	0	0	2	3	3	1	2	2	1	0	1	1	2	2
CO 3	0	0	2	3	3	1	2	2	1	0	1	1	2	2
CO 4	0	0	2	3	3	1	2	2	1	0	1	1	2	2
CO 5	0	0	2	3	3	1	2	2	1	0	1	1	2	2
Total	0	0	10	12	12	5	10	10	5	0	5	5	10	10
Scaled	0	0	2	3	3	1	2	2	1	0	1	1	2	2

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

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SYLLABUS FOR

ONE CREDIT (MINOR) COURSES

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ELECTRICAL SAFETY

Course Outcomes (XEE M0*):		Domain	Level
CO1	Describe electrical hazards and safety equipment.	Cognitive	Understanding
CO2	Analyze and apply various grounding and bonding techniques.	Cognitive	Applying
CO3	Select appropriate safety method for low, medium and high voltage equipment.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE M0*	ELECTRICAL SAFETY	1	0	0	1
C:P: A		L	T	P	H
3:0:0		1	0	0	1

Topics **15**

Principles of electric safety - Electricity & Human body - Earthing / Grounding Risk assessment & management - Safety against over voltage, extra-low and residual voltages - Safe practices – RCD, PPE, CB, lockout/tag out -Hazardous areas, Electrical insulation - Electrical fires, Arc flash - Electrical safety in hospitals and Industries. Hazards of electricity - basic physics of electrical hazards - electrical safety equipment safety procedures and methods - grounding and bonding of electrical systems and equipment - electrical maintenance and its Relationship to safety - regulatory and legal safety requirements and standards accident prevention, accident investigation, rescue, and first aid - medical aspects of electrical trauma - low-voltage, medium- and high-voltage safety synopsis Human factors in electrical safety.

LECTURE	TUTORIAL	TOTAL
15	0	15

TEXT BOOKS

1. “Electrical Safety Handbook”, John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, McGraw-Hill Education, 4th Edition, 2012.

REFERENCE BOOKS

1. “Electrical Safety- a guide to the causes and prevention of electric hazards”, Maxwell Adams.J, The Institution of Electric Engineers, IET 1994(Reprint).
2. “Electrical Safety in the Workplace”, Ray A. Jones, Jane G. Jones, Jones & Bartlett Learning, 2000.

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MICROGRIDS

Course Outcomes (XEE M0*):		Domain	Level
CO1	Understand concept of microgrid and implementation issues.	Cognitive	Understanding
CO2	Understand issues related to power electronics interface.	Cognitive	Understanding
CO3	Acquire knowledge about modelling and stability analysis of solving power quality issues in Microgrid.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE M0*	MICROGRIDS	1	0	0	1
C:P: A		L	T	P	H
3:0:0		1	0	0	1

Topics **15**

Concept and definition of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid: AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, modes of operation and control of microgrid: grid connected and islanded mode, Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics.

	LECTURE	TUTORIAL	TOTAL
	15	0	15

TEXT BOOKS

1. "Renewable Energy Resources", John Twidell and Tony Weir, Taylor and Francis Publications, 2006.
2. "Microgrids and Active Distribution", S. Chowdhury, S. P. Chowdhury, P. Crossley The Institution of Engineering and Technology (June 24, 2009).

REFERENCE BOOKS

1. "Solar Photo Voltaics", Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi, 2009.
2. "Wind Energy Conversion System", Freris, Prentice Hall, 1990.

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PLC PROGRAMMING

Course Outcomes (XEE M0*):		Domain	Level
CO1	Understanding about the basics of PLC	Cognitive	Understanding
CO2	Describe different problems in PLC	Psychomotor	Perception

COURSE CODE	COURSE NAME	L	T	P	C
XEE M0*	PLC PROGRAMMING	1	0	0	1
C:P: A		L	T	P	H
1:0:0		1	0	0	1

Topics **6**

Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic function blocks logical / mathematical operators & data types, array & data structure.

Lab Exercises **9**

1. Draw and verify the ladder diagram for the given problem using the PLC: - Double acting Cylinder operation using solenoid valves.
2. Problems on OR logic ex: Stair case lighting problems, Problems on AND logic ex: Pressing unit other relevant simple problems like Railway platform example, flashing of light, Burglar alarm, Selection committee, testing unit, Pressing unit problem, Drilling tool etc.
3. Problems on Timers

LECTURE	TUTORIAL	TOTAL
15	0	15

TEXT BOOKS

1. "Programmable Logic Controllers" by W.Bolton, Newnes; 6 edition (March 17, 2015)
2. "Programmable Logic Controllers and Industrial Automation: An Introduction" by Madhuchhanda Mitra, Samarjit Sen Gupta Penram International Publishing (India) Pvt. Ltd, Second edition, 2017.

REFERENCE BOOKS

1. "Programmable Logic Controllers: Programming Methods and Applications" by Hackworth, Prentice Hall (April 21, 2003)

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ENERGY AUDITING

Course Outcomes (XEE M0*):		Domain	Level
CO1	Understand the importance of energy auditing & energy management.	Cognitive	Understanding
CO2	Apply their own ideas in optimizing the energy requirements to overcome the demand.	Cognitive	Applying
CO3	Acquire knowledge about energy monitoring and targeting to improve the energy efficiency.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE M0*	ENERGY AUDITING	1	0	0	1
C:P: A		L	T	P	H
1:0:0		1	0	0	1

Topics **15**

Energy Scenario: energy needs of growing economy, energy pricing, energy sector reforms, Re-structuring of the energy supply sector, Energy Conservation Act-2010 and its features - Need for energy audit - Energy management & audit approach: understanding energy, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, energy audit instruments. Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques -energy consumption, production, cumulative sum of differences (CUSUM) - Energy Efficiency in Electrical Utilities: electrical load management and maximum demand control, power factor improvement, energy saving opportunities with energy efficient motors.

	LECTURE	TUTORIAL	TOTAL
	15	0	15

TEXT BOOKS

1. "Energy Management Principles: Applications, Benefits, Savings", Craig B. Smith Kelly Parmenter, Elsevier,2nd Edition, 21st November 2015 eBook ISBN: 9780128026441
2. "Industrial Energy Management and Utilization "by L.C. Witte, P.S. Schmidt, D.R. Brown Hemisphere Publication, Washington, 1988, Published online 2010.

REFERENCE BOOKS

1. "Industrial Energy Conservation Manuals" by Elias P. Gyftopoulos, MIT Press, Mass, 1982© 2019 The MIT Press
2. "Energy Conservation guide book" by Patrick/Patrick/Fardo, Prentice hall, Third Edition,2014.
3. "Energy Management Handbook" by Wayne C. **Turner** & Steve Doty", John Wiley and Sons, A Wiley Interscience publication, 6th Edition, 2013.

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PROGRAMMING WITH ARDUINO

Course Outcomes (XEE M0*):		Domain	Level
CO1	Understand the basics of Arduino kit	Cognitive	Understanding
CO2	Applying the programming concept with different interfaces	Cognitive	Applying

COURSE CODE	COURSE NAME	L	T	P	C
XEE M0*	PROGRAMMING WITH ARDUINO	1	0	0	1
C:P: A		L	T	P	H
1:0:0		1	0	0	1
					15

Arduino Basics - The Arduino platform - Block Diagram – Architecture. Basic programming essentials - Control structure - Functions - operators - Sketch Structure. Interfacing LED with Arduino. Interfacing 7-Segment display with Arduino. Interfacing LCD display with Arduino. Interfacing different sensors with Arduino

	LECTURE	TUTORIAL	TOTAL
	15	0	15

TEXT BOOKS

1. "Arduino: 101 Beginners Guide: How to get started with Your Arduino (Tips, Tricks, Projects and More!)" by Erik Savasgard, 2nd Edition, July 2015.
2. "Exploring Arduino: Tools and Techniques for Engineering Wizardry" by Jeremy Blum, 2013.

REFERENCE BOOKS

1." Arduino Workshop: A Hands-On Introduction with 65 Projects" by John Boxall, No Starch Press; 1 edition (May 13, 2013)

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ELECTIVE GROUP - I

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PROTECTION AND SWITCHGEAR

Course Outcomes (XEE E11):		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

COURSE CODE	COURSE NAME	L	T	P	C
XEE E11	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.	
UNIT -V: PROTECTION AGAINST OVERVOLTAGE	**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, Earth wires, insulation co-ordination.

	LECTURE	TUTORIAL	TOTAL
	45	0	45

TEXTBOOKS

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**'**, Wiley Eastern Ltd., 2000.

REFERENCES

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

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

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	2	1	1	1	1	-	-	-	1	-	1	2	2
CO 2	1	1	2	2	1	1	1	-	-	1	-	1	1	1
CO 3	2	1	1	2	-	-	-	-	-	1	-	2	2	2
CO 4	1	1	1	1	-	-	1	-	-	1	-	1	2	2
CO 5	1	1	1	1	-	-	-	-	-	1	-	1	1	1
Total	7	7	6	5	5	2	2	0	0	5	0	6	8	8
Scaled	2	2	2	1	1	1	1	0	0	1	0	2	2	2

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

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XEE E12 ELECTRICAL MACHINE DESIGN

Course Outcomes (XEE E12):		Domain	Level
CO1	Able to **define** and **recall** the different fundamental concepts of electrical and magnetic circuit parameters.	Cognitive	Remembering
CO2	Categorize different types of Transformer based on its design. **Understand** about single phase and three phase transformer parameters and its efficiency calculation.	Cognitive	Understanding Analyzing
CO3	**Compare** the main dimensions of different machines, and **relate** its impact on the **Analyze** various parts of induction machines.	Cognitive	Understanding Analyzing
CO4	**Classify** types of three phase Synchronous motor. **Analyze** the design procedure of each part of the motor	Cognitive	Understanding Analyzing
CO5	Use of software tools to do design calculations.	Cognitive	Applying Analyzing

Learning Objectives:

Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines

COURSE CODE	COURSE NAME	L	T	P	C
XEE E12	ELECTRICAL MACHINE DESIGN	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT – I: INTRODUCTION	**9**
Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.	
UNIT – II: TRANSFORMERS	**9**
Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers.	
UNIT – III: INDUCTION MOTORS	**9**
Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of polyphase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.	
UNIT – IV: SYNCHRONOUS MACHINES	**9**
Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of airgap length, design of rotor,	

design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.
UNIT – V: COMPUTER AIDED DESIGN (CAD) **9**
Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design. Introduction to complex structures of modern machines- PMSMs, BLDCs, SRM and claw-pole machines.

	LECTURE	TUTORIAL	TOTAL
	45	0	45

TEXTBOOKS

1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 2016.
2. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.
3. S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.

REFERENCES

1. K. L. Narang, "A Text Book of Electrical Engineering Drawings", Satya Prakashan, 1969.
2. A. Shanmugasundaram, G. Gangadharan and R. Palani, "Electrical Machine Design Data Book", New Age International, 1979.
3. K. M. V. Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications, 2008.
4. Electrical machines and equipment design exercise examples using Ansoft's Maxwell 2D machine design package.

E REFERENCES

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

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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

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Scaled	2	1	1	1	2	2	1	2	1	1	1	0	2	2

ELECTRICAL SAFETY, OPERATIONS AND REGULATIONS

Course Outcomes (XEE E13):		**Domain**	**Level**
CO1	**Understand** about modern safety techniques	Cognitive	Understanding
CO2	**Understand** about the various audit methods and components.	Cognitive	Understanding
CO3	**List** the various accidents investigations and reports	Cognitive	Understanding
CO4	**Analysis** the performance of the safety and monitoring.	Cognitive	Analysis
CO5	**Understand** the various training and education of electrical safety	Cognitive	Understanding

Learning Objectives:

Understand about the various audit methods and components and recent safety techniques. Understand about the various accidents' investigations and reports. Understand the various training and education of electrical safety.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E13	**ELECTRICAL SAFETY, OPERATIONS AND REGULATIONS**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: CONCEPTS AND TECHNIQUES	**9**
History of Safety movement –Evolution of modern safety concept- general concepts of management – planning for safety for optimization of productivity -productivity, quality and safety-line and staff functions for safety-budgeting for safety-safety policy.	
UNIT- II: SAFETY AUDIT - INTRODUCTION	**9**
Components of safety audit, types of audit, audit methodology, non-conformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats – implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.	
UNIT- III: ACCIDENT INVESTIGATION AND REPORTING	**9**

Concept of an accident, reportable and non-reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – role of safety committee –cost of accident.
UNIT- IV: SAFETY PERFORMANCE MONITORING **9**
ANSI (Z16.1) Recommended practices for compiling and measuring work injury experience – permanent total disabilities, permanent partial disabilities, temporary total disabilities - Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety "t" score, safety activity rate – problems.
UNIT- V: SAFETY EDUCATION AND TRAINING **9**
Importance of training-identification of training needs-training methods – programmes, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

LECTURE	TUTORIAL	TOTAL
45	0	45

TEXT BOOKS

1. John Cadick, 'Electrical Safety Handbook, 4th Edition Hardcover – Import, 16 Mar 2012
2. James R white, 'Electrical Safety: A Practical Guide to OSHA and NFPA 7 – 2 Jul 2012

REFERENCE BOOKS

1. S. Rao, 'Electrical Safety, Fire Safety Engineering and Safety Management Paperback – 1997

Mapping of COs with POs

	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	0	2	1	0	2	0	1	0	1	0	0	0	0	3
CO2	0	0	0	1	2	0	1	0	0	0	0	0	3	1
CO3	1	2	3	1	2	0	0	1	1	0	0	0	1	2
CO4	0	2	0	1	3	0	1	0	0	0	0	0	2	1
CO5	2	0	1	0	0	1	1	1	1	0	0	1	1	2
Total	3	6	5	3	9	1	4	2	3	0	0	1	7	9
Scaled	1	2	1	1	2	1	1	1	1	0	0	1	2	3

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COMPUTER ARCHITECTURE

Course Outcomes (XEE E14):		Domain	Level
CO1	Understand the basic concepts of Computer organization	Cognitive	Understanding
CO2	Describe the various types and organization of memory	Cognitive	Understanding
CO3	Explain accessing of Input – Output devices	Cognitive	Understanding
CO4	Understand the various addressing modes and instruction set of 16 and 32 microprocessors	Cognitive	Understanding
CO5	Explain Pipelining and compare Different Architectures	Cognitive	Understanding

Learning Objectives:

Conceptualize the basics of organizational and architectural issues of a digital computer and understand various data transfer techniques in digital computer and processor performance improvement using instruction level parallelism

COURSE CODE	COURSE NAME	L	T	P	C
XEE E14	COMPUTER ARCHITECTURE	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: INTRODUCTION TO COMPUTER ORGANIZATION	**06**
Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic- Multiplication, Division, Fixed and Floating-point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Microinstruction, microprogramming, System buses, Multi-bus organization	
UNIT- II: MEMORY ORGANIZATION	**06**
System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optica l Disks	
UNIT - III: INPUT–OUTPUT ORGANIZATION	**09**
Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface Circuits-Parallel and serial port. Features of PCI and PCI Express bus.	
UNIT -IV: 16 AND 32 MICROPROCESSORS	**08**
80x86 Architecture, IA–32 and IA–64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, addressing modes of 80x86, Instruction set of 80x86, I/O addressing in 80x86.	
UNIT- V: PIPELINING AND DIFFERENT ARCHITECTURES	**16**
Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set. VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor and programming.	

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	LECTURE	PRACTICAL	TOTAL
	45	0	45

TEXTBOOKS

1. V.Carl, G.Zvonko and S.G.Zaky,"Computer organization",McGrawHill,1978.
2. B.Brey and C.R.Sarma,"The Intel microprocessors", Pearson Education,2000.
3. J.L.Hennessy and D.A.Patterson," Computer Architecture A Quantitative Approach", Morgan Kauffman,2017
4. W.Stallings, "Computer organization",PHI,1987.
5. P.Barry and P.Crowley, "Modern Embedded Computing", Morgan Kaufmann,2012.
6. N.Mathivanan,"Microprocessors, PC Hardware and Interfacing", Prentice Hall,2004.

REFERENCES

1.Y.C.Lieu and G.A.Gibson, "Microcomputer Systems:The8086/8088Family", Prentice Hall India,1986.
2. J.Uffenbeck,"The 8086/8088 Design, Programming, Interfacing", Prentice Hall,1987.
3. B.Govindarajalu,"IBMPC and Clones",TataMcGrawHill,1991.
4. P. Able, "8086 Assembly Language Programming", Prentice Hall India.

E REFERENCES

www.nptel.ac.in

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1	1		1	1					1	2	1	1	1
CO 2	1	1		1	1					1	2	2		
CO 3	1	1		1	1					1	2	2	1	1
CO 4	1	1		1	1					1	2	1		
CO 5	1	1		1	1					1	2	2	1	1
Total	5	5	0	5	2	0	0	0	0	5	10	8	3	3
Scaled	1	1	0	1	1	0	0	0	0	1	2	1	1	1

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

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ELECTIVE GROUP - II

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MEASUREMENTS AND INSTRUMENTATION

Course Outcomes (XEE E21):		Domain	Level
CO1	**Describe** the different errors in measurements and **Describe** the working principle of different measuring instruments.	Cognitive Psychomotor	Remembering Perception
CO2	**Understanding** about the instruments used for different types of AC measurements. **Carryout** calibration test for measuring electrical instruments	Cognitive Psychomotor	Understanding Set
CO3	**Use** different types bridge circuits for the measurements of unknown passive elements. **Relate** the different types of the transducers. **Demonstrate** the use of different bridges and transducers.	Cognitive Psychomotor	Applying Mechanism
CO4	**Explain** the construction and operation of recording and display instruments. **Establish** Relations between analog and digital signal conversions.	Cognitive Psychomotor	Understanding Set
CO5	**Explain** the construction and working of different types signal conditioners. **Demonstrate** the recent trends in measurement of AC quantities.	Cognitive Psychomotor	Remembering Mechanism

Learning Objectives:

Understanding about the instruments used for different types of AC measurements. Understanding about various types of AC and DC bridges. Understanding about various types of transducers and display units.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E21	MEASUREMENTS AND INSTRUMENTATION	3	0	1	4
C:P: A		L	T	P	H
3:1:0		3	0	2	5

UNIT- I: INTRODUCTION **9+9**

Measurements – Errors & classification, Measurement of voltage & current - permanent magnet moving coil and moving iron meters, Measurement of power and energy - dynamometer and induction instruments, Instrument transformers – Current and Potential transformers

List of Experiments

1. Calibration of Current Transformer and Potential transformer.
2. Measurement of three phase active, Reactive Power and Power factor
3. Calibration of Single phase / Three Phase Energy meter

UNIT – II: DC AND AC BRIDGES **9+9**

Measurement of resistance, inductance and capacitance using dc and ac bridges, Wheatstone bridge, Maxwell bridge, Kelvin's Bridge, Schering Bridge

List of Experiments

4. Resistance measurement using Wheat stone bridge
5. Inductance measurement using Maxwell Bridge
6. Capacitance measurement using Schering Bridge

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UNIT - III: TRANSDUCERS	**9+6**
Active and Passive transducers, Piezoelectric transducer, Photoelectric transducers, Thermocouples, Strain gauge transducers, LVDT, differential capacitive transducers, Fiber optic transducers, Resistive, Inductive and capacitive transducers. **List of Experiments** 7. Study of Transducers	
UNIT- IV: SIGNAL CONDITIONING UNITS	**9+3**
Signal conditioners – Instrumentation amplifiers, voltage–current converters, A/D and D/A converters, voltage-frequency converters, analog multiplexers and de-multiplexers. Microprocessor Based Measurements, Case Studies in Instrumentation. **List of Experiments** 8. A/D converters 9. D/A converters	
UNIT -V: RECORDERS AND DISPLAY	**9+3**
Signal sources – Oscillators, Function generator and pulse generators. Oscilloscopes - CRO, Digital storage and Analog storage Oscilloscope, Digital Phosphor Oscilloscopes. Analog and Digital Recorders and printers. Spectrum Analyzers, Data and Logic Analyzers. **List of Experiments** 10. Measurement of Current / Voltage / power / Energy using Arduino board.	

	LECTURE	**TUTORIAL**	**PRACTICAL**	**TOTAL**
	45	**0**	**30**	**75**

TEXTBOOKS

1. A. K. Sawhney, 'A Course in Electrical and Electronic Measurements and Instrumentation', Dhanpat Rai & Co., 9th Edition, 2015.
2.Bouwens A. J., 'Digital Instrumentation', Tata McGraw Hill Publications, 16th Reprint (2008).
3. Kalsi H.S, 'Electronic Instrumentation', Tata McGraw-Hill Education, 3rd Edition, 2010.
4. Deobelin, 'Measurements Systems', Tata McGraw Hill Publications, 2nd Edition, 2010.

REFERENCES

1.W. D. Cooper, 'Electronic Instrumentation and Measurement Techniques', Prentice Hall of India Publications, 1st Edition, 2009.
2.Rangan C.S., 'Instruments Devices and System', Tata McGraw Hill Publications, 2nd Edition, 2009.

E REFERENCES

1. NTPEL, Electrical Machines (Web Course), Prof.N.K.De, Prof.T.K.Bhattacharya and Prof. G. D. Roy, IIT Kharagpur.

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	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
Scaled	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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ELECTROMAGNETIC WAVES

Course Outcomes (XEE E22):		**Domain**	**Level**
CO1	Understand and Analyze transmission lines and estimate voltage and current at any point on transmission line for different load conditions.	Cognitive	Understanding Analyze
CO2	Understand and Provide solution to real life plane wave problems for various boundary conditions.	Cognitive	Understanding Analyze
CO3	Understand and Analyze the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.	Cognitive	Understanding Analyze
CO4	Understand and Analyze TE and TM mode patterns of field distributions in a rectangular wave-guide.	Cognitive	Understanding Analyze
CO5	Understand and analyze radiation by antennas.	Cognitive	Remembering Understanding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E22	**ELECTROMAGNETIC WAVES**	**3**	**0**	**0**	**3**
C:P:A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: TRANSMISSION LINES **09**

Introduction, Concept of distributed elements, Equations of voltage and current, Standing waves and impedance transformation, Lossless and low-loss transmission lines, Power transfer on a transmission line, Analysis of transmission line in terms of admittances, Transmission line calculations with the help of Smith chart, Applications of transmission line,
Impedance matching using transmission lines.

UNIT – II: MAXWELL'S EQUATIONS **09**

Basic quantities of Electromagnetics, Basic laws of Electromagnetics Gauss's law, Ampere's Circuital law, Faraday's law of Electromagnetic induction. Maxwell's equations, Surface charge and surface current, Boundary conditions at media interface.

UNIT - III: UNIFORM PLANE WAVE **09**

Homogeneous unbound medium, Wave equation for time harmonic fields, Solution of the wave equation, Uniform plane wave, Wave polarization, Wave propagation in conducting
Medium, Phase velocity of a wave, Power flow and Poynting vector.

UNIT- IV: PLANE WAVES AT MEDIA INTERFACE **09**

Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction of waves at dielectric interface, Total internal reflection, Wave polarization at media interface, Brewster angle, Fields and power flow at media interface, Lossy media interface, Reflection from conducting boundary.

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UNIT- V: WAVE GUIDES AND ANTENNAS	**09**
Parallel plane waveguide Transverse Electric (TE)mode, transverse Magnetic (TM)mode, Cut-off frequency, Phase velocity and dispersion. Transverse Electromagnetic (TEM)mode, Analysis of waveguide- general approach, Rectangular waveguides. Radiation parameters of antenna, Potential functions, Solution for potential functions, Radiations from Hertz dipole, Near field, Far field, Total power radiated by a dipole, Radiation resistance and radiation pattern of Hertz dipole, Hertz dipole in receiving mode.	

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

TEXTBOOKS

1.R.K.Shevgaonkar,**"**ElectromagneticWaves**"**,Tata McGraw Hill, 2005
2.D.K.Cheng,"Field and Wave Electromagnetics**"**,Addison-Wesley,1989.

REFERENCES

1. M.N.O.Sadiku,"Elements of Electromagnetics**"**, Oxford University Press, 2007.
2. C.A.Balanis,"Advanced Engineering Electromagnetics" John Wiley & Sons, 2012.
3. C.A.Balanis,"Antenna Theory: Analysis and Design**"**, John Wiley & Sons, 2005.

E REFERENCES

www.nptel.ac.in
Department of Physics, Indian Institute of Technology, Kharagpur.

Mapping of COs with POs

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

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

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COMPUTATIONAL ELECTROMAGNETICS

Course Outcomes (XEE E23):		**Domain**	**Level**
CO1	Understand the basic concepts of electromagnetics	Cognitive	Understanding
CO2	Understand computational techniques for computing fields	Cognitive	Understanding
CO3	Apply the techniques to simple real-life problems.	Cognitive	Apply
CO4	Understand computational techniques for finite element method.	Cognitive	Understanding
CO5	Understand and analyze the field computation for different application.	Cognitive	Understanding Analyze

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E23	**COMPUTATIONAL ELECTROMAGNETICS**	**3**	**0**	**0**	**3**
C:P:A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION **09**

Conventional design methodology, Computer aided design aspects–Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics, Development of Helmhotz equation, energy transformer vectors-Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

UNIT- II: ANALYTICAL METHODS **09**

Analytical methods of solving field equations, method of separation of variables, Roth's method, integral methods- Green's function, method of images.

UNIT - III: FINITE DIFFERENCE METHOD **09**

Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD)method- Uniqueness and convergence

UNIT -IV: FINITE ELEMENT METHOD **09**

Overview of FEM, Vibrational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

UNIT- V: SPECIALTOPICS AND APPLICATIONS **09**

Background of experimental methods- electrolytic tank, R-C network solution, Field plotting (graphical method), hybrid methods, coupled circuit-field computations, electromagnetic – thermal and electromagnetic-structural coupled computations, solution of equations, method of moments, Poisson's fields, Low frequency electrical devices, static/time harmonic/ transient problems in transformers, rotating machines, actuators, CAD packages

	LECTURE	**PRACTICAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1.R.K.Shevgaonkar,**"**ElectromagneticWaves**"**,Tata McGraw Hill, 2005
2.M.N.O.Sadiku,"Numerical Techniques in Electromagnetics", CRC Press, 2001.

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REFERENCES
1. C.A.Balanis,"Advanced Engineering Electromagnetics", John Wiley & Sons, 2012. 2. C.A.Balanis, "Antenna Theory: Analysis and Design", John Wiley & Sons, 2005.
E REFERENCES
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Mapping of COs with POs

	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	1	1	1	1	1	1	1	-	-	1	-	1	1	1
CO2	1	1	1	1	-	-	-	-	-	-	1	-	2	1
CO3	2	2	-	-	-	1	-	-	-	-	-	1	1	2
CO4	2	2	-	-	-	-	1	-	-	-	-	-	1	2
CO5	2	2	-	-	-	-	-		-	-	-	-	1	1
Total	8	8	2	2	1	2	2	0	0	1	1	2	7	7
Scaled	2	3	1	1	1	1	1	0	0	1	1	1	2	2

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

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DIGITAL CONTROL SYSTEMS

Course Outcomes (XEE E24):		Domain	Level
CO1	Obtain the discrete representation of LTI systems.	Cognitive	Remembering Understanding
CO2	Analyze stability of open loop and closed loop discrete-time systems.	Cognitive	Remembering Understanding
CO3	Design and analyze state space models of discrete system	Cognitive	Understanding Applying
CO4	Design state feedback controllers.	Cognitive	Understanding Applying
CO5	Design output feedback controllers.	Cognitive	Understanding Applying

Learning Objectives:

To make students understand the concept of nonlinear control, Internal Model Control and Optimal Control. To Study the stability of Non-Linear and Linear systems.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E24	DIGITAL CONTROL SYSTEMS	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT - I: DISCRETE REPRESENTATION OF CONTINUOUS SYSTEMS — **9**

Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.

UNIT - II: STABILITY AND ANALYSIS OF DISCRETE TIME SYSTEM — **9**

Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response. Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response.

UNIT – III: STATE SPACE APPROACH FOR DISCRETE TIME SYSTEMS — **9**

State space models of discrete systems, State space analysis. Lyapunov Stability, Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability &observability.

UNIT - IV: DESIGN OF DIGITAL CONTROL SYSTEM — **9**

Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.

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UNIT – V: DISCRETE OUTPUT FEEDBACK CONTROL			9
Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.			
	LECTURE	**TUTORIAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. K. Ogata, "Modern Control Engineering", Prentice Hall, Englewood Cliffs, 5th Edition,2009.
2. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
3. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison- Wesley, 3rd Edition, 1997.

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1. Charles L. Phillips , Troy Nagle , James Brickley , Aranya Chakrabortty "Digital Control System Analysis & Design, Global Edition", by 4th edition, Pearsons, 2015
2. B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 2nd Edition,1980.

E-REFERENCES

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

Mapping of COs with 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
Scaled	2	2	1	2	1	1	1	1	1	1	1	1	1	1

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

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ELECTIVE GROUP - III

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INDUSTRIAL AUTOMATION

Course Outcomes (XEE E31):		**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 Mechanism	Remembering Understanding Psychomotor
CO2	Apply the knowledge of electrical ladder diagram for hydraulic and pneumatic system and able to define pressure proximity switches and intelligent relays	Cognitive	Remembering Applying
CO3	**Explain** and **Categorize** different types of Sensors and their application. **List** out timer, counter and their application.	Cognitive Mechanism	Remembering Understanding Analyzing Psychomotor
CO4	**Illustrat**e the knowledge in the PLC logic, Architecture and design the industrial automation system for specific applications and apply the knowledge for PLC programming to interface pneumatics.	Cognitive Mechanism	Applying Understanding Psychomotor
CO5	**Outline** the overview of robotics and their application. Apply the knowledge of robotics programming	Cognitive	Applying Understanding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E31	**INDUSTRIAL AUTOMATION**	**3**	**0**	**1**	**4**
C:P: A		**L**	**T**	**P**	**H**
3:1:0		**3**	**0**	**2**	**5**

UNIT -I: INTRODUCTION TO PNEUMATICS AUTOMATION **9 + 6**

Introduction to Pneumatics- Overall structure- Electro pneumatic –hydraulics- Overall –structure – Advantages and disadvantages – Application-Electrical drives.

List of Experiments

1. Control of Pneumatically operated single acting cylinder
2. Extension and Retraction of double acting cylinder
3. Control of pneumatically operated double acting cylinder using sensor
4. Control of pneumatically operated double acting cylinder using timer
5. Sequential control of two double acting cylinder

UNIT- II: APPLICATIONS OF RELAYS **9 + 6**

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 **9 + 6**

Introduction to sensors- characteristics- types of sensors-resistive - inductive-capacitive- magnetic-ultrasonic - photoelectric- Nano sensors- timers-counters-types-application.

List of Experiments

6. Study of Sensor

UNIT -IV: PROGRAMMABLE LOGIC CONTROLLERS	**9+12**

Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – PLC interface to pneumatics.

List of Experiments

7. AND and OR Logical function PLC
8. Automatic tank filing control using PLC
9. Traffic light control using PLC
10. Starter control of motor using PLC

UNIT -V: ROBOTICS	**9**

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	**PRACTICAL**	**TOTAL**
	45	**30**	**75**

TEXTBOOKS

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.

REFERENCES

1. Anthony Esposito, "Fluid Power with Applications", Pearson Education, 5th Edition, New Delhi, 2000.
2. Stuart A. Boyer.," SCADA: Supervisory Control and Data Acquisition", 4th Edition (Kindle), 2016.
3. "The Instrumentation systems and Automation Society", 2013.
4. "Micro-sensors; principles and applications" J.W.Gardner", Wiley, 1 edition (August 1994).
5. "Semiconductor sensors and its application" S.M.Sze, Wiley-Interscience, 1 edition (October 1994)

E REFERENCES

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

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Mapping of COs with POs

	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
Scaled	3	2	1	1	1	1	1	1	1	1	1	0	2	2

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DIGITAL SIGNAL PROCESSING

Course Outcomes (XEE E32):		**Domain**	**Level**
CO1	Understand the signals mathematically in continuous and discrete-time, and in the frequency domain.	Cognitive	Understanding
CO2	Analyze discrete-time systems using z-transform.	Cognitive	Analyze
CO3	Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.	Cognitive	Understanding
CO4	Design and analyze digital filters for various applications.	Cognitive	Analyze
CO5	Apply digital signal processing for the analysis of real-life signals.	Cognitive	Applying

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E32	**DIGITAL SIGNAL PROCESSING**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT –I: DISCRETE-TIMESIGNALS AND SYSTEMS	**9**
Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals-aliasing; Sampling theorem and Nyquist rate.	
UNIT -II: Z-TRANSFORM	**9**
z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms. Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.	
UNIT - III: DISCRETE FOURIER TRANSFORM	**9**
Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.	
UNIT- IV: DESIGN OF DIGITAL FILTERS	**9**
Design of FIR Digital filters: Window method, Park-McClellan's method, Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band-Stop and High-pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.	
UNIT - V: APPLICATIONS OF DIGITAL SIGNAL	**9**
CorRelation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.	

	LECTURE	**PRACTICAL**	**TOTAL**
	45	**0**	**45**

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TEXTBOOKS

1. S. K. Mitra, "Digital Signal Processing: A computer-based approach", McGrawHill,2011.
2. A.V.Oppenheim and R.W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
3. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Prentice Hall,1997.

REFERENCES

1. L.R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
2. J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall,1992.
3. D.J. De Fatta, J.G.Lucas and W.S.Hodgkiss,"Digital Signal Processing", John Wiley &Sons, 1988.

E REFERENCES

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

Mapping of COs with POs

	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	2	2	-	-	1	1	-	1	-	1	3	2	2	1
CO3	2	3	-	-	2	2	1	-	-	-	-	1	1	1
CO4	2	1	3	-	-	1	-	1	1	-	-	1	-	2
CO5	2	2		-	1	-	-	2	-	-	-	1	-	2
Total	11	10	3	2	5	5	2	4	1	2	4	5	5	7
Scaled	3	2	1	1	1	1	1	1	1	1	1	0	2	2

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ELECTRICAL ENERGY CONSERVATION AND AUDITING

Course Outcomes (XEE E33):		DOMAIN	LEVEL
CO1	**Understand** the energy and environment, energy security and energy conservation	Cognitive	Understanding
CO2	**Understand** the various form of energy.	Cognitive	Remembering
CO3	**Understand** energy auditing and planning.	Cognitive	Understanding
CO4	**Understand** the various energy saving opportunities with energy efficient equipments	Cognitive	Remembering
CO5	**Understand** about industrial energy management systems.	Cognitive	Understanding

Learning Objectives: Understand about various energy conservation techniques and planning.
Understand about basics of energy auditing and evaluation scheme.
Understand about industrial based energy management systems.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E33	ELECTRICAL ENERGY CONSERVATION AND AUDITING	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: ENERGY SCENARIO — **9**

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2012 and its features.

UNIT- II: BASICS OF ENERGY AND ITS VARIOUS FORMS — **9**

Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT- III: ENERGY MANAGEMENT & AUDIT — **9**

Definition, energy audit, need, types of energy audit. Energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

UNIT- IV: ENERGY EFFICIENCY IN ELECTRICAL SYSTEMS — **9**

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF

capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

UNIT- V: ENERGY EFFICIENCY IN INDUSTRIAL SYSTEMS	**9**

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

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

TEXT BOOKS:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities

REFERENCE BOOKS:

1. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
2. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Mapping of COs with POs

	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	0	2	1	0	2	0	1	0	1	0	0	0	0	3
CO2	0	0	0	1	2	0	1	0	0	0	0	0	3	1
CO3	1	2	3	1	2	0	0	1	1	0	0	0	1	2
CO4	0	2	0	1	3	0	1	0	0	0	0	0	2	1
CO5	2	0	1	0	0	1	1	1	1	0	0	1	1	2
Total	3	6	5	3	9	1	4	2	3	0	0	1	7	9
Scaled	1	2	1	1	2	1	1	1	1	0	0	1	2	3

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INDUSTRIAL ELECTRICAL SYSTEMS

Course Outcomes (XEE E34):		Domain	Level
CO1	Understand the basic Electrical System Components	Cognitive	Understanding
CO2	Elaborate on Residential and Commercial Electrical Systems	Cognitive	Understanding
CO3	Understand Illumination Systems	Cognitive	Understanding
CO4	Understand various components of industrial electrical systems	Cognitive	Understanding
CO5	Understand various electrical system components and their role in Industrial Electrical System Automation	Cognitive	Understanding

Learning Objectives:

Understand the electrical wiring systems and the various components for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings and SLD.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E34	INDUSTRIAL ELECTRICAL SYSTEMS	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT -I: ELECTRICAL SYSTEM COMPONENTS	**9**
LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components-Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD)of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices	
UNIT –II: RESIDENTIAL AND COMMERCIAL ELECTRICAL SYSTEMS	**9**
Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components	
UNIT - III: ILLUMINATION SYSTEMS	**9**
Understanding various terms regarding light, lumen, intensity, candlepower, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of alighting scheme for a residential and commercial premise, floodlighting	
UNIT – IV: INDUSTRIAL ELECTRICAL SYSTEMS	**9**
HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction– KVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT	

Breakers, MCB and other LT panel components. DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks			
UNIT - V: INDUSTRIAL ELECTRICAL SYSTEM AUTOMATION			**9**
Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.			
	LECTURE	**PRACTICAL**	**TOTAL**
	45	**0**	**45**
TEXTBOOKS			
1. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating &Costing", Khanna publishers, 2008. 2. K.B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007. 3. S. Singh and R.D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co.,2014.			
REFERENCES			
1. Website for IS Standards. 2. H. Joshi,"ResidentialCommercialandIndustrialSystems",McGrawHillEducation,2008.			
E REFERENCES			
www.nptel.ac.in			

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2	2	1	2	1	1	1	1	1	1	1	2	2
CO 2	3	2	2	1	2	1	1	1	1	1	1	1	2	2
CO 3	3	2	2	1	2	1	1	1	1	1	1	2	2	2
CO 4	3	2	2	1	2	1	1	1	1	1	1	1	2	2
CO 5	3	2	2	1	2	1	1	1	1	1	1	1	2	2
Total	15	10	10	5	2	5	5	5	5	5	3	6	10	10
Scaled	3	2	2	1	1	1	1	1	1	1	1	2	2	2

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

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ELECTIVE GROUP - IV

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HIGH VOLTAGE ENGINEERING

Course Outcomes (XEE E41):		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

Learning Objectives:

Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials. Knowledge of generation and measurement of D. C., A.C., & Impulse voltages. Knowledge of tests on H.V. equipment and on insulating materials, as per the standards. Knowledge of how over-voltages arise in a power system, and protection against these over-voltages.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E41	HIGH VOLTAGE ENGINEERING	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT - I: OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS **9**

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 **9**

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.

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UNIT – III: GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS	9
Generation of High DC, AC, impulse voltages and currents. Tripping and control of impulse generators.	
UNIT – IV: MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS	**9**
Measurement of High direct current voltages – measurement of voltages: alternating and impulse voltages and measurement of currents: direct, alternating and impulse currents. Digital techniques in high voltage measurement	
UNIT – V: HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS	**9**
International and Indian standards-Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment. -Insulation co-ordination.	

LECTURE	PRACTICAL	TOTAL
45	0	45

TEXTBOOKS

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, 4thEdition, 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.

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1. C.L.Wadhwa, 'High Voltage Engineering', New Age International (P) Ltd, 2nd Edition, 2006.
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.

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

Mapping of COs with POs

	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

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EMBEDDED SYSTEMS

Course Outcomes (XEE E42):		Domain	Level
CO1	Understand the structural units of Embedded Systems	Cognitive	Understanding
CO2	Explain and understand networking protocols and interfaces in Embedded Systems	Cognitive	Understanding
CO3	Understand and elaborate Embedded Firmware development	Cognitive	Understanding
CO4	Explain and understand the basic concepts of RTOS	Cognitive	Understanding
CO5	Understand how Embedded System Application Development is done	Cognitive	Understanding

Learning Objectives:

To introduce the Building Blocks of Embedded System, Bus Communication in processors, Input/output interfacing Basics of RTOS and to educate in Various Embedded Development Strategies, imparting knowledge in various processor scheduling algorithms.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E42	EMBEDDED SYSTEMS	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT –I: INTRODUCTION TO EMBEDDED SYSTEMS	**9**
Introduction to Embedded Systems – The build process for embedded systems-Structural units in Embedded processor, selection of processor & memory devices- DMA – Memory management methods- Timer and Counting devices, Watchdog Timer, Real Time Clock, In circuit emulator, Target Hardware Debugging	
UNIT- II: EMBEDDED NETWORKING	**9**
Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols – RS232 standard – RS422 – RS485 – CAN Bus -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) –need for device drivers	
UNIT –III: EMBEDDED FIRMWARE DEVELOPMENT ENVIRONMENT	**9**
Embedded Product Development Life Cycle- objectives, different phases of EDLC, Modelling of EDLC; issues in Hardware-software Co-design, Data Flow Graph, state machine model, Sequential Program Model, concurrent Model, object-oriented Model	

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UNIT - IV: RTOS BASED EMBEDDED SYSTEM DESIGN	9
Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication shared memory, message passing, Inter process Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: Vx Works, µC/OS-II, RT Linu0078	
UNIT- V: EMBEDDED SYSTEM APPLICATION DEVELOPMENT	**9**
Case Study of Washing Machine- Automotive Application- Smart card System Application, Mobile Embedded System	

	LECTURE	PRACTICAL	TOTAL
	45	0	45

TEXTBOOKS

1. Rajkamal, ‘Embedded System-Architecture, Programming, Design’, Mc Graw Hill, 2013.
2. Peckol, “Embedded system Design”, John Wiley & Sons,2010
3. Lyla B Das,” Embedded Systems-An Integrated Approach”, Pearson, 2013

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1. Shibu. K.V, “Introduction to Embedded Systems”, Tata McGraw Hill,2009.
2. Elicia White,” Making Embedded Systems”, O’ Reilly Series, SPD,2011.
3. Tammy Noergaard, “Embedded Systems Architecture”, Elsevier, 2006.
4. Han-Way Huang, “Embedded system Design Using C8051”, Cengage Learning,2009.
5. Rajib Mall “Real-Time systems Theory and Practice” Pearson Education, 2007

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https://learnengineering.in/ee6602-embedded-systems/

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2				1				1	1	1	1	1	1
CO 2	2				1				1	1	1	1	1	1
CO 3	2				1				1	1	1	1	1	1
CO 4	2				1				1	1	1	1	1	1
CO 5	2				1				1	1	1	1	1	1
Total	10	0	0	0	5	0	0	0	5	5	5	5	5	5
Scaled	3	0	0	0	1	0	0	0	1	1	1	1	1	1

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POWER SYSTEM RESTRUCTURING

Course Outcomes (XEE E43):		Domain	Level
CO1	Understand the restructuring of power industry and market models.	Cognitive	Understanding
CO2	Understand the transmission congestion management	cognitive	Understanding
CO3	Understand knowledge on fundamental concepts of congestion management.	cognitive	Understanding
CO4	Analyze the concepts of locational marginal pricing and financial transmission rights.	cognitive	Analyze
CO5	Analyze the various power sectors in India	cognitive	Analyze

COURSE CODE	COURSE NAME	L	T	P	C
XEE E43	POWER SYSTEM RESTRUCTURING	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY — **9**

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis other commodities, Market architecture, Case study.

UNIT- II: TRANSMISSION CONGESTION MANAGEMENT — **9**

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods –Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

UNIT – III: LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS — **9**

Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality –Simultaneous feasibility test and revenue adequacy – FTR issuance process: FTR auction, FTR allocation– Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT - IV: ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK — **9**

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - How to obtain ancillary service –Co-optimization of energy and

reserve services - Transmission pricing – Principles – Classification– Rolled in transmission pricing methods – Marginal transmission pricing paradigm –Composite pricing paradigm – Merits and demerits of different paradigm.			
UNIT - V: REFORMS IN INDIAN POWER SECTOR			**9**
Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff– Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future			
	LECTURE	**TUTORIAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
3. Paranjothi, S.R., "Modern Power Systems" Paranjothi, S.R. , New Age International, 2017.

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1. Sally Hunt," Making competition work in electricity", John Willey and Sons Inc. 2002.
2. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

E REFERENCES

www.nptel.ac.in

Learning objectives:

To study the complete process of deregulation and restructuring of Power Industry.

Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1	2	1	1	1	1	-	-	-	-	-	1	2	2
CO 2	1	3	2	2	1	1	1	-	-	-	-	0	1	1
CO 3	1	1	1	2	1	0	-	-	-	-	-	2	1	1
CO 4	1	1	1	1	1	0	1	-	-	-	-	1	2	2
CO 5	1	1	1	1	0	1	-	-	-	-	-	1	0	0
Total	5	8	6	7	4	3	2	0	0	5	0	6	6	6
Scaled	2	2	2	1	1	1	1	0	0	1	0	2	2	2

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LINE COMMUTATED AND ACTIVE RECTIFIERS

Course Outcomes (XEE E44):		**Domain**	**Level**
CO1	Understand and Analyse controlled rectifier circuits.	Cognitive	Understand Analyse
CO2	Understand the operation of line-commutated rectifiers - six pulse and multi-pulse configurations.	Cognitive	Understand
CO3	Understand the operation of PWM rectifiers – operation in rectification and regeneration modes and lagging, leading and unity power factor mode.	Cognitive	Understand
CO4	Understand the operation of Single-phase ac-dc single-switch boost converter and ac-dc Fly back converter**.**	Cognitive	Understand
CO5	Understand the operation of Ac-dc bidirectional boost converter**.**	Cognitive	Understand

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E44	**LINE COMMUTATED AND ACTIVE RECTIFIERS**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: DIODE RECTIFIERS WITH PASSIVE FILTERING	**09**
Half-wave diode rectifier with RL and RCloads;1-phase full-wave diode rectifier with L, C andLCfilter;3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current wave shape, effect of source inductance; commutation overlap.	
UNIT -II: THYRISTOR RECTIFIERS WITH PASSIVE FILTERING	**09**
Half-wave thyristor rectifier with RL and RC loads; single phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.	
UNIT - III: MULTI-PULSE CONVERTER	**09**
Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac,6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.	
UNIT–IV: SINGLE-PHASE AC- DC SINGLE- SWITCHBOOST CONVERTER AND AC-DC FLY BACK CONVERTER	**09**
Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure. Dc-dc fly back converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc fly back converter, steady state analysis, unity power factor operation, closed loop control structure	

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UNIT-V: AC-DC BIDIRECTIONAL BOOST CONVERTER			**09**
Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.			
	LECTURE	**TUTORIAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. G. De, "Principles of Thyristorised Converters", Oxford &IBH PublishingCo,1988.
2. J.G. Kassakian, M. F. Schlecht and G.C. Verghese, "Principles of Power Electronics", Addison-Wesley,1991.
3. L.Umanand,"Power Electronics: Essentials and Applications", Wiley India,2009.

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1. N.Mohan and T.M.Undeland,"Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
2. R.W.Erickson and D.Maksimovic, "Fundamentals of Power Electronics", Springer Science & BusinessMedia,2001.

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Mapping of COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	2	2	1	1	1	-	-	-	-	1	-	1	2	2
CO 2	3	2	1	2	1	-	-	-	-	1	-	1	1	1
CO 3	2	1	1	2	1	-	-	-	-	1	-	2	1	1
CO 4	1	1	0	0	1	-	-	-	-	1	-	1	0	0
CO 5	1	1	1	1	1	-	-	-	-	1	-	1	1	1
Total	9	7	4	5	5	0	0	0	0	5	0	6	6	6
Scaling	2	2	1	1	1	0	0	0	0	1	0	2	2	2

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ELECTIVE GROUP -V

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ELECTRICAL DRIVES

Course Outcomes (XEE E51):		Domain	Level
CO1	**Understand** the characteristics of DC drives and its multi-quadrant operation	Cognitive	Understanding
CO2	**Understand** the various control techniques of DC Drives.	Cognitive	Remembering
CO3	**Categorize** the different speed control methods for an Induction motor drive at stator side.	Cognitive	Understanding
CO4	**Illustrate** the various control techniques of induction motor Drives at rotor side.	Cognitive	Understanding
CO5	**Illustrate** the various control techniques and application of Synchronous motor drives.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE E51	ELECTRICAL DRIVES	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: DC MOTOR DRIVE CHARACTERISTICS AND ITS MULTI-QUADRANT OPERATIONS	**9**
Fundamentals of Electrical Drives - Advantage of Electrical Drives - Selection of Motor Power Rating - Review of emf and torque equations of DC machine - Review of torque-speed characteristics of separately excited dc motor - Four quadrant operation of dc machine – Steady state operation of multi-quadrant chopper fed dc drive, regenerative braking.	
UNIT- II: CONTROL OF DC DRIVES	9
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 – Industrial Applications of DC drives	
UNIT- III: STATOR CONTROLLED INDUCTION MOTOR DRIVES	**9**
Induction Motor Drives - Stator Control - Stator Voltage and Frequency Control - VSI, CSI and Cycloconverter Fed Induction Motor Drives - Open Loop and Closed Loop V/f Control. Conventional space vector modulation; Steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation - Industrial Applications of Stator controlled Induction Motor drives.	
UNIT- IV: ROTOR CONTROLLED INDUCTION MOTOR DRIVES	**9**
Impact of rotor resistance of the induction motor torque-speed curve - Operation of slip-ring induction motor with external rotor resistance, starting torque - Power electronic based rotor side control of slip ring motor - Slip Power Recovery, sub-synchronous and Super Synchronous Operations - Power	

Factor Improvement - Closed Loop Control- - Industrial Applications of Rotor controlled Induction Motor drives.	
UNIT- V: SYNCHRONOUS MOTOR DRIVES	**9**
Separate Controlled Mode - Self Controlled Mode of Synchronous Motor - Constant Marginal Angle Control and Motor Power Factor Control - Cycloconverter Fed Synchronous Motors - Digital Control and Drive Applications.	

LECTURE	TUTORIAL	TOTAL
45	0	45

TEXT BOOKS

1. Dubey G.K, 'Fundamentals of Electrical Drives', Narosa Publications, 2008.
2. B. K. Bose, 'Power Electronics and AC Drives', Prentice Hall Onglewood cliffs, New Jersey, 1998.
3. Krishnan. R, 'Electric motor& Drives; Modelling, Analysis and Control', Prentice Hall of India, 2001.
4. Dubey G. K., 'Power Semiconductor Controlled Drives', Prentice Hall, 1989.

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1. Murphy, J.M.D and Turnbull F.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 Hill Publishing company Ltd., 2011.
4. Leonhard. W, 'Control of Electric Drives', Springer Science & Business Media, 2001

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Lecture Series on Solid State Devices by Prof.S.Karmalkar, Department of Electrical Engineering, IIT Madras.

Mapping of COs with POs

	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	1	0	2	0	1	0	0	0	0	0	0	3
CO2	3	1	0	0	2	0	1	0	0	0	0	0	3	2
CO3	1	2	3	0	2	0	0	1	0	0	0	0	1	2
CO4	0	2	0	0	3	0	1	0	0	0	0	0	2	2
CO5	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
Scaled	2	2	1	0	2	1	1	1	0	0	0	1	2	3

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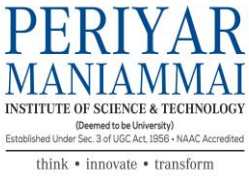

0 –No Relation 1 – Low Relation 2 – Medium Relation 3 – High Relation

POWER SYSTEM DYNAMICS AND CONTROL

Course Outcomes (XEE E52):		**Domain**	**Level**
CO1	Understandtheproblemofpowersystemstabilityanditsimpactonthesystem.	Cognitive	Understand
CO2	Analyze linear dynamical systems and use of numerical integration methods.	Cognitive	Analyze
CO3	Understand different power system components for the study of stability.	Cognitive	Understand
CO4	Understand different power system components for the study of stability.	Cognitive	Understand
CO5	Understand the methods to improve stability.	Cognitive	Understand

Learning Objectives:

Remember the dynamic characteristics of power system equipment
Recognize dynamic performance of power systems
Illustrate the system stability and controls.

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E52	**POWER SYSTEM DYNAMICS AND CONTROL**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION TO POWER SYSTEM OPERATIONS	**09**
Introduction to power system stability. Power System Operations and Control. Stability Problems in Power System. Impact on Power System Operations and control.	
UNIT-II: ANALYSIS OF LINEAR DYNAMICAL SYSTEM AND NUMERICAL METHODS	**09**
Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability. Modal Analysis of Linear System. Analysis using Numerical Integration Techniques. Issues in Modelling: Slow and Fast Transients, Stiff System.	
UNIT-III: MODELING OF SYNCHRONOUS MACHINES AND ASSOCIATED CONTROLLERS	**09**
Modelling of synchronous machine: Physical Characteristics. Rotor position dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit Transient Analysis of a Synchronous Machine. Synchronization of Synchronous Machine to an Infinite Bus. Modelling of Excitation and Prime Mover Systems. Physical Characteristics and Models. Excitation System Control. Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.	
UNIT –IV: MODELING OF OTHER POWER SYSTEM COMPONENTS	**09**

Modelling of Transmission Lines and Loads. Transmission Line Physical Characteristics. Transmission Line Modelling. Load Models - induction machine model. Frequency and Voltage Dependence of Loads. Other sub systems – HVDC and FACTS controllers, Wind Energy Systems.

UNIT -V: STABILITY ANALYSIS AND ENHANCING SYSTEM STABILITY	**09**
Angular stability analysis in Single Machine Infinite Bus System. Angular Stability in multi machine systems – Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governor droop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon. Stability Analysis Tools Transient Stability Programs, Small Signal Analysis Programs. Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control. Emergency Control.	

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

TEXTBOOKS

1. K.R. Padiyar, “Power System Dynamics, Stability and Control”, B. S. Publications, 2002.
2. P. Kundur, “Power System Stability and Control”, McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Prentice Hall, Stipes Publishing Co.; 1st edition (January 18, 2007)

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1. “Power System Dynamics: Stability and Control” by Dr Jonathan Moore and Prof. Hillary Simpson,2015.
2. “Nonlinear Control Systems and Power System Dynamics” by Shengwei Mei, Yuanzhang Sun Qiang Lu Springer; 2001 edition (March 31, 2001).

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Mapping of COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	2	2	1	1	1	-	-	-	-	1	-	1	2	2
CO 2	2	3	2	2	1	-	-	-	-	1	-	0	1	1
CO 3	2	1	1	2	1	-	-	-	-	1	-	2	1	1
CO 4	1	1	0	0	1	-	-	-	-	1	-	1	0	0
CO 5	1	1	1	0	0	-	-	-	-	1	-	1	2	2
Total	8	8	5	5	4	-	-	0	0	5	0	6	6	6
Scaling	2	2	2	1	1	1	1	0	0	1	0	2	2	2

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

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HVDC TRANSMISSION SYSTEMS

Course Outcomes (XEE E53)		Domain	Level
CO1	**Understand** the advantages of dc transmission over ac transmission.	Cognitive	Understanding
CO2	**Understand** the operation of Line Commutated Converters and Voltage Source Converters.	Cognitive	Understanding
CO3	**Understand** the control strategies used in HVDC transmission system.	Cognitive	Understanding
CO4	**Understand** the improvement of power system stability using an HVDC system.	Cognitive	Understanding
CO5	**Understand** the concept of MTDC system.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE E53	HVDC TRANSMISSION SYSTEMS	3	0	0	3
C:P: A = 3:0:0		L	T	P	H
		3	0	0	3

UNIT – I: DC TRANSMISSION TECHNOLOGY	**09**
Comparison of AC and DC Transmission (Economics, Technical Performance and Reliability)- Application of DC Transmission –Types of HVDC Systems –Components of a HVDC System –Line Commutated Converter and Voltage Source Converter Based systems.	
UNIT– II: ANALYSIS OF LINE COMMUTATED AND VOLTAGE SOURCE CONVERTERS	**09**
Line Commutated Converters (LCCs) Six Pulse Converter – Analysis neglecting Commutation Overlap, Harmonics – Twelve Pulse Converters – Inverter Operation –Effect of Commutation Overlap – Effect of Commutation Failure, Misfire and Current Extinction in LCC links. Voltage Source Converters (VSCs): Two and Three-Level VSCs –PWM Schemes: Selective Harmonic Elimination, Sinusoidal Pulse width Modulation. Analysis of a six-pulse converter –Real and Reactive power control using VSC.	
UNIT– III: CONTROL OF HVDC CONVERTERS AND COMPONENTS OF HVDC SYSTEM	**09**
Principles of Link Control in LCC HVDC System - Control Hierarchy, Firing Angle Controls –Phase Locked Loop, Current and Extinction Angle Control – Starting and Stopping of a Link - Principles of Link Control in a VSC HVDC system: Power Flow and DC Voltage Control. Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC Systems DC Line, Corona Effects - Insulators, Transient Over-voltages DC Line faults in LCC Systems.	
UNIT – IV: STABILITY ENHANCEMENT USING HVDC CONTROL	**09**
Basic Concepts: Power System Angular -Voltage and Frequency Stability –Power Modulation: Basic Principles –Synchronous and Asynchronous Links - Voltage Stability Problem in AC/DC Systems.	

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UNIT – V: MTDC LINKS			**09**
Multi-Terminal and Multi- Infeed Systems – Series and Parallel MTDC Systems using LCCs - MTDC Systems using VSCs – Modern Trends in HVDC Technology –Introduction to Modular Multi-level Converters.			
	LECTURE	**TUTORIAL**	**TOTAL**
	45	**0**	**45**
TEXTBOOKS:			
1. Padiyar. K. R, 'HVDC Power Transmission Systems', New Age International publishers, 2011. 2. Arrillaga. J, 'High Voltage Direct Current Transmission', Peter Peregrinus Ltd., Institution of Engineering and Technology; 2nd edition (30 June 1998)			
REFERENCES:			
1. Kimbark. E.W, 'Direct Current Transmission', Vol.1, Wiley-Interscience,1971.			
E-REFERENCES:			
1. www.nptel.ac.in			

Mapping of COs with POs

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

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

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POWER QUALITY AND FACTS

Course Outcomes (XEE E54):		Domain	Level
CO1	**Inference** of series and shunt reactive power compensation in ac transmission line.	Cognitive	Remembering Understanding
CO2	**Explain** the working principles of thyristor-based flexible AC transmission controllers	Cognitive	Understanding Applying
CO3	**Describe** the various voltage source converter-based controllers in transmission line	Cognitive	Understanding Applying
CO4	**Infer** the electrical power quality terms, power quality events and causes of reduction of power and analyse the voltage sag performance, mitigation of sag	Cognitive	Remembering Understanding
CO5	**Construct a** circuit for harmonics and power factor improvement techniques	Cognitive	Understanding Applying

Learning Objectives: Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation. Understand the working principles of Thyristor based FACTS and Voltage source converter-based controller. Understand the basic concepts of power quality and devices to improve power quality.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E54	POWER QUALITY AND FACTS	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT-I: TRANSMISSION LINES AND SERIES/SHUNT REACTIVE POWER COMPENSATION	**9**
Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.	
UNIT – II: THYRISTOR-BASED FLEXIBLE AC TRANSMISSION CONTROLLERS	**9**
Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter	
UNIT - III: VOLTAGE SOURCE CONVERTER BASED CONTROLLERS	**9**
Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Reactive Power Control: Type I and Type II controllers, Static	

Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.
UNIT - IV: POWER QUALITY PROBLEMS IN DISTRIBUTION SYSTEMS | **9**
Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

UNIT – V: DSTATCOM			**9**
Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Current Control Techniques in for DSTATCOM. Dynamic Voltage Restorer-Unified Power Quality Conditioner (UPQC).			
	LECTURE	**PRACTICAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. N. G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
3. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.
4. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991

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1. Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.Wayne Beaty, **“**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

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

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Mapping of COs with POs

	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	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
Scaled	3	2	2	2	1		1		1	1		1	2	1

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ELECTIVE GROUP -VI

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ELECTRICAL AND HYBRID VEHICLES

Course Outcomes (XEE E61):		Domain	Level
CO1	To understand the working and performance of conventional vehicles	Cognitive	Understanding
CO2	To understand Hybrid Electric Vehicles and Drive-trains	Cognitive	Understanding
CO3	To explain basic concepts of Electric Drive Trains	Cognitive	Understanding
CO4	To explain the various types of Energy Storage Systems	Cognitive	Understanding
CO5	To understand different types of Energy management strategies	Cognitive	Understanding

Learning Objectives:

Understand the models to describe hybrid vehicles and their performance and Understand the different strategies related to energy storage systems design.

COURSE CODE	COURSE NAME	L	T	P	C
XEE E61	ELECTRICAL AND HYBRID VEHICLES	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: INTRODUCTION	**9**
Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	
UNIT – II: HYBRID ELECTRIC VEHICLES	**9**
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	
UNIT – III: ELECTRIC DRIVE TRAINS	**9**
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-Train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switched Reluctance Motor drives, drive system efficiency	
UNIT – IV: ENERGY STORAGE	**9**
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of	

different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics**,** selecting the energy storage technology, Communications, supporting subject systems

UNIT – V: ENERGY MANAGEMENT STRATEGIES			**9**
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies, Charging Stations. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).			
	LECTURE	**PRACTICAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. C. Mi, M.A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. S.Onori, L.Serrao and G.Rizzoni,"Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.

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1.M. Ehsani, Y.Gao, S.E.Gay and A.Emadi,"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004.
2.T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016

E REFERENCES

www.nptel.ac.in

Mapping of COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	3									1		1		2
CO 2	3									1		1		2
CO 3	3	2								1	1	2		2
CO 4	3	2			1					1	1	1		3
CO 5	3	2			1					1	1	1		3
Total	15	6	0	0	2	0	0	0	0	5	3	6		12
Scaled	3	1	0	0	1	0	0	0	0	1	1	1		3

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

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WIND AND SOLAR SYSTEMS

Course Outcomes (XEE E62):		**Domain**	**Level**
CO1	Understand the basic physics of wind and solar power generation.	Cognitive	Understanding
CO2	Understand the various types of wind generators	Cognitive	Understanding
CO3	Understand the power electronic interfaces for wind and solar generation.	Cognitive	Understanding
CO4	Understand the issues related to the grid- integration of solar and wind Energy systems.	Cognitive	Understanding
CO5	Understand the issues related to the grid-integration of solar and wind Energy systems.	*Cognitive*	*Understanding*

Learning Objectives:

Understand the technologies involved in wind power and solar power generation systems as well as grid network integration issues

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E62	**WIND AND SOLAR SYSTEMS**	**3**	**0**	**0**	**3**
C:P:A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: PHYSICS OF WIND POWER	**9**
History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Power from Wind, Parts of Wind Turbine, Characteristics of Wind Turbines, Wind speed statistics- probability distributions, Wind speed and power-cumulative distribution functions. Review of modern wind turbine technologies, Fixed and Variable speed wind turbines	
UNIT- II: WIND GENERATOR TOPOLOGIES	**9**
Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.	
UNIT –III: THE SOLAR RESOURCE	**9**
Introduction, solar radiation spectra, solar geometry, solar constant, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.	
UNIT - IV: SOLAR PHOTOVOLTAIC	**9**
Technologies- Amorphous, mono crystalline, polycrystalline V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum PowerPoint Tracking (MPPT) algorithms. Converter Control. Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, Solar chimney, elementary analysis.	
UNIT- V: NETWORK INTEGRATION ISSUES	**9**
Overview of grid code technical requirements. Fault ride-through for wind farms-real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during	

grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.			
	LECTURE	**TUTORIAL**	**TOTAL**
	45	**0**	**45**

TEXTBOOKS

1. T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd.,2005.
2. G.M. Masters, "Renewable and Efficient Electric Power Systems**",** John Wiley and Sons,2004.
3. S.P.Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill, 17 Jun 2008.
4. H.Siegfried and R.Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd.,2006.

REFERENCES

1. G.N.Tiwari and M.K.Ghosal, "Renewable Energy Applications", Narosa Publications,2004.
2. J.A.Duffie and W.A.Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, 17 May 2013.

E REFERENCES

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Mapping of COs with POs

	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**
CO 1	3				1					1		1	1	3
CO 2	3				1					1		1	1	3
CO 3	3	2			1					1	1	2	1	3
CO 4	3	2			1					1	1	1	1	3
CO 5	3	2			1					1	1	1	1	3
Total	15	6	0	0	2	0	0	0	0	5	3	6	5	15
Scale	3	2	0	0	1	0	0	0	0	1	1	2	1	3

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

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POWER SYSTEM PROTECTION

Course Outcomes (XEE E63):		**Domain**	**Level**
CO1	Understand the different components of a protection system.	Cognitive	Understand
CO2	Evaluate fault current due to different types of fault in a network.	Cognitive	Evaluate
CO3	Understand the protection schemes for different power system components.	Cognitive	Understand
CO4	Understand the basic principles of digital protection.	Cognitive	Understand
CO5	Understand system protection schemes and the use of wide-area measurements.	Cognitive	Understand

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E63	**POWER SYSTEM PROTECTION**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION AND COMPONENTS OF A PROTECTION SYSTEM	**09**
Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers.	
UNIT –II: FAULTS AND OVER-CURRENT PROTECTION	**09**
Review of Fault Analysis, Sequence Networks. Introduction to Over current Protection and over current relay co-ordination.	
UNIT - III: EQUIPMENT PROTECTION SCHEMES	**09**
Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Busbar arrangement schemes.	
UNIT- IV: DIGITAL PROTECTION	**09**
Computer-aided protection, Fourier analysis and estimation of Phasors from DFT Sampling, aliasing issues.	
UNIT -V: MODELING AND SIMULATION OF PROTECTION SCHEMES AND SYSTEM PROTECTION	**09**
CT/PT modeling and standards, Simulation of transients using Electro Magnetic Transients (EMT) programs. Relay Testing. Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, under-voltage and df/dt relays, Out-of-step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.	

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

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TEXTBOOKS

1. J. Lewis Blackburn and Thomas J. Domin, "Protective Relaying: Principles and Applications", Taylor & Francis Group, LLC, NewYork,2007.
2. Y.G.Paithankar and S.R.Bhide, "Fundamentals of power system protection", Prentice Hall,India,2010.
3. A.G.Phadke and J.S.Thorp, "Computer Relaying for Power Systems", John Wiley& Sons, 2nd Edition 2009.

REFERENCES

1. A. G. Phadke and J. S. Thorp, "Synchronized Phasor Measurements and their Applications" Springer,2008.
2. D.Reimert,"Protective Relaying for Power Generation Systems",TaylorandFrancis,2006.

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Mapping of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	2	1	1	1	1	-	-	-	1	-	1	2	2
CO 2	2	3	2	2	1	1	1	-	-	1	-	0	1	1
CO 3	1	1	1	2	1	0	-	-	-	1	-	2	1	1
CO 4	1	1	1	1	1	0	1	-	-	1	-	1	0	0
CO 5	1	1	1	0	0	1	-	-	-	1	-	1	1	1
Total	7	8	6	6	4	3	2	0	0	5	0	6	5	5
Scaled	2	2	2	1	1	1	1	0	0	1	0	2	2	2

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

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ADVANCED ELECTRIC DRIVES

Course Outcomes (XEE E64):		**Domain**	**Level**
CO1	**Explain** the operation of power electronic converters and their control strategies.	Cognitive	Remembering Understanding Applying
CO2	**Categorize** the different speed control methods for an Induction motor drive	Cognitive	Remembering Understanding
CO3	**Detailed** description of control strategies of synchronous motor drive.	Cognitive	Remembering Understanding
CO4	**Classify** various permanent magnet motor and **explain** its speed & torque control technique.	Cognitive	Remembering Understanding
CO5	**Illustrate** the different types of SRM drives.	Cognitive	Remembering Understanding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE E64	**ADVANCED ELECTRIC DRIVES**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT – I: POWER CONVERTERS FOR AC DRIVES	**12**
PWM Control of Inverter - Selected Harmonic Elimination - Space Vector Modulation, Current Control of VSI, Three Level Inverter - Different Topologies - SVM for Three Level Inverter, Diode Rectifier with Boost Chopper, PWM Converter as Line Side Rectifier, Current Fed Inverters with Self-Commutated Devices. Control of CSI, H bridge as a 4-Q drive. DSP Based Motion Control.	
UNIT – II: INDUCTION MOTOR DRIVES	**09**
Different Transformations and Reference Frame Theory -Modelling of Induction Machines - Voltage Fed Inverter Control- V/f Control, Vector Control - Direct Torque and Flux Control (DTC).	
UNIT– III: SYNCHRONOUS MOTOR DRIVES	**08**
Modelling of Synchronous Machines - Open Loop V/f Control - Vector Control - direct torque Control - CSI Fed Synchronous Motor Drives.	
UNIT – IV: PERMANENT MAGNET MOTOR DRIVES	**08**
Introduction to Various PM Motors - BLDC and PMSM Drive Configuration –Comparison, Block Diagrams, Speed and torque control in BLDC and PMSM.	
UNIT – V: SWITCHED RELUCTANCE MOTOR DRIVES	**08**
Evolution of Switched Reluctance Motors - Various Topologies for SRM Drives, Comparison, Closed Loop Speed and Torque Control of SRM.	

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

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TEXTBOOKS

1. Bose. B. K, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.
2. Krause. P. C, Wasynczuk. O and Sudhoff S. D, 'Analysis of Electric Machinery and Drive Systems', John Wiley & Sons, 2013.
3. Vedam Subrahmaniyam, "Electric Drives Concepts and Applications", Tata McGraw Hill Publishing Company Ltd., 2011.
4. Taliyat H. A and Campbell. S. G., 'DSP Based Electromechanical Motion Control', CRC Press, 2003.

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1. Murphy J.M.D. and Turnbull F.G, 'Thyristor Control of AC Motors', Pergamon Press,1990.
2. Krishnan R, 'Permanent Magnet Synchronous and Brushless DC motor Drives', CRC Press, 2009.
3. Dubey G.K, 'Fundamentals of Electrical drives', Narosa Publications, 2008.
4. Bose B.K, 'Power Electronics and AC Drives', Prentice Hall Onglewood cliffs, New Jersey, 1998.

E REFERENCES

Lecture Series on Solid state devices by Prof. S.Karmalkar, Department of Electrical Engineering, IIT Madras.
http://nptel.ac.in/courses/108108077/

Mapping of COs with POs

	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	1	0	2	0	1	0	0	0	0	0	0	3
CO2	3	1	0	0	2	0	1	0	0	0	0	0	3	2
CO3	1	2	3	0	2	0	0	1	0	0	0	0	1	2
CO4	0	2	0	0	3	0	1	0	0	0	0	0	2	2
CO5	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
Scaled	2	2	1	0	2	1	1	1	0	0	0	1	2	3

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

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VALUE ADDED COURSES

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ELECTRICAL SYSTEM DESIGN USING ETAP

COURSE CODE	COURSE NAME
VAC1	ELECTRICAL SYSTEM DESIGN USING ETAP

Topics

Introduction to Electrical System Design, Introduction to Electrical Power system, Structure of Electrical power system, Sources of Electrical Energy, Elements of Power system, Generation, Transmission and Distribution, Types of systems for power transmission, Introduction to Power Substation, Bus Bar, Single Line Diagram, Design a Single line diagram, inserting Circuit Elements, Load Flow Analysis, Short circuit analysis and run the Relay Co-ordination, Motor Acceleration, Transformer Sizing with ETAP software, Arc Flash, Introduction to Power System Protection, Types of Relay, Protective Relays, Relay Co-ordination.

	LECTURE	TUTORIAL	TOTAL
	30	0	30

ELECTRICAL SYSTEM DESIGN USING HMI

COURSE CODE	COURSE NAME
VAC2	ELECTRICAL SYSTEM DESIGN USING HMI

TOPICS

Introduction to HMI, Architecture of HMI, KTP600 DP Basic HMI device, Working with Control Panel, Changing MPI/DP settings, Working With HMI, Create a Screen for HMI, Working with win CC flexible, Hardware Configuration inSTEP-7, Interfacing PLC to HMI. Transfer settings, Transfer the Screen from WinCC Flexible Design, Data Logging, Real time trend, Historical trend, Industrial Level Practicals

	LECTURE	TUTORIAL	TOTAL
	30	0	30

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AUTO CAD - ELECTRICAL

COURSE CODE	COURSE NAME
VAC3	AUTO CAD - ELECTRICAL

Topics

Introduction about AutoCAD, Advantages in using AutoCAD, File management, Drawing Tools, Object Properties, Layer Management, Block, Creating & Inserting Blocks, WBlock, Introduction about AutoCAD Electrical, Application of AutoCAD Electrical, Projects, Introduction to Project Manager, Creating an AutoCAD Electrical project, Drawing Properties, Symbol Libraries, Inserting Multiple Components, Circuit Builder, PLC, Point to Point Wiring Tools, Panel Layout, Generating Reports.

	LECTURE	TUTORIAL	TOTAL
	30	0	30

ELECTRICAL SYSTEM DESIGN USING PLC & SCADA

COURSE CODE	COURSE NAME
VAC4	ELECTRICAL SYSTEM DESIGNUSING PLC & SCADA

Topics

Introduction to Automation, Programmable Logic Controller, Introduction to Omron Cp1e Series, Introduction to SCADA

	LECTURE	TUTORIAL	TOTAL
	30	0	30

ELECTRICAL SYSTEM DESIGN USING VFD

COURSE CODE	COURSE NAME
VAC5	ELECTRICAL SYSTEM DESIGN USING VFD

Topics

Introduction to VFD Driver, Architecture and Benefits of VFD, Types of Starters, Block Diagram for Sinamics G110VFD, Basic Commissioning in Sinamics G110VFD, Wire Connection between PLC and VFD, Manual Control and Auto Control method for Motor, Industrial Level Practicals

	LECTURE	TUTORIAL	TOTAL
	30	0	30

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ELECTRICAL SYSTEM DESIGN USING INTERNET OF THINGS

COURSE CODE	COURSE NAME
VAC6	ELECTRICAL SYSTEM DESIGN USING INTERNET OF THINGS

Topics

Basics of Electronics, Introduction to IoT concepts and Technologies, Arduino Programming Language concepts, Working with Arduino IDE 1.8.6 and programming Arduino MEGA Hardware, Serial Communication – UART Protocol, IoT Communication Wired and Wireless Protocols Layers and Protocols - TCP/IP Layer, Collecting Real time data using Temperature Sensor (DHT11) – DHT11 libraries and principle, Cloud Computing – Introduction, ESP8266 WiFi Chip – Working Principle, Send Messages to IoT devices using Talkback. REST Client, Python – Introduction, Environment Setup, Python Common Gateway Interface – Introduction, Integration of Cloud with Raspberry pi as an IoT Gateway, IoT Protocol, IoT Data Analytics

	LECTURE	TUTORIAL	TOTAL
	30	0	30

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OPEN ELECTIVES

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OE1 INDUSTRIAL AUTOMATION

Course Outcomes (XEE OE1):		**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	Understanding
CO2	**Apply** the knowledge of electrical ladder hydraulic and pneumatic system and able to **define** pressure, proximity switches and intelligent Relays.	Cognitive	Applying
CO3	**Explain** and **Categorize** different types of Sensors and their application. **List** out timer, counter and their application.	Cognitive	Analyzing
CO4	**Illustrate** the knowledge in the PLC logic, Architecture and design the industrial automated system applications and **Apply** the knowledge of PLC programming to interface pneumatics.	Cognitive	Applying
CO5	**Outline** the overview of robotics and their application. **Apply** the knowledge of robotics programming	Cognitive	Applying

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE OE1	**INDUSTRIAL AUTOMATION**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION TO PNEUMATICS AUTOMATION	**9**
Introduction to Pneumatics- Overall structure- Electro pneumatic –hydraulics- Overall structure – Advantages and disadvantages – Application-Electrical drives.	
UNIT – II: APPLICATIONS OF RELAYS	**9**
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	**9**
Introduction to sensors- characteristics- types of sensors-resistive - inductive-capacitive- magnetic-ultrasonic - photoelectric- Nano sensors- timers-counters-types-applications.	
UNIT – IV: PROGRAMMABLE LOGIC CONTROLLERS	**9**
Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC –Relay logic and Ladder logic – Functional blocks – PLC interface to pneumatics**.**	

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UNIT – V: ROBOTICS			**9**
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	**TUTORIAL**	**TOTAL**
	45	**0**	**45**
TEXTBOOKS			
1. "Programmable Logic Controllers" by W.Bolton, Newnes; 6 edition (March 17, 2015) 2. "Programmable Logic Controllers and Industrial Automation: An Introduction" by Madhuchhanda Mitra, Samarjit Sen Gupta Penram International Publishing (India) Pvt. Ltd, Second edition, 2017.			
REFERENCES			
1. "Programmable Logic Controllers: Programming Methods and Applications" by Hackworth, Prentice Hall (April 21, 2003)			
E REFERENCES			
https://www.automation.com/library/education/reference-guides			

Mapping COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	3	2	-	2	1	1	1	-	-	1	1	-		
CO 2	3	2	-	-	1	1	-	1	-	1	3	2		
CO 3	2	3	-	-	1	1	1	-	-	-	-	1		
CO 4	2	1	3	-	-	1	-	1	1	-	-	1		
CO 5	2	2		-	1	-	-	2	-	-	-	1		
Total	12	10	3	2	4	4	2	4	1	2	4	5		
Scaled	3	2	1	1	1	1	1	1	1	1	1	2		

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

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ENERGY MANAGEMENT AND AUDITING

Course Outcomes (XEE OE2):		Domain	Level
CO1	**Explain** the stages and process of energy management Programme.	Cognitive	Understanding
CO2	**Analyze** economic models of load management systems. **Explain** monitoring and control of energy management systems.	Cognitive	Analyzing
CO3	**Compare** different energy management techniques for Electric loads and drives.	Cognitive	Understanding
CO4	**Explain** the different metering arrangement and their performance in an electrical system.	Cognitive	Understanding
CO5	**Define** the lighting scheme and Standards for energy conservation. **Explain** the methods of improving the power quality.	Cognitive	Understanding

COURSE CODE	COURSE NAME	L	T	P	C
XEE OE2	ENERGY MANAGEMENT AND AUDITING	3	0	0	3
C:P: A		L	T	P	H
3:0:0		3	0	0	3

UNIT- I: INTRODUCTION **9**

Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting-energy audit process.

UNIT – II: ENERGY COST AND LOAD MANAGEMENT **9**

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation Load management: Demand control techniques-Utility monitoring and control system- HVAC and energy management.

UNIT–III: ENERGY MANAGEMENT FOR MOTORS, SYSTEMS AND ELECTRICAL EQUIPMENT **9**

Systems and equipment- Electric Motors-Transformers and reactors-Capacitors and synchronous machines-Energy management in industrial drive.

UNIT – IV: METERING FOR ENERGY MANAGEMENT **9**

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements.

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UNIT – V: LIGHTING SYSTEMS & COGENERATION	**9**
Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting Controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards-BEE standards	

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

TEXTBOOKS

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, **"**Guide to Energy Management**"**, Fifth Edition, The Fairmont Press, Inc., 2006
2. Eastop T.D. & Croft D.R., "Energy Efficiency for Engineers and Technologists", Longman Scientific & Technical, ISBN -0-582-03184, 1990.

REFERENCES

1. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 2011.
2. Amit K. Tyagi, **'**Handbook on Energy Audits and Management**'**, TERI,2003

E REFERENCES

E-learning course on Energy audit and management, Dr.K.Shanti Swarup, Indian Institute of Technology, Chennai.

Mapping COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO 1	1	3							2	1			3	1
CO 2	1					1					2		3	1
CO 3	1			1	1			1		1			3	1
CO 4	1	2	2								3	1	3	1
CO 5		2					2					1	3	1
Total	4	7	2	1	1	1	2	1	2	2	5	2	15	5
Scaled	1	2	1	1	1	1	1	1	1	1	1	1	3	1

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

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OE3 RENEWABLE ENERGY TECHNOLOGY

Course Outcomes (XEE OE3):		**Domain**	**Level**
CO1	**Infer** Power Demand and **Identify** the various renewable energy systems to meet out the demand.	Cognitive	Applying
CO2	**Explain** about the Performance of various solar collectors and **Apply** the recent advancement in PV systems to improve the efficiency.	Cognitive	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	**Compare** the role-play of various energy resources	Cognitive	Understanding

COURSE CODE	**COURSE NAME**	**L**	**T**	**P**	**C**
XEE OE1	**RENEWABLE ENERGY TECHNOLOGY**	**3**	**0**	**0**	**3**
C:P: A		**L**	**T**	**P**	**H**
3:0:0		**3**	**0**	**0**	**3**

UNIT- I: INTRODUCTION **9**

Primary energy sources, Renewable Vs non-renewable primary e n e r g y 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 **9**

Solar Radiation and its measurements, Solar Thermal Energy Conversion from Flat-plate Solar 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 Grid Connected PV Systems

UNIT – III: WIND ENERGY **9**

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 **9**

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 gasifier, Application of biomass and biogas plants and their economics.

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UNIT – V: OTHER TYPES OF ENERGY	**9**
Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, Potential in India. Tidal and wave energy.	

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

TEXTBOOKS

1. G.D. Rai, "Non-Conventional Energy Sources"- Khanna Publishers,2004.
2. Twidell and Wier, "Renewable Energy Resources" –CRC Press (Taylor & Francis), Third Edition ,2015.
3. D.P.Kothari, K.C.Singhal and Rakesh Ranjan, "Renewable energy sources and emerging technologies" - P.H.I., 2nd Edition, 2011.
4. Mukund R.Patel ,"Wind And Solar Power Systems", Copyright 1999.- CRC Press.

REFERENCES

1. G.N.Tiwari and M.K.Ghosal, "Renewable Energy Resources: Basic Principles and Applications", Narosa Publishing House (1 August 2004).
2. K Mittal, "Non-Conventional Energy Systems", A H Wheeler Publishing Co Ltd (January 31, 1999)
3. Volker Quaschning, "Understanding the Renewable Energy Systems", 2nd Edition, 2016 Earth Scan, London, UK,

E REFERENCES

1. http://www.nptelvideos.in/2012/11/energy-resources-and-technology.html
2. NPTEL, Lecture Series on Energy Resources and Technology, Prof.S.Banerjee,Department of Electrical Engineering, IIT Kharagpur.
3. http://freevideolectures.com/Course/2352/Power-System-Generation-Transmission-and-Distribution/6 NPTEL, Renewable Energy Technology, Prof. D.P.Kothari IIT Delhi Course.
4. 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.

Mapping COs with POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	2	2			1		3	1	1	1		1		3
CO 2	2	2	2	2			2	1	1	1	2	1		
CO 3	3	3												
CO 4	3	2	2		3		3	1	1	1		1		
CO 5		2												
Total	10	11	4	2	4	0	8	3	3	3	2	3		
Scaled	2	3	1	1	1	0	2	1	1	1	1	1		

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

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