Bachelor of Technology

(Electrical and Electronics Engineering)

CURRICULUM

(Effective from 2024 - 25 Onwards)

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015, INDIA.

VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

To be a centre of excellence in Electrical Energy Systems

MISSION OF THE DEPARTMENT

- Empowering students and professionals with state-of-art knowledge and technological skills.
- Enabling industries to adopt effective solutions in energy areas through research and consultancy.
- Evolving appropriate sustainable technologies for rural needs.

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR-YEAR B.Tech. and 3 Year B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	22	56	34.36
PC (Programme Core)	15	55	33.74
Programme Elective (PE) / Open Elective (OE)	12	36	22.08
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.82
Total	**57**	**163**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).
2. Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).
3. For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the department (163 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.
4. To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.
5. Project work is compulsory for B. Tech. programme. However, those students wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree.

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	8	19	-	-	-	-	-	-	**19**	**40**
II	7	17	1	4	-	-	-	-	**21**	
III	1	4	4	14	2	4	1	3	**25**	**50**
IV	-	-	3	12	2	4	3	9	**25**	
V	1	3	4	15	2	4	1	3	**25**	**49**
VI	2	4	3	10	2	4	2	6	**24**	
VII	2	3	-	-	-	-	4	12	**15**	**24**
VIII	1	6	-	-	-	-	1	3	**9**	
Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	8	19	-	-	-	-	-	-	**19**	**40**
	II	7	17	1	4	-	-	-	-	**21**	
	III	1	4	4	14	2	4	1	3	**25**	**50**
	IV	-	-	3	12	2	4	3	9	**25**	
B.Sc. Exit	**V**	1	3	2	8	2	4	1	3	**18**	**34**
	VI	4#	12	-	-	2	4	-	-	**16***	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	3	10	-	-	4	12	**22**	**39**
	VIII	1	1	2	7	-	-	3	9	**17**	
	Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

#(Summer internship (2), Project Work (6), Professional Ethics (3), and Industrial Lecture (1))

GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES

Sl. No.	Course	Number of Courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1	3
	Physics Laboratory	1	2
3.	Chemistry	1	3
	Chemistry Laboratory	1	2
4.	Industrial Economics	1	3
5.	English for Communication	1	4
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course (Introduction to the Branch of study)	1	2
13.	Summer Internship	1	2
14.	Project work	1	6
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Pass / Fail
Total		**22**	**56**

Curriculum Framework and Credit System (EE) / 163

Semester I (July Session)

Sl. No.	Code	Course	Credits	Category
1	MAIR12	Linear Algebra and Calculus	3	GIR
2	PHIR11	Physics	3	GIR
3	ENIR11	Energy and Environmental Engineering	2	GIR
4	CSIR11	Introduction to Computer Programming (T + L)	3	GIR
5	CEIR11	Basics of Civil Engineering	2	GIR
6	MEIR11	Basics of Mechanical Engineering	2	GIR
7	PRIR11	Engineering Practice	2	GIR
8	PHIR12	Physics Laboratory	2	GIR
		Total	**19**	

Semester II (January Session)

Sl. No.	Code	Course	Credits	Category
1.	HSIR11	English for Communication (Theory & Lab)	4	GIR
2.	MAIR21	Complex Analysis and Differential Equations	3	GIR
3.	CHIR11	Chemistry	3	GIR
4.	EEIR15	Introduction to Electrical and Electronics Engineering (Branch Specific Course)	2	GIR
5.	MEIR12	Engineering Graphics	3	GIR
6.	CHIR12	Chemistry Laboratory	2	GIR
7.	SWIR11	NSS/NCC/NSO	0	GIR
8.	EEPC10	Circuit Theory (Programme Core – I)	4	PC
		Total	**21**	

Semester III (July Session)

Sl. No.	Code	Course	Credits	Category
1.	MAIR32	Fourier Transforms and Numerical Techniques	4	GIR
2.	EEPC11	Signals and Systems (Programme Core – II)	4	PC
3.	EEPC12	DC Machines and Transformers (Programme Core – III)	4	PC
4.	EEPC13	Electron Devices (Programme Core - IV)	3	PC
5.	EEPC14	Digital Electronics (Programme Core - V)	3	PC
6.		Programme Elective – I	3	PE
7.	EELR10	Circuits and Digital Laboratory (Laboratory - I)	2	ELR
8.	EELR11	DC Machines & Transformers Laboratory (Laboratory - II)	2	ELR
		Total	**25**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 25 credits.

Semester IV (January Session)

Sl. No.	Code	Course	Credits	Category
1.	EEPC15	AC Machines (Programme Core – VI)	4	PC
2.	EEPC16	Analog Electronic Circuits (Programme Core - VII)	4	PC
3.	EEPC17	Transmission & Distribution of Electrical Energy (Programme Core - VIII)	4	PC
4.		Programme Elective – II	3	PE
5.		Programme Elective – III	3	PE
6.		Programme Elective – IV / Open Elective – I	3	PE/OE
7.	EELR12	Electronics Circuits Laboratory (Laboratory - III)	2	ELR
8.	EELR13	Synchronous & Induction Machines Laboratory (Laboratory - IV)	2	ELR
		Total	**25**	

Semester V (July Session) / Continuing B.Tech.

Sl. No.	Code	Course	Credits	Category
1.	HSIR13	Industrial Economics	3	GIR
2.	EEPC18	Power System Analysis (Programme Core - IX)	4	PC
3.	EEPC19	Power Electronics (Programme Core - X)	4	PC
4.	EEPC20	Control Systems (Programme Core - XI)	4	PC
5.	EEPC21	Linear Integrated Circuits (Programme Core - XII)	3	PC
6.		Programme Elective – V / Open Elective – II	3	PE/OE
7.	EELR14	Integrated Circuits Laboratory (Laboratory - V)	2	ELR
8.	EELR15	Power Electronics Laboratory (Laboratory - VI)	2	ELR
		Total	**25**	

Semester V (July Session) / B.Sc. (Engineering) Exit

Sl. No.	Code	Course	Credits	Category
1.	HSIR13	Industrial Economics	3	GIR
2.	EEPC18	Power System Analysis (Programme Core – IX)	4	PC
3.	EEPC19	Power Electronics (Programme Core - X)	4	PC
4.		Programme Elective – V / Open Elective – II	3	PE/OE
5.	EELR14	Integrated Circuits Laboratory (Laboratory - V)	2	ELR
6.	EELR15	Power Electronics Laboratory (Laboratory - VI)	2	ELR
		Total	**18**	

Semester VI (January Session) / Continuing B.Tech.

Sl. No.	Code	Course	Credits	Category
1.	EEIR19	Industrial Lecture	1	GIR
2.	EEIR14	Professional Ethics	3	GIR
3.	EEPC24	Power System Protection & Switchgear (Programme Core - XIII)	4	PC
4.	EEPC22	Microprocessors & Microcontrollers (Programme Core – XIV)	3	PC
5.	EEPC23	Measurements & Instrumentation (Programme Core – XV)	3	PC
6.		Programme Elective - VI	3	PE
7.		Programme Elective – VII / Open Elective – III	3	PE/OE
8.	EELR16	Microcomputing Laboratory	2	ELR
9.	EELR17	Power Systems Laboratory (Laboratory - VIII)	2	ELR
		Total	**24**	

Semester VI (January Session) / B.Sc. (Engineering) Exit

Sl. No.	Code	Course	Credits	Category
1.	EEIR19	Industrial Lecture	1	GIR
2.	EEIR14	Professional Ethics	3	GIR
3.	EEIR16	Winter Internship	2	GIR
4.	EEIR17	Project Work	6	GIR
5.	EELR16	Microcomputing Laboratory (Laboratory – VII)	2	ELR
6.	EELR17	Power Systems Laboratory (Laboratory – VIII)	2	ELR
		Total	**16**	

Semester VII (July Session) / Continuing B.Tech.

Sl. No.	Code	Course	Credits	Category
1.	EEIR16	Summer Internship	2	GIR
2.	EEIR18	Comprehensive Viva Voce	1	GIR
3.		Programme Elective – VIII	3	PE
4.		Programme Elective – IX	3	PE
5.		Programme Elective – X / Open Elective – IV	3	PE/OE
6.		Programme Elective – XI / Open Elective – V	3	PE/OE
		Total	**15**	

Semester VII (July Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Code	Course	Credits	Category
1.	EEPC20	Control Systems (Programme Core – XI)	4	PC
2.	EEPC21	Linear Integrated Circuits (Programme Core – XII)	3	PC
3.	EEPC23	Measurements & Instrumentation (Programme Core – XV)	3	PC
4.		Programme Elective – VI	3	PE
5.		Programme Elective – VII	3	PE
6.		Programme Elective – VIII	3	PE
7.		Programme Elective – IX / Open Elective – III	3	PE/OE
		Total	**22**	

Semester VIII (January Session) / Continuing B.Tech.

Sl. No.	Code	Course	Credits	Category
1.		Programme Elective – XII / Open Elective – VI	3	PE/OE
2.	EEIR17	Project Work	6	GIR
		Total	**9**	

Semester VIII (January Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Code	Course	Credits	Category
1.	EEPC24	Power System Protection and Switchgear (Programme Core – XIV)	4	PC
2.	EEPC22	Microprocessors and Microcontrollers (Programme Core – XV)	3	PC
3.		Programme Elective – X	3	PE
4.		Programme Elective – XI	3	PE
5.		Programme Elective – XII / Open Elective – IV	3	PE/OE
6.	EEIR18	Comprehensive Viva Voce	1	GIR
		Total	**17**	

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
B.Tech.	**19**	**21**	**25**	**25**	**25**	**24**	**15**	**9**	**163**
B.Sc.	**19**	**21**	**25**	**25**	**18**	**16**	**22**	**17**	**163**

Note:

1. Out of 12 elective courses (PE/OE), the students should study at least eight programme elective courses (PE).
2. Minor (MI): 15 credits over and above the minimum credit as specified by the department (163).
3. Honours (HO): 15 credits over and above the minimum credit as specified by the department (163).

ELECTIVES CHOICES

Option 1 / Regular B.Tech.

To get a B.Tech. degree in Electrical and Electronics Engineering, possible choices of electives in Programme Electives and Open Electives are,

Program Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Program Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in Electrical and Electronics Engineering, and minor in other programmes, choices of electives in Programme Electives, Open Electives and Minor Electives are,

Program Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honours

To get a B.Tech. Honors degree in Electrical and Electronics Engineering, choices of electives inProgramme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honours and Minor

To get a B.Tech. Honors degree in Electrical and Electronics Engineering, and minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honours will be awarded for B.Sc. But student can credit minors and honours during the 6 semesters, and redeem it to obtain a minor or honours after rejoining and completing B.Tech. Also, B.Sc. students shall only do programme electives in place of their project work in 6th semester.

LIST OF COURSES

(I) PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	EEPC10	Circuit Theory	MAIR12 4	4
2.	EEPC11	Signals and Systems	EEPC10	4
3.	EEPC12	DC Machines and Transformers	EEPC10	4
4.	EEPC13	Electron Devices	-	3
5.	EEPC14	Digital Electronics	-	3
6.	EEPC15	AC Machines	EEPC12	4
7.	EEPC16	Analog Electronic Circuits	EEPC13	4
8.	EEPC17	Transmission and Distribution of Electrical Energy	EEPC10	4
9.	EEPC18	Power System Analysis	MAIR32, EEPC10	4
10.	EEPC19	Power Electronics	MAIR32 EEPC10, EEPC13	4
11.	EEPC20	Control Systems	MAIR32	4
12.	EEPC21	Linear Integrated Circuits	EEPC10	3
13.	EEPC22	Microprocessors and Microcontrollers	EEPC14	3
14.	EEPC23	Measurements and Instrumentation	EEPC21	3
15.	EEPC24	Power System Protection and Switchgear	EEPC18	4

(II) ELECTIVES

a. PROGRAMME ELECTIVES

LIST OF PROGRAMME ELECTIVE COURSES				
Sl. No.	**Course Code**	**Course Title**	**Pre-Req.**	**Credits**
1	EEPE10	Power Generation Systems	-	3
2	EEPE11	Electrical Safety	-	3
3	EEPE12#	Thermodynamics and Mechanics of Fluids	-	3
4	EEPE13	Fuzzy Systems and Genetic Algorithms	-	3
5	EEPE14	Industrial Automation	-	3
6	EEPE15	High Voltage Engineering	EEPC10	3
7	EEPE16	Computer Organization and Architecture	EEPC14	3
8	EEPE17	Digital System Design and HDLS	EEPC14	3
9	EEPE18	Digital Signal Processing	MAIR32, EEPC14	3
10	EEPE19	Artificial Neural Networks	MAIR32	3
11	EEPE20	Design of Electrical Apparatus	EEPC15	3
12	EEPE21	Utilization of Electrical Energy	EEPC15	3
13	EEPE22	Computer Networks	-	3
14	EEPE23	Modern Control Systems	EEPC20	3
15	EEPE24	Fundamentals of FACTS	EEPC11, EEPC19	3
16	EEPE25	Special Electrical Machines	EEPC15, EEPC19	3
17	EEPE26	Wind and Solar Electrical Systems	EEPC15, EEPC19	3
18	EEPE27	Solid State Drives	EEPC15, EEPC19.	3

19	EEPE28	Embedded System Design	EEPC22	3
20	EEPE29	Power System Economics and Control Techniques	EEPC20, EEPC18	3
21	EEPE30	Digital Control Systems	EEPC20	3
22	EEPE31*	Operations Research	MAIR32	3
23	EEPE32	Electric Vehicle Technology	-	3
24	EEPE33	Design Thinking	-	3
25	EEPE34	Machine Learning and Deep Learning	MAIR32	3
26	EEPE35	Nano Electronics	EEPC13	3
27	EEPE36##	Communication Systems	EEPC14, EEPC17	3
28	EEPE37	Data Structures and Algorithms	-	3
29	EEPE38	Electric Power Quality	EEPC17, EEPC18	3
30	EEPE39	VLSI Design	EEPC14, EEPC21	3
31	EEPE40	Power System Restructuring	EEPC18	3
32	EEPE41	Economic Evaluation of Power Projects	EEPC17	3
33	EEPE42	Introduction to Switched Mode Power Supplies	EEPC19	3
34	EEPE43	Optimal and Robust Control	EEPC20	3
35	EEPE44	Robotics	-	3
36	EEPE45	Battery Management Systems	-	3
37	EEPE46	Power System Reliability	EEPC17	3
38	EEPE47	Electronic System Design	-	3

**Will be offered by the Department of Mathematics.*

 # Will be offered by Department of Mechanical Engineering

Will be offered by the Department of Electronics and Communication Engineering

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Electrical and Electronics Engineering for the students of all Departments

LIST OF OPEN ELECTIVES				
S.No.	**Course Code**	**Course Title**	**Pre-Req**	**Credits**
1.	EEOE10	Electrical Safety	-	3
2.	EEOE11	Fuzzy Systems and Genetic Algorithms	-	3
3.	EEOE12	Artificial Neural Networks	-	3
4.	EEOE13	Modern Control Systems	-	3
5.	EEOE14	Digital Control Systems	-	3
6.	EEOE15	Electric Vehicle Technology	-	3
7.	EEOE16	Basics of Electrical Circuits*	-	3
8.	EEOE17	Electrical Machines*	-	3
9.	EEOE18	Control Systems Engineering*	-	3
10.	EEOE19	Analog and Digital Electronics*	-	3
11.	EEOE20	Power Electronic Systems*	-	3
12.	EEOE21	Power Systems Engineering*	-	3
13.	EEOE22	Electric Power Utilization*	-	3
14.	EEOE23	Renewable Power Generation Systems*	-	3
15.	EEOE24	Design Thinking	-	3
16.	EEOE25	Optimal and Robust Control	-	3
17.	EEOE26	Robotics	-	3
18.	EEOE27	Battery Management Systems	-	3
19.	EEOE28	Electronic System Design	-	3

Offered only to the students of other departments

c. MINOR (MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in Electrical and Electronics Engineering can opt to study any 5 courses listed below.

LIST OF COURSES FOR B.Tech. (MINOR) PROGRAMME				
S.No.	**Course Code**	**Course Title**	**Pre-Req**	**Credits**
1.	EEMI10	Basics of Electrical Circuits	-	3
2.	EEMI11	Electrical Machines	-	3
3.	EEMI12	Control Systems Engineering	-	3
4.	EEMI13	Analog and Digital Electronics	EEMI10	3
5.	EEMI14	Power Electronic Systems	EEMI11	3
6.	EEMI15	Power Systems Engineering	EEMI11	3
7.	EEMI16	Electric Power Utilization	EEMI11	3
8.	EEMI17	Introduction to Microcontrollers	EEMI13	3
9.	EEMI18	Renewable Power Generation Systems	EEMI14	3

(III) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Prerequisites/ Corequisites	Credits
1.	EELR10	Circuits and Digital Laboratory	EEPC10	2
2.	EELR11	DC Machines and Transformers Laboratory	EEPC12	2
3.	EELR12	Electronic Circuits Laboratory	EEPC13	2
4.	EELR13	Synchronous and Induction Machines Laboratory	EEPC15	2
5.	EELR14	Integrated Circuits Laboratory	-	2
6.	EELR15	Power Electronics Laboratory	EEPC19	2
7.	EELR16	Microcomputing Laboratory	-	2
8.	EELR17	Power Systems Laboratory	EEPC18	2

IV. ONLINE COURSES (OC)

The department will give a list of recommended online courses in every session as open elective courses. Students shall opt for online courses recommended by any department of the institute as open elective courses.

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

LIST OF ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)				
S.No.	**Course Code**	**Course Title**	**Pre-Req.**	**Credits**
1.	EEHO10	Distribution System Automation	EEPC11	3
2.	EEHO11	EHV AC and DC Transmission	EEPC11	3
3.	EEHO12	Non-linear Control Systems	EEPC20	4
4.	EEHO13	Power Switching Converters	EEPC19	4
5.	EEHO14	Vehicular Electric Power Systems	EEPC15, EEPC19	4
6.	EEHO15	Power System Dynamics	EEPC18	4
7.	EEHO16	Modern Optimization Techniques for Electric Power Systems	EEPC18	4
8.	EEHO17	Computer Relaying and Phasor Measurement Unit	EEPC24	3
9.	EEHO18	Electricity Markets	EEPC18	4
10.	EEHO19	Design with PIC Microcontrollers	EEPC14	4
11.	EEHO20	Aircraft Electronic Systems	EEPC22	3

VI. MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Students are advised to take 4-week courses from NPTEL/SWAYAM platforms

Course Code	:	EEIR15
Course Title	:	**Introduction to Electrical and Electronics Engineering**
Type of Course	:	GIR
Prerequisites	:	-
Contact Hours	:	
Course Assessment Methods	:	Continuous Assessment, Final Assessment

Course Learning Objectives (CLOs)

CLO1	to get a comprehensive exposure to electrical and electronics engineering.

Course Content

Brief overview of the curriculum, department, laboratories and software packages. History, major inventions, scope, significance and job opportunities in electrical and electronics engineering. Interaction with Alumni and industrial experts on recent developments in electrical and electronic industries.

Introduction to various energy resources, basics of energy conversion, power apparatus used in power generation, transmission and distribution, power apparatus used in various industries.

Introduction to different types of electrical circuits, basic idea about utility supply, house wiring, SI units and representations, electricity tariff, electrical safety, energy audit and importance of energy saving, introduction to standards.

Introduction to electronic components, specifications of electronic components, importance of datasheet, development in electronic devices, electronic testing and measuring equipment, electronic industries.

Introduction to electronic circuits for signal processing, processors and controllers, embedded systems, computer applications in electrical and electronics engineering.

References

1.	Clayton Paul, Syed A Nasar and Louis Unnewehr, 'Introduction to Electrical Engineering', 2nd Edition, McGraw-Hill, 1992.
2.	Hughes, 'Electrical and Electronic Technology', Pearson Education India, 10th Edition, 2010.
3.	Shock and Awe: The Story of Electricity -- Jim Al-Khalili BBC Horizon https://www.youtube.com/watch?v=Gtp51eZkwoI

Course Outcomes (COs)

At the end of the course student will be able to

CO1	develop an insightful knowledge on various aspects of electrical and electronics engineering
CO2	understand the electricity tariff, house wiring concepts, power plant structure and components
CO3	understand the significance of electronics and computing systems in various industrial applications

PROGRAMME CORE

Course Code	**:**	EEPC10
Course Title	**:**	**CIRCUIT THEORY**
Type of Course	**:**	PC
Prerequisites	**:**	MAIR12
Contact Hours	**:**	4 Hours/Week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO	To provide the key concepts and tools in a logical sequence to analyze and understand electrical and electronic circuits.

Course Content

Fundamental concepts of R, L and C elements, DC circuits, series and parallel circuits - loop and nodal analysis, AC circuits - complex impedance - phasor diagram, real and reactive power - loop and nodal analysis applied to AC circuits.

Voltage source –current source transformations, Various Network theorems and applications to dc and ac circuits, star-delta transformations.

Resonance in series and parallel circuits, self and mutual inductances, coefficient of coupling - dot convention - analysis of coupled circuits.

Three-phase star and delta circuits with balanced and unbalanced loads - power measurements - power factor calculations.

Time response of RL, RC and RLC circuits for step and sinusoidal inputs.

References

1	Hayt, W. H, Kemmerly J. E. & Durbin, ‘Engineering Circuit Analysis’, McGraw Hill Publications, 8th Edition, 2013.
2	Charles K. Alexander, Matthew N.O.Sadiku, ‘Fundamentals of Electric Circuits’, McGraw-Hill Publications, 5th Edition, 2013.
3	Joseph. A. Edminister, ‘Electric Circuits - Schaum's Outline Series’, McGraw-Hill Publications, 6th Edition, 2003.
4.	Robins & Miller, ‘Circuit Analysis Theory and Practice’, Delmar Publishers, 5th Edition, 2012

Course Outcomes (CO)

At the end of the course student will be able to

CO1	apply mesh and nodal analysis techniques and solve simple dc and single-phase ac circuits in steady state.
CO2	apply network theorems to solve dc and ac circuits with single or multiple independent and dependent sources.
CO3	analyze the phenomena of resonance in series-parallel circuits and solve simple electro-magnetic circuits.
CO4	perform computations needed in three-phase circuits in steady state
CO5	compute the transient and steady-state responses of simple dc and ac circuits.

Course Code	:	EEPC11
Course Title	:	**SIGNALS AND SYSTEMS**
Type of Course	:	PC
Prerequisites	:	EEPC10
Contact Hours	:	4 Hours/Week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand and explore the fundamental characteristics of signal and systems
CLO2	To understand and analyze the electric circuits excited with non-sinusoidal and non-periodic source

Course Content

Introduction to signals, representation in terms of elementary signals, Signal Classification, Continuous/ Discrete Time Signals, sampling theorem, aliasing, signal operations, Continuous-time Convolution

Definition and Classification of Systems, Linear time-invariant (LTI) systems, Properties of LTI systems, Causality, Stability, Impulse Response, response to an arbitrary input signal

Exponential and trigonometric Fourier series representation of periodic signals, properties of Fourier series, application to simple electrical circuits, Fourier transform and its properties, frequency response, harmonic analysis

Laplace transform and its properties, Region of Convergence, inverse Laplace Transform, zero-state and zero-input response, circuit analysis in S-domain, driving point functions, Two port networks, interconnection of LTI systems

Introduction to discrete time system, difference equations, z-transform and its properties, RoC, Inverse z-Transform, discrete-time linear shift invariant (LSI) systems, Impulse Response of LSI Systems, solution of difference equation

References

1.	A. V. Oppenheim, A. S. Willsky, and H. S. Nawab, ‘Signals and Systems’, 2nd edition. Pearson Education, 2015.
2.	S. Haykin and B. V. Veen, ‘Signals and Systems’, 2nd edition, Wiley, 2007.
3.	D. Roy Choudhury, ‘Networks and Systems’, New Age International Publications, 1st Edition, 2013.
4.	James W. Nilsson and Susan A. Riedel, ‘Electric Circuits’, Pearson Education Publications, 9th Edition, 2011.
5.	A Kumar, ‘Signals and Systems’, 3rd edition, Prentice Hall India, 2013.
6.	Hayt, W. H, Kemmerly J. E. & Durbin, ‘Engineering Circuit Analysis’, McGraw Hill Publications, 8th Edition, 2013.
7.	B. P. Lathi, ‘Signal Processing & Linear Systems’ Oxford University Press, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the signal operations and representation of continuous-time and discrete-time signals.
CO2	Classify systems based on their properties and determine the response of LTI system
CO3	Understand the significance of Fourier series and Fourier Transform and apply them for typical electrical circuits.
CO4	Apply Laplace Transform and Z-transform for the analysis of continuous-time and discrete time systems.
CO5	Apply and analyse the interconnected networks.

Course Code	:	EEPC12
Course Title	:	**DC MACHINES AND TRANSFORMERS**
Type of Course	:	PC
Prerequisites	:	EEPC10
Contact Hours	:	4 Hours/Week
Course Assessment Methods	:	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course aims to equip the students with a basic understanding of DC machines and Transformer fundamentals, machine parts and help to gain the skills for operating DC machines and Transformers
CLO2	The course also equips students with ability to understand and analyze the equivalent circuits of DC machines and Transformers.

Course Content

Principles of Energy conversion – basic magnetic circuit analysis, Faraday's law of electromagnetic induction – singly and doubly excited magnetic field systems – torque production in rotating machines and general analysis of electromechanical system.

DC Generator – construction, principle of operation – emf equation– types, Characteristics, commutation - armature reaction.

DC motor – principle of operation – torque equation – types – electrical & mechanical characteristics–starting – speed control – various testing – braking.

Transformers – principle of operation – types – basic construction – equivalent circuit - regulation and efficiency – auto transformer.

Three-phase transformer connection-Scott connection – all day efficiency - Sumpner's test - parallel operation of transformers.

References

1.	Dr. P.S. Bhimbra, 'Electrical Machinery', Khanna Publications, 7th Edition, 2007.
2.	Nagrath, I.J. and Kothari, D.P., 'Electrical Machines', Tata McGraw-Hill Education Private Limited Publishing Company Ltd., 4th Edition, 2010.
3.	A.E. Fitzgerald and Charles Kingsley, 'Electric Machinery', Tata McGraw-Hill Education Publications, 6th Edition, 2002.
4.	Vincent Del Toro, 'Electrical Engineering Fundamentals', 2nd Edition, Prentice Hall Publications, 2003.
5.	Parker Smith, N.N., 'Parker Smith's Problems in Electrical Engineering', 9th Edition, CBS Publishers and Distributers, 9th Edition, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand various properties and applications of magnetic circuits in linear and rotational systems.
CO2	Understand constructional details and principles of DC machines and transformers.
CO3	Analyze the performance parameters/characteristics of the DC machines under

	various operating conditions through proper testing
CO4	Evaluate the performance of single-phase transformer using equivalent circuits and phasor diagrams
CO5	Understand various connection and performance testing of various transformers

Course Code	:	EEPC13
Course Title	:	**ELECTRON DEVICES**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3 hours/Week
Course Assessment Methods	:	Continuous Assessments, End Assessment

Course Learning Objectives (CLO)

CLO	To educate on the construction and working of common electronic devices and to prepare for application areas.

Course Content

Semi-conductors – charge carriers, electrons and holes in intrinsic and extrinsic semi-conductors –Hall effect.

Diodes – PN junction – current equation – Junction Capacitance – breakdown characteristics of Zener diode, Tunnel diode, Schottky diode.

Bipolar junction transistors – Characteristics – Analysis of CB, CE, CC amplifier configurations.

Unipolar devices – FET, MOSFET, UJT and Opto-Electronic devices – theory and characteristics.

Rectifiers and switched mode power supplies – theory and design, filter circuits, applications.

References

1.	David, A. Bell, ‘Electronic Devices and Circuits’, PHI, 5th Edition, 2008.
2.	Millman and Halkias ‘Electronic Devices and Circuits’, McGraw - Hill International Student, 2nd Edition, 2007.
3.	Robert L. Boylestad and Louis Nashelsky, ‘Electronic Devices and Circuit Theory’, Pearson Prentice Hall, 10th Edition, 2009.
4.	Thomas L. Floyd, ‘Electronic Devices’, Pearson Education Limited, 9th Edition, 2013.
5.	Allen Mottershead, ‘Electronic Devices and Circuits - An Introduction’, PHI, 18th Reprint, 2010.
6.	Albert Malvino and David J Bates, ‘Electronic Principles’, McGraw Hill, 7th Edition, 2007.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the semiconductor physics of the intrinsic, p and n materials and various devices and characteristics.
CO2	Analyze simple diode circuits under DC and AC excitation.
CO3	Analyze and design simple amplifier circuits using BJT in CE, CC and CB configurations
CO4	Understand the analysis and salient features of CE, CC & CB amplifier circuits
CO5	Understand the construction and characteristics of FET, MOSFET and UJT.

Course Code	:	EEPC14
Course Title	:	**DIGITAL ELECTRONICS**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3 hours/Week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO	This subject exposes the student to digital fundamentals

Course Content

Review of number systems, binary codes, error detection and correction codes. Digital Logic Families – MOS Logic Circuits. Combinational logic representation of logic functions – SOP and POS forms, K-map representations – minimization using K-maps

Simplification and implementation of combinational logic – multiplexers and demultiplexers – Decoder and Encoder – Priority Encoder - code converters, adders, subtractors, magnitude comparator. Memory units – Types of memory units – RAM and ROM – Importance of memory units – Programmable Logic device (PLD) and its types
.
Sequential logic- SR, JK, D and T flip-flops – level triggering and edge triggering – counters – Pulse forming circuits - asynchronous and synchronous type – Modulo counters – Shift registers – Ring counters.

Synchronous Sequential Logic circuits - state table and excitation tables - state diagrams - Moore and Mealy models - design of counters - analysis of synchronous sequential logic circuits - state reduction and state assignment – Sequence detector

Asynchronous sequential logic circuits-Transition table, flow table – race conditions – circuits with latches, analysis of asynchronous sequential logic circuits – implication table – Races and hazards in logic circuits - Introduction to Hardware Description Languages – VHDL – Modeling styles.

References

1.	Morris Mano.M, 'Digital Logic and Computer Design', Prentice Hall of India, 3rd Edition, 2005.
2.	Anil K. Maini, "Digital Electronics: Principles, Devices and Applications", Wiley, 1st Edition, 2007.
3.	Thomas L Floyd, 'Digital fundamentals', Pearson Education Limited, 11th Edition, 2015.
4.	Tocci R.J., Neal S. Widmer, 'Digital Systems: Principles and Applications', Pearson Education Asia, 2014.
5.	Donald P Leach, Albert Paul Malvino, Goutam Sha, 'Digital Principles and Applications', Tata McGraw Hill, 7th Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Interpret, convert and represent different number systems and Simplify the Boolean expressions for digital design.

CO2	Manipulate and examine Boolean algebra, logic operations and design Combinational logic circuits.
CO3	Design the basic components for the sequential logic circuits.
CO4	Analyse the synchronous sequential logic circuits.
CO5	Evaluate the Asynchronous sequential logic circuits.

Course Code	**:**	EEPC15
Course Title	**:**	**AC MACHINES**
Type of Course	**:**	PC
Prerequisites	**:**	EEPC12
Contact Hours	**:**	4 hours/Week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course provides a basic understanding of AC machinery fundamentals, machine parts and helps to gain the skills for operating AC machines.
CLO2	The course also equips students with ability to understand and analyse the phasor diagrams and equivalent circuits of AC Induction and Synchronous Machines

Course Content

Alternators – construction, principle and types - armature reaction - load characteristics – voltage regulation – two-reaction theory – parallel operation.

Synchronous motors - Synchronous machines on infinite bus bars - phasor diagram - V and inverted-V curves - Hunting and its suppression - starting methods.

Poly-phase induction motors - construction, principle and types – no-load and load characteristics – no-load and blocked rotor test - equivalent circuit – circle diagram.

Poly-phase induction motors - Starting and speed control methods – Braking methods. Induction generators – types, principle of operation, equivalent circuit and applications.

Single-phase induction motors - construction, principle and types - double revolving field theory – equivalent circuit. Permanent magnet brushless motors – construction, principle and types – torque equation.

References

1.	Dr. P.S. Bhimbra, 'Electrical Machinery', Khanna Publications, 7th Edition, 2007.
2.	Nagrath, I.J. and Kothari, D.P., 'Electrical Machines', Tata McGraw Hill Education Private Limited Publishing Company Ltd., 4th Edition, 2010.
3.	M. G. Say, 'Performance and Design of Alternating Current Machines', CBS Publishers & Distributors Pvt. Ltd., New Delhi, 3rd Edition, 2002
4.	Arthur Eugene Fitzgerald and Charles Kingsley, 'Electric Machinery', Tata McGraw Hill Education Publications, 6th Edition, 2002.
5.	Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press- Oxford, 1989.
6.	Parkar Smith, N.N., 'Problems in Electrical Engineering', CBS Publishers and Distributers, 9th Edition, 1984.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the constructional details and principle of operation of AC Induction and Synchronous Machines.
CO2	Understand and appraise the principle of operation and performance of single-phase induction motors and other special motors.

CO3	Analyze the performance of the AC Induction and Synchronous Machines using the phasor diagrams and equivalent circuits.
CO4	Select appropriate AC machine for any application and appraise its significance.

Course Code	**:**	EEPC16
Course Title	**:**	**ANALOG ELECTRONIC CIRCUITS**
Type of Course	**:**	PC
Prerequisites	**:**	EEPC13
Contact Hours	**:**	4 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To give a comprehensive exposure to all types of amplifiers and oscillators constructed with discrete components such as BJTs and FETs.
CLO2	To develop a strong basis for building linear and digital integrated circuits.

Course Content

Small signal amplifiers - biasing circuits of BJT and FET transistors, analysis and design of BJT and FET amplifiers, chopper stabilized amplifiers, case studies – application of current amplifiers in SCR firing circuits and power supplies.

Large signal amplifiers – analysis and design of class A and class B power amplifiers, class C and class D amplifiers, thermal considerations, tuned amplifiers.

Feedback amplifiers – gain with feedback – effect of feedback on gain stability, distortion, bandwidth, input and output impedances; topologies of feedback amplifiers, case studies – application of negative feedback in dc-dc converters.

Oscillators – Barkhausen criterion for oscillation – Hartley & Colpitt's oscillators – phase shift, Wien bridge and crystal oscillators - Clapp oscillator – oscillator amplitude stabilization.

Pulse circuits – attenuators – RC integrator and differentiator circuits – diode clampers and clippers – multivibrators - Schmitt Trigger- UJT Oscillator, case studies – application of UJT oscillator in SCR firing circuits and opto-electronic control circuits.

References

1.	Jacob Millman, 'Microelectronics', McGraw Hill, 2nd Edition, Reprinted, 2009.
2.	David A Bell, 'Fundamentals of Electronic Devices and Circuits', Oxford University Press, Incorporated, 2009.
3.	Allen Mottershead, 'Electronic Devices and Circuits-An Introduction', PHI, 18th Reprint, 2006.
4.	Thomas L. Floyd, David M. Buchla, 'Electronics Fundamentals', Pearson Prentice Hall, 7th Edition, 2010.
5.	Robert.L.Boylestad, 'Electronic Devices and Circuit Theory', Pearson, 10th Edition, 2009.
6.	Sedra Smith, 'Microelectronic Circuits', Oxford University Press, 6th Edition, 2010.
7.	Jacob Millman and Christos C. Halkias, 'Integrated Electronics: Analog and Digital Circuits and Systems', 2nd Edition, Tata McGraw Hill Education, 2011.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the working of different types of amplifiers, oscillator and multivibrator circuits.
CO2	Design BJT and FET amplifier and oscillator circuits
CO3	Analyze transistorized amplifier and oscillator circuits.
CO4	Understand the applications of different types of amplifiers, oscillator, attenuators and multivibrator circuits.

Course Code	:	EEPC17
Course Title	:	**TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY**
Type of Course	:	PC
Prerequisites	:	EEPC10
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	Identify major components of power transmission and distribution systems.
CLO2	Describe the principle of operation of transmission and distribution equipment.
CLO3	Know and appreciate the key factors in transmission and distribution system equipment specification and network design

Course Content

Transmission line parameters – Resistance, Inductance and Capacitance calculations – Single-phase and three-phase lines – double circuit lines – effect of earth on transmission line capacitance.

Performance of transmission lines – 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.

Mechanical design of overhead lines – Line supports – Insulators, Voltage distribution in suspension insulators – Testing of insulators – string efficiency – Stress and sag calculation – effects of wind and ice loading.

Underground cables – Comparison with overhead line – Types of cables – insulation resistance –potential gradient – capacitance of single-core and three-core cables.

Distribution systems – 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.

References

1.	D.P.Kothari and I.J. Nagrath, ‘Power System Engineering’, Tata McGraw–Hill, 2ndEdition, 2008.
2.	Gupta B.R, 'Power System Analysis & Design', S.Chand and Company Ltd., 5th Edition, 2001.
3.	John .J. Grainger & Stevenson. W. D., 'Power System Analysis', McGraw-Hill, 1st Edition, 2003
4.	Turan Gonen, ‘Electric Power Distribution System Engineering’, CRC Press INC, 2ndEdition 2007.
5.	‘Electrical Transmission and Distribution Reference Book’, Westinghouse Electric Corporation, 4thEdition 2007

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the major components of Transmission and Distribution Systems (TDS) and its practical significance.
CO2	Have good Knowledge of various equipment specifications and design for TDS.
CO3	Have awareness of latest technologies in the field of electrical transmission and distribution.

Course Code	**:**	EEPC18
Course Title	**:**	**POWER SYSTEM ANALYSIS**
Type of Course	**:**	PC
Prerequisites	**:**	EEPC10, MAIR32
Contact Hours	**:**	4 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To model various power system components
CLO2	To carry out load flow, short-circuit and stability studies.

Course Content

Modeling of power system components – single line diagram – per unit quantities– bus impedance and admittance matrix.

Power flow analysis methods – Gauss-Seidel, Newton-Raphson and Fast decoupled methods of load flow analysis.

Fault studies – Symmetrical fault analysis, Analysis through impedance matrix, Current limiting reactors.

Fault analysis - Unsymmetrical short circuit analysis - LG, LL, LLG; Fault parameter calculations – Open circuit faults.

Stability studies – Steady state and transient stability– Swing equation - Equal area criterion – multi-machine stability analysis.

References

1.	John. Grainger & Stevenson., 'Power System Analysis', McGraw Hill, 1st Edition, 2003.
2.	D P Kothari, I J Nagrath ‘Modern Power System Analysis’, 3rd Edition, 2011.
3.	Hadi Saadat, ‘Power System Analysis’, Tata McGraw-Hill Education, 2nd Edition, 2002.
4.	J. Duncan Glover, M.S.Sarma & Thomas J. Overbye, ‘Power System Analysis and Design’, Cengage Learning, 5th Edition, 2011.
5.	J.C.Das, ‘Power System Analysis, ‘Short-Circuit Load Flow and Harmonics’, Marcel Dekker Inc., 1st Edition, 2002.
6.	Arthur R. Bergen, ‘Power System Analysis’, Pearson Education India, 2nd Edition, 2009.
7.	Gupta B.R., 'Power system Analysis & Design', S.Chand and Company Ltd., 5th Edition, 2001

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Carry out load flow study of a practical system.
CO2	Simulate and analyze fault.
CO3	Study the stability of power systems.

Course Code	**:**	EEPC19
Course Title	**:**	**POWER ELECTRONICS**
Type of Course	**:**	PC
Prerequisites	**:**	MAIR32, EEPC10 & EEPC13
Contact Hours	**:**	4 hours / Week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip the students with a basic understanding of modern power semiconductor devices, and various important topologies of power converter circuits for specific types of applications.
CLO2	To equip students with an ability to understand and analyze non-linear circuits involving power electronic converters.

Course Content

Power Semiconductor Devices –power diodes, power transistors, SCRs, TRIAC, GTO, power MOSFETs, IGBTs-Principles of operation, characteristics, ratings, protection and gate drive circuits.

Controlled rectifiers- single- phase and three-phase- power factor improvement - dual converters.

DC-DC converters- Buck, Boost, Buck-Boost- with circuit configuration and analysis.

DC-AC converters- single-phase/three-phase, VSI, CSI, frequency and voltage control.

AC-AC converters- single/three-phase controllers, phase control, PWM AC voltage controller, Principle of ON-OFF control and cyclo-converters.

References

1.	Rashid, M.H, 'Power Electronics - Circuits, Devices and Applications', Prentice Hall Publications, 3rd Edition, 2003.
2.	M.D.Singh and K.B.Kanchandhani, 'Power Electronics', Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 2006.
3.	Ned Mohan, Tore M. Undeland, William P. Robbins, 'Power Electronics', John Wiley & Sons Publications, 3rd Edition, 2006.
4.	Vedam Subramaniam, 'Power Electronics', New Age International (P) Ltd Publishers, 2001.
5.	Philip T. Krein, 'Elements of Power Electronics', Oxford University Press, 1st Edition, 2012.
6.	V.R.Moorthi, 'Power Electronics- Devices, Circuits and Industrial Applications', Oxford University Press, 1st Edition, 2005.
7.	P.S. Bimbhra, 'Power Electronics', Khanna Publishers, 3rd Edition, 13th Reprint, 2004

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the principle of operation of commonly employed power electronic converters.
CO2	Analyze non -linear circuits with several power electronic switches.
CO3	Take up advanced courses in Power Electronics and its application areas

Course Code	:	EEPC20
Course Title	:	**CONTROL SYSTEMS**
Type of Course	:	PC
Prerequisites	:	MAIR32
Contact Hours	:	4 hours / Week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO	**To equip the students with the fundamental concepts in control systems**

Course Content

Modelling of physical systems: Electrical systems - Electromechanical systems – Mechanical systems – Transfer function and state space models – Block Diagram Reduction – Signal Flow Graph

Time domain analysis - Time-domain specifications - Generalized error series – various test signals and its importance - Routh-Hurwitz stability criterion – Frequency Domain Analysis – Bode plot

Stability Analysis – BIBO stability – Nyquist stability – Routh-Hurwitz stability criterion – Stability Margin – Internal Stability

Controller design: Design of P, PI, PID using root locus technique, lag, lead, lead-lag compensator design – Controllability – State Feedback Controller Design

References

1.	Katsuhiko Ogata, 'Modern Control Engineering ', Pearson Education Publishers, 5th Edition, 2010.
2.	Nagrath I.J. and Gopal M, 'Control Systems Engineering', New Age International Publications, 5th Edition, 2010.
3.	Benjamin C. Kuo and Farid Golnaraghi, 'Automatic Control Systems', John Wiley & Sons Publications, 8th Edition, 2002.
4.	Chi-Tsong Chen, 'Linear System Theory and Design', Oxford University Press, Fourth Edition 2014
5.	Norman S. Nise, 'Control Systems Engineering', John Wiley & Sons, Eighth Edition, 2019
6.	Richard C. Dorf and Robert H. Bishop. 'Modern Control Systems', Pearson Prentice Hall Publications, 12th Edition, 2010.
7.	Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, 'Feedback Control of Dynamic Systems', Pearson Education India Publications, 6th Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concepts of closed loop control systems.
CO2	Analyze the stability of closed loop systems.
CO3	Apply the control techniques to any electrical systems.
CO4	Design the classical controllers such as P, PI, etc., for electrical systems.

Course Code	:	EEPC21
Course Title	:	**LINEAR INTEGRATED CIRCUITS**
Type of Course	:	PC
Prerequisites	:	EEPC10
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO	To provide in-depth instructions on the characteristics and applications of operational amplifiers, timers and voltage regulators.

Course Content

Block diagram of a typical op-amp – characteristics of ideal and practical op-amp - parameters of op-amp – inverting and non-inverting amplifier configurations - frequency response - circuit stability.

DC and AC amplifiers - summing amplifier – difference amplifier – voltage follower – differentiator – integrator- clamper - clipper– filters.

Oscillators, sine wave, square wave, triangular wave, saw tooth wave generation, Schmitt trigger, window detector.

Analog-to-digital, digital-to-analog, sample and hold circuits; voltage controlled oscillator, phase locked loop – operating principles, applications of PLL.

IC555 Timer, monostable and astable modes of operation; voltage regulators - fixed voltage regulators, adjustable voltage regulators - switching regulators.

References

1.	Gayakwad R.A., 'Op-amps & Linear Integrated Circuits', Prentice Hall of India, New Delhi, 4th Edition, 2009.
2.	Roy Choudhury and Shail Jain, ‘Linear Integrated Circuits’, 4th Edition, New Age International Publishers, 2010.
3.	Sergio Franco,’ Design with Operational Amplifiers and Analog Integrated Circuits’, Tata McGraw Hill, 3rd Edition, 2002.
4.	Sedra Smith, ‘Microelectronic Circuits’, Oxford University Press, 6th Edition, 2009.
5.	R P Jain, ‘Modern Digital Electronics’, Tata McGraw-Hill Education, 3rd Edition, 2003

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the various ideal and practical characteristics of an OPAMP.
CO2	Develop simple OPAMP based circuits.
CO3	Implement various analog signal processing circuits.
CO4	Analyze and design various types of ADCs and DACs.
CO5	Analyze and construct various application circuits using 555 timer

Course Code	:	EEPC22

Course Title	**:**	**MICROPROCESSORS AND MICROCONTROLLERS**
Type of Course	**:**	PC
Prerequisites	**:**	EEPC14
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To gain knowledge on the architecture of 8085 microprocessors and 8051 micro controller, their programming and associated peripheral interface devices.

Course Content

8-Bit Microprocessor - 8085 architecture and memory interfacing (RAM & ROM), interfacing I/O devices - instruction set - addressing modes - assembly language programming – interrupts - timing diagram.

8051 Microcontroller - Intel 8051 architecture, memory organization, flags, stack, and special function registers, I/O, ports - connecting external memory, counters and timers, serial data I/O, Interrupts.

Microcontroller instructions - addressing modes, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns.

Microcontroller programming – Assembly Language Programming, timer and counter programming, connection to RS 232 and RS 485, Interrupt programming.

Peripherals and interfacing - Serial and parallel I/O (8251 and 8255), Programmable DMA controller, Programmable interrupt controller, ADC/DAC interfacing.

References

1.	Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Applications with 8085', Penram Intl. Publishing, 6th Edition, 2013.
2.	Kenneth Ayala, 'The 8051 Microcontroller', Cengage Learning Publications, 3rd Edition, 2007
3.	Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay 'The 8051 Microcontroller and Embedded Systems using Assembly and C', Prentice Hall Publications, 2nd Edition, 2008
4.	Sencer Yeralan, Helen Emery, 'Programming and Interfacing the 8051 Microcontroller', AddisonWesley Publications, 1st Edition, 2000.
5.	Krishna Kant, 'Microprocessors and Microcontrollers, Architecture, Programming and System Design - 8085, 8086, 8051, 8096', Prentice Hall India Ltd Publications, 1st Edition, 2010.
6.	Ray A.K., Bhurchandi K.M., 'Advanced Microprocessor and Peripherals', Tata McGraw-Hill Publications, 3rd Edition, 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Summarize the architecture of 8085 microprocessor and 8051 microcontroller
CO2	Develop assembly language code for a given problem
CO3	Design a microcontroller/ microprocessor based system for timer-counter/serial

	communication /interrupt operation
CO4	Interface appropriate peripheral devices, memory with microprocessor/microcontroller for a given application/problem

Course Code	:	EEPC23
Course Title	:	**MEASUREMENTS AND INSTRUMENTATION**
Type of Course	:	PC
Prerequisites	:	EEPC21
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic operation of different measuring instruments and thereby able to choose appropriate instruments for measuring different parameters.

Course Content

Measuring Instruments: Classification, characteristics, errors & error analysis in measurements. Electromechanical Instruments – permanent magnet moving coil, moving iron instruments and Electrodynamometer type instruments. Measurement of voltage & current.

Measurement of power and energy - dynamometer and induction instruments, kVAh and kVARh meters, Instrument transformers – Current and Potential transformers.

Measurement of resistance, inductance and capacitance using dc and ac bridges, Transducers –Position transducers, force transducers, piezo-electric transducers, Hall effect transducers. Temperature measurement.

Signal sources, Oscilloscopes, digital multi-meters, Digital voltmeters.

Signal Generators, Function generator, Signal conditioners – Instrumentation amplifiers, voltage–current converters, voltage-frequency converters, analog multiplexers and de-multiplexers.

References

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.
5.	David A. Bell, ‘Electronic Instrumentation and Measurements’ Oxford University Press, 3rd Edition, 2013
6.	W. D. Cooper, ‘Electronic Instrumentation and Measurement Techniques’, Prentice Hall of India Publications, 1st Edition, 2009.
7.	Rangan C.S., ‘Instruments Devices and System’, Tata McGraw Hill Publications, 2nd Edition, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the working principle of analog measuring instruments.
CO2	Describe the working principle of digital measuring instruments.
CO3	Choose appropriate measuring instruments for measuring various parameters in their laboratory courses.
CO4	Analyse the operation and usage of oscilloscopes and signal generators for practical applications.

Course Code	**:**	EEPC24
Course Title	**:**	**POWER SYSTEM PROTECTION AND SWITCHGEAR**
Type of Course	**:**	PC
Prerequisites	**:**	EEPC18
Contact Hours	**:**	4 hours / Week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To give a broad coverage on all types of protective relays, circuit breakers and provide a strong background for working in a practical power system protection.

Course Content

Relays – General classification, Principle of operation, types, characteristics, Torque equation, Relaying Schemes, Relay Co-ordination.

Apparatus and line protection – Line Protection – Distance, Differential protection and Carrier current protection. Generator protection – protection against abnormal condition, stator and rotor protection Transformer Protection – Incipient fault–Differential protection, Feeder and Bus bar protection.

Introduction to substation architecture, automation and protection - Protection against over voltages – Causes of over voltage, Ground wires, Surge absorbers and diverters. Earthing - types. Insulation co-ordination.

Theory of arcing and arc quenching circuit breakers-types – rating and comparison, RRRV, Resistor switching and capacitor switching.

Introduction to Static relays – Digital relays - Microprocessor based relays – Apparatus and line protection – Basics of Numerical relays.

References

1.	Badri Ram and Vishwakarma, D.N., 'Power System Protection and Switchgear', Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2011.
2.	Ravindranath B., and Chander, N., 'Power Systems Protection and Switch Gear', Wiley Eastern Ltd., 1st Edition, 1977.
3.	Sunil S. Rao, 'Protective Switch Gear', Khanna Publishers, New Delhi, 13th Edition, 2008.
4.	Y. G. Paithangar, 'Fundamentals of Power System Protection', PHI Learning Private Limited, 2nd Edition, 2010.
5.	C.L. Wadhwa, 'Electrical Power Systems', Wiley-Blackwell, 6th Edition, 2007.
6.	Ramesh Bansal, "Power System Protection in Smart Grid Environment", CRC Press, 1st Edition, 2019

Course Outcomes (CO)

At the end of the course student will be able

CO1	Classify and describe the working of various relaying schemes.
CO2	Identify and implement an appropriate relaying scheme for different power apparatus.
CO3	Illustrate the function of various CBs and related switching issues.
CO4	Describe the causes of overvoltage and protection against overvoltage

ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Course Code	**:**	EELR10
Course Title	**:**	**CIRCUITS AND DIGITAL LABORATORY**
Type of Course	**:**	Essential Laboratory Requirement (ELR)
Co-requisites	**:**	EEPC10
Contact Hours	**:**	2 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand and analyze the basic theorems of Circuit theory
CLO2	Understand and analyze series & parallel circuits and measurement of single and three-phase power.
CLO3	Understand and analyze different applications of combinational circuits.
CLO4	Understand the basics of digital design sequential circuits

List of Experiments

- Characteristics of CB and CE configuration of BJT.
- Verification of Thevenin and Maximum Power Transfer Theorem.
- Verification of Superposition Theorem.
- Verification of Kirchhoff's Current and Voltage law.
- Transient characteristics of RC/RL/R-L-C circuit.
- Design of combinatorial logic circuits
- Design of synchronous sequential logic circuits
- Design of asynchronous sequential logic circuits

Mini Project

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Verify the network theorems and operation of typical electrical and electronic circuits.
CO2	Choose the appropriate equipment for measuring electrical quantities and verify the same for different circuits.
CO3	Prepare the technical report on the experiments carried.
CO4	Design basic digital logic circuits

Course Code	:	EELR11
Course Title	:	**DC MACHINES AND TRANSFORMERS LABORATORY**
Type of Course	:	Essential Laboratory Requirement (ELR)
Co-requisites	:	EEPC12
Contact Hours	:	2 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The main objective of the course is to give the students an insight into the constructional details of dc machines and transformers with a view for better understanding of their working principles.
CLO2	The course also equips the students to test and evaluate the performance of various dc machines and Single-phase transformers by conducting appropriate experiments.

List of Experiments

A demonstration of the static and rotational electrical machines (constructional details) is ought to be done in an introductory class.

- Open circuit and load characteristics of DC shunt/compound generator
- Swinburne's test and Speed control of DC shunt motor
- Load test on DC shunt motor
- Load test on DC series motor
- Open circuit and short circuit test on single-phase transformer
- Sumpner's test
- Parallel operation of single-phase transformer
- Electrical braking in DC shunt motor
- Three-phase transformer connections

Mini-Project

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Interpret the constructional details of the DC machines and Transformers and also understand the significance of different connections of three-phase transformers.
CO2	Estimate or test the performance of any DC machine (shunt, series or compound) and single-phase transformer, by conducting suitable experiments and report the results.
CO3	Experiment and analyze the various speed control and braking techniques for DC motors.
CO4	Develop simulation models and prototype modules in view of implementing any control technique upon dc motors and single-phase transformers for various applications.

Course Code	:	EELR12
Course Title	:	**ELECTRONIC CIRCUITS LABORATORY**
Type of Course	:	Essential Laboratory Requirement (ELR)
Co-requisites	:	EEPC13
Contact Hours	:	2 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	Design of amplifiers and other electronic systems to satisfy specifications

List of Experiments

- Frequency analysis of Common Emitter amplifier.
- Measurement of input/output impedance of Common Collector amplifier.
- Design and verification of characteristics of RC oscillators.
- Design and characterization of Monostable multivibrator.
- Design and characterization of Astable multivibrator.
- Characteristics of UJT and applications of UJT oscillator.
- Frequency analysis of FET Amplifier.
- Frequency response of series voltage negative feedback Amplifier.
- Square waveform generation using transistor based Schmitt trigger.
- Design and characterization of Bistable Multivibrator.

Mini-Project.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design a complete electronic circuit using a top-down approach which starts from specifications.
CO2	Design and analyze electronic circuits using BJT and FET.
CO3	Design and characterization of electronic circuits using UJT.
CO4	Waveform generator circuit design using electronic devices.
CO5	Prepare the technical report and provide solutions to real time problems.

Course Code	**:**	EELR13
Course Title	**:**	**SYNCHRONOUS AND INDUCTION MACHINES LABORATORY**
Type of Course	**:**	Essential Laboratory Requirement (ELR)
Co-requisites	**:**	EEPC15
Contact Hours	**:**	2 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The main objective of the course is to give the students an insight into the constructional details of the induction and synchronous machines with a view for better understanding of their working principles
CLO2	The course also equips the students to test and evaluate the performance of induction and synchronous machines by conducting appropriate experiments.

List of Experiments

A demonstration of the static and rotational electrical machines (constructional details) is ought to be done in an introductory class.

- Load test on three-phase induction motor
- No-load and blocked rotor test on three-phase induction motor
- Load test on grid connected induction generator
- Load test on self-excited induction generator
- Load test on single-phase induction motor
- Regulation of three-phase alternator by E.M.F and M.M.F methods
- Load test on three-phase alternator
- Synchronization of three-phase alternator with infinite bus bar
- V and inverted V-curves of synchronous motor
- Speed Control on three-phase induction motor

Mini-Project.

Course Outcomes (CO): At the end of the course student will be able to

CO1	Estimate or test the performance of induction and synchronous machines by conducting suitable experiments and report the results.
CO2	Experiment and analyze the speed control techniques for three-phase induction motors.
CO3	Evaluate the different modes of operating the induction generators and justify their usage in wind power generation.
CO4	Experiment synchronization of alternators and power exchange with the grid to get convinced with their usage at conventional power generation stations.
CO5	Develop simulation models and prototype modules in view of implementing any control technique upon Single-phase and three-phase induction motors for various applications

Course Code	**:**	EELR14
Course Title	**:**	**INTEGRATED CIRCUITS LABORATORY**
Type of Course	**:**	Essential Laboratory Requirement (ELR)
Co-requisites	**:**	EEPC21
Contact Hours	**:**	2 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enrich the students' knowledge on practical circuit design using analog and digital ICs

List of Experiments

- Understanding of Op-Amp Imperfections
- Linear Applications of Op-Amp
- Non-Linear Applications of Op-Amp
- Design of Active filters using Op-Amp
- Analog-to-Digital Conversion
- Digital-to-Analog conversion
- Timing circuits using 555 Timer
- Combinational and Sequential logic circuits
- Design of Code converter with seven-segment display

Mini-Project

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the non-ideal behaviour of Op-amp.
CO2	Analyze and prepare the technical report on the experiments carried out.
CO3	Design application-oriented circuits using Op-amp and 555 timer ICs.
CO4	Create and demonstrate live project using ICs.
CO5	Understand the non-ideal behaviour of Op-amp.

Course Code	:	EELR15
Course Title	:	**POWER ELECTRONICS LABORATORY**
Type of Course	:	Essential Laboratory Requirement (ELR)
Co-requisites	:	EEPC19
Contact Hours	:	2 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enable the students to develop hands-on experience in analyzing, designing and carrying out experiments on various electrical networks by make use of power electronic components.
CLO2	It aims to familiarize the switching devices, power converters and their applications in various systems for power control.

List of Experiments

- Characteristics of SCR, IGBT, MOSFET
- Single-phase Fully Controlled SCR Converter
- Buck Converter using MOSFET
- Boost Converter using MOSFET
- Buck-Boost Converter using IGBT
- Single-phase Inverter using IGBT
- Single-phase step-down Cyclo-converter
- Speed Control of single-phase A.C Motor
- Single-phase Half Controlled SCR Converter
- Illumination Control of Lamp
- Speed Control of single-phase Capacitor Run Induction Motor

Mini-Project

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the characteristics of various switching devices and appreciate its applications in various electrical networks/systems.
CO2	Analyze and design the operation of power switching converters.
CO3	Develop practical control circuits for various real time applications.
CO4	Analyze and prepare the technical report on the experiments carried out.

Course Code	**:**	EELR16
Course Title	**:**	**MICROCOMPUTING LABORATORY**
Type of Course	**:**	Essential Laboratory Requirement (ELR)
Co-requisites	**:**	NIL
Contact Hours	**:**	2 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enrich the students' knowledge on practical circuit design using analog and digital ICs

List of Experiments

- An assembly language program to perform different arithmetic operations.
- An assembly language program to perform different logical operations.
- An assembly language program to generate waveforms using DAC.
- Programming for Transmission and Reception of data through serial port.
- Interface of 7-Segment display.
- Interface of ADC /DAC
- Implementation and study of steeper motor / DC motor control.
- Interfacing sensors for measurement of metrics such as temperature / voltage/ current.

Mini-Project

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Summarize the architecture of 8085 microprocessor and 8051 micro- controller
CO2	Develop assembly language code for a given problem
CO3	Interface appropriate peripheral devices, memory with microprocessor/ microcontroller for a given application/problem

Course Code	:	EELR17
Course Title	:	**POWER SYSTEMS LABORATORY**
Type of Course	:	Essential Laboratory Requirement (ELR)
Co-requisites	:	EEPC18
Contact Hours	:	2 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enhance the analyzing and problem-solving skills of the students in power system through computer programming and simulation

List of Experiments

- Real and Reactive Power Computation
- Transmission Line Parameter Calculation
- Bus Admittance Matrix Formulation
- Load Flow Analysis
- Z-bus Formation
- Symmetrical Fault Analysis
- Unsymmetrical Fault Analysis

Mini-Project

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Develop computer programs for power system studies.
CO2	Design, simulate and analyze power systems using simulation packages.
CO3	Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner.

PROGRAMME ELECTIVES

Course Code	**:**	EEPE10
Course Title	**:**	**POWER GENERATION SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the working of different types of power generation systems and to realize the necessity for interconnected operation of different power stations

Course Content

Hydro-electric power plants – selection of site, elements of power plant, classification, water turbines, governor action, hydro-electric generator, plant layout, pumped storage plants.

Thermal steam power plants – selection of site, elements and operational circuits of the power plant, turbo-alternators, plant layout, steam turbines, controls and auxiliaries.

Nuclear power plants – selection of site, nuclear reaction – fission process and chain reaction, constituents of power plant and layout, nuclear reactor – working, classification, control, shielding and waste disposal.

Renewable power plants – Solar power generation – Photo-voltaic and solar thermal generation – solar concentrators, Wind power generation – types of windmills, wind generators, tidal, biomass, geothermal and magneto-hydro dynamic power generation, micro-hydel power plants, fuel cells and diesel and gas power plants

Combined operation of power plants – plant selection, choice of size and number of generator units, interconnected systems, real and reactive power exchange among interconnected systems. Major electrical equipment in power plants, DC systems in power plants, station control - switch yard and control room. Economic considerations – types of costs, tariff and consumers.

References

1.	Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A Text Book on Power Systems Engg', Dhanpat Rai and Sons, New Delhi, 2nd Revised Edition, 2010.
2.	J.B.Gupta, ‘A Course in Power Systems’, S.K.Kataria and Sons, Reprint 2010-2011.
3.	B.R.Gupta, ‘Generation of Electrical Energy’, S. Chand Limited, 2009
4.	Wadhwa, C.L., ‘Generation Distribution and Utilisation of Electrical Energy', New Age International Publishers, 3rd Edition, 2010.
5.	Deshpande M.V, `Elements of Electrical Power Systems Design’, Pitman, New Delhi, PHI Learning Private Limited, 1st Edition, 2009.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Appreciate the different types of tariffs, consumers and different types of power generation plants.
CO2	Determine the significance of various components of the power generation plants.

CO3	Correlate the importance of interconnected operation of different power generation systems.
CO4	Plan an appropriate scheduling of electric power to satisfy the demand constraint.

Course Code	**:**	EEPE11
Course Title	**:**	**ELECTRICAL SAFETY**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To provide a comprehensive exposure to electrical hazards, various grounding techniques, safety procedures and various electrical maintenance techniques.

Course Content

Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit.

General requirements for grounding and bonding- definitions- grounding of electrical equipment- bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment- system grounding- purpose of system grounding- grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage and high voltage systems.

The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment, procedure for low, medium and high voltage systems- the one-minute safety audit

Electrical safety programme structure, development- company safety team- safety policy- programme implementation- employee electrical safety teams- safety meetings- safety audit- accident prevention- first aid- rescue techniques-accident investigation

Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance programme- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code- standard for electrical safety in workplace- occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.

References

1.	John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield ,‘Electrical Safety Handbook’, McGraw-Hill Education, 4thEdition, 2012.
2.	Maxwell Adams.J, ‘Electrical Safety- a guide to the causes and prevention of electric hazards’, The Institution of Electric Engineers, IET 1994.
3.	Ray A. Jones, Jane G. Jones, ‘Electrical Safety in the Workplace’, Jones & Bartlett Learning, 2000.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe electrical hazards and safety equipment.
CO2	Analyze and apply various grounding and bonding techniques.
CO3	Select appropriate safety method for low, medium and high voltage equipment.
CO4	Participate in a safety team.
CO5	Carry out proper maintenance of electrical equipment by understanding various standards.

Course Code	**:**	EEPE12
Course Title	**:**	**THERMODYNAMICS AND MECHANICS OF FLUIDS#**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To achieve an understanding of the principles of thermodynamics and to be able to use it in accounting for the bulk behavior of simple physical systems.
CLO2	To provide in-depth study of thermodynamic properties of various working fluids.
CLO3	To enlighten the basic concepts of energy interacting devices through various thermodynamic cycles.
CLO4	To provide basic awareness about fluid behaviour under rest and dynamic conditions.
CLO5	To impart knowledge about hydraulic machines.

Course Content

Basic concepts: Thermodynamic equilibrium, quasi-static process, Temperature and zeroth law, work and heat interactions, properties of pure substances, phase equilibrium diagrams. First law for closed and open systems

Heat engine, second law statements, reversibility, Carnot theorem, Clausius inequality, entropy principle. Available energy: Availability and irreversibility.

Otto, diesel and dual cycles, Brayton cycle with regeneration, inter-cooling reheat, Joule-Thompson effect, Rankine cycle, reheat and regenerative cycle, properties of ideal gas, Stirling and Ericson cycles.

Classification of fluids and their physical properties, Fluid statics, manometers, pressure on submerged bodies - Vapour Pressure – Pressure at a point its variation – Measurement with Piezo meter, manometers and gauges - Continuity equation in one dimension – Bernoulli's equation – Venturi meters and Orifice meters.

Pumps – General principles of displacement and Centrifugal pumps – Efficiency and Performance Curves of Pumps – Cavitation in Pumps – Turbines – Efficiency – Governing of turbines.

References

1.	Gordan Van Wylen, Richard Sonntag., 'Fundamentals of Classical Thermodynamics', John Wiley and Sons, 1994.
2.	Yunus A.Cengel and Michel A.Boles, 'Thermodynamics: An Engineering Approach', McGraw-Hill Higher Education, 2006.
3.	T.R.Banga and S.C.Sharma, 'Hydraulic Machines', Khanna Publishers, 2004.
4.	Kothandaraman. C.P., `A Course in Thermodynamics and Heat Engines', Dhanpat, Rai and Sons, 1992.
5.	Nag, P.K., `Engineering Thermodynamics', Tata McGraw Hill, 1997.
6.	R.K.Rajput, 'Thermal Engineering', Laxmi Publications, 2006.
7.	Nagarathnam, S. 'Fluid Mechanics', Khanna Publishers, New Delhi, 1995.
8.	Dr.R.K.Bansal, 'A Text Book of Fluid Mechanics and Hydraulic Machines', Laxmi Publications(P) Ltd, 2005.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamentals of first and second laws of thermodynamics and their application to a wide range of systems.
CO2	Familiarize with calculations of the efficiencies of heat engines and other engineering devices.
CO3	Familiarize the construction and principles governing the form of simple and complex one-component phase diagrams such as pressure-temperature, volume-temperature & and pressure-volume and the steam tables in the analysis of engineering devices and systems.
CO4	Calculate various fluid flow parameters.
CO5	Determine the optimum working conditions for hydraulic machines

Will be offered by the Department of Mechanical Engineering.

Course Code	:	EEPE13
Course Title	:	**FUZZY SYSTEMS AND GENETIC ALGORITHMS**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course aims to expose students to the fundamental principles of fuzzy logic systems.
CLO2	Enable the students to apply fuzzy logic concepts to existing and new applications.

Course Content

Different faces of imprecision – inexactness, ambiguity, undecidability, Fuzziness and certainty, Fuzzy sets and crisp sets.

Intersection of Fuzzy sets, Union of Fuzzy sets - the complement of Fuzzy sets-Fuzzy reasoning.

Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions and defuzzification.

Methodology of fuzzy design- Direct & Indirect methods with single and multiple experts, Applications– Fuzzy controllers – Control and Estimation.

Genetic Algorithms- basic structure-coding steps of GA, convergence characteristics, applications.

References

1.	Zimmermann H.J., 'Fuzzy Set Theory - and its Applications', Springer Netherlands, 2nd Edition, Illustrated, 2014.
2.	Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', John Wiley & Sons Ltd Publications, 3rd Edition, 2011.
3.	M. Mitchell, 'Introduction to Genetic Algorithms", Indian Reprint, MIT press Cambridge, 2nd Edition, 2014.
4.	John Yen, Reza Langari, 'Fuzzy Logic, Intelligence, Control & Information', Pearson Education Inc., India, 2007.
5.	Zdenko Kovacic, Stjepan Bogdan, 'Fuzzy Controller Design Theory and Applications', CRC Press, 1st Edition, 2006.
6.	Riza C. Berkaan, Sheldon L. Trubatch, 'Fuzzy Systems Design Principles – Building Fuzzy IF THEN Rule Based', IEEE Press, 1997.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamentals of Fuzzy logic theory.
CO2	Employ fuzzy logic principles to existing engineering applications and compare the results with existing methods.
CO3	Design Fuzzy logic Systems for engineering applications.

Course Code	:	EEPE14
Course Title	:	**INDUSTRIAL AUTOMATION**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The contents aim to develop the knowledge of the student in the field of automation in industries. This will be compromising knowledge of PLC, DCS and SCADA systems.
CLO2	To get familiar with different industrial standard protocols

Course Content

Process Control: Introduction, Process Control block diagram, Control System Evaluation, and Digital Control: Supervisory Control, Direct Digital Control, Networked Control Systems, and Distributed Digital Control. Smart Sensor. Definitions of the terms used to describe process control. Data Acquisition Systems: DAS Hardware, DAS Software. Data Logger.

Controller Principles: Process Characteristics: Process Equation, Process Load, Process Lag, Self- Regulation. Control System parameters: Error, Variable Range, Control parameter Range, Control Lag, Dead Time, Cycling, Controller Modes. Discontinuous Controller Mode: Two Position Mode, Multiposition Mode, Floating Control Mode. Continuous Control Mode: Proportional Control Mode, Integral Control Mode, Derivative Control Mode. Composite Control Modes: PI Control, PD Control, PID Control.

Analog Controllers: Introduction, Electronic Controllers: Error Detector, Single Controller Modes, Composite Controller Modes. Pneumatic Controllers: General features, Mode Implementation.

Programmable Logic Controller: Evaluation of PLC, PLC Architecture, Basic Structure. PLC Programming: Ladder Diagram – Ladder diagram symbols, Ladder diagram circuits. PLC Communications and Networking, PLC Selection: I/O quantity and Type, Memory size and type, Programmer Units. PLC Installation, Advantages of using PLCs.

Distributed Control System: Introduction, Overview of Distributed Control System, DCS Software configuration, DCS Communication, DCS Supervisory Computer Tasks, DCS Integration with PLCs and Computers, Features of DCS, Advantages of DCS.

References

1.	C.D. Johnson, 'Process Control Instrumentation Technology', PHI, 8th Edition, 2013.
2.	S.K. Singh, 'Computer Aided Process Control', PHI, 2004.
3.	Thomas E. Kissell, 'Industrial Electronics', PHI, 3rd Edition, 2003.
4.	Noel M. Morris, 'Control Engg', McGraw-Hill, 4th Edition, 1992.
5.	Lukcas M.P., 'Distributed Control Systems', Van Nostrand Reinhold Co, Illustrated, 1986.
6.	Huges T, 'Programmable Controllers', ISA press, 4th Edition Illustrated, 2005.
7.	A.K. Ghosh, 'Introduction to Instrumentation & Control', PHI Learning Pvt. Ltd, 2004.
8.	George C. Barney, 'Intelligent Instrumentation', Prentice Hall India.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Implement low-cost automation systems using pneumatic and electrical means.
CO2	Learn about the modern techniques and devices used for the monitoring and control of manufacturing systems including programming of programmable logic controllers and their interfacing with various sensors and actuators.
CO3	Design automated assembly system for industrial applications.

Course Code	**:**	EEPE15
Course Title	**:**	**HIGH VOLTAGE ENGINEERING**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC10
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To dispense an overview of various generation, measurement and testing methodologies of high DC and AC voltages and currents and to edify the background of various breakdowns.

Course Content

Causes and types of over voltages, effects of over voltages on power system components, Surge diverters, EMI and EMC protection against over voltages; Insulation coordination.

Generation of high AC, DC, impulse and switching voltages; Generation of high impulse currents.

Measurement of high AC, DC, impulse voltages using sphere gaps, peak voltmeters, potential dividers, High speed CRO and digital techniques. Measurement of high currents.

Dielectric breakdown - break down in gases, liquids and solids; partial discharges and corona discharges.

High Voltage Testing- testing of circuit breakers, insulators, bushings and surge diverters. Standards and specifications.

References

1.	Wadhwa,C.L., ' High Voltage Engineering', 3rd Edition, New Age International Publishers Ltd., New Delhi, 2010.
2.	Naidu, M.S. and Kamaraju,V., 'High Voltage Engineering', 4th Edition, Tata McGraw-Hill Publishing Company, New Delhi,4th Edition, 2009.
3.	E. Kuffel, W. S. Zaengl, J. Kuffel, ‘High Voltage Engineering: Fundamentals’, Butterworth-Heinemann, 2nd Edition, 2000.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the causes and types of overvoltage.
CO2	Illustrate different methods of generating and measuring various high voltages and currents.
CO3	Explain various breakdown phenomena occurring in gaseous, liquid and solid dielectrics.
CO4	Identify appropriate testing method(s) for various high voltage apparatus.

Course Code	**:**	EEPE16
Course Title	**:**	**COMPUTER ORGANIZATION AND ARCHITECTURE**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC14
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course will render the basic structure of computers, their control design, memory organizations and an introduction to parallel processing.

Course Content

Computer – Functional units, Addressing modes, Instruction formats, Stacks and Subroutines. Processing Unit – Execution of instructions - Control step sequence.

Control Design - Hardwired control- design - multiplier control unit - CPU control unit and Micro programmed control – microinstructions - Sequencing - prefecting.

Arithmetic and Logic Unit-Fixed point and floating-point numbers and operations. Design of arithmetic units.

Memories - cache memories - virtual memories. Input-Output Organization - Data transfer-synchronization- Interrupt handling-I/O interfaces

Introduction to parallel processing- Generation of computer systems – Parallelism in uniprocessor system – Parallel computer structures- architectural classification schemes.

References

1.	David A. Patterson and John L. Hennessy, 'Computer Organization and Design: The Hardware/Software Interface', 4th Edition, Elsevier, 2009.
2.	Morris Mano.M., 'Computer System Architecture', Prentice Hall India, 3rd Edition 2008.
3.	William Stallings, 'Computer Organization and Architecture – Designing for Performance', 8th Edition, Pearson Education, 2010.
4.	Behrooz Parhami, 'Computer Architecture from up to Super Computer', Oxford press, Reprinted 2014.
5.	John P. Hayes, 'Computer Architecture and Organization', Tata McGraw-Hill, 3rd Edition, 1998.
6.	Carl Hamachar, Zvonkoran Vranesic, Safwatzaky, 'Computer Organization', Tata McGraw-Hill, 6th Revised Edition, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the general architecture of computers.
CO2	Be familiar with the history and development of modern computers, the Von Neumann architecture and functional units of the processor such as the register file and arithmetic logical unit.
CO3	Understand the major components of a computer including CPU, memory, I/O and storage, how computer hardware has evolved to meet the needs of multi-processing systems, the uses for cache memory, parallelism both in terms of a single processor

	and multiple processors.
CO4	Design principles in instruction set design including RISC architectures.
CO5	Analyze and design computer hardware components.

Course Code	:	EEPE17
Course Title	:	**DIGITAL SYSTEM DESIGN AND HDLS**
Type of Course	:	PE
Prerequisites	:	EEPC14
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart the concepts of Digital systems and hardware description languages.

Course Content

Finite State machines - Mealy and Moore, state assignments, design and examples – Asynchronous finite state machines – design and examples – multi-input system controller design.

Programmable Devices: Simple and Complex Programmable logic devices (SPLD and CPLDs), Field Programmable Gate Arrays (FPGAs), Internal components of FPGA, Case study: A CPLD and a 10 million gates type of FPGA.

VHDL- Modeling styles – structural – Behavioral – Dataflow - Design of simple/ complex combinational and sequential circuits using VHDL – Data types – Test bench and simulation. Case study on system design.

Verilog HDL - Modeling styles – structural – Behavioral – Dataflow - Design of simple/ complex combinational and sequential circuits using Verilog – Test bench and simulation – case study on system design.

Fault classes and models – Stuck at faults, Bridging faults - Transition and Intermittent faults. Fault Diagnosis of combination circuits by conventional methods - Path sensitization technique - Boolean different method and Kohavi algorithm.

References

1.	William I. Fletcher, ‘An Engineering Approach to Digital Design’, Prentice Hall, 2009.
2.	Donald D.Givone, ‘Digital Principles and Design’, Tata McGraw-Hill, 1st Edition, 2003.
3.	Morris Mano, ‘Digital Design’, PHI, 3rd Edition, 2005.
4.	J. Bhaskar, ‘Verilog HDL Primer’, BPB publications, 2000.
5.	Samuel C. Lee, ‘Digital Circuits and Logic Design’, PHI Learning, 1st Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the insights of the finite state machines.
CO2	Appreciate and classify the programmable logic devices and FPGA.
CO3	Design the logic circuits using VHDL.
CO4	Develop the systems using Verilog HDL.
CO5	Test the circuits for different faults.

Course Code	**:**	EEPE18
Course Title	**:**	**DIGITAL SIGNAL PROCESSING**
Type of Course	**:**	PE
Prerequisites	**:**	MAIR32, EEPC14
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To explore the basic concepts of digital signal processing in a simple and easy-to-understand manner.

Course Content

Classification of discrete-time systems and elementary sequences, Unit sample response characterization, convolution summation, linear difference equations with constant coefficients and their solution using Z-transform, System function-concept.

Discrete-time Fourier Transform and its properties, Discrete Fourier Transform and its properties, Circular convolution, Linear convolution of two finite length sequences through circular convolution, Sectioned convolutions, Relationship between Z Transform, DTFT and the DFT, Introduction to radix-2 FFT, decimation-in-time and decimation-in-frequency radix-2 algorithm.

Concept of filtering, Characteristics of Linear phase filters, Amplitude and phase response of FIR filters, Design of linear phase FIR filters- Windowing, Frequency sampling technique, Introduction to optimal filters.

Properties of IIR digital filters, Design of IIR filters from continuous time filters – Impulse invariance and Bilinear transformation technique, Frequency transformation techniques, Finite Word Length Effects

Architecture and features of signal processor and applications.

References

1.	Oppenheim and Schaffer, 'Discrete Time Signal processing', Pearson Education Publications, 3rdEdition, 2010.
2.	John G Proakis, Dimitris K Manolakis, 'Digital Signal Processing', Prentice Hall International, 4th Edition, 2007.
3.	Ludemann L. C., 'Fundamentals of Digital Signal Processing', Harper and Row Publications, 1st Edition, 1992.
4.	Rabiner & Gold, 'Theory and Applications of Digital Signal Processing', PHI Learning Publications, 1st Edition, 2009.
5.	Hamid A.Toliyat and Steven G. Campbell, 'DSP Based Electro Mechanical Motion Control', CRC Press, 1st Edition, 2004.

Course Outcomes (CO): At the end of the course student will be able to

CO1	Understand the operations on digital signals.
CO2	Analyze the signal processing concepts.
CO3	Design the systems required for digital signal processing.

Course Code	:	EEPE19
Course Title	:	**ARTIFICIAL NEURAL NETWORKS**
Type of Course	:	PE
Prerequisites	:	MAIR32
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To learn the fundamentals of ANN and its application to electrical systems**.**

Course Content

Introduction to Neural Networks - Biological Inspiration- Biological Neural Networks to Artificial Neural Networks – Classification of ANN Networks – Development of neural network models – Perceptron Network – Linear Separability.

Adaline Network – Madaline Network – Back propagation Neural Networks – Kohenen Neural Network – Learning Vector Quantization – Hamming Neural Network-applications

Adaptive Resonance Theory Neural Networks – Boltzmann Machine Neural Networks – Radial Basis Function Neural Networks – Bi-directional Associative Memory-applications

Hopfield Neural Networks – Support Vector Machines – Introduction to Spiking Neural Networks –Spike Neuron Models – Hybrid Neural Networks-applications

Deep Neural Networks- Recurrent Neural Networks- Backpropagation through time (BPTT)- Vanishing and Exploding Gradients- Truncated BPTT-LSTM (Long Short-Term Memory) - Bilinear LSTM- Gated Recurrent Units-applications

References

1.	Hagan, Demuth, Beale, 'Neural Network Design', PWS Publishing Company, 1st Edition, 2002.
2.	Freeman, J.A and Skapura, D.M., 'Neural Networks - Algorithms, Applications and Programming Techniques', Addison Wesley Publications, Digitized Reprint (2007), 1991.
3.	Andrew Glassner, "Deep Learning: From Basics to Practice" Vol-2, The Imaginary Institute, Seattle, WA, February 20, 2018
4.	Satish Kumar, 'Neural Networks–A Classroom Approach', Tata McGraw-Hill Publishing Company Limited, 2013.
5.	N.P. Padhy, S.P. Simon, 'Soft Computing with MATLAB Programming', Oxford University Press, 2015.
6.	Simon Haykins, 'Neural Networks: A Comprehensive Foundation', Prentice-Hall Inc., 3rd Edition, 2008.
7.	Andrew Glassner, "Deep Learning: From Basics to Practice" Vol-1, The Imaginary Institute, Seattle, WA, February 20, 2018

Course Outcomes (CO): At the end of the course student will be able to

CO1	Describe the development of artificial neural networks (ANN) and classify various ANN models.
CO2	Solve and design various ANN models.
CO3	Apply and construct ANN models to various applications of electrical systems.

Course Code	:	EEPE20
Course Title	:	**DESIGN OF ELECTRICAL APPARATUS**
Type of Course	:	PE
Prerequisites	:	EEPC15
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course offers the preliminary instructions and techniques to design the main dimensions and other major part of the transformer and DC and AC rotating machines.
CLO2	The course also provides the students with an ability to understand the step-by-step procedure for the complete design of electrical machines.

Course Content

General concepts in the design of rotating machines-output equation-Magnetic and electric loadings-Common design features of all rotating machines-Conducting, insulating and magnetic materials used in electrical apparatus - mmf calculation for the magnetic circuit of rotating machines-Leakage reactance calculation.

Armature winding –output equation-Choice of specific loadings-Choice of poles-design of conductors, winding, slot, air gap, field poles and field coils, commutator and brush-Predetermination of efficiency, temperature rise and open circuit characteristics from design data (qualitative treatment only).

Output equation-Design of core and coils for single phase and three phase transformers-Design of tank and cooling tubes-Predetermination of circuit parameters, magnetising current, losses, efficiency, temperature rise and regulation from design data (qualitative treatment only).

Output equation-Choice of specific loadings-Design of stator-Design of squirrel cage and slip ring rotors-Stator and rotor winding designs-Predetermination of circuit parameters, magnetising current, efficiency and temperature rise from design data (qualitative treatment only).

Constructional features of synchronous machines-SCR-Output equation-specific loadings-Main dimensions-Stator design-Design of salient pole field coil.

References

1.	Sawhney, A.K., 'A Course in Electrical Machines Design', Dhanpat Rai and Sons Publications, 4th Edition, 2010.
2.	Sen, S.K., 'Principles of Electrical Machine Design with Computer Programmes', Oxford and I.B.H Publishing Co. Pvt. Ltd, 2nd Edition, 2006.
3.	Rai, H.M., 'Principles of Electrical Machines Design', Sathya Prakash Publications, 3rd Edition, 1994.

Course Outcomes (CO): At the end of the course student will be

CO1	Able to understand the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
CO2	Capable of evaluating the procedure for the design of main dimensions and other

	major part of the transformer and DC and AC rotating machines.
CO3	Equipped to apply in-depth knowledge related to the design of electrical machines.

Course Code	**:**	EEPE21
Course Title	**:**	**UTILIZATION OF ELECTRICAL ENERGY**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC15
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To design illumination systems
CLO2	choose appropriate motors for any drive application
CLO3	to debug a domestic refrigerator circuit
CLO4	to design battery charging circuitry for specific applications

Course Content

Illumination – Terminology, Laws of illumination, Photometry, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps. Design of lighting schemes - factory lighting - flood lighting – street lighting.

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air conditioning system and their applications, smart air conditioning units - Energy Efficient motors: Standard motor efficiency, need for more efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFFLINE UPS, Batteries. Power quality aspects – nonlinear and domestic loads. Earthing – domestic, industrial and sub-station.

Electric Heating- Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding, Electrolytic processes – electro-metallurgy and electro-plating.

Traction system – power supply, traction drives, electric braking, tractive effort calculations and speed-time characteristics. Locomotives and train - recent trend in electric traction.

References

1.	Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 15th Edition, 2014.
2.	Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S. K. Kataria and Sons, 10th Edition, 2012.
3.	Rajput R.K., 'Utilisation of Electrical Power', Laxmi Publications, 1st Edition, 2006.
4.	N. V. Suryanarayana, 'Utilisation of Electrical Power', New Age International Publishers, Reprinted 2005.
5.	C. L. Wadhwa, 'Generation Distribution and Utilization of Electrical Energy', New Age International Publishers, 4th Edition, 2011.
6.	H. Partab, 'Modern Electric Traction', Dhanpat Rai & Co., 3rd Edition, 2012.
7.	Energy Efficiency in Electrical Utilities, BEE Guidebook, 2010.

Course Outcomes (CO): At the end of the course student will be able to

CO1	Develop a clear idea on various illumination techniques and hence design lighting scheme for specific applications.

CO2	Identify an appropriate method of heating for any particular industrial application.
CO3	Evaluate domestic wiring connection and debug any faults occurred.
CO4	Construct an electric connection for any domestic appliance like refrigerator as well as to design a battery charging circuit for a specific household application.
CO5	Realize appropriate type of electric supply system and to evaluate the performance of traction unit.

Course Code	**:**	EEPE22
Course Title	**:**	**COMPUTER NETWORKS**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To know about different network architectures and network protocols, data communications and different IEEE standards.

Course Content

Introduction - Architecture, Network hardware and software. Physical layer- Guided transmission media -Cable television.

Data Link Layer –Design issues–Channel allocation problem –Multiple access protocols - Ethernet – Wireless LAN -802.11architecture.

Network Layer - Design issues – Routing algorithms - Congestion control algorithms -Quality of Service – Internet working.

Transport Layer - Transport service -Elements of transport protocols-User Datagram Protocol-Transmission Control Protocol.

Application Layer – DNS – Electronic mail – World Wide Web – Multimedia – Network security.

References

1.	Behrouz A. Forouzan," Data Communications and Networking", McGraw Hill, Sixth edition, 2022
2.	W.Stallings, 'Data and Computer Communications', Pearson Education, 8th Edition, 2007.
3.	James F.Kurose, Keith W.Ross, " Computer Networking A Top-Down Approach", Pearson Education, Eigth edition, 2022, Pearson India.
4.	Andrew S. Tanenbaum, Nick Feamster, David J.Wetherall," Computer Networks", Pearson Education, Sixth edition, 2022, Pearson India
5.	Douglas E.Comer, 'Computer Networks and Internets', Pearson education, 4th Edition, 2008.
6.	Larry L. Peterson and Bruce S. Davie, 'Computer Networks - A Systems Approach', Harcourt Asia/Morgan Kaufmann, 5th Edition, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamental network issues.
CO2	Analyze the significance of the network layers and their functions.
CO3	Gain knowledge about the basic network protocols.
CO4	Have a basic understanding of TCP / IP.

Course Code	:	EEPE23
Course Title	:	**MODERN CONTROL SYSTEMS**
Type of Course	:	PE
Prerequisites	:	EEPC20
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	Apply modern control techniques to electrical systems

Course Content

Modelling of physical system in state space format- Definition of state- Basic properties of state- transition matrix - solution to vector differential equation.

Concept of controllability and observability - Concept of stabilizability and detectability - Kalman decomposition.

Pole placement design of controller - Observer design - Stability of controller design based on the observer using separation principle.

Introduction to non-linear systems - Phase plane analysis - Multiple equilibrium points.

Stability analysis of non-linear system using Lyapunov direct method - Instability theorem - Lasalle's invariance principle.

References

1.	Chi-Tsong Chen, 'Linear System Theory and Design', Oxford University Press, 4th Edition, 2012.
2.	Khalil H.K., 'Nonlinear Systems', Prentice Hall Publications, 3rd Edition, 2002
3.	Stanley M. Shiners, 'Modern Control System theory and Design', John Wiley and Sons Publications, 2nd Edition, 1998.
4.	Ogata K. 'Modern Control Engineering', Prentice Hall Publications, 5th Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concepts of modern control theory using state-space approach.
CO2	Compare and analyse the classical control system with modern control system.
CO3	Develop advanced controllers to the existing system using modern control design techniques.

Course Code	**:**	EEPE24
Course Title	**:**	**FUNDAMENTALS OF FACTS**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC11, EEPC19
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize the students with the basic concepts, different types, scope and applications of FACTS controllers in power transmission.

Course Content

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters-power circuit configurations.

UPFC-Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.

References

1.	Hingorani, L. Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', Standard Publishers Distributors, 1st Edition, 2011.
2.	R.M. Mathur and R.K. Varma, 'Thyristor-Based FACTS Controllers for Electrical Transmission Systems', Wiley India Pvt. Limited Publications, 1st Edition, 2011.
3.	K. R. Padiyar, 'FACTS Controllers in Power Transmission and Distribution', New Age International Publications, 1st Edition, 2009.
4.	Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho, 'FACTS: Modelling and Simulation in Power Networks', John Wiley & Sons, 2004.
5.	Enrique Acha, Vassilios Agelidis, Olimpo Anaya, T.J.E.Miller, 'Power Electronic Control in Electrical Systems', Newness Power Engineering Series, 2002.
6.	T.J.E.Miller, 'Reactive Power Control in Electric Systems', Wiley Publications, 1982.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand various Power flow control issues in transmission lines, for the purpose of identifying the scope and for selection of specific FACTS controllers.
CO2	Apply the concepts in solving problems of simple power systems with FACTS controllers.
CO3	Design simple FACTS controllers.

Course Code	**:**	EEPE25
Course Title	**:**	**SPECIAL ELECTRICAL MACHINES**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC15, EEPC19
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the construction, principle of operation and performance of special electrical machines as an extension to the study of basic electrical machines.

Course Content

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations – Phasor diagram - Characteristics.

Constructional features–Principle of operation–Variable reluctance motor –Hybrid motor–Single and multi-stack configurations –Torque equations – Modes of excitations–Characteristics–Drive circuits–Microprocessor control of stepping motors – Closed loop control.

Constructional features–Rotary and Linear SRMs-Principle of operation–Torque production–Steady state performance prediction – Analytical method – Power Converters and their controllers– Methods of Rotor position sensing–Sensor less operation–Closed loop control of SRM- Characteristics.

Permanent Magnet materials–Magnetic Characteristics –Permeance coefficient-Principle of operation–Types–Magnetic circuit analysis–EMF and torque equations –Commutation- Power controllers–Motor characteristics and control.

Principle of operation–Ideal PMSM – EMF and Torque equations – Armature reaction MMF–Synchronous Reactance – Sinewave motor with practical windings - Phasor diagram – Torque/speed characteristics- Power controllers- Converter Volt-ampere requirements.

References

1.	T.J.E.Miller, ‘Brushless Permanent Magnet and Reluctance Motor Drives’, Clarendon Press, Oxford, 1993.
2.	T.Kenjo, ‘Stepping Motor and Their Microprocessor Controls’, Clarendon Press London, 1995.
3.	R.Krishnan, ‘Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application’, CRC Press, New York, 2001.
4.	P.P.Aearnley, ‘Stepping Motors – A Guide to Motor Theory and Practice’, Peter Perengrinus London, 2002.
5.	T.Kenjo and S.Nagamori, ‘Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1988.

Course Outcomes (CO): Upon completion of the course the students would be able to understand the construction, principle of operation and performance of

CO1	Synchronous Reluctance motors
CO2	Stepping motors
CO3	Switched Reluctance motors
CO4	Permanent Magnet Brushless D.C. motors
CO5	Permanent Magnet Synchronous motors.

Course Code	**:**	EEPE26
Course Title	**:**	**WIND AND SOLAR ELECTRICAL SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC15, EEPC19
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize the students with basics of solar and wind energy systems and various techniques for the conversion of solar and wind energy into electrical energy.

Course Content

Basic characteristics of sunlight – solar spectrum – insolation specifics– irradiance and irradiation- pyranometer – solar energy statics- Solar PV cell – I-V characteristics –P-V characteristics– fill factor- Modeling of solar cell– maximum power point tracking.

PV module – blocking diode and bypass diodes– composite characteristics of PV module – PV array– PV system –PV-powered fan–PV fan with battery backup–PV-powered pumping system –PV powered lighting systems–grid- connected PV systems.

Wind source–wind statistics-energy in the wind –turbine power characteristics - aerodynamics – rotor types – parts of wind turbines– braking systems–tower- control and monitoring system.

General characteristics of induction generators– grid-connected and self-excited–steady-state equivalent circuit-performance predetermination–PMSG–steady-state performance.

Power electronic converters for interfacing wind electric generators – power quality issues-hybrid systems-wind-diesel systems – wind-solar systems.

References

1.	S N Bhadra, S Banerjee and D Kastha, 'Wind Electrical Systems', Oxford University Press, 1st Edition, 2005.
2.	Chetan Singh Solanki, 'Solar Photovoltaics: Fundamentals, Technologies and Applications' PHI Learning Publications, 2nd Edition, 2011.
3.	Roger A. Messenger and Jerry Ventre, 'Photovoltaic Systems Engineering', Taylor and Francis Group Publications, 2nd Edition, 2003.
4.	M. Godoy Simoes and Felix A. Farret, 'Alternative Energy Systems: Design and Analysis with Induction Generators', CRC Press, 2nd Edition, 2008.
5.	Ion Boldea, 'The Electric Generators Handbook- Variable Speed Generators', CRC Press, 2010.
6.	Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, 'Power Conversion and Control of Wind Energy Systems', IEEE Press Series on Power Engineering, John Wiley & Sons, 2011.
7.	S. Sumathi,L. Ashok Kumar,P. Surekha ,'Solar PV and Wind Energy Conversion Systems', Springer 2015.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the solar radiation, measurements and characteristics of solar PV cell.
CO2	Develop the model of a PV system and its applications.
CO3	Describe the basic types and mechanical characteristics and model of wind turbine.
CO4	Analyze the electrical characteristics and operation of various wind-driven electrical generators.
CO5	Understand various power electronic converters used for hybrid system.

Course Code	**:**	EEPE27
Course Title	**:**	**SOLID STATE DRIVES**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC15, EEPC19
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic concept of DC and AC Drives.
CLO2	To understand the various control techniques involved with both DC and AC Drives.
CLO3	To brief about the working principle of Special Electrical Drives.

Course Content

Introduction to solid state drives, various components – power converters, motors, loads, coupling mechanisms – Stability of drive.

Modeling of DC motor drives – Transfer function and state-space models - Experimental determination of drive parameters – Speed control using AC to DC converters- Input performance parameters, Speed reversal schemes.

Chopper fed DC motor drives – Four quadrant operation, Input filters design – Dynamic braking with DC chopper - Type-C chopper fed regenerative braking - Operation with non-receptive lines.

Power converters for induction motor speed control - Harmonic behavior of induction motors-harmonic currents and harmonic torques using per phase equivalent circuit – Stator voltage control schemes - Speed control of wound type motors.

State-space modeling of induction motors – Voltage source-Inverter fed operation - Field oriented control schemes – Current source-inverter drives – Principle of vector control.

References

1.	P.C.Sen, 'Thyristor DC Drives' John Wiley & Sons Publishers, New York, 2008.
2.	R .Krishnan, 'Electric Motor Drives - Modeling, Analysis, and Control', Pearson Education Publishers, 1st Edition, 2011.
3.	B.K.Bose, 'Modern Power Electronics and AC Drives', Pearson Education Publications, 2nd Edition, 2005.
4.	G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publishing House, 2nd Edition, 2008.
5.	T. Wildi, 'Electrical Machines Drives and Power Systems', Pearson Education Publications, 6thEdition, 2013.
6.	Mohamed A. El-Sharkawi, 'Fundamentals of Electric Drives', Brooks/Cole, 2000.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Learns the fundamental concepts of power electronic converter fed DC and AC machines.
CO2	Can analyze the converter fed motor under different torque/speed conditions.
CO3	Will be able to design converter fed drives with existing/new control techniques.

Course Code	**:**	EEPE28
Course Title	**:**	**EMBEDDED SYSTEM DESIGN**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC22
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enable the learner to design a system with combination of hardware and software for a specific application**.**

Course Content

Embedded System Architectures – ARM processor and SHARC processor - architectural design - memory organization -data operation-bus configurations. System on-chip, scalable bus architectures, Design example: Alarm clock, hybrid architectures.

Sensor and Actuator I/O – ADC, DAC, timers, Servos, Relays, stepper motors, H-Bridge, CODECs, FPGA, ASIC, diagnostic port.

Real time operating systems (RTOS) – real time kernel – OS tasks – task states – task scheduling – interrupt processing – clocking communication and synchronization – control blocks – memory requirements and control – kernel services.

Embedded Networks – Distributed Embedded Architecture – Hardware and Software Architectures, Networks for embedded systems– I2C, CAN Bus, Ethernet, Internet, Network-based design– Communication Analysis, system performance Analysis, Hardware platform design, Allocation and scheduling, Design Example: Elevator Controller.

System Design – Specification, Requirements and Architectural design of PBX systems, Set-top box, Ink-jet printer, Laser printer, Personal digital Assistants.

References

1.	Wayne Wolf, 'Computers as Components: Principles of Embedded Computing System Design', Morgan Kaufman Publishers, 2nd Edition, 2010.
2.	C.M Krishna, Kang G. Shin, 'Real time systems', Mc-Graw Hill, 1st Edition, 2010.
3.	Galski D. Vahid F., Narayan S., 'Specification and Design of Embedded Systems', Prentice Hall, 1st Impression, 2007.
4.	Herma K., 'Real Time Systems: Design for Distributed Embedded Applications', Springer, 2nd Edition, 2011.
5.	William Hohl, 'ARM Assembly Language, Fundamentals and Techniques', CRC Press, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Remember the concepts of process and controllers.
CO2	Apply the concepts for real-time applications.
CO3	Create a real-time system for particular applications.

Course Code	**:**	EEPE29
Course Title	**:**	**POWER SYSTEM ECONOMICS AND CONTROL TECHNIQUES**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC20, EEPC18
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the economics of power system operation and planning.
CLO2	To realize the requirements and methods of real and reactive power control in power system.
CLO3	To recognize the recent advancements in power system operation.

Course Content

Load curves and forecasting – load factor, demand factor, diversity factor, capacity factor, utilization factor - Types of Electrical Tariff – Economic decision making in power system planning

Restructuring of power system – spot and derivative markets – economics of microgrids and distributed generation

Economic Dispatch and Unit Commitment - General problem formulation and constraints - Offer and locational marginal pricing-based dispatch - Solution methods.

Load frequency control of single area and two area systems - Tie line bias control - Automatic Voltage Regulator and its dynamics

Reactive power and Voltage control – General concepts of series and shunt compensation – Introduction to FACTS

References

1.	Allen J. Wood, Bruce F. Wollenberg and Gerald B Sheble, ‘Power Generation, Operation, and Control’, John Wiley and Sons, 3rd Edition, 2014.
2.	Steven Stoft, ‘Power system economics’, Wiley India, 2002
3.	Abhijit Chakrabarti & Sunita Halder, ‘Power System Analysis- Operation & Control’, PHI New Delhi, 3rd Edition, 2010.
4.	Daniel Kirschen and Goran Strbac, ‘Fundamentals of Power System Economics’, John Wiley, 2004
5.	Robert H.Miller, James H.Malinowski, ‘Power System Operation’, Tata McGraw-Hill,2nd Edition, 2009.
6.	Nikos Hatziargyrio, ‘Microgrids – Architectures and Control’, Wiley-IEEE Press, 2014

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Calculate various factors such as load factor, demand factor, etc. and interpret different tariff and pricing structures.
CO2	Develop generation dispatching schemes for conventional and restructured

	power systems.
CO3	Apply frequency, voltage and reactive power control schemes on power system.

Course Code	:	EEPE30
Course Title	:	**DIGITAL CONTROL SYSTEMS**
Type of Course	:	PE
Prerequisites	:	EEPC20
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To learn the digital control design techniques.

Course Content

Introduction- Comparison between analog and digital control-Importance of digital control-Structure of digital control- Examples of digital control system- Difference equations- Z-transform- MATLAB examples. Frequency response of discrete-time systems- Properties of frequency response of discrete-time systems-Sampling theorem.

ADC model-DAC model-Transfer function of zero order hold-DAC, Analog Subsystem, and ADC Combination Transfer Function-Closed loop transfer function–Steady state error and its constants (MATLAB commands).

Definitions of stability (Asymptotic stability, exponential stability etc) – stable z-domain pole placement locations-stability conditions-Stability determination (Routh array)-Nyquist criterion.

Root locus-root locus design (P-control, PI -control, PD) - Z-domain root locus- z-domain root locus design-digital implementation of analog controller design (differencing methods forward and backward)- bilinear transformation-direct z- domain controller design-frequency response design-Finite time response settling time.

Concept of state space method-state space representations of discrete time systems- solving discrete time state space equations- Pulse transfer function matrix- Discretization of continuous state space equations-Liapunov stability analysis (discrete time) Controllability – observability-design via pole placement-state observers.

References

1.	Kannan M. Moudgalya, 'Digital Control', Wiley Publishers, 1st Illustrated Edition, 2007.
2.	M.Gopal, 'Digital Control Engineering', New Age International (ltd) Publishers, 1st Edition Reprint (2003), 1998.
3.	M. Sam Fadalli, 'Digital Control Engineering Analysis and Design', Elsevier Publication, 1st Edition, 2012.
4.	Katsuhiko Ogata, 'Discrete Time Control Systems', Pearson Education Publications, 2nd Edition, 2005

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamental differences between continuous time control and digital control.
CO2	Analyse the advantages of digital control over the continuous time control.
CO3	Develop digital controllers explicitly compared to continuous time controller.

Course Code	:	EEPE31
Course Title	:	**OPERATIONS RESEARCH #**
Type of Course	:	PE
Prerequisites	:	MAIR32
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip students to identify and formulate real life problems using mathematical modeling; devise a solution procedure; analyze and interpret the results; revise for the process based on the actual results.

Course Content

Linear Programming: Basic concepts – Mathematical formulation of L.P.P – Graphical solution – simplex method – Charnes' Big-M method – Two-phase method – Dual Theory - Dual simplex method.

Sensitivity Analysis - Transportation and Assignment problems: Transportation problem – Assignment problem.

Integer programming and CPM-PERT: Gomory's method – Branch and bound technique – Critical path in networks – CPM – Time and Cost aspects in networks – PERT.

Queueing Theory and Inventory models: Classification of queues – Poisson arrivals – Exponential service time – M/M/1 and M/M/c models – Inventory control – E.O.Q. with uniform demand, with finite rate of replenishment and with shortage – Buffer stock – Inventory with price breaks – Basic probabilistic models.

Dynamic programming: Recursive equation approach – applications to shortest path network, Inventory and production control – solution of LPP by dynamic programming - Travelling salesman problem.

References

1.	Hamdy A. Taha, 'Operation Research – An Introduction', Pearson Education, 9th Edition, 2014.
2.	Gass, S.I., 'Linear Programming: Methods and Applications', McGraw-Hill Ltd, 1975.
3.	Hillier, F.S., and Lieberman, G.J., 'Operation Research', McGraw-Hill Ltd, 9th Edition, 2009.
4.	Harvey. M.Wagner, 'Principles of Operations Research with Applications to Managerial Decisions', Prentice Hall India, 2nd Edition, 1999.
5.	Gillet, M.N., 'Introduction to Operation Research', Tata McGraw-Hill Education Pvt Ltd, 1st Edition, 2010

Course Outcomes (CO)

At the end of the course student will be able

CO1	Increase the analytical skill of identifying and solving engineering problems.
CO2	Optimizing the resources and input-output process.
CO3	Devising new techniques for the better understanding of real-life situation.

#Will be offered by the Department of Mathematics.

Course Code	**:**	EEPE32
Course Title	**:**	**ELECTRIC VEHICLE TECHNOLOGY**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The main objective of this course is to understand the basics of vehicle dynamics, drive train control, energy storage technology and vehicle design

Course Content

Introduction to vehicle dynamics – Fundamentals of vehicle propulsion and brake – Vehicle Resistance – Dynamic equation of vehicle motion – Tire-Ground Adhesion – Maximum tractive effort – Power train tractive effort – Vehicle power plant characteristics – Transmission characteristics – Vehicle Performance – Gradeability – Acceleration performance – Brake performance

Basic components of electric vehicles – Fundamentals of electric traction – Basic architecture of electric drive trains – Electric vehicle drive train topologies – Configuration and power flow control of series, parallel and hybrid drive trains – Power converters for electric vehicles

Electric vehicle storage technology – Different types of batteries for electric vehicles – Basic battery parameters – Battery modeling and equivalent circuit – Methods of electric vehicle battery charging – Alternative energy sources – Hydrogen storage systems – Reformers – Supercapacitors/Ultracapacitors - Fuel cell powered vehicles – Flywheel technology

Electric propulsion drive systems – DC motor drives and control – Induction motor drives and control – Permanent magnet brushless DC motor drives and control – AC and Switch reluctance motor drives and control – Drive system efficiency

Design specifications – Selection of motor and sizing – Selection of power electronics components and sizing – Inverter technology – Design of battery pack and auxiliary energy storage system – Design of ancillary systems – EV recharging and refueling system design

References

1.	K. T. Chau, ‘Electric vehicle machines and drives: Design, analysis and application’, first edition, John Willey and Sons Singapore pte. ltd., 2015.
2.	M. Ehsani, Y. Gao and A. Emadi, ‘Modern electric, hybrid electric and fuel cell vehicles: Fundamentals, Theory and design’, second edition, CRC press, 2011.
3.	J. Larminie and J. Lowry, ‘Electric vehicle technology explained’, second edition, John Willey and Son ltd., 2012.
4.	I. Husain, ‘Electric and hybrid vehicles: Design fundamentals’, CRC press, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze dynamics, performance and characteristics of electric vehicles.
CO2	Understand the concept of electric traction and drive train topologies.
CO3	Explain the energy storage and drive control techniques used for electric propulsion systems.
CO4	Design electric vehicle drives, controllers and energy storage units.

Course Code	**:**	EEPE33
Course Title	**:**	**DESIGN THINKING**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the design philosophy of growth-oriented business ideas by creative thinking.

Course Content

Understanding human needs
Creating, Delivering and Sustaining values, empathy and understanding, opportunities.

Concept visualization
Methods and Mind sets – outcome formation – case studies

Strategies
Principles and framework, scalability, Assessing current stage, framing opportunities

Transformation
Enterprise innovation, preparing quests, competency mapping, team charters and articulation

Data Mining and Analysis
Data mining, soft data conversion, creating human archetypes, experience mapping, creating activity systems

References

1.	Heather M.A. Fraser, Design Works, University of Toronto Press, 2012
2.	Nigel Cross, Design Thinking, Bloomsbury Academic, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Conceive need for an enterprise
CO2	Carry out strategic planning
CO3	Evolve methodology for innovative implementation

Course Code	:	EEPE34
Course Title	:	**MACHINE LEARNING AND DEEP LEARNING**
Type of Course	:	PE
Prerequisites	:	MAIR32
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To get familiarize with the introduction to machine learning and deep learning
CLO2	To analyse and illustrate various categories of learning schemes
CLO3	To develop skills of solving practical applications

Course Content

Introductions to Machine Learning: Categories, Supervised learning (SL), Classification, Regression-error based learning, examples, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Unsupervised Learning (USL), Application of USL for clustering-noise reduction- Dimensionality Reduction, Semi Supervised learning, Reinforced Learning –Genetic algorithm

Classification and Clustering: k-means clustering, Binary Classification, Multi- Class, Classification Techniques, k-nearest neighbours, Support Vector Machines, Naïve Bayes Classifier-Gaussian based Naïve Bayes, Decision Trees-Binary and Bushy tress-tree building process- Regression trees-Stopping criteria & pruning

Introduction to neural network: Biological Neural networks- Perceptron Learning Algorithm, Linear Separability-Feedforward Networks: Multilayer Perceptron, Gradient Descent; Training Neural Network-validation and testing, Backpropagation neural networks, Empirical Risk Minimization, regularization, autoencoders, model selection, and optimization

Deep Neural Networks: Convolutional Neural networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Recurrent Neural Networks, Long Short-Term Memory, Gate Recurrent Unit, Deep Belief Network, Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms

ML and DL Applications: Control, Optimisation, Forecasting, Data mining, Pattern recognition, Deep learning tools, Recent trends.

References

1.	E. Alpaydin, Introduction to Machine Learning, MIT Press, 2009
2.	Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016. J.
3.	D. Kelleher, B. M. Namee and Aoife D'Arcy, MIT Press, 2015.
4.	Bishop, C., M., Pattern Recognition and Machine Learning, Springer, 2006.
5.	Fundamentals of Neural. Networks: Architectures, Algorithms, and. Applications, Laurene Fausett, Prentice-. Hall, 1994
6.	Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
7.	Golub, G.,H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
8.	Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.
9.	T. M. Mitchell, Machine Learning, McGraw-Hill, 1997
10.	P. Harrington, Machine learning in action, Manning Publications Co,2012

11.	J. Bell, Machine Learning for Big Data, Wiley 2014.
12.	Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning. Cambridge University Press. 2017. [SS-2017]
13.	P. Flach. Machine Learning: The Art and Science of Algorithms that Make Sense of Data. First Edition, Cambridge University Press, 2012.
14.	S. J. Russell, P. Norvig. Artificial Intelligence: A Modern Approach. Third Edition, Prentice-Hall, 2010.
15.	Y. S. Abu-Mostafa, M. Magdon-Ismail, H.-T. Lin. Learning from Data: A Short Course. First Edition, 2012.
16.	Pattern Recognition and Machine Learning, Christopher Bishop, 2007
17.	Zbigniew Michalewicz. Genetic Algorithms. + Data Structures. = Evolution Programs,Third Edition 1995.
18.	NPTEL and IEEE Journals related to ML and DL.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Remember various types of machine learning and deep learning algorithms
CO2	Analyse various classification and Clustering methods in ML and DL
CO3	Apply ML and DL algorithms for solving practical applications related to electrical and electronics engineering

Course Code	**:**	EEPE35
Course Title	**:**	**NANO ELECTRONICS**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC13
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	A unique course to explore the nano-electronic devices and its applications.

Course Content

Limitations of conventional MOSFETS at Nano scales, introductory concepts of Ballistic transport and Quantum confinement, Difference in few electron devices (as analog version) and single Electron Devices (as digital version) of Nano Electronic devices, Quantum Effects in MOSFETS, Double – gate MOSFET, Multi- gate MOSFETs, FIN- FET.

Resonant Tunneling phenomena and applications in diodes & Transistors – principles of single electron Transistor – split- gate transistor, Electron wave Transistor, Electron – spin transistor, Quantum Oscillators, Quantum cellular Automata (QCA), Introduction to Quantum computing devices.

Carbon – Nano tube theory: Structure & nomenclature, Optical properties, electronic structure of graphene, SW & MW CNTs, 1D quantization in nano tubes, CNTFETs, CNT memories, CNT based switches, Logic gates,

Overview, Characterization of switches and complex molecular devices, poly phenylene based molecular rectifying diode switches. Polymer electronics, self – assembling circuits, optical molecular memories technologies, Quantum mechanical Tunnel devices, Quantum Dots & Quantum wires.

Introduction to spintronics, principles & concepts, spintronic devices & applications, spin – filters, spin diodes, spin transistors.

References

1.	Shunri Oda, David Ferry, “Silicon Nano electronics”, CRC Press, 2006.
2.	CNR Rao & A. Govindaraj , “Nano tubes & nano wires”, RSC publishing, 2005
3.	Ben Rogers, Jesse Adams, Sumita Pennathur,“Nano technology”, CRC Press, 2017.
4.	M. Meyyappan, “Carbon Nanotubes – Science and applications”, CRC Press, 2004.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	To enrich the electronic device concepts and operation.
CO2	To understand the devices made for quantum electronics.
CO3	To appreciate the concepts of carbon nanotubes and its application to circuits.
CO4	To apply the nanoelectronics concepts for different applications
CO5	To enlighten the concepts of spintronics and its use in electronic device

Course Code	**:**	EEPE36
Course Title	**:**	**COMMUNICATION SYSTEMS#**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC14, EEPC17
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To develop a fundamental understanding on communication systems with emphasis on
CLO2	analog and digital modulation techniques.

Course Content

Basic blocks of Communication System. Analog Modulation - Principles of Amplitude Modulation, DSB-SC, SSB-SC and VSB-SC. AM transmitters and receivers.

Angle Modulation - Frequency and Phase Modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Transmitters and Receivers.

Sampling theorem - Pulse Modulation Techniques - PAM, PWM and PPM concepts - PCM system - Data transmission using analog carriers (BASK, BFSK, BPSK, QPSK).

Error control coding techniques – Linear block codes- Encoder and decoder. Cyclic codes – Encoder, Syndrome Calculator. Convolution codes.

Modern Communication Systems – Microwave communication systems - Optical communication system - Satellite communication system - Mobile communication system.

References

1.	Simon Haykins, 'Communication Systems', John Wiley, 3rd Edition, 1995.
2.	D.Roddy & J.Coolen, 'Electronic Communications', Prentice Hall of India, 4th Edition, 1999.
3.	Kennedy G, 'Electronic Communication System', McGraw Hill, 1987.
4.	Shulin Daniel, 'Error Control Coding', Pearson, 2nd Edition, 2011.
5.	B.P. Lathi and Zhi Ding, 'Modern Digital and Analog Communication Systems', OUP USA Publications, 4th Edition, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the basics of communication system, analog and digital modulation techniques.
CO2	Apply the knowledge of digital electronics and understand the error control coding techniques.
CO3	Summarize different types of communication systems and its requirements.

Will be offered by the Department of Electronics and Communication Engineering

Course Code	**:**	EEPE37
Course Title	**:**	**DATA STRUCTURES AND ALGORITHMS**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To obtain knowledge on data structures, their storage representation, and their usage in an algorithmic perspective

Course Content

Algorithms – Algorithmic Notation, Statements and Control Structures, Operations and Expressions, Functions, Procedures, Time, and Space requirement Analysis. Information - nature, storage and transmission of information, Primitive Data structures.

Linear Data structures and their sequential storage representation – arrays, hash, structures and array of structures, stacks, queues; their storage representation and applications. Strings – storage representation and string manipulation applications.

Linear Data structures and their linked storage representation – pointers, linked allocation-single, double and circular linked list and their applications.

Nonlinear data structures – Trees, storage representation and operation on binary trees, application of trees; Graphs- representations and applications of graphs.

Sorting and searching – Selection Sort – Bubble Sort – Merge Sort – Tree Sort – Partition-Exchange Sort. Searching – Sequential Searching – Binary Searching- Search trees, Hash-Table methods.

File Structures - External Storage Devices, Record Organization, File types and their structure. Exercises covering topics of functions, arrays, stacks, queues, linked lists and trees.

References

1.	Mark Allen Weiss, 'Data Structures and Algorithm Analysis in C++', Pearson, 4th Edition, 2013.
2.	Debasis Samanta, 'Classic Data Structures', 2nd Edition, PHI learning, 2009.
3.	Adam Drozdek-Duquesne, 'Data Structures and Algorithms in C++', Thomson Press, 3rd Edition, India Ltd., 2006.
4.	Michael T. Goodrich, Roberto Tamassia, David M. Mount, 'Data Structures and Algorithms in C++', 2nd Edition, Wiley, 2011.
5.	John R.Hubbard, 'Schaum's Outline of Theory and Problems of Data Structures with C++', McGraw-Hill, New Delhi, 2000.
6.	Jean Paul Tremblay and Paul.G.Sorenson, 'An Introduction to Data Structures with Applications', Tata McGraw Hill, 2nd Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Knowledge on algorithmic notations and concepts; basic algorithmic complexity and primitive data structures.
CO2	Familiarity with linked linear and non-linear data structures and operations on such data structures.
CO3	Ability to program data structures and use them in implementations of abstract data types
CO4	Identify appropriate data structures and algorithms for problems and to justify that

Course Code	:	EEPE38
Course Title	:	**ELECTRIC POWER QUALITY**
Type of Course	:	PE
Prerequisites	:	EEPC17, EEPC18
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge about various electric power quality phenomenon, causes and consequences.
CLO2	To familiarize the students to monitoring methods and essential mitigation techniques.

Course Content

Electric power quality phenomena: Introduction to power quality, IEEE and IEC - EMC standards, overview of power quality disturbances - voltage variations, interruptions, transients, waveform distortion and power frequency variations.

Power quality indices and monitoring: Power definitions and power quality indices for single-phase, three-phase balanced and unbalanced systems under sinusoidal and nonsinusoidal conditions – importance and introduction to power quality monitoring.

Voltage variations: Definitions, sources, measurement, impact on equipment and mitigation of voltage sag, swell, interruption and voltage fluctuation.

Harmonics: Harmonic sources, measurement of harmonic distortion, current and voltage limits of distortion, harmonic analysis using Fourier transform, effects of harmonic distortion and harmonic filters – passive, active and hybrid.

Custom Power Devices: Introduction to shunt and series compensators, DSTATCOM, Dynamic Voltage Restorer (DVR) and Unified Power Quality Conditioner (UPQC).

References

1.	Dugan R. C., Mc Granaghan M. F. Surya Santoso, and Beaty H. W., ‘Electrical Power System Quality’, McGraw-Hill 2003.
2.	Math H. Bollen, ‘Understanding Power Quality Problems: Voltage sags and interruptions’, IEEE Press, New York, 2000.
3.	Ghosh, Arindam, and Gerard Ledwich, ‘Power quality enhancement using custom power devices’ Springer Science & Business Media, 2012.
4.	Math H. Bollen, Irene Gu, ‘Signal Processing of Power Quality Disturbances’ Wiley-IEEE Press, 2006.
5.	J. Arrillaga, N.R. Watson, S. Chen, ‘Power System Quality Assessment’, Wiley, 2011.

Course Outcomes (CO) : At the end of the course student will be able to

CO1	Understand different types of power quality problems with their source of generation.
CO2	Interpret results of power quality monitoring equipment and classify the power quality disturbances.
CO3	Recommend viable solutions for mitigation of the power quality problems
CO4	Design active & passive filters for harmonic elimination.

Course Code	:	EEPE39
Course Title	:	**VLSI DESIGN**
Type of Course	:	PE
Prerequisites	:	EEPC14, EEPC21
Contact Hours	:	3 hours / Week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To enrich the student with the concepts of VLSI devices and its fabrication and also to develop different electronic circuits.

Course Content

MOS characteristics: NMOS characteristics, inverter action – CMOS characteristics, inverter action - models and second order effects of MOS transistors – Current equation – MOSFET Capacitances - MOS as Switch, Diode/ resistor – current source and sink – Current mirror.

CMOS Fabrication – n-well, p-well, twin-tub processes – fabrication steps – crystal growth – photolithography – oxidation – diffusion – Ion implantation – etching – metallization.

CMOS Logic Circuits: Implementation of logic circuits using nMOS and CMOS, Pass transistor and transmission gates – Implementation of combinational circuits – parity generator – magnitude comparator – stick diagram – layout design.

Memory design – SRAM cell – 6T SRAM – DRAM – 1T, 3T, 4T cells, CMOS Sequential circuits: Static and Dynamic circuits – True Single-phase clocked registers – Clocking schemes.

ASIC - Types of ASICs - Design flow – Design Entry – Simulation – Synthesis – Floor planning – Placement – Routing - Circuit extraction – Programmable ASICs.

References

1.	Neil Weste, David Harris, ‘CMOS VLSI Design: A Circuits and Systems Perspective’, Addison-Wesley, 4th Edition, 2010.
2.	Debaprasad Das, ‘VLSI Design’, Oxford University Press, 2010.
3.	Ken Martin, ‘Digital Integrated Circuits’, Oxford University Press, 1999.
4.	Peter Van, ‘Microchip Fabrication’, Mc-Graw Hill Professional, 6th Edition, 2014.
5.	M. J. S. Smith, ‘Application Specific Integrated Circuits’, Addison Wesley, 1997.
6.	Uyemura, ‘Introduction to VLSI Circuits and Systems’, Wiley, 1st Edition, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	To understand the insights of the MOS devices and its characteristics.
CO2	To appreciate the different VLSI process technologies.
CO3	To design the CMOS combinational logic circuits and its layout.
CO4	To develop the sequential circuits and clocking schemes.
CO5	To realize the Design flow of application-specific Integrated circuit.

Course Code	:	EEPE40
Course Title	:	**POWER SYSTEM RESTRUCTURING**
Type of Course	:	PE
Prerequisites	:	EEPC18
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario.

Course Content

Introduction – Market Models–Entities– Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world

Operational and planning activities of a GENCO -Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design – Ancillary Services - Automatic Generation Control (AGC).

Introduction-Components of restructured system-Transmission pricing in Open-access system - Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management-Open-access Coordination Strategies; Power Wheeling- Transmission Cost Allocation Methods

Open Access Distribution – Changes in Distribution Operations-The Development of Competition– Maintaining Distribution Planning

Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market-Online power trading.

References

1.	Daniel S. Kirschen, Goran Strbac, 'Fundamentals of Power System Economics, Wiley, 2018.
2.	Mohammad Shahidehpour, Hatim Yamin, 'Market Operations in Electric Power Systems', John Wiley & Sons Inc., 2002.
3.	Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation', Taylor & Francis, New York, 2nd Edition, 2006.
4.	Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, INC., New York, 1st Edition, 2001.
5.	Indian Energy Exchange: http://www.iexindia.com/
6.	Power Exchange India Limited: http://www.powerexindia.com/
7.	Indian Electricity Regulations: http://www.cercind.gov.in/

Course Outcomes (CO): At the end of the course student will be able to

CO1	Explain and differentiate the key issues involved in the regulated and de-regulated power markets.
CO2	Describe the operational activities in Generation, Transmission and Distribution system in the restructured environment.
CO3	Illustrate and solve problems in the de-regulated power System.
CO4	Explain and analyze the restructuring activities in Indian Power System.

Course Code	:	EEPE41
Course Title	:	**ECONOMIC EVALUATION OF POWER PROJECTS**
Type of Course	:	PE
Prerequisites	:	EEPC17
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To assess the feasibility of power projects from business, financial, and sustainability perspectives

Course Content

Considerations in Project Evaluation – Project Selection and Evaluation – Project Development – Pre-investment stage – Investment Stage – Operational Stage – Post Operational Phase

Evaluation of Power Generation Projects – Cost of Power Generation – Levelized Cost of Energy – Generation Planning – Investment Analysis– Time Value of Money – Net Present Value – Benefit/cost Ratio – Payback Period - Profit/investment Ratio – Business Economic Feasibility Study – Power Purchase Agreements

Investing in Transmission – The Nature of the Transmission Business – Cost-Based Transmission Expansion – Value-Based Transmission Expansion – TSO economics

Distribution System Finance – Tariff and Energy Bills – Financing Distributed Generation Projects – Net Metering – Net Feed-in - Rooftop Solar PV Business models – Grid-Connected and Stand-alone PV systems - Customer Savings Analysis – Grid Parity – Utility and DSO economics

Case Studies – Evaluation of Renewable and Non-Renewable Energy projects

References

1.	Hisham Khatib, 'Economic Evaluation of Projects in the Electricity Supply Industry', 3rd edition, IET, 2014.
2.	Marcelino Madrigal and Steven Stoft, 'Transmission Expansion for Renewable Energy Scale-Up', 2012, Washington DC, World Bank.
3.	Santosh Raikar, Seabron Adamson, 'Renewable Energy Finance: Theory and Practice', Elsevier, 2019.
4.	Daniel S. Kirschen, Goran Strbac, 'Fundamentals of Power System Economics, Wiley, 2018.
5.	Steven Stoft, 'Power System Economics: Designing Markets for Electricity', Wiley-IEEE Press, 2002.
6.	Contemporary Research Papers, Project Reports and Allied Materials

Course Outcomes (CO)

At the end of the course student will be able to

CO1	do a basic cost-benefit analysis of power projects in generation, transmission, and distribution
CO2	study the different business models in power systems
CO3	study the different metering techniques
CO4	analyze and evaluate the economics of power projects

Course Code	**:**	EEPE42
Course Title	**:**	**INTRODUCTION TO SWITCHED MODE POWER SUPPLIES**
Type of Course	**:**	PE
Prerequisites	**:**	EEPC19
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessment, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts and design of switched mode power converters for real world applications

Course Content

Linear power supplies, Shunt Regulators, concept of switched mode power supplies, ideal characteristics of switch, realization of ideal switch characteristics from semiconductor switches, current bidirectional switch realization, voltage bidirectional switch realization, four quadrant switch realization, Volt- second balance, charge second balance, small ripple approximation.

Steady state analysis of basic non-isolated converters, Continuous conduction mode operation, Analysis of basic converters in discontinuous conduction mode, selection of components-switches, Diodes, Inductor, capacitor.

Steady state analysis of isolated converters, forward converter, Core resetting techniques in forward converters, flyback converter, flyback converter with RCD clamp, Two switch flyback converter, Half bridge and full bridge DC/DC converter.

Gate Driver Design, Capacitors for Power supplies, Magnetic materials for Power Electronics, high frequency Inductor design, high-frequency Transformer design, Heat sink design, Snubber circuit design.

Applications of switched mode power supplies in consumable electronics, fuel cell power generation system, solar PV systems, Data centre power system, EV onboard and offboard battery charging systems, microgrid.

References

1.	Ned Mohan “Power Electronics: A First Course,”, First edition, Wiley Publication, 2011.
2.	Robert Erickson, Dragan Maksimovic “Fundamentals of power electronics”, Springer publications, 2001.
3.	Simon S. Ang, Alejandro Oliva, “Power-Switching Converters” CRC Press Publications, 3rd edition,2010.
4.	Daniel Hart “Power Electronics” McGraw Hill; 1st edition, 2010

Course Outcomes (CO)
At the end of the course student will be able to

CO1	realize ideal switching characteristics of various semiconductor switches
CO2	analyse various non-isolated and isolated power converters
CO3	analyse and design the HF inductor, transformer, gate drivers
CO4	apply the knowledge to real world applications

Course Code	:	EEPE43
Course Title	:	**OPTIMAL AND ROBUST CONTROL**
Type of Course	:	PE
Prerequisites	:	EEPC20
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic characteristics of system dynamics and control
CLO2	To characterize model uncertainties in dynamic systems
CLO3	To determine robustness through stability margins
CLO4	To parameterize the stabilizing controllers and interpret stabilizing solutions
CLO5	To understand standard LQR problems and stability margin

Course Content

Linear dynamical system – concept of observers – observers-based controllers – state space realizations for transfer matrices – Lyapunov equations – Balanced realizations – Hidden modes and pole zero cancellation – multivariable system poles and zeros

Normed spaces, Hilbert spaces - Hardly spaces - power and spectral signals – induced system gains – computing norms - feedback structure - well-posedness of feedback loop – Internal stability – Coprime factorization – concept of loop shaping – weighted performance

Model reduction by balanced truncation – frequency and weighted balanced model reduction – relative and multiplicative model reduction – optimal Hankel norm approximation – Toeplitz operators – Nehari's theorem – Model uncertainty – small gain theorem – stability under stable unstructured uncertainties - unstructured robust performance

Structure singular value – structured robust stability and performance – overview on µ synthesis – existence stabilizing controllers – parametrization of all stabilizing controllers – Youla parameterization – co-prime factorization – stabilizing solutions – Riccatti equation

Regulator problem – standard LQR problem – Extended LQR problem – Guaranteed stability margins of LQR – standard H2 problems- separation theory – output feed H∞ control – disturbance feedback – optimal controller H∞ loop shaping – controller order reduction – discrete time control

References

1.	Robust and Optimal Control, K. Zhou, J. Doyle, and K. Glover, Prentice Hall, 1st edition, 1995, ISBN-13: 978- 0134565675.
2.	Optimal Control, F. L. Lewis, D. Vrabie, V. L. Syrmos, Wiley, 3rd edition, 2012, ISBN-10: 0136024580.
3.	Optimal Control Theory for Applications, D. G. Hull, Springer, 2010, ISBN-13: 9781441922991.
4.	Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004.
5.	A.P. Sage, Optimum Systems Control, Prentice Hall, 1977.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	perform problem formulation, performance measure and mathematicaltreatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.
CO2	Solve optimal control design problems by taking into consideration the physical constraints on practical control systems.
CO3	Produce optimal solutions to controller design problems taking into consideration the limitation on control energy and robustness in the real practical world.

Course Code	:	EEPE44
Course Title	:	**ROBOTICS**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the functional elements of robotics
CLO2	To impart knowledge on the direct and inverse kinematics
CLO3	To introduce the manipulator differential motion and control
CLO4	To educate on various path planning techniques
CLO5	To introduce the dynamics and control of manipulators

Course Content

Robot classifications - Mathematical representation of Robots - Position and orientation – Homogeneous transformation- Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom-Direct kinematics-Inverse kinematics- SCARA robots- Solvability – Solution methods-Closed form solution.

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance - Joint space technique - Use of p-degree polynomial-Cubic polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler Formulation-Dynamic model – Manipulator control problem-Linear control schemes-PID control scheme-Force control of robotic manipulator.

Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground based beacons, active ranging, motion/speed sensors, vision-based sensors. Low level control, Control architectures, software frameworks, Robot Learning, case studies of learning robots.

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.

References

1.	R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2.	JohnJ.Craig, Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.
3.	M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand basic concepts of robotics.
CO2	analyze instrumentation systems and their applications to various robot model.
CO3	choose different sensors and measuring devices according to the applications.
CO4	explain about the differential motion add statics in robotics
CO5	model various path planning techniques.
CO6	explain about the dynamics and control in robotics industries.

Course Code	**:**	EEPE45
Course Title	**:**	**BATTERY MANAGEMENT SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic operation and parameters associated with a battery.
CLO2	To know the functions of Battery Management System.
CLO3	To differentiate different types of Battery Management System.
CLO4	To analyze the battery performance and fault.
CLO5	To understand the protection mechanisms of Battery Management System.

Course Content

Basic battery parameters -Cells & Batteries -Nominal voltage and capacity - C rate - State of Charge - State of Health - Energy and power – series and parallel operation - Charging and Discharging Process - Overcharge and Undercharge - Modes of Charging - Equivalent-circuit models.

Introduction and BMS functionality - Battery pack topology - BMS Functionality - Voltage Sensing - Temperature Sensing - Current Sensing - High-voltage contactor control - Isolation sensing - Thermal control – Protection - Communication Interface - Range estimation - State-of-charge estimation - Cell Balancing - Cell total energy - cell total power.

Battery state of charge estimation - voltage-based methods to estimate of charge – Model based state estimation - Battery State of Health Estimation - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode.

Types of BMS - Centralized BMS - Modular BMS - Master-Slave BMS - Distributed BMS - Comparison of the different topology.

Protection of BMS - Thermal management - Types of thermal management system - Thermal management impact on battery performance - Cell Balancing - Types of Cell balancing - External Communication of BMS.

References

1.	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
2.	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
3.	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.
4.	Bergveld, H.J., Kraits, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.
5.	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.
6.	Halil S. Hamut, Nader Javani, Ibrahim Dinçer "Thermal Management of Electric Vehicle Battery Systems" John Wiley & Sons, 29-Dec-2016.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Interpret the role of battery management system
CO2	Identify the requirements of Battery Management System
CO3	Interpret the concept associated with battery charging / discharging process
CO4	Calculate the various parameters of battery and battery pack
CO5	Design the model of battery pack

Course Code	:	EEPE46
Course Title	:	**POWER SYSTEM RELIABILITY**
Type of Course	:	PE
Prerequisites	:	EEPC17
Contact Hours	:	3 hours / Week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand theoretical foundations of reliability analysis and to apply them on power system reliability evaluation

Course Content

Introduction to Probability and Statistics: introduction to probability, probability density function, probability distribution function, Expectation, Variance, Covariance and Correlation and stochastic processes, Bernoulli Random Variable, Binomial Random Variable, Poisson Random Variable, Uniform Random Variable, Exponential Random Variable, Normal Random Variable, Weibull Random Variable

General reliability modeling and evaluation: system modeling for reliability; methods of reliability assessment: state space, cut-set and tie-set analysis, decomposition; Markov Approach

Reliability modeling and analysis of electric power systems: bulk power systems, distribution systems, and industrial systems. Component modeling: generator modeling, transmission line modeling, load modeling; capacity outage table; probability and frequency distributions; unit addition algorithm; load modelling algorithm. Generation adequacy assessment using discrete convolution: discrete convolution of generation and load models; generation reserve model; determination of LOLP, LOLF, EUE.

Reliability of multi-node systems: methods for multi-area and composite system analysis; contingency enumeration/ranking; equivalent assistance; stochastic/ probabilistic load flow; state space decomposition; Monte Carlo simulation, Analysis of risk in power systems; understanding of causes and remedial measures; Modelling of variable energy resources

References

1.	Chanan Singh, Panida Jirutitijaroen, Joydeep Mitra, 'Electric Power Grid Reliability Evaluation: Models and Methods', 1st edition, Wiley-IEEE Press, 2018.
2.	Marko Čepin, 'Assessment of Power System Reliability: methods and Applications', 1st edition, Springer, 2011.
3.	G.F. Kovalev, L.M. Lebedeva, 'Reliability of Power Systems', 1st edition, Springer, 2019.
4.	Wenyuan Li, 'Risk Assessment of Power Systems: Models, Methods, and Applications', 2nd edition, Wiley-IEEE Press, 2014.
5.	Roy Billington, Ronald N Allan, 'Reliability Evaluation of Power Systems', 2nd edition, Springer, 1996

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Model and assess reliability of systems undergoing stochastic events
CO2	Apply probabilistic models to evaluation of power system reliability
CO3	Model variations in load demand and output of renewable energy sources

Course Code	:	EEPE47
Course Title	:	**ELECTRONIC SYSTEM DESIGN**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip students with a thorough understanding of the basics of electronic circuit design, with a focus on the design of digital and analog circuits and assembling them on a printed circuit board (PCB) using a computer-aided design (CAD) tool.

Course Content

Introduction to electronic circuit design, characteristics of diode and mosfet, manufacturing process of CMOS integrated circuits, packaging types.

Interconnection parameters - resistance - capacitance - inductance, electrical wire models, transmission line models in SPICE, CMOS Inverter.

Designing combinational logic gates in CMOS, designing sequential logic circuits, effect of parasitic in the design – Industry standards

Understanding the printed circuit board (PCB) – single layer – multi layer – holes – vias – layers limitations – track widths – design rules – issues of EMC and EMI.

Design of PCB – creation of footprint – schematics – components placement – routing – labels and identifiers – design files – examples

References

1.	J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic ‘Digital Integrated Circuits’ Pearson, 2nd Edition, 2016.
2.	K. Mitzner, Bob Doe, Alexander Akulin, Anton Suponin and Dirk Muller, ‘Complete PCB Design Using OrCAD Capture and Layout’, Academic Press, 2nd Edition, 2019.
3.	Neil Weste, David Harris, ‘CMOS VLSI Design: A Circuits and Systems Perspective’, Addison-Wesley, 4th Edition, 2010.
4.	Thomas L Floyd, ‘Digital fundamentals’, Pearson Education Limited, 11th Edition, 2015.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the electronic circuit elements and CMOS inverter
CO2	Understand the design of CMOS based logical circuits
CO3	Realize the importance and various elements of PCB
CO4	Construct a PCB for different applications

OPEN ELECTIVES

Course Code	:	EEOE10
Course Title	:	**ELECTRICAL SAFETY**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To provide a comprehensive exposure to electrical hazards, various grounding techniques, safety procedures and various electrical maintenance techniques.

Course Content

Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment-flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit.

General requirements for grounding and bonding- definitions- grounding of electrical equipment- bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment- system grounding- purpose of system grounding-grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage and high voltage systems.

The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment, procedure for low, medium and high voltage systems- the one-minute safety audit

Electrical safety programme structure, development- company safety team- safety policy-programme implementation- employee electrical safety teams- safety meetings- safety audit-accident prevention- first aid- rescue techniques-accident investigation

Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance programme- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code- standard for electrical safety in workplace- occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.

References

1.	John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield ,'Electrical Safety Handbook', McGraw-Hill Education, 4thEdition, 2012.
2.	Maxwell Adams.J, 'Electrical Safety- a guide to the causes and prevention of electric hazards', The Institution of Electric Engineers, IET 1994.
3.	Ray A. Jones, Jane G. Jones, 'Electrical Safety in the Workplace', Jones & Bartlett Learning, 2000.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe electrical hazards and safety equipment.
CO2	Analyze and apply various grounding and bonding techniques.
CO3	Select appropriate safety method for low, medium and high voltage equipment.
CO4	Participate in a safety team.
CO5	Carry out proper maintenance of electrical equipment by understanding various standards.

Course Code	:	EEOE11
Course Title	:	**FUZZY SYSTEMS AND GENETIC ALGORITHMS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course aims to expose students to the fundamental principles of fuzzy logic systems.
CLO2	Enable the students to apply fuzzy logic concepts to existing and new applications.

Course Content

Different faces of imprecision – inexactness, ambiguity, undecidability, Fuzziness and certainty, Fuzzy sets and crisp sets.

Intersection of Fuzzy sets, Union of Fuzzy sets - the complement of Fuzzy sets-Fuzzy reasoning.

Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions and defuzzification.

Methodology of fuzzy design- Direct & Indirect methods with single and multiple experts, Applications– Fuzzy controllers – Control and Estimation.

Genetic Algorithms- basic structure-coding steps of GA, convergence characteristics, applications.

References

1	Zimmermann H.J., 'Fuzzy Set Theory - and its Applications', Springer Netherlands, 2nd Edition, Illustrated, 2014.
2	Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', John Wiley & Sons Ltd Publications, 3rd Edition, 2011.
3	M. Mitchell, 'Introduction to Genetic Algorithms", Indian Reprint, MIT press Cambridge, 2nd Edition, 2014.
4	John Yen, Reza Langari, 'Fuzzy Logic, Intelligence, Control & Information', Pearson Education Inc., India, 2007.
5	Zdenko Kovacic, Stjepan Bogdan, 'Fuzzy Controller Design Theory and Applications', CRC Press, 1st Edition, 2006.
6	Riza C. Berkaan, Sheldon L. Trubatch, 'Fuzzy Systems Design Principles – Building Fuzzy IF THEN Rule Based', IEEE Press, 1997.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamentals of Fuzzy logic theory.
CO2	Employ fuzzy logic principles to existing engineering applications and compare the results with existing methods.
CO3	Design Fuzzy logic Systems for engineering applications.

Course Code	:	EEOE12
Course Title	:	**ARTIFICIAL NEURAL NETWORKS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To learn the fundamentals of ANN and its application to electrical systems**.**

Course Content

Introduction to Neural Networks - Biological Inspiration- Biological Neural Networks to Artificial Neural Networks – Classification of ANN Networks – Development of neural network models – Perceptron Network – Linear Separability.

Adaline Network – Madaline Network – Back propagation Neural Networks – Kohenen Neural Network – Learning Vector Quantization – Hamming Neural Network-applications

Adaptive Resonance Theory Neural Networks – Boltzmann Machine Neural Networks – Radial Basis Function Neural Networks – Bi-directional Associative Memory-applications

Hopfield Neural Networks – Support Vector Machines – Introduction to Spiking Neural Networks –Spike Neuron Models – Hybrid Neural Networks-applications

Deep Neural Networks- Recurrent Neural Networks- Backpropagation through time (BPTT)- Vanishing and Exploding Gradients- Truncated BPTT-LSTM (Long Short-Term Memory) - Bilinear LSTM- Gated Recurrent Units-applications

References

1.	Hagan, Demuth, Beale, 'Neural Network Design', PWS Publishing Company, 1st Edition, 2002.
2.	Freeman, J.A and Skapura, D.M., 'Neural Networks - Algorithms, Applications and Programming Techniques', Addison Wesley Publications, Digitized Reprint (2007), 1991.
3.	Andrew Glassner, "Deep Learning: From Basics to Practice" Vol-2, The Imaginary Institute, Seattle, WA, February 20, 2018
4.	Satish Kumar, 'Neural Networks–A Classroom Approach', Tata McGraw-Hill Publishing Company Limited, 2013.
5.	N.P. Padhy, S.P. Simon, 'Soft Computing with MATLAB Programming', Oxford University Press, 2015.
6.	Simon Haykins, 'Neural Networks: A Comprehensive Foundation', Prentice-Hall Inc., 3rd Edition, 2008.
7.	Andrew Glassner, "Deep Learning: From Basics to Practice" Vol-1, The Imaginary Institute, Seattle, WA, February 20, 2018

Course Outcomes (CO): At the end of the course student will be able to

CO1	Describe the development of artificial neural networks (ANN) and classify various ANN models.
CO2	Solve and design various ANN models.
CO3	Apply and construct ANN models to various applications of electrical systems.

Course Code	**:**	EEOE13
Course Title	**:**	**MODERN CONTROL SYSTEMS**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	Apply modern control techniques to electrical systems

Course Content

Modelling of physical system in state space format- Definition of state- Basic properties of state- transition matrix - solution to vector differential equation.

Concept of controllability and observability - Concept of stabilizability and detectability - Kalman decomposition.

Pole placement design of controller - Observer design - Stability of controller design based on the observer using separation principle.

Introduction to non-linear systems - Phase plane analysis - Multiple equilibrium points.

Stability analysis of non-linear system using Lyapunov direct method - Instability theorem - Lasalle's invariance principle.

References

1.	Chi-Tsong Chen, 'Linear System Theory and Design', Oxford University Press, 4th Edition, 2012.
2.	Khalil H.K., 'Nonlinear Systems', Prentice Hall Publications, 3rd Edition, 2002
3.	Stanley M. Shiners, 'Modern Control System theory and Design', John Wiley and Sons Publications, 2nd Edition, 1998.
4.	Ogata K. 'Modern Control Engineering', Prentice Hall Publications, 5th Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concepts of modern control theory using state-space approach.
CO2	Compare and analyze the classical control system with modern control system.
CO3	Develop advanced controllers to the existing system using modern control design techniques.

Course Code	:	EEOE14
Course Title	:	**DIGITAL CONTROL SYSTEMS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To learn the digital control design techniques.

Course Content

Introduction- Comparison between analog and digital control-Importance of digital control-Structure of digital control- Examples of digital control system- Difference equations- Z-transform- MATLAB examples. Frequency response of discrete-time systems- Properties of frequency response of discrete-time systems-Sampling theorem.

ADC model-DAC model-Transfer function of zero order hold-DAC, Analog Subsystem, and ADC Combination Transfer Function-Closed loop transfer function–Steady state error and its constants (MATLAB commands).

Definitions of stability (Asymptotic stability, exponential stability etc) – stable z-domain pole placement locations-stability conditions-Stability determination (Routh array)-Nyquist criterion.

Root locus-root locus design (P-control, PI -control, PD) - Z-domain root locus- z-domain root locus design-digital implementation of analog controller design (differencing methods forward and backward)- bilinear transformation-direct z- domain controller design-frequency response design-Finite time response settling time.

Concept of state space method-state space representations of discrete time systems- solving discrete time state space equations- Pulse transfer function matrix- Discretization of continuous state space equations-Liapunov stability analysis (discrete time) Controllability – observability-design via pole placement-state observers.

References

1.	Kannan M. Moudgalya, 'Digital Control', Wiley Publishers, 1st Illustrated Edition, 2007.
2.	M.Gopal, 'Digital Control Engineering', New Age International (ltd) Publishers, 1st Edition Reprint (2003), 1998.
3.	M. Sam Fadalli, 'Digital Control Engineering Analysis and Design', Elsevier Publication, 1st Edition, 2012.
4.	Katsuhiko Ogata, 'Discrete Time Control Systems', Pearson Education Publications, 2nd Edition, 2005

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamental differences between continuous time control and digital control.
CO2	Analyse the advantages of digital control over the continuous time control.
CO3	Develop digital controllers explicitly compared to continuous time controller.

Course Code	**:**	EEOE15
Course Title	**:**	**ELECTRIC VEHICLE TECHNOLOGY**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The main objective of this course is to understand the basics of vehicle dynamics, drive train control, energy storage technology and vehicle design

Course Content

Introduction to vehicle dynamics – Fundamentals of vehicle propulsion and brake – Vehicle Resistance – Dynamic equation of vehicle motion – Tire-Ground Adhesion – Maximum tractive effort – Power train tractive effort – Vehicle power plant characteristics – Transmission characteristics – Vehicle Performance – Gradeability – Acceleration performance – Brake performance

Basic components of electric vehicles – Fundamentals of electric traction – Basic architecture of electric drive trains – Electric vehicle drive train topologies – Configuration and power flow control of series, parallel and hybrid drive trains – Power converters for electric vehicles

Electric vehicle storage technology – Different types of batteries for electric vehicles – Basic battery parameters – Battery modeling and equivalent circuit – Methods of electric vehicle battery charging – Alternative energy sources – Hydrogen storage systems – Reformers – Supercapacitors/Ultracapacitors - Fuel cell powered vehicles – Flywheel technology

Electric propulsion drive systems – DC motor drives and control – Induction motor drives and control – Permanent magnet brushless DC motor drives and control – AC and Switch reluctance motor drives and control – Drive system efficiency

Design specifications – Selection of motor and sizing – Selection of power electronics components and sizing – Inverter technology – Design of battery pack and auxiliary energy storage system – Design of ancillary systems – EV recharging and refueling system design

References

1.	K. T. Chau, ‘Electric vehicle machines and drives: Design, analysis and application’, first edition, John Willey and Sons Singapore pte. ltd., 2015.
2.	M. Ehsani, Y. Gao and A. Emadi, ‘Modern electric, hybrid electric and fuel cell vehicles: Fundamentals, Theory and design’, second edition, CRC press, 2011.
3.	J. Larminie and J. Lowry, ‘Electric vehicle technology explained’, second edition, John Willey and Son ltd., 2012.
4.	I. Husain, ‘Electric and hybrid vehicles: Design fundamentals’, CRC press, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze dynamics, performance and characteristics of electric vehicles.
CO2	Understand the concept of electric traction and drive train topologies.
CO3	Explain the energy storage and drive control techniques used for electric propulsion systems.
CO4	Design electric vehicle drives, controllers and energy storage units.

Course Code	:	EEOE16
Course Title	:	**BASICS OF ELECTRICAL CIRCUITS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course deals with analysis techniques that can be applied to electrical circuits. After completion of this course, one should be able to analyze any linear circuit comprising of circuit elements, R, L and C along with the voltage and current sources

Course Content

Review of Electrical elements and circuits, Kirchhoff's laws, voltage and current sources, controlled sources, RMS and average values for typical waveforms, power and energy in electrical elements, phasor representation, series and parallel RLC circuits -simple examples.

Self and mutual inductance, coefficient of coupling, Capacitance, Series-parallel combination of inductance and capacitance, Series and parallel resonant circuits.

Circuit analysis using Node voltage and Mesh current methods, analysis with dependent source and special case.

Equivalent circuits, star-delta transformation, source transformation, Thevenin, Norton, Superposition and Maximum power transfer theorems.

Three-phase circuits balanced three-phase voltages, analysis of three-phase star and delta connected circuits, balanced and unbalanced systems, power calculations, power measurement using two wattmeter method.

References

1.	James W. Nilsson and Susan A. Riedel, “Electric Circuits”, International Edition Adapted by Lalit Goel, Pearson Education, 8th Edition, Seventh Impression, 2012.
2.	A. Sudhakar and Shyammohan S Pillai, “Circuits and Networks”, Tata McGraw Hill, New Delhi, 4th Edition, 2010.
3.	William H. Hayt, Jack Kemmerly, Steven Durbin, “Engineering Circuit Analysis”, McGraw Hill, 8th Edition, 2012.
4.	Mahmood Nahvi, Joseph Edminister, “Schaum’s Outline of Electric Circuits”, McGraw Hill Education, 6th Edition, 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concept of phasors, waveforms and behaviour of basic circuit components.
CO2	Obtain the equivalent inductance and capacitance and understand the operation of resonant circuits.
CO3	Use node voltage and mesh current methods to solve electrical circuits.
CO4	Obtain the equivalent circuit and apply network theorems to circuits.
CO5	Analyze the three-phase system.

Course Code	**:**	EEOE17
Course Title	**:**	**ELECTRICAL MACHINES**
Type of Course	**:**	OE
Prerequisites	**:**	Basic Electrical and Electronics Engineering
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To disseminate an overview of various electric machines used in industries, power generation and home appliances with a technical know-how on the control techniques

Course Content

DC motors: Construction and working principle, emf equation, torque equation, starting and running characteristics, speed control, braking, duty of operation, choice of motors.

Transformers: Construction and working principle, equivalent circuit, regulation and efficiency, auto-transformers, industrial applications – welding transformer and furnace transformer.

Three-phase induction machines: Construction and working principle. Induction motors - torque-equation, torque–slip characteristics, starting and running characteristics, speed control, braking, choice of motor for industrial applications and traction.

Synchronous Machines: Construction, principle of operation and types, various types of excitation systems, stand alone and grid connected modes of operation, voltage and frequency control.

Fractional horsepower machines: Single phase induction motors – Construction and principle of operation, types, applications in home appliances. Construction, operation and applications of Brushless DC motors, Stepper motors, Servomotors and AC Series motors.

References

1.	D.P.Kothari and I.J.Nagrath, 'Electric Machines', McGraw Hill Education Private Limited, 4th Edition, 2010.
2.	Gopal K. Dubey, 'Fundamentals of Electrical Drives', Narosa publishing house, 2nd Edition, 2011.
3.	A Fitzgerald , Charles Kingsley , Stephen Umans, 'Electric Machinery', McGraw Hill Education Private Limited, 6th Edition, 2002.
4.	K. Murugesh Kumar, 'Induction & Synchronous Machines', Vikas Publishing House Pvt Ltd., 2009.
5.	Edward Hughes, 'Electrical and Electronic Technology', Dorling Kindersley (India) Pvt. Ltd., 10th Edition, 2011.
6.	Ashfaq Husain, 'Electric machines', Dhanpat Rai & Company, 2nd Edition, 2002.

Course Outcomes (CO):
At the end of the course student will be able to

CO1	Understand the constructional details and principle of operation of DC motors, induction machines, alternators, transformers and fractional horse-power motors.
CO2	Evaluate the performance of starting and operating characteristics of various electrical machines used in industrial and domestic applications.
CO3	Choose an appropriate method of speed control and braking for the drive motors.

Course Code	**:**	EEOE18
Course Title	**:**	**CONTROL SYSTEMS ENGINEERING**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip the students with the fundamental concepts in control systems

Course Content

Modelling of physical systems – Time-domain specifications - Generalized error series – various test signals and its importance- Routh-Hurwitz stability criterion

Root Locus Technique – Definitions - Root locus diagram - Rules for construction of root loci - Effect of pole zero additions on the root loci - root contours.

Frequency domain analysis – Bode plot - Polar plot - Nyquist plot.

Phase margin - gain margin - Nyquist stability criterion.

Controller design - P, PI, PID, lag, lead, lead-lag compensator design.

References

1.	Katsuhiko Ogata, ‘Modern Control Engineering ‘, Pearson Education Publishers, 5th Edition, 2010.
2.	Nagrath I.J. and Gopal M, ‘Control Systems Engineering', New Age International Publications, 5th Edition, 2010.
3.	Richard C. Dorf and Robert H. Bishop. ‘Modern Control Systems’, Pearson Prentice Hall Publications, 12th Edition, 2010.
4.	Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, ‘Feedback Control of Dynamic Systems’, Pearson Education India Publications, 6th Edition, 2008.
5.	Benjamin C.Kuo and Farid Golnaraghi, ‘Automatic Control Systems’, John Wiley & Sons Publications, 8th Edition, 2002.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concepts of closed loop control systems.
CO2	Analyse the stability of closed loop systems.
CO3	Apply the control techniques to any electrical systems.
CO4	Design the classical controllers such as P, PI, etc., for electrical systems.

Course Code	**:**	EEOE19
Course Title	**:**	**ANALOG AND DIGITAL ELECTRONICS**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts of analog and digital circuits
CLO2	To impart knowledge on signal generation and measuring equipment

Course Content

Review of analog devices – Rectifier circuits - Wave shaping circuits - Clippers and Clampers – Regulators - Zener and op-amp based regulator circuits - Introduction to switched mode power supplies.

Review of digital components - Code converters- Programmable logic devices- CPLDs and FPGAs- Introduction to hardware description languages.

Oscillators & signal generator circuits - Function generator circuit - Pulse generator circuit - AM/FM signal generator circuit – Qualitative analysis.

Display Units - optoelectronic devices – Seven-segment displays - LCD and LED display units and applications.

Special electronic circuits – UJT Sawtooth generator circuit – Schmitt trigger – Analog-to-digital converter – Digital-to-analog converter circuits.

References

1.	David A Bell, 'Fundamentals of Electronic Devices and Circuits', Oxford University Press, Incorporated, 25- Jun-2009.
2.	Bouwens A. J., 'Digital Instrumentation', Tata McGraw Hill Publications, 16th Reprint (2008).
3.	Kalsi H.S, 'Electronic Instrumentation', Tata McGraw-Hill Education, 3rdEdition, 2010.
4.	Morris Mano.M, 'Digital Logic and Computer Design', Prentice Hall of India, 3rdEdition, 2005.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and develop circuits using analog and digital components.
CO2	Understand the different generators and analyzers.
CO3	Appreciate the use of display units.
CO4	Identify the suitable oscilloscope for measurement.

Course Code	:	EEOE20
Course Title	:	**POWER ELECTRONIC SYSTEMS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To introduce characteristics of power electronic devices, design of various power converter circuits and speed control concepts of AC and DC drives.

Course Content

Power Semiconductor Devices –power diodes, power transistors, SCRs, TRIAC, GTO, power MOSFETs, IGBTs-Principle of operation, characteristics, ratings, protection and gate drive circuits.

Power Converters – AC to DC, AC to AC converters.

PWM based Power Converters: DC to DC, DC to AC converters.

Introduction to motor drives – Solid-state speed control of DC motor drive system.

Solid-state speed control of induction motor drive system.

References

1.	Rashid, M.H, 'Power Electronics - Circuits, Devices and Applications', Prentice Hall Publications, 3rd Edition, 2003.
2.	P.C Sen, 'Thyristor DC Drives', John Wiley and Sons, New York, 1991.
3.	R. Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
4.	P.S. Bhimbra, 'Power Electronics', Khanna Publishers, 4th Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify various power electronic devices and plot their switching characteristics.
CO2	Design DC power conversion circuits for simple applications.
CO3	Analyze inverter and cyclo-converter circuits.
CO4	Perform speed control of dc and induction motors.

Course Code	:	EEOE21
Course Title	:	**POWER SYSTEMS ENGINEERING**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on power generation, transmission, distribution and protection systems, and overview of power system economics and regulations.

Course Content

Overview of generation systems: Sources of Energy, Steam, Diesel, Nuclear and Hydro power plants – site selection - Layout – essential components and operation.

Modes of Transmission and Distribution: HVAC and HVDC Transmission system – over-head lines – towers, conductors and insulators, underground cables – types – laying methods and fault location, comparison of over-head and underground systems, distribution system – classification – components, power factor correction.

Basic protection and switchgears: System faults and abnormal conditions, system grounding, need for protection system, overview of apparatus protection, switch gear mechanisms – fuse, switch, isolator and circuit breakers.

Economics on power systems: Factors affecting cost of generation – load curve – load factor – diversity, base load and peak load stations – reduction of generation cost by interconnection of stations, price of electricity – types of tariff for HT and LT consumers.

Regulation / Electricity Act: Evolution of Indian electricity act – regulator commissions, grid code, Introduction to restructuring of power system – GenCo, TransCo and DisCo, Independent power producers, Introduction to smart grid.

References

1.	R K Rajput, ‘Power System Engineering’, Laxmi Publications Ltd., 2006.
2.	A Chakrabarti, M L Soni, P V Gupta and U S Bhatnagar, ‘Power System Engineering’, Dhanpat Rai & Co., Ltd., 2010.
3.	S N Singh. ‘Electric Power Generation, Transmission and Distribution’, PHI Publications, 2008.
4.	B.R. Gupta, ‘Power System Analysis and Design’, S. Chand Limited, 5th Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Illustrate the layout and operation of various power plants.
CO2	Infer the modes of transmission and distribution of electrical energy.
CO3	Select the appropriate protection scheme for various power apparatus.
CO4	Identify tariff structure and calculate the energy pricing.
CO5	Discuss about Indian electricity act and regulations.

Course Code	:	EEOE22
Course Title	:	**ELECTRIC POWER UTILIZATION**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles of operation and utilization of power in domestic and industrial appliances.

Course Content

Illumination – Terminology, Laws of illumination, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps, Design of lighting schemes - factory lighting - flood lighting – street lighting.

Refrigeration - Domestic refrigerator and Air coolers, Air-Conditioner – circuit diagram, types and principle of operation.

Domestic utilization of electrical energy – House wiring, Induction based appliances, Online and OFFLINE UPS, Earthing – domestic, industrial and sub-station.

Electric Heating - Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding.

Electric Drives and Traction System – Type of drives and loads, Rating and heating of the motors, Types of Traction, Speed-Time curves, recent trends in traction.

References

1.	Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 2009.
2.	Rajput R.K.,'Utilisation of Electrical Power', Laxmi Publications, 1st Edition, 2007.
3.	N.V Suryanarayana, 'Utilization of Electric Power' New Age International Publishers, Reprinted 2005.
4.	C.L.Wadhwa, 'Generation, Distribution and Utilization of Electrical Energy', New Age International Publishers, 4th Edition, 2011.
5.	Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S.K.Kataria and Sons, 10th Edition, 1990.
6.	H. Pratab, 'Modern Electric Traction', Dhanpat Rai & Co., 3rd Edition, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Develop a clear idea on various illumination techniques and hence design lightening scheme for specific applications.
CO2	Construct an electric connection for any domestic appliance like refrigerator and air conditioner units.
CO3	Evaluate domestic wiring connection and debug any faults occurred.
CO4	Identify an appropriate method of heating and welding for any particular industrial application.
CO5	Realize the appropriate type of electrical supply system as to evaluate the performance of tractions and electrical drives.

Course Code	:	EEOE23
Course Title	:	**RENEWABLE POWER GENERATION SYSTEMS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge on various forms of renewable energy sources and the process of electric energy conversion.

Course Content

Environmental aspects of electric power generation from conventional sources: Limitation of fossil fuels - Atmospheric pollution – effects of hydro-electric projects – disposal of nuclear waste – GHG emission from various energy sources and its effects – need for renewable energy sources.

Solar Photo-Voltaic system: Solar radiation and its measurement – Angle of sun rays on solar collector – optimal angle for fixed collector – sun tracking, an introduction to solar cell, solar PV module, PV system design and applications – stand-alone and grid connected systems, environmental impacts.

Wind power generation: Wind energy, classification of wind turbines – aerodynamic operation of wind turbine, extraction of wind turbine power, wind turbine power curve, horizontal axis wind turbine generator – modes of wind power generation – stand-alone and grid connected system, environmental impacts.

Fuel cell system: Principle of operation of fuel cell, technical parameters of fuel cell, Type of fuel cell – advantages of fuel cell power plants, energy output, efficiency and emf of fuel cell – operating characteristics, applications and environmental impacts.

Hybrid energy systems: Need for hybrid systems, types, configuration and coordination, electrical interface – PV-Diesel, Wind-diesel, wind-PV, wind-PV- fuel cell.

References

1.	G D Rai, 'Non-conventional Energy sources', Khanna Publishers, 5th Edition, 2014.
2.	D P Kothari, K C Singal and Rakesh Ranjan, 'Renewable Energy Sources and Emerging Technologies' 2nd Edition, 2012.
3.	C S Solanki, 'Solar Photo-voltaics – Fundamentals, Technologies and Applications', PHI Pvt., Ltd., 2nd Edition, 2011.
4.	S N Bhadra, D Kastha and S Banerjee, 'Wind Electric Systems', Oxford Publications, 2nd Edition, 2007.

Course Outcomes (CO): At the end of the course student will be able to

CO1	Apprise the environmental impacts of conventional energy sources and the need of renewable energy.
CO2	Explain the process of PV generation and design stand-alone and grid connected system.
CO3	Explain the process of wind power generation and choose stand-alone and grid connected configuration.
CO4	Explain the process of fuel cell power generation and its applications.
CO5	Suggest and configure the various hybrid systems.

Course Code	**:**	EEOE24
Course Title	**:**	**DESIGN THINKING**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the design philosophy of growth-oriented business ideas by creative thinking.

Course Content

Understanding human needs
Creating, Delivering and Sustaining values, empathy and understanding, opportunities.

Concept visualization
Methods and Mind sets – outcome formation – case studies

Strategies
Principles and framework, scalability, Assessing current stage, framing opportunities

Transformation
Enterprise innovation, preparing quests, competency mapping, team charters and articulation

Data Mining and Analysis
Data mining, soft data conversion, creating human archetypes, experience mapping, creating activity systems

References

1.	Heather M.A. Fraser, Design Works, University of Toronto Press, 2012
2.	Nigel Cross, Design Thinking, Bloomsbury Academic, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Conceive need for an enterprise
CO2	Carry out strategic planning
CO3	Evolve methodology for innovative implementation

Course Code	:	EEOE25
Course Title	:	**OPTIMAL AND ROBUST CONTROL**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic characteristics of system dynamics and control
CLO2	To characterize model uncertainties in dynamic systems
CLO3	To determine robustness through stability margins
CLO4	To parameterize the stabilizing controllers and interpret stabilizing solutions
CLO5	To understand standard LQR problems and stability margin

Course Content

Linear dynamical system – concept of observers – observers-based controllers – state space realizations for transfer matrices – Lyapunov equations – Balanced realizations – Hidden modes and pole zero cancellation – multivariable system poles and zeros

Normed spaces, Hilbert spaces - Hardly spaces - power and spectral signals – induced system gains – computing norms - feedback structure - well-posedness of feedback loop – Internal stability – Coprime factorization – concept of loop shaping – weighted performance

Model reduction by balanced truncation – frequency and weighted balanced model reduction – relative and multiplicative model reduction – optimal Hankel norm approximation – Toeplitz operators – Nehari's theorem – Model uncertainty – small gain theorem – stability under stable unstructured uncertainties - unstructured robust performance

Structure singular value – structured robust stability and performance – overview on μ synthesis – existence stabilizing controllers – parametrization of all stabilizing controllers – Youla parameterization – co-prime factorization – stabilizing solutions – Riccatti equation

Regulator problem – standard LQR problem – Extended LQR problem – Guaranteed stability margins of LQR – standard H2 problems- separation theory – output feed H_∞ control – disturbance feedback – optimal controller H_∞ loop shaping – controller order reduction – discrete time control

References

1.	Robust and Optimal Control, K. Zhou, J. Doyle, and K. Glover, Prentice Hall, 1st edition, 1995, ISBN-13: 978- 0134565675.
2.	Optimal Control, F. L. Lewis, D. Vrabie, V. L. Syrmos, Wiley, 3rd edition, 2012, ISBN-10: 0136024580.
3.	Optimal Control Theory for Applications, D. G. Hull, Springer, 2010, ISBN-13: 9781441922991.
4.	Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004.
5.	A.P. Sage, Optimum Systems Control, Prentice Hall, 1977.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	perform problem formulation, performance measure and mathematicaltreatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.
CO2	Solve optimal control design problems by taking into consideration the physical constraints on practical control systems.
CO3	Produce optimal solutions to controller design problems taking into consideration the limitation on control energy and robustness in the real practical world.

Course Code	**:**	EEOE26
Course Title	**:**	**ROBOTICS**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the functional elements of robotics
CLO2	To impart knowledge on the direct and inverse kinematics
CLO3	To introduce the manipulator differential motion and control
CLO4	To educate on various path planning techniques
CLO5	To introduce the dynamics and control of manipulators

Course Content

Robot classifications - Mathematical representation of Robots - Position and orientation – Homogeneous transformation- Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom-Direct kinematics-Inverse kinematics- SCARA robots- Solvability – Solution methods-Closed form solution.

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance - Joint space technique - Use of p-degree polynomial-Cubic polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler Formulation-Dynamic model – Manipulator control problem-Linear control schemes-PID control scheme-Force control of robotic manipulator.

Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground based beacons, active ranging, motion/speed sensors, vision-based sensors. Low level control, Control architectures, software frameworks, Robot Learning, case studies of learning robots.

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.

References

1.	R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2.	JohnJ.Craig, Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.
3.	M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand basic concepts of robotics.
CO2	analyze instrumentation systems and their applications to various robot model.
CO3	choose different sensors and measuring devices according to the applications.
CO4	explain about the differential motion add statics in robotics
CO5	model various path planning techniques.
CO6	explain about the dynamics and control in robotics industries.

Course Code	:	EEOE27
Course Title	:	**BATTERY MANAGEMENT SYSTEMS**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic operation and parameters associated with a battery.
CLO2	To know the functions of Battery Management System.
CLO3	To differentiate different types of Battery Management System.
CLO4	To analyze the battery performance and fault.
CLO5	To understand the protection mechanisms of Battery Management System.

Course Content

Basic battery parameters -Cells & Batteries -Nominal voltage and capacity - C rate - State of Charge - State of Health - Energy and power – series and parallel operation - Charging and Discharging Process - Overcharge and Undercharge - Modes of Charging - Equivalent-circuit models.

Introduction and BMS functionality - Battery pack topology - BMS Functionality - Voltage Sensing - Temperature Sensing - Current Sensing - High-voltage contactor control - Isolation sensing - Thermal control – Protection - Communication Interface - Range estimation - State-of-charge estimation - Cell Balancing - Cell total energy - cell total power.

Battery state of charge estimation - voltage-based methods to estimate of charge – Model based state estimation - Battery State of Health Estimation - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode.

Types of BMS - Centralized BMS - Modular BMS - Master-Slave BMS - Distributed BMS - Comparison of the different topology.

Protection of BMS - Thermal management - Types of thermal management system - Thermal management impact on battery performance - Cell Balancing - Types of Cell balancing - External Communication of BMS.

References

1.	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
2.	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
3.	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.
4.	Bergveld, H.J., Kraits, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.
5.	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.
6.	Halil S. Hamut, Nader Javani, Ibrahim Dinçer "Thermal Management of Electric Vehicle Battery Systems" John Wiley & Sons, 29-Dec-2016.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Interpret the role of battery management system
CO2	Identify the requirements of Battery Management System
CO3	Interpret the concept associated with battery charging / discharging process
CO4	Calculate the various parameters of battery and battery pack
CO5	Design the model of battery pack

Course Code	**:**	EEOE28
Course Title	**:**	**Electronic System Design**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip students with a thorough understanding of the basics of electronic circuit design, with a focus on the design of digital and analog circuits and assembling them on a printed circuit board (PCB) using a computer-aided design (CAD) tool.

Course Content

Introduction to electronic circuit design, characteristics of diode and mosfet, manufacturing process of CMOS integrated circuits, packaging types.

Interconnection parameters - resistance - capacitance - inductance, electrical wire models, transmission line models in SPICE, CMOS Inverter.

Designing combinational logic gates in CMOS, designing sequential logic circuits, effect of parasitic in the design – Industry standards

Understanding the printed circuit board (PCB) – single layer – multi layer – holes – vias – layers limitations – track widths – design rules – issues of EMC and EMI.

Design of PCB – creation of footprint – schematics – components placement – routing – labels and identifiers – design files – examples

References

1	J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic 'Digital Integrated Circuits' Pearson, 2nd Edition, 2016.
2	K. Mitzner, Bob Doe, Alexander Akulin, Anton Suponin and Dirk Muller, 'Complete PCB Design Using OrCAD Capture and Layout', Academic Press, 2nd Edition, 2019.
3	Neil Weste, David Harris, 'CMOS VLSI Design: A Circuits and Systems Perspective', Addison-Wesley, 4th Edition, 2010.
4	Thomas L Floyd, 'Digital fundamentals', Pearson Education Limited, 11th Edition, 2015.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the electronic circuit elements and CMOS inverter
CO2	Understand the design of CMOS based logical circuits
CO3	Realize the importance and various elements of PCB
CO4	Construct a PCB for different applications

MINORS

Course Code	**:**	EEMI10
Course Title	**:**	**BASICS OF ELECTRICAL CIRCUITS**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	Nil
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course deals with analysis techniques that can be applied to electrical circuits. After completion of this course, one should be able to analyze any linear circuit comprising of circuit elements, R, L and C along with the voltage and current sources

Course Content

Review of Electrical elements and circuits, Kirchhoff's laws, voltage and current sources, controlled sources, RMS and average values for typical waveforms, power and energy in electrical elements, phasor representation, series and parallel RLC circuits -simple examples.

Self and mutual inductance, coefficient of coupling, Capacitance, Series-parallel combination of inductance and capacitance, Series and parallel resonant circuits.

Circuit analysis using Node voltage and Mesh current methods, analysis with dependent source and special case.

Equivalent circuits, star-delta transformation, source transformation, Thevenin, Norton, Superposition and Maximum power transfer theorems.

Three-phase circuits balanced three-phase voltages, analysis of three-phase star and delta connected circuits, balanced and unbalanced systems, power calculations, power measurement using two wattmeter method.

References

1.	James W. Nilsson and Susan A. Riedel, “Electric Circuits”, International Edition Adapted by Lalit Goel, Pearson Education, 8th Edition, Seventh Impression, 2012.
2.	A. Sudhakar and Shyammohan S Pillai, “Circuits and Networks”, Tata McGraw Hill, New Delhi, 4th Edition, 2010.
3.	William H. Hayt, Jack Kemmerly, Steven Durbin, “Engineering Circuit Analysis”, McGraw Hill, 8th Edition, 2012.
4.	Mahmood Nahvi, Joseph Edminister, “Schaum’s Outline of Electric Circuits”, McGraw Hill Education, 6th Edition, 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concept of phasors, waveforms and behaviour of basic circuit components.
CO2	Obtain the equivalent inductance and capacitance and understand the operation of resonant circuits.
CO3	Use node voltage and mesh current methods to solve electrical circuits.
CO4	Obtain the equivalent circuit and apply network theorems to circuits.
CO5	Analyze the three-phase system.

Course Code	:	EEMI11
Course Title	:	**ELECTRICAL MACHINES**
Type of Course	:	Minor (MI)
Prerequisites	:	Basic Electrical and Electronics Engineering
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To disseminate an overview of various electric machines used in industries, power generation and home appliances with a technical know-how on the control techniques

Course Content

DC motors: Construction and working principle, emf equation, torque equation, starting and running characteristics, speed control, braking, duty of operation, choice of motors.

Transformers: Construction and working principle, equivalent circuit, regulation and efficiency, auto-transformers, industrial applications – welding transformer and furnace transformer.

Three-phase induction machines: Construction and working principle. Induction motors - torque-equation, torque–slip characteristics, starting and running characteristics, speed control, braking, choice of motor for industrial applications and traction.

Synchronous Machines: Construction, principle of operation and types, various types of excitation systems, stand alone and grid connected modes of operation, voltage and frequency control.

Fractional horsepower machines: Single phase induction motors – Construction and principle of operation, types, applications in home appliances. Construction, operation and applications of Brushless DC motors, Stepper motors, Servomotors and AC Series motors.

References

1.	D.P.Kothari and I.J.Nagrath, 'Electric Machines', McGraw Hill Education Private Limited, 4th Edition, 2010.
2.	Gopal K. Dubey, 'Fundamentals of Electrical Drives', Narosa publishing house, 2nd Edition, 2011.
3.	A Fitzgerald , Charles Kingsley , Stephen Umans, 'Electric Machinery', McGraw Hill Education Private Limited, 6th Edition, 2002.
4.	K. Murugesh Kumar, 'Induction & Synchronous Machines', Vikas Publishing House Pvt Ltd., 2009.
5.	Edward Hughes, 'Electrical and Electronic Technology', Dorling Kindersley (India) Pvt. Ltd., 10th Edition, 2011.
6.	Ashfaq Husain, 'Electric machines', Dhanpat Rai & Company, 2nd Edition, 2002.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the constructional details and principle of operation of DC motors, induction machines, alternators, transformers and fractional horse-power motors.
CO2	Evaluate the performance of starting and operating characteristics of various electrical machines used in industrial and domestic applications.
CO3	Choose an appropriate method of speed control and braking for the drive motors.

Course Code	:	EEMI12
Course Title	:	**CONTROL SYSTEMS ENGINEERING**
Type of Course	:	Minor (MI)
Prerequisites	:	Nil
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To equip the students with the fundamental concepts in control systems

Course Content

Modelling of physical systems – Time-domain specifications - Generalized error series – various test signals and its importance- Routh-Hurwitz stability criterion

Root Locus Technique – Definitions - Root locus diagram - Rules for construction of root loci - Effect of pole zero additions on the root loci - root contours.

Frequency domain analysis – Bode plot - Polar plot - Nyquist plot.

Phase margin - gain margin - Nyquist stability criterion.

Controller design - P, PI, PID, lag, lead, lead-lag compensator design.

References

1.	Katsuhiko Ogata, 'Modern Control Engineering ', Pearson Education Publishers, 5th Edition, 2010.
2.	Nagrath I.J. and Gopal M, 'Control Systems Engineering', New Age International Publications, 5th Edition, 2010.
3.	Richard C. Dorf and Robert H. Bishop. 'Modern Control Systems', Pearson Prentice Hall Publications, 12th Edition, 2010.
4.	Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, 'Feedback Control of Dynamic Systems', Pearson Education India Publications, 6th Edition, 2008.
5.	Benjamin C.Kuo and Farid Golnaraghi, 'Automatic Control Systems', John Wiley & Sons Publications, 8th Edition, 2002.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concepts of closed loop control systems.
CO2	Analyse the stability of closed loop systems.
CO3	Apply the control techniques to any electrical systems.
CO4	Design the classical controllers such as P, PI, etc., for electrical systems.

Course Code	**:**	EEMI13
Course Title	**:**	**ANALOG AND DIGITAL ELECTRONICS**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	EEMI10
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts of analog and digital circuits
CLO2	To impart knowledge on signal generation and measuring equipment

Course Content

Review of analog devices – Rectifier circuits - Wave shaping circuits - Clippers and Clampers – Regulators - Zener and op-amp based regulator circuits - Introduction to switched mode power supplies.

Review of digital components - Code converters- Programmable logic devices- CPLDs and FPGAs- Introduction to hardware description languages.

Oscillators & signal generator circuits - Function generator circuit - Pulse generator circuit - AM/FM signal generator circuit – Qualitative analysis.

Display Units - optoelectronic devices – Seven-segment displays - LCD and LED display units and applications.

Special electronic circuits – UJT Sawtooth generator circuit – Schmitt trigger – Analog-to-digital converter – Digital-to-analog converter circuits.

References

1.	David A Bell, 'Fundamentals of Electronic Devices and Circuits', Oxford University Press, Incorporated, 25- Jun-2009.
2.	Bouwens A. J., 'Digital Instrumentation', Tata McGraw Hill Publications, 16th Reprint (2008).
3.	Kalsi H.S, 'Electronic Instrumentation', Tata McGraw-Hill Education, 3rdEdition, 2010.
4.	Morris Mano.M, 'Digital Logic and Computer Design', Prentice Hall of India, 3rdEdition, 2005.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and develop circuits using analog and digital components.
CO2	Understand the different generators and analyzers.
CO3	Appreciate the use of display units.
CO4	Identify the suitable oscilloscope for measurement.

Course Code	**:**	EEMI14
Course Title	**:**	**POWER ELECTRONIC SYSTEMS**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	EEMI11
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To introduce characteristics of power electronic devices, design of various power converter circuits and speed control concepts of AC and DC drives.

Course Content

Power Semiconductor Devices –power diodes, power transistors, SCRs, TRIAC, GTO, power MOSFETs, IGBTs-Principle of operation, characteristics, ratings, protection and gate drive circuits.

Power Converters – AC to DC, AC to AC converters.

PWM based Power Converters: DC to DC, DC to AC converters.

Introduction to motor drives – Solid-state speed control of DC motor drive system.

Solid-state speed control of induction motor drive system.

References

1.	Rashid, M.H, 'Power Electronics - Circuits, Devices and Applications', Prentice Hall Publications, 3rd Edition, 2003.
2.	P.C Sen, 'Thyristor DC Drives', John Wiley and Sons, New York, 1991.
3.	R. Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
4.	P.S. Bhimbra, 'Power Electronics', Khanna Publishers, 4th Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify various power electronic devices and plot their switching characteristics.
CO2	Design DC power conversion circuits for simple applications.
CO3	Analyze inverter and cyclo-converter circuits.
CO4	Perform speed control of dc and induction motors.

Course Code	**:**	EEMI15
Course Title	**:**	**POWER SYSTEMS ENGINEERING**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	EEMI11
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on power generation, transmission, distribution and protection systems, and overview of power system economics and regulations.

Course Content

Overview of generation systems: Sources of Energy, Steam, Diesel, Nuclear and Hydro power plants – site selection - Layout – essential components and operation.

Modes of Transmission and Distribution: HVAC and HVDC Transmission system – over-head lines – towers, conductors and insulators, underground cables – types – laying methods and fault location, comparison of over-head and underground systems, distribution system – classification – components, power factor correction.

Basic protection and switchgears: System faults and abnormal conditions, system grounding, need for protection system, overview of apparatus protection, switch gear mechanisms – fuse, switch, isolator and circuit breakers.

Economics on power systems: Factors affecting cost of generation – load curve – load factor – diversity, base load and peak load stations – reduction of generation cost by interconnection of stations, price of electricity – types of tariff for HT and LT consumers.

Regulation / Electricity Act: Evolution of Indian electricity act – regulator commissions, grid code, Introduction to restructuring of power system – GenCo, TransCo and DisCo, Independent power producers, Introduction to smart grid.

References

1.	R K Rajput, ‘Power System Engineering’, Laxmi Publications Ltd., 2006.
2.	A Chakrabarti, M L Soni, P V Gupta and U S Bhatnagar, ‘Power System Engineering’, Dhanpat Rai & Co., Ltd., 2010.
3.	S N Singh. ‘Electric Power Generation, Transmission and Distribution’, PHI Publications, 2008.
4.	B.R. Gupta, ‘Power System Analysis and Design’, S. Chand Limited, 5th Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Illustrate the layout and operation of various power plants.
CO2	Infer the modes of transmission and distribution of electrical energy.
CO3	Select the appropriate protection scheme for various power apparatus.
CO4	Identify tariff structure and calculate the energy pricing.
CO5	Discuss about Indian electricity act and regulations.

Course Code	**:**	EEMI16
Course Title	**:**	**ELECTRIC POWER UTILIZATION**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	EEMI11
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles of operation and utilization of power in domestic and industrial appliances.

Course Content

Illumination – Terminology, Laws of illumination, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps, Design of lighting schemes - factory lighting - flood lighting – street lighting.

Refrigeration - Domestic refrigerator and Air coolers, Air-Conditioner – circuit diagram, types and principle of operation.

Domestic utilization of electrical energy – House wiring, Induction based appliances, Online and OFFLINE UPS, Earthing – domestic, industrial and sub-station.

Electric Heating - Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding.

Electric Drives and Traction System – Type of drives and loads, Rating and heating of the motors, Types of Traction, Speed-Time curves, recent trends in traction.

References

1.	Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 2009.
2.	Rajput R.K.,'Utilisation of Electrical Power', Laxmi Publications, 1st Edition, 2007.
3.	N.V Suryanarayana, 'Utilization of Electric Power' New Age International Publishers, Reprinted 2005.
4.	C.L.Wadhwa, 'Generation, Distribution and Utilization of Electrical Energy', New Age International Publishers, 4th Edition, 2011.
5.	Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S.K.Kataria and Sons, 10th Edition, 1990.
6.	H. Pratab, 'Modern Electric Traction', Dhanpat Rai & Co., 3rd Edition, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Develop a clear idea on various illumination techniques and hence design lightening scheme for specific applications.
CO2	Construct an electric connection for any domestic appliance like refrigerator and air conditioner units.
CO3	Evaluate domestic wiring connection and debug any faults occurred.
CO4	Identify an appropriate method of heating and welding for any particular industrial application.
CO5	Realize the appropriate type of electrical supply system as to evaluate the performance of tractions and electrical drives.

Course Code	**:**	EEMI17
Course Title	**:**	**INTRODUCTION TO MICRO-CONTROLLERS**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	EEMI13
Contact Hours	**:**	3 hours/ week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on different micro-computing systems and its use in real time.

Course Content

8051 Micro controller – Architecture - Addressing modes - Instruction set - Interfacing with real time peripherals.

PIC Micro controller – PIC16F7X series- Architecture- Instruction set- Programs for pulse generation.

Motivation for MSP430 microcontrollers – Main characteristics of a MSP430 microcontroller, Main features of the MSP430X RISC CPU architecture.

Addressing modes & Instruction set of MSP 430 - Double operand instructions, Single operand instructions, Program flow control – Jumps, Emulated instructions and programming

Controllers for Motor control – stepper motor and servo motor control – Case study: Industrial Controllers using 8051/ PIC16F7X/ MSP 430.

References

1.	Kenneth Ayala, ‘The 8051 Microcontroller’, Cengage Learning Publications, 3rd Edition, 2007.
2.	John H Davies, “MSP430 Microcontroller Basics”, Newnes Publications, 2008
3.	Chris Nagy, “Embedded systems Design using TI MSP430 Series”, Newnes, 2003.
4.	John B. Peatman, ’Design with PIC Microcontrollers’, Pearson Education Publications, 1st Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the real time functioning of 8051.
CO2	Appreciate the functions of PIC microcontroller
CO3	Develop systems using MSP430 Microcontroller.

Course Code	:	EEMI18
Course Title	:	**RENEWABLE POWER GENERATION SYSTEMS**
Type of Course	:	Minor (MI)
Prerequisites	:	EEMI14
Contact Hours	:	3 hours/ week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge on various forms of renewable energy sources and the process of electric energy conversion.

Course Content

Environmental aspects of electric power generation from conventional sources: Limitation of fossil fuels - Atmospheric pollution – effects of hydro-electric projects – disposal of nuclear waste – GHG emission from various energy sources and its effects – need for renewable energy sources.

Solar Photo-Voltaic system: Solar radiation and its measurement – Angle of sun rays on solar collector – optimal angle for fixed collector – sun tracking, an introduction to solar cell, solar PV module, PV system design and applications – stand-alone and grid connected systems, environmental impacts.

Wind power generation: Wind energy, classification of wind turbines – aerodynamic operation of wind turbine, extraction of wind turbine power, wind turbine power curve, horizontal axis wind turbine generator – modes of wind power generation – stand-alone and grid connected system, environmental impacts.

Fuel cell system: Principle of operation of fuel cell, technical parameters of fuel cell, Type of fuel cell – advantages of fuel cell power plants, energy output, efficiency and emf of fuel cell – operating characteristics, applications and environmental impacts.

Hybrid energy systems: Need for hybrid systems, types, configuration and coordination, electrical interface – PV-Diesel, Wind-diesel, wind-PV, wind-PV- fuel cell.

References

1.	G D Rai, 'Non-conventional Energy sources', Khanna Publishers, 5th Edition, 2014.
2.	D P Kothari, K C Singal and Rakesh Ranjan, 'Renewable Energy Sources and Emerging Technologies' 2nd Edition, 2012.
3.	C S Solanki, 'Solar Photo-voltaics – Fundamentals, Technologies and Applications', PHI Pvt., Ltd., 2nd Edition, 2011.
4.	S N Bhadra, D Kastha and S Banerjee, 'Wind Electric Systems', Oxford Publications, 2nd Edition, 2007.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apprise the environmental impacts of conventional energy sources and the need of renewable energy.
CO2	Explain the process of PV generation and design stand-alone and grid connected system.
CO3	Explain the process of wind power generation and choose stand-alone and grid connected configuration.
CO4	Explain the process of fuel cell power generation and its applications.
CO5	Suggest and configure the various hybrid systems.

ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

Course Code	**:**	EEHO10
Course Title	**:**	**DISTRIBUTION SYSTEM AUTOMATION**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC11
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand and appreciate the basic control techniques involved in distribution automation
CLO2	To get introduced to the various communication systems involved in distribution automation
CLO3	To enable the students capable of analyzing the economics behind the automation of distribution system automation.

Course Content

Introduction to Distribution Automation, Control System Interfaces, Control and Data requirements, Centralized (Vs) Decentralized Control, Distribution Automation System, DAS Hardware, DAS Software, DA Capabilities, Automation system computer facilities.

Layout of substations and feeders - design considerations. Distribution system load flow - optimal siting and sizing of substations - optimal capacitor placement. Distribution system monitoring and control - SCADA, Remote metering and load control strategies - Optimum feeder switching

DA Communication Requirements - reliability, Cost Effectiveness, Data Rate Requirements, Two Way Capability - outages and faults, Ease of operation and maintenance - Communication Systems used - Distribution line carrier (Power line carrier), Telephone, Cable TV, Radio, AM Broadcast, FM SCA, VHF Radio, UHF Radio etc.

DA Benefit Categories - Capital Deferred Savings - Operation and Maintenance Savings - Interruption Related Savings - Customer-related Savings - Operational savings. Improved operation - Function Benefits.

Economic impacts - Automation on Distribution Systems, Integration of benefits into economic evaluation. Development and Evaluation of Alternate plans - Operation and Maintenance Cost Evaluation, Evaluation of Alternatives.

References

1.	Momoh A. Momoh, James A. Momoh., 'Electric Power Distribution, Automation, Protection, and Control', CRC Press, 2007.
2.	Gonen., 'Electric Power Distribution System Engineering', BSP Books, Pvt. Ltd, 2007.
3.	D. Bassett, K. Clinard, J. Grainger, S. Purucker, and D. Ward, 'Tutorial Course: Distribution Automation', IEEE Tutorial Publication 88EH0280-8-PWR, 1988.
4.	IEEE Working Group on 'Distribution Automation'.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the Distribution Automation Systems and the Control techniques involved.
CO2	Develop a clear idea on the layout of the substations and feeders and also on the various management techniques viz., load management and voltage management.
CO3	Identify an appropriate method of communication for any particular distribution system with a view of automation.
CO4	Evaluate the economic aspects of any distribution system with automation.

Course Code	**:**	EEHO11
Course Title	**:**	**EHV AC AND DC TRANSMISSION**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC11
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand and analyze the HVAC and HVDC transmission systems.
CLO2	To plan an appropriate transmission system between two destinations based on the load requirement and anticipated technical performance of power transmission.

Course Content

Design aspects of HVAC – conductor, tower, insulator and substation structure design, mechanical design - sag-tension calculations, design of EHVAC lines based on steady state limits and transient over voltages - design of extra HV cables - XLPE cables and gas insulated cables.

Real and reactive power flows in HVAC systems – reactive power compensation, FACTS devices in EHV Transmission, short circuit level & real power transfer capacity. Stability-voltage stability and control. Theory of travelling and stationary waves.

Introduction to HVDC transmission - Bridge converters – rectifier and inverter operation, equivalent circuit representation, power reversal, desired features of control and actual control characteristics.

Basic HVDC controllers, converter faults, commutation failure, bypass action in bridges, protection issues in HVDC - DC reactors, voltage and current oscillations, DC circuit breakers and over voltage protection.

Harmonics in HVDC - characteristics and uncharacteristic harmonics, troubles due to harmonics, harmonic filters – active and passive filters. Introduction to Hybrid HVDC and Off-shore wind power evacuation schemes.

References

1.	S.Rao, 'EHV-AC, HVDC Transmission and Distribution Engineering', Khanna Publishers, 3rd Edition, 2012.
2.	Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International Publishers, 3rd Edition, 2009.
3.	Padiyar K.R., 'HVDC Transmission Systems', New Age International Publishers, 2nd Revised Edition, 2012.
4.	http://nptel.iitm.ac.in/courses/108104013

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Distinguish between the usage of EHVAC and HVDC transmission systems.
CO2	Judge when and where to use EHAV / HVDC transmission systems in practice.
CO3	Design implementation circuitry for various controllers used in HVDC transmission systems.
CO4	Plan an appropriate electric power transmission system between two destinations to satisfy the pre-defined load requirement without compromising the technical performance.

Course Code	:	EEHO12
Course Title	:	**NON-LINEAR CONTROL SYSTEMS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC20
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	The aim of this course is to introduce the concept of non-linear controller design to the undergraduate student.

Course Content

Open and closed sets, compact set, dense set, Continuity of functions, Lipschitz condition, smooth functions, Vector space, norm of a vector, normed linear space, inner product space.

Mathematical modeling of simple mechanical and electrical systems, concept of equilibrium points, isolated equilibrium points and limit cycles.

Stability analysis of nonlinear systems – Lyapunov stability, asymptotic stability, relative stability, finite-time stability and exponential stability. Lasalles invariance principle.

Feedback linearization- dynamic feedback linearization, flatness and back stepping controllers design.

Sliding mode controller design, Lyapunov redesign and energy-based controller design.

References

1.	Khalil H.K., ‘Nonlinear Systems’, Prentice Hall, 3rd Edition, 2002.
2.	Vidyasagar M., ‘Nonlinear System Analysis’, Prentice Hall, 2nd Edition, 2002.
3.	A. Isidori, ‘Nonlinear Control Systems’, Communications and Control Engineering, Springer Science & Business Media, 3rd Edition, 2013.
4.	Jean - Jacques. E. Slotine and W. Li, ‘Applied Nonlinear Control’, Prentice Hall, Englewood Cliffs, NJ, 1991.
5.	Zhihua Qu, ‘Robust Control of Nonlinear Uncertain Systems’, John Wiley & Sons, Interscience Division, New York, 1998.
6.	H. Nijmeijer and A. J. van der Schaft, ‘Nonlinear Dynamical Control Systems’, Springer New York, 2016.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concept of non-linear system.
CO2	Design non-linear controller for electrical system.

Course Code	**:**	EEHO13
Course Title	**:**	**POWER SWITCHING CONVERTERS**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC19
Contact Hours	**:**	4 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course aims at modeling, analysis and control of various power converter circuits

Course Content

Basic converter topologies: Buck, Boost, Buck-Boost converter, steady state converter analysis - Equivalent circuit modelling.

State space averaging of converters- Transfer function of converters- Design of feedback compensators-voltage and current loop.

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Isolated converters: forward converter, push-pull converter, fly back converter, half bridge and full bridge converter-operating principles.

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, multi-resonant converters and Load resonant converters-operating principles.

References

1.	Simon Ang, Alejandro Oliva, 'Power Switching Converters', Taylor & Francis, 3rd Edition, 2010.
2.	Robert W. Erickson, Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer Science & Business Media, 2nd Edition, 2007.
3.	Ned Mohan, Tore M. Undeland, and William P.Robbins, 'Power Electronics: Converters, Applications, and Design', 3rd Edition, Wiley Publishers, 2002.
4.	M. Rashid, 'Power Electronics: Circuits, Devices, and Applications', Pearson Education, 4th Edition 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the classification and operation of different types of DC-DC converters.
CO2	Analyze the Steady-state operation of DC-DC converter circuits.
CO3	Develop the transfer function of DC-DC converter circuits.
CO4	Design the compensator and reactive elements of DC-DC converter circuits.
CO5	Illustrate different soft switching techniques in DC-DC converter circuits.

Course Code	:	EEHO14
Course Title	:	**VEHICULAR ELECTRIC POWER SYSTEMS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC15, EEPC19
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course introduces the fundamental concepts, principles and analysis of hybrid and electric vehicles.

Course Content

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance, Capabilities, Automation system computer facilities.

Introduction to electric components used in hybrid and electric vehicles- Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switched Reluctance Motor drives- drive system efficiency.

Energy storage technologies in hybrid vehicles-flywheel, hydraulic, fuel cell and hybrid fuel cell energy storage system-ultra capacitors- comparison- battery charging control.

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

Electrical power system in aircraft, sea and undersea vehicles, space vehicles-hybrid vehicle control strategies-supporting subsystem.

References

1.	Ali Emadi, Mehrdad Ehsani, John M. Miller, ‘Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles’, CRC Press, 2003.
2.	Ion Boldea and S.A Nasar, ‘Electric drives’, CRC Press, 2005.
3.	Sandeep Dhameja, ’Electric Vehicle Battery Systems’, Newnes, 2002.
4.	Chris Mi, M. Abul Masrur, David Wenzhong Gao, ’Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives’, Wiley, 2011.
5.	Iqbal Husain, ‘Electric and Hybrid Vehicles: Design Fundamentals’, CRC Press, 2nd Edition, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the various aspects of hybrid and electric vehicles.
CO2	Plan the selection of electrical machines for hybrid and electric vehicles.
CO3	Select various energy storage technologies for hybrid and electric vehicles.
CO4	Implement energy management techniques for hybrid and electric vehicles.
CO5	Demonstrate the power system of various vehicular system

Course Code	:	EEHO15
Course Title	:	**POWER SYSTEM DYNAMICS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC18
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To explain the power system stability problem.
CLO2	To understand the behavior of synchronous and induction machines during disturbance.
CLO3	To employ mathematical tools for power system stability analysis.

Course Content

Synchronous machines – Modeling torque, magnetization and induced emf – Clarke's and Park's transformation – Modeling of excitation system – Modeling of prime-movers - Load modeling concepts

Stability considerations – Dynamic modeling requirements – Angle stability – Critical fault clearing time and angle – Numerical integration techniques – Transient energy function approach

Small Signal stability – State space representation – Eigen value analysis - Modal matrices – Single machine infinite bus system

Voltage stability – V-Q sensitivity analysis, Q-V modal analysis – Loadability limits – PV curve – QV curve

Sub-synchronous oscillations – Resonance – Tortional frequencies and mode shapes

References

1.	Prabha S. Kundur, Om P Malik, 'Power System Stability and Control', McGraw-Hill, New York, 2nd edition, 2022.
2.	Vijay Vittal, James D McCalley, 'Power System Control and Stability', 3rd Edition, Wiley IEEE Press, 2020.
3.	Jan Machowski, Zbigniew Lubosny, Janusz W Bialek, 'Power System Dynamics, Stability and Control, 3rd Edition, John Wiley, 2020
4.	Krause P.C., 'Analysis of Electric Machinery', McGraw-Hill, 3rd Revised Edition, 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understanding of the dynamic phenomena of power system operation.
CO2	Knowledge to employ modeling techniques for investigating the response of system during disturbance.
CO3	Ability to interpret results coming from the simulation of differential - algebraic systems.

Course Code	**:**	EEHO16
Course Title	**:**	**MODERN OPTIMIZATION TECHNIQUES FOR ELECTRIC POWER SYSTEMS**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC18
Contact Hours	**:**	4 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To learn the concepts and techniques of evolutionary and optimization techniques in power system applications.

Course Content

Definition-Classification of optimization problems-Unconstrained and Constrained Optimization-Optimality Conditions-Classical Optimization techniques (Linear and nonlinear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).

Evolution in nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch Solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

Fundamental principle - Velocity Updating - Advanced operators - Parameter selection - Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues - Convergence issues - PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

Simulated annealing algorithm- Tabu search algorithm - SA and TS for unit commitment - Ant colony optimization - Bacteria Foraging optimization.

Concept of pareto optimality - Conventional approaches for MOOP - Multi objective GA - Fitness assignment - Sharing function - Economic Emission dispatch using MOGA – Multi objective PSO (Dynamic neighborhood PSO, Vector evaluated PSO) – Multi objective OPF problem.

References

1.	Soliman Abdel Hady, Abdel Aal Hassan Mantawy, “Modern Optimization Techniques with Applications in Electric Power Systems”, Springer, 2012.
2.	D.P.Kothari and J.S.Dhillon, “Power System Optimization”, 2nd Edition, PHI Learning Private Limited, 2010.
3.	Kalyanmoy Deb, “Multi Objective Optimization using Evolutionary Algorithms”, Wiley India Pvt ltd, 2010.
4.	Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, 2nd Edition, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the concept of optimization techniques.
CO2	Apply evolutionary algorithms for unit commitment and economic dispatch problems.
CO3	Interpret hybrid approach for power system reliability and security.

Course Code	**:**	EEHO17
Course Title	**:**	**COMPUTER RELAYING AND PHASOR MEASUREMENT UNIT**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC24
Contact Hours	**:**	3 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand and analyze the basic architecture of Digital Relay.
CLO2	Understand the basics of Phasor Measurement unit (PMU).
CLO3	Applications of PMUs in power system.

Course Content

Mathematical background to protection algorithms-Finite difference technique-Numerical Differentiation-Least Squares Method-Fourier analysis-Fourier analysis of analog signals-Fourier analysis of discrete signals-Walsh function analysis.

Basic elements of digital protection-Signal conditioning subsystem-Transducers-Surge protection circuits-Analog Filtering-Analog Multiplexers-Conversion Subsystem-Sampling Theorem-Signal aliasing error-Sample and hold circuit-Digital multiplexing-Digital-to-Analog Conversion-Analog-to-Digital Conversion-Processor-Data and Program memory-Digital relay hardware unit.

Phasor Measurement Unit– Introduction- Phasor representation of sinusoids- Phasor Estimation of Nominal Frequency Signals- Formulas for updating phasors – Non recursive updates-Recursive updates- Frequency Estimation.

Phasor Measurement Applications-State Estimation-History- Operator’s load flow- Weighted least square - Linear weighted least squares; Nonlinear weighted least squares- Static state estimation- State estimation with Phasor measurements- linear state estimation.

Adaptive protection- Differential and distance protection of transmission lines- Adaptive out-of-step protection.

References

1.	Arun G. Phadke, James S. Thorp, ‘Computer Relaying for Power Systems’, A John Wiley and Sons Ltd., Research Studies Press Limited, 2009.
2.	A.G. Phadke, J.S. Thorp, ‘Synchronized Phasor Measurements and Their Applications’, Springer, 2008.
3.	A. T. Johns and S. K. Salman, ‘Digital Protection for Power Systems’, Peter Peregrinus Ltd, 1997.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the operation of computer relay.
CO2	Understand the basics of phasor measurement unit.
CO3	Understand the different applications of PMUs in power systems

Course Code	:	EEHO18
Course Title	:	**ELECTRICITY MARKETS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC18
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles and working of restructured power systems and electricity markets around the world

Course Content

Power market fundamentals – Why deregulate? – What to deregulate – Pricing power, energy, and capacity - Power supply and demand – Market structure and architecture – Spot market – Day ahead market – Real time market – Reserve market – Ancillary services

Electricity pricing – Concept of marginal cost - Market equilibrium – Market clearing price – Congestion pricing fundamentals – Locational marginal pricing – Operating reserve pricing – Value-of-lost-load pricing – Pricing losses on lines - Pricing losses at nodes

Markets around the world – US and European market evolution - Reforms in Indian power sector - IEX India – Power purchase agreements in India

Derivative markets – Hedging risk – Contract for difference - Forwards - Futures – Options – Swaps

Local energy markets – Virtual power plant and microgrids – Microgrid prosumer consortium – Peer-to-Peer transactive energy markets – Role of DSO – Business models

References

1.	Steven Stoft, 'Power System Economics: Designing Markets for Electricity', Wiley-IEEE Press, 2002.
2.	Daniel S. Kirschen, Goran Strbac, 'Fundamentals of Power System Economics, Wiley, 2018.
3.	Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems: Operation: Trading, and Volatility', Marcel Dekker Inc., 2001.
4.	Mohammad Shahidehpour, Hatim Yamin, Zuyi Li, 'Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management', IEEE Press, 2002.
5.	Indian Energy Exchange: http://www.iexindia.com/
6.	Power Exchange India Limited: http://www.powerexindia.com/
7.	Indian Electricity Regulations: http://www.cercind.gov.in/

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Illustrate and solve problems in the de-regulated power system.
CO2	Explain how electricity is priced in deregulated power markets.
CO3	Explain the working of various electricity markets around the world

Course Code	:	EEHO19
Course Title	:	**DESIGN WITH PIC MICROCONTROLLERS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC14
Contact Hours	:	4 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To understand the internal structure and operation of PIC16F876 microcontroller,
CLO2	Assembly language programming with MPLAB and PICSTART plus and design methodology for software and hardware applications.

Course Content

Introduction to PIC microcontrollers - PIC 16F876 microcontroller – device overview-pin diagrams-memory organisation.

Special Function Registers - I/O ports - Timers – Capture/Compare/PWM modules (CCP) – Analog-to-digital converter module - selection – reset – interrupts - watchdog timer.

Instruction set - instruction description – PIC16F876 assembly language programming – simple programs.

Introduction to MPLABIDE and PICSTART plus – Device Programming using MPLAB and PICSTART plus.

Assembly language programming for – Zero crossing detectors - square wave generation – pulse generation for typical applications - ADC program – hardware demonstration.

References

1.	PIC16F87X datasheet, 28/40- pin 8 bit CMOS Flash Microcontrollers, Microchip Technology Inc, 2001.
2.	Myke Predko, 'Programming and Customizing the PIC Microcontroller', Tata McGraw-Hill Publications, 1st Edition, 2007.
3.	John B. Peatman, 'Design with PIC Microcontrollers', Pearson Education Publications, 1st Edition, 2008.
4.	MPLABIDE Quick Start Guide Microchip Technology Inc., 2007.
5.	M. D. Singh and K. B. Khanchandani, 'Power Electronics', Tata McGraw Hill Publishing Company Limited, 2nd Edition, 2006.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the architecture of PIC 16F876 microcontroller and its instruction set.
CO2	Be able to develop assembly language program.
CO3	Be able to develop the program using MPLAB and download it to the microcontroller chip using suitable developer.
CO4	Be able to design and generate pulses for typical applications.

Course Code	:	EEHO20
Course Title	:	**AIRCRAFT ELECTRONIC SYSTEMS**
Type of Course	:	Honours (HO)
Prerequisites	:	EEPC22
Contact Hours	:	3 hours / week
Course Assessment Methods	:	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	To inculcate the habit of applying theory in practical electronic systems.

Course Content

Basic flight instruments – Electronic flight instrument systems – primary flight display – navigation display – Display processor unit - Electronic attitude and direction indicator (EADI) – Electronic Horizontal situation indicator (EHSI) – Multi-function processor unit.

Electronic centralized aircraft Monitor - Engine indicating and crew alerting system - Flight management system – cockpit layouts.

Electrostatic sensitive devices (ESD) – Different devices and its features - tribo-electric series – handling and transporting ESDs - Electromagnetic compatibility – EMI generation – EMC and avionics equipment – spectrum analysis.

Airframe control and indicating systems - Landing gear - Trailing edge flaps - Control surfaces - Electronic indicating systems – Terrain awareness warning systems.

Flight data and cockpit voice recorders - Health and usage monitoring system (HUMS) - Aircraft Communication Addressing and Reporting System - Fly-by-wire (FBW).

References

1.	Mike Tooley, 'Aircraft Digital Electronic and Computer Systems: Principles, Operation and Maintenance', 1st Edition, Elsevier, 2007.
2.	Mike Tooley and David Wyatt, 'Aircraft Electrical and Electronic Systems: Principles, Operation and Maintenance', Elsevier, 2009.
3.	IEEE Guide for Aircraft Electric Systems, 1976.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the insights of the flight instruments.
CO2	Appreciate and classify the monitoring and management systems.
CO3	Differentiate electrostatic and electromagnetic effects.
CO4	List the control and indicating systems in aircraft.
CO5	Enrich about recording and reporting systems in aircraft.

Course Code	**:**	EEHO13
Course Title	**:**	**POWER SWITCHING CONVERTERS**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	EEPC19
Contact Hours	**:**	4 hours / week
Course Assessment Methods	**:**	Continuous Assessments, Final Assessment

Course Learning Objectives (CLO)

CLO1	This course aims at modeling, analysis and control of various power converter circuits

Course Content

Basic converter topologies: Buck, Boost, Buck-Boost converter, steady state converter analysis - Equivalent circuit modelling.

State space averaging of converters- Transfer function of converters- Design of feedback compensators-voltage and current loop.

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Isolated converters: forward converter, push-pull converter, fly back converter, half bridge and full bridge converter-operating principles.

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, multi-resonant converters and Load resonant converters-operating principles.

References

1.	Simon Ang, Alejandro Oliva, 'Power Switching Converters', Taylor & Francis, 3rd Edition, 2010.
2.	Robert W. Erickson, Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer Science & Business Media, 2nd Edition, 2007.
3.	Ned Mohan, Tore M. Undeland, and William P.Robbins, 'Power Electronics: Converters, Applications, and Design', 3rd Edition, Wiley Publishers, 2002.
4.	M. Rashid, 'Power Electronics: Circuits, Devices, and Applications', Pearson Education, 4th Edition 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the classification and operation of different types of DC-DC converters.
CO2	Analyze the Steady-state operation of DC-DC converter circuits.
CO3	Develop the transfer function of DC-DC converter circuits.
CO4	Design the compensator and reactive elements of DC-DC converter circuits.
CO5	Illustrate different soft switching techniques in DC-DC converter circuits.

CO-PO & CO-PSO MAPPING

Program Specific Outcomes and Program Outcomes

Programme Specific Outcomes (PSOs)

1. Apply fundamental knowledge of Electrical , Electronics and Computer Engineering concepts to understand, analyse and solve complex problems in Power Engineering and allied areas.
2. Analyse, design and devolop Electronics circuits and systems
3. Adapt to the changing needs for self and continuous learning, communicate effectively and practice professional ethics for societal benefits.

Programme Outcomes (POs)

The students who have undergone the B.Tech. programme in Electrical and Electronics Engineering (EEE):

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex 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. Conduct investigations of complex problems: 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.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: 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. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: 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. Project management and finance: 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. Life-long learning: 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

Course Code & Name	EEIR15 INTRODUCTION TO ELECTRICAL AND ELECTRONICS ENGINEERING															
Course Learning Objective	Facilitating the students to get a comprehensive exposure to electrical and electronics engineering.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Develop an insightful knowledge on various aspects of electrical and electronics engineering	3	3	2	1	1	-	1	1	3	2	-	3	3	1	2
CO2	Understand the electricity tariff, house wiring concepts, power plant structure and components	3	3	2	1	1	2	2	1	3	2	-	3	3	1	2
CO3	Understand the significance of electronics and computing systems in various industrial applications	3	3	2	1	3	-	1	1	3	2	-	3	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC10 CIRCUIT THEORY															
Course Learning Objective	To provide the key concepts and tools in a logical sequence to analyze and understand electrical and electronic circuits.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Apply mesh and nodal analysis techniques and solve simple dc and single-phase ac circuits in steady state.	3	3	1	1	2	-	-	-	2	1	1	2	3	2	-
CO2	Apply network theorems to solve dc and ac circuits with single or multiple independent and dependent sources.	3	3	1	1	2	-	-	-	2	1	1	2	3	2	-
CO3	Analyze the phenomena of resonance in series-parallel circuits and solve simple electro-magnetic circuits.	3	3	1	1	2	-	-	-	2	1	1	2	3	2	-
CO4	Perform computations needed in three-phase circuits in steady state	3	3	1	1	2	-	-	-	2	1	1	2	3	2	-
CO5	Compute the transient and steady-state responses of simple dc and ac circuits.	3	3	1	1	2	-	-	-	2	1	1	2	3	2	-

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC11 SIGNALS AND SYSTEMS															
Course Learning Objective	• To understand and explore the fundamental characteristics of signal and systems • To understand and analyze the electric circuits excited with non-sinusoidal and non-periodic source															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the signal operations and representation of continuous-time and discrete-time signals.	2	2	2	3	1	1	1	1	3	1	1	1	3	1	1
CO2	Classify systems based on their properties and determine the response of LTI system	3	3	3	3	1	1	1	1	3	1	1	1	3	2	1
CO3	Understand the significance of Fourier series and Fourier Transform and apply them for typical electrical circuits.	3	3	3	3	1	1	1	1	3	1	1	1	3	3	1
CO4	Apply Laplace Transform and Z-transform for the analysis of continuous-time and discrete time systems.	3	3	3	3	1	1	1	1	3	1	1	1	3	3	1
CO5	Apply and analyse the interconnected networks.	3	3	3	3	1	1	1	1	3	1	1	1	3	3	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC12 DC MACHINES AND TRANSFORMERS															
Course Learning Objective	This course aims to equip the students with a basic understanding of DC machines and Transformer fundamentals, machine parts and help to gain the skills for operating DC machines and Transformers. The course also equips students with ability to understand and analyze the equivalent circuits of DC machines and Transformers.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand various properties and applications of magnetic circuits in linear and rotational systems.	2	2	1	2	-	-	-	1	-	1	1	2	3	1	2
CO2	Understand constructional details and principles of DC machines and transformers.	2	2	1	2	-	-	-	-	-	1	1	2	3	1	2
CO3	Analyze the performance parameters/characteristics of the DC machines under various operating conditions through proper testing	3	3	2	3	2	-	2	2	-	2	2	3	3	1	2
CO4	Evaluate the performance of single-phase transformer using equivalent circuits and phasor diagrams	3	3	2	3	2	-	2	2	-	2	2	3	3	1	2
CO5	Understand various connection and performance testing of various transformers	2	2	2	2	-	-	-	-	-	1	1	3	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC13 ELECTRON DEVICES															
Course Learning Objective	To educate on the construction and working of common electronic devices and to prepare for application areas.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the semiconductor physics of the intrinsic, p and n materials and various devices and characteristics.	2	2	1	1	1	2	1	2	3	2	1	2	2	3	2
CO2	Analyze simple diode circuits under DC and AC excitation.	3	3	2	2	2	1	1	2	3	2	1	2	2	3	2
CO3	Analyze and design simple amplifier circuits using BJT in CE, CC and CB configurations.	3	3	2	2	2	1	1	2	3	2	1	2	2	3	2
CO4	Understand the analysis and salient features of CE, CC & CB amplifier circuits.	3	3	3	2	3	1	1	2	3	3	1	2	2	3	2
CO5	Understand the construction and characteristics of FET, MOSFET and UJT	2	2	1	1	1	2	1	2	3	2	1	2	2	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC14 DIGITAL ELECTRONICS															
Course Learning Objective	This subject exposes the student to digital fundamentals.															
CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Interpret, convert and represent different number systems and Simplify the Boolean expressions for digital design.	2	2	1	1	1	1	1	3	3	3	1	3	2	3	2
CO2	Manipulate and examine Boolean algebra, logic operations and design Combinational logic circuits.	2	2	1	1	1	1	1	3	3	3	1	3	2	3	2
CO3	Design the basic components for the sequential logic circuits.	3	2	3	1	2	1	3	3	3	3	3	3	2	3	2
CO4	Analyse the synchronous sequential logic ciruits.	3	2	3	1	2	2	3	3	3	3	3	3	2	3	2
CO5	Evaluate the Asynchronous sequential logic circuits.	3	2	3	1	2	2	3	3	3	3	3	3	2	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC15 **AC MACHINES**															
Course Learning Objective	This course provides a basic understanding of AC machinery fundamentals, machine parts and helps to gain the skills for operating AC machines. The course also equips students with ability to understand and analyse the phasor diagrams and equivalent circuits of AC Induction and Synchronous Machines.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the constructional details and principle of operation of AC Induction and Synchronous Machines.	2	1	1	2	-	2	2	1	2	1	1	3	3	1	2
CO2	Understand and appraise the principle of operation and performance of single-phase induction motors and other special motors.	2	1	1	2	-	2	2	1	2	1	1	3	3	1	2
CO3	Analyze the performance of the AC Induction and Synchronous Machines using the phasor diagrams and equivalent circuits.	3	3	3	3	2	2	2	2	2	2	2	3	3	1	2
CO4	Select appropriate AC machine for any application and appraise its significance.	3	2	2	3	1	2	2	2	2	1	2	3	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC16 **ANALOG ELECTRONIC CIRCUITS**															
Course Learning Objective	To give a comprehensive exposure to all types of amplifiers and oscillators constructed with discrete components such as BJTs and FETs. This helps to develop a strong basis for building linear and digital integrated circuits															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the working of different types of amplifiers, oscillator and multivibrator circuits.	3	2	-	-	1	-	-	-	-	-	-	2	2	3	2
CO2	Design BJT and FET amplifier and oscillator circuits.	3	2	3	-	1	-	-	-	-	-	-	2	2	3	2
CO3	Analyze transistorized amplifier and oscillator circuits	3	-	2	-	1	-	-	-	-	-	-	1	2	3	2
CO4	Understand the applications of different types of amplifiers, oscillator, attenuators and multivibrator circuits.	3	1	3	2	-	-	-	-	-	-	-	1	2	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC17 TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY															
Course Learning Objective	• Identify major components of power transmission and distribution systems. • Describe the principle of operation of transmission and distribution equipment. • Know and appreciate the key factors in transmission and distribution system equipment specification and network design.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the major components of Transmission and Distribution Systems (TDS) and its practical significance.	3	3	2	1	1	-	-	1	3	2	-	1	3	1	2
CO2	Have good knowledge of various equipment specifications and design for TDS	3	3	3	1	1	-	1	1	3	2	1	1	3	1	2
CO3	Have awareness of latest technologies in the field of electrical transmission and distribution.	3	3	3	1	2	-	1	1	3	2	1	3	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC18 POWER SYSTEM ANALYSIS															
Course Learning Objective	To model various power system components and carry out load flow, short-circuit and stability studies.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Carry out load flow study of a practical system.	3	3	2	2	3	1	1	1	3	1	1	1	3	1	2
CO2	Simulate and analyze fault	3	3	3	3	3	1	1	1	3	1	1	1	3	1	2
CO3	Study the stability of power systems	3	3	2	3	3	1	1	1	3	1	1	1	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPC19 POWER ELECTRONICS**															
Course Learning Objective	This course aims to equip the students with a basic understanding of modern power semiconductor devices, various important topologies of power converter circuits for specific types of applications. The course also equips students with an ability to understand and analyze non-linear circuits involving power electronic converters.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the principle of operation of commonly employed power electronic converters.	3	2	2	3	-	2	3	3	2	2	2	2	2	3	2
CO2	Analyze non -linear circuits with several power electronic switches	2	2	3	3	2	-	2	3	3	-	2	2	2	3	2
CO3	Equipped to take up advanced courses in Power Electronics and its application areas.	2	3	2	3	-	-	2	3	2	2	2	2	2	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC20 CONTROL SYSTEMS															
Course Learning Objective	To equip the students with the fundamental concepts in control systems.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the concepts of closed loop control systems	3	3	3	3	3	-	3	3	2	2	2	3	3	1	2
CO2	Analyze the stability of closed loop systems	3	3	2	1	2	-	3	3	2	2	2	3	3	1	2
CO3	Apply the control techniques to any electrical systems	3	3	2	1	3	-	3	3	2	1	3	3	3	1	2
CO4	Design the classical controllers such as P, PI, etc., for electrical systems	3	3	2	1	2	-	3	3	2	1	3	2	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC21 **LINEAR INTEGRATED CIRCUITS**															
Course Learning Objective	To provide in-depth instructions on the characteristics and applications of operational amplifiers, timers and voltage regulators.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Describe the various ideal and practical characteristics of an OPAMP.	3	2	2	1	2	2	2	2	1	2	1	2	3	3	2
CO2	Develop simple OPAMP based circuits.	3	3	3	1	3	2	2	2	2	2	3	2	3	3	2
CO3	Implement various analog signal processing circuits	3	3	3	1	3	2	2	2	2	2	3	3	3	3	2
CO4	Analyze and design various types of ADCs and DACs.	3	3	3	1	3	2	2	2	1	2	2	2	3	3	2
CO5	Analyze and construct various application circuits using 555 timer	3	3	3	1	3	2	2	2	1	2	2	3	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC22 MICROPROCESSORS AND MICROCONTROLLERS															
Course Learning Objective	To gain knowledge on the architecture of 8085 microprocessors and 8051 micro controller, their programming and associated peripheral interface devices.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Summarize the architecture of 8085 microprocessor and 8051 microcontroller	3	2	2	3	2	2	1	2	3	3	3	2	3	2	3
CO2	Develop the assembly language code for a given problem	3	2	3	3	2	2	1	2	3	3	3	2	3	2	3
CO3	Interface appropriate peripheral devices, memory with microprocessor/microcontroller for a given application/problem	3	2	3	3	2	2	1	2	3	3	3	2	3	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC23 **MEASUREMENTS AND INSTRUMENTATION**															
Course Learning Objective	To understand the basic operation of different measuring instruments and thereby able to choose appropriate instruments for measuring different parameters.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Describe the working principle of analog measuring instruments.	3	3	1	-	-	-	-	-	1	1	-	1	3	3	2
CO2	Describe the working principle of digital measuring instruments.	3	2	1	-	-	-	-	-	1	-	-	2	3	3	2
CO3	Choose appropriate measuring instruments for measuring various parameters in their laboratory courses	3	3	2	-	-	-	-	-	1	-	-	1	3	3	2
CO4	Analyse the operation and usage of oscilloscopes and signal generators for practical applications.	3	3	3	2	2	-	-	-	-	-	2	2	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPC24 POWER SYSTEM PROTECTION AND SWITCHGEAR															
Course Learning Objective	To give a broad coverage on all types of protective relays, circuit breakers and provide a strong background for working in a practical power system protection.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Classify and describe the working of various relaying schemes.	-	-	-	-	3	-	-	3	3	-	3	-	3	1	2
CO2	Identify and implement an appropriate relaying scheme for different power apparatus.	-	3	-	-	3	-	-	3	3	3	3	-	3	1	2
CO3	Illustrate the function of various CBs and related switching issues	-	-	-	-	3	-	-	3	3	-	3	-	3	1	2
CO4	Describe the causes of overvoltage and protection against overvoltage	-	3	-	-	3	-	-	3	3	-	3	-	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR10 CIRCUITS AND DIGITAL LABORATORY															
Course Learning Objective	Enabling the students to understand basic theorems of circuit theory and basics of digital design.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Verify the network theorems and operation of electrical and electronic circuits.	3	2	3	3	3	2	2	3	3	3	2	3	3	1	2
CO2	Choose the appropriate equipment for measuring the electrical quantities and verify the same for different circuits	3	2	3	3	3	2	2	3	3	3	2	3	3	1	2
CO3	Prepare the technical report on the experiments carried out	3	2	3	3	2	2	2	3	3	3	3	3	3	3	2
CO4	Design basic digital logic circuits	3	2	3	3	3	2	2	3	3	3	2	3	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR11 DC MACHINES AND TRANSFORMERS LABORATORY															
Course Learning Objective	to give the students an insight into the constructional details of dc machines and transformers with a view for better understanding of their working principles.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Interpret the constructional details of the DC machines and Transformers and also understand the significance of different connections of three-phase transformers.	3	1	1	2	1	1	-	1	3	2	2	3	3	1	2
CO2	Estimate or test the performance of any DC machine (shunt, series or compound) and single-phase transformer, by conducting suitable experiments and report the results.	3	3	3	3	2	2	2	3	3	3	3	3	3	1	2
CO3	Experiment and analyze the various speed control and braking techniques for DC motors.	3	3	3	3	2	2	2	3	3	3	3	3	3	3	2
CO4	Develop simulation models and prototype modules in view of implementing any control technique upon dc motors and single-phase transformers for various applications.	3	3	3	3	3	2	2	3	3	3	3	3	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR12 ELECTRONIC CIRCUITS LABORATORY															
Course Learning Objective	Design of amplifiers and other electronic systems to satisfy specifications.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Design a complete electronic circuit using a top-down approach which starts from specifications.	3	3	1	1	1	-	-	2	3	3	2	2	3	1	2
CO2	Design and analyze electronic circuits using BJT and FET.	3	3	1	1	1	-	-	2	3	3	2	2	3	1	2
CO3	Design and characterization of electronic circuits using UJT.	3	3	1	1	1	-	-	2	3	3	2	2	3	3	2
CO4	Waveform generator circuit design using electronic devices.	3	3	1	1	1	-	-	2	3	3	2	2	3	3	2
CO5	Prepare the technical report and provide solutions to real time problems.	2	2	1	-	-	-	-	1	1	3	-	1	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EELR13 SYNCHRONOUS AND INDUCTION MACHINES LABORATORY**															
Course Learning Objective	The main objective of the course is to give the students an insight into the constructional details of the induction and synchronous machines with a view for better understanding of their working principles. The course also equips the students to test and evaluate the performance of induction and synchronous machines by conducting appropriate experiments.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Estimate or test the performance of induction and synchronous machines by conducting suitable experiments and report the results.	3	3	3	3	2	3	3	3	3	3	3	3	3	1	2
CO2	Experiment and analyze the speed control techniques for three-phase induction motors.	3	3	3	3	2	3	3	3	3	3	3	3	3	1	2
CO3	Evaluate the different modes of operating the induction generators and justify their usage in wind power generation.	3	3	3	3	2	3	3	3	3	3	3	3	3	1	2
CO4	Experiment synchronization of alternators and power exchange with the grid to get convinced with their usage at conventional power generation stations.	3	3	3	3	2	3	3	3	3	3	3	3	3	1	3
CO5	Develop simulation models and prototype modules in view of implementing any control technique upon Single-phase and three-phase induction motors for various applications.	3	3	3	3	3	3	3	3	3	3	3	3	3	1	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR14 INTEGRATED CIRCUITS LABORATORY															
Course Learning Objective	To enrich the students' knowledge on practical circuit design using analog and digital ICs.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the non-ideal behaviour of Op-amp.	2	2	3	2	-	-	2	2	2	2	-	3	3	3	1
CO2	Analyze and prepare the technical report on the experiments carried out	3	3	1	2	-	-	2	2	1	1	-	3	2	1	1
CO3	Design application-oriented circuits using Op-amp and 555 timer ICs.	3	3	3	2	-	-	3	2	1	1	-	3	3	3	3
CO4	Create and demonstrate live project using ICs.	2	3	3	1	-	-	3	2	1	2	-	3	3	3	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR15 **POWER ELECTRONICS LABORATORY**															
Course Learning Objective	To enable the students to develop hands-on experience in analyzing, designing and carrying out experiments on various electrical networks by make use of power electronic components. It aims to familiarize the switching devices, power converters and their applications in various systems for power control.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the characteristics of various switching devices and appreciate its applications in various electrical networks/systems	3	2	2	2	2	1	1	2	3	2	2	3	3	1	1
CO2	Analyze and design the operation of power switching converters.	3	2	2	3	3	1	1	2	3	2	2	3	3	3	1
CO3	Develop practical control circuits for various real time applications.	3	2	2	3	3	1	1	2	3	2	2	3	3	3	3
CO4	Analyze and prepare the technical report on the experiments carried out.	3	2	2	3	3	1	1	2	3	2	2	3	1	1	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EELR16** **MICROCOMPUTING LABORATORY**															
Course Learning Objective	To train the students to use micro-controller for computational and logical applications. Also, this course prepares the students to provide solutions to real-time problems.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Develop assembly language code for a given problem	3	3	3	3	2	-	-	-	3	2	1	1	3	3	3
CO2	Interface peripheral devices with microprocessor/ microcontroller for a given application.	3	3	3	2	2	-	-	-	3	2	1	1	3	3	3
CO3	Design and implement control circuitry using microprocessor/ micro-controller for real time application	3	3	3	3	2	1	1	1	3	2	1	1	3	3	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EELR17 **POWER SYSTEMS LABORATORY**															
Course Learning Objective	To enhance the analyzing and problem-solving skills of the students in power system through computer programming and simulation.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Develop computer programs for power system studies	3	3	3	3	3	2	2	1	1	1	1	1	3	1	3
CO2	Design, simulate and analyze power systems using simulation packages.	3	3	3	3	3	2	2	1	1	1	1	1	3	1	3
CO3	Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner.	3	3	3	2	2	2	1	1	1	3	1	1	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE10 POWER GENERATION SYSTEMS															
Course Learning Objective	To understand the working of different types of power generation systems and to realize the necessity for interconnected operation of different power stations.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Appreciate the different types of tariff, consumers and different types of power generation plants	3	3	2	1	1	2	3	1	3	1	3	3	3	1	1
CO2	Determine the significance of various components of the power generation plants.	1	1	1	1	3	3	3	1	3	1	2	3	3	1	1
CO3	Correlate the importance of interconnected operation of different power generation systems.	3	2	1	1	3	2	3	1	3	1	1	3	3	1	1
CO4	Plan an appropriate scheduling of electric power to satisfy the demand constraint.	2	3	2	1	3	1	3	1	3	1	3	3	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPE11 / EEOE10** **ELECTRICAL SAFETY**
Course Learning Objective	To provide a comprehensive exposure to electrical hazards, various grounding techniques, safety procedures and various electrical maintenance techniques.

CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	PSO3
CO1	Describe electrical hazards and safety equipment	3	3	3	3	-	-	-	-	3	-	-	-	3	-	1
CO2	Analyze and apply various grounding and bonding techniques.	3	3	3	3	-	-	-	-	3	-	-	-	3	-	1
CO3	Select appropriate safety method for low, medium and high voltage equipment.	3	3	3	3	-	-	-	-	3	-	-	-	3	-	1
CO4	Participate in a safety team	-	-	-	-	-	-	-	-	3	3	-	-	3	-	1
CO5	Carry out proper maintenance of electrical equipment by understanding various standards.	3	3	3	3	-	-	-	-	3	-	-	-	3	-	1

3 - High; 2 - Medium; 1 – Low

<table>
<tr><td>Course Code & Name</td><td colspan="16">EEPE12
THERMODYNAMICS AND MECHANICS OF FLUIDS</td></tr>
<tr><td>Course Learning Objective</td><td colspan="16">• To achieve an understanding of the principles of thermodynamics and to be able to use it in accounting for the bulk behavior of simple physical systems.
• To provide in-depth study of thermodynamic properties of various working fluids.
• To enlighten the basic concepts of energy interacting devices through various thermodynamic cycles.
• To provide basic awareness about fluid behaviour under rest and dynamic conditions.
• To impart knowledge about hydraulic machines</td></tr>
<tr><td>CO</td><td>Statement</td><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PO8</td><td>PO9</td><td>PO10</td><td>PO11</td><td>PO12</td><td>PSO1</td><td>PSO2</td><td>PSO3</td></tr>
<tr><td>CO1</td><td>Understand the fundamentals of first and second laws of thermodynamics and their application to a wide range of systems.</td><td>3</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>1</td><td>2</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>CO2</td><td>Familiarize with calculations of the efficiencies of heat engines and other engineering devices</td><td>3</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>1</td><td>2</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>CO3</td><td>Familiarize the construction and principles governing the form of simple and complex onecomponent phase diagrams such as pressure-temperature, volume-temperature & and pressurevolume and the steam tables in the analysis of engineering devices and systems.</td><td>3</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>1</td><td>2</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>CO4</td><td>Calculate various fluid flow parameters.</td><td>3</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>1</td><td>2</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>CO5</td><td>Determine the optimum working conditions for hydraulic machines</td><td>3</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>1</td><td>2</td><td>-</td><td>-</td><td>1</td><td>-</td><td>-</td><td>1</td></tr>
</table>

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE13 / EEOE11 FUZZY SYSTEMS AND GENETIC ALGORITHMS															
Course Learning Objective	• This course aims to expose students to the fundamental principles of fuzzy logic systems. • Enable the students to apply fuzzy logic concepts to existing and new applications.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the fundamentals of Fuzzy logic theory.	1	3	1	1	-	-	-	-	1	-	-	2	3	2	1
CO2	Employ fuzzy logic principles to existing engineering applications and compare the results with existing methods.	3	2	1	1	-	-	-	-	1	3	3	2	3	2	1
CO3	Design Fuzzy logic Systems for engineering applications.	3	2	3	1	-	-	-	-	1	1	-	2	3	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE14 **INDUSTRIAL AUTOMATION**															
Course Learning Objective	The contents aim to develop the knowledge of the student in the field of automation in industries. This will be compromising knowledge of PLC, DCS and SCADA systems. They will also get familiar with different industrial standard protocols.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Implement low cost automation systems using pneumatic and electrical means.	3	3	3	3	2	1	1	1	3	1	1	2	3	3	3
CO2	Learn about the modern techniques and devices used for the monitoring and control of manufacturing systems including programming of programmable logic controllers and their interfacing with various sensors and actuators.	3	3	3	3	2	1	1	1	3	1	1	2	3	3	2
CO3	Design automated assembly system for industrial applications.	3	3	3	3	2	1	1	1	3	1	1	2	3	3	3

3 High; 2 - Medium; 1 – Low

Course Code & Name	EEPE15 HIGH VOLTAGE ENGINEERING															
Course Learning Objective	To dispense an overview of various generation, measurement and testing methodologies of high DC and AC voltages and currents and also to edify the background of various breakdowns.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Describe the causes and types of overvoltage.	3	2	2	1	1	2	1	-	-	-	1	2	3	1	1
CO2	Illustrate different methods of generating and measuring various high voltages and currents.	3	2	2	2	1	-	1	-	-	1	1	2	3	1	1
CO3	Explain various breakdown phenomena occurring in gaseous, liquid and solid dielectrics.	3	3	3	2	-	-	-	-	-	-	-	1	3	1	1
CO4	Identify appropriate testing method(s) for various high voltage apparatus.	3	1	1	3	3	1	-	-	-	1	1	1	3	1	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE16 COMPUTER ORGANIZATION AND ARCHITECTURE
Course Learning Objective	This course will render the basic structure of computers, their control design, memory organizations and an introduction to parallel processing.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Describe the general architecture of computers.	3	3	2	-	-	-	-	-	-	-	3	3	3	2	1
CO2	Be familiar with the history and development of modern computers, the Von Neumann architecture and functional units of the processor such as the register file and arithmetic logical unit.	3	3	3	3	2	-	-	-	-	-	2	3	3	2	1
CO3	Understand the major components of a computer including CPU, memory, I/O and storage, how computer hardware has evolved to meet the needs of multi-processing systems, the uses for cache memory, parallelism both in terms of a single processor and multiple processors.	3	3	3	2	3	-	2	-	-	2	2	3	3	2	1
CO4	Design principles in instruction set design including RISC architectures.	2	3	3	3	2	-	-	-	2	-	3	3	3	2	1
CO5	Analyze and design computer hardware components.	3	3	3	2	3	-	-	-	3	-	3	3	3	2	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE17 DIGITAL SYSTEM DESIGN AND HDLS															
Course Learning Objective	To impart the concepts of Digital systems and hardware description languages.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the insights of the finite state machines.	3	2	2	2	3	1	1	1	3	1	1	1	3	3	2
CO2	Appreciate and classify the programmable logic devices and FPGA.	3	2	2	2	3	1	1	1	3	1	1	1	3	3	2
CO3	Design the logic circuits using VHDL.	3	3	3	3	3	1	1	1	3	1	1	1	3	3	2
CO4	Develop the systems using Verilog HDL.	3	3	3	3	3	1	1	1	3	1	1	1	3	3	2
CO5	Test the circuits for different faults.	3	3	3	3	3	1	1	1	3	1	1	1	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE18 DIGITAL SIGNAL PROCESSING															
Course Learning Objective	To explore the basic concepts of digital signal processing in a simple and easy-to-understand manner.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the operations on digital signals.	3	3	2	2	2	1	-	1	2	3	2	2	3	1	2
CO2	Analyze the signal processing concepts.	3	3	2	3	2	1	-	1	2	3	2	2	3	1	2
CO3	Design the systems required for digital signal processing.	3	3	3	3	3	1	-	1	2	3	2	2	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE19 / EEOE12 ARTIFICIAL NEURAL NETWORKS															
Course Learning Objective	To learn the fundamentals of ANN and its application to electrical systems.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Describe the development of artificial neural networks (ANN) and classify various ANN models.	3	3	2	3	2	2	1	1	3	1	1	1	3	2	2
CO2	Solve and design various ANN models.	3	3	3	3	2	3	1	1	3	1	1	1	3	2	2
CO3	Apply and construct ANN models to various applications of electrical systems.	3	3	3	3	2	3	1	1	3	1	1	1	3	2	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE20 **DESIGN OF ELECTRICAL APPARATUS**															
Course Learning Objective	This course offers the preliminary instructions and techniques to design the main dimensions and other major part of the transformer and DC and AC rotating machines. The course also provides the students with an ability to understand the step-by-step procedure for the complete design of electrical machines.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Able to understand the design of main dimensions and other major part of the transformer and DC and AC rotating machines.	3	3	3	3	1	1	1	1	3	1	1	1	3	1	1
CO2	Capable of evaluating the procedure for the design of main dimensions and other major part of the transformer and DC and AC rotating machines.	3	3	3	3	3	1	1	1	3	1	1	1	3	1	1
CO3	Equipped to apply in-depth knowledge related to the design of electrical machines.	3	3	3	3	3	1	1	1	3	1	1	1	3	1	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPE21** **UTILIZATION OF ELECTRICAL ENERGY**
Course Learning Objective	To design illumination systems, choose appropriate motors for any drive application, to debug a domestic refrigerator circuit and to design battery charging circuitry for specific applications.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Develop a clear idea on various illumination techniques and hence design lighting scheme for specific applications.	3	3	3	3	2	2	2	1	2	2	2	3	3	1	2
CO2	Identify an appropriate method of heating for any particular industrial application	3	3	3	3	2	2	2	1	2	1	2	3	3	1	2
CO3	Evaluate domestic wiring connection and debug any faults occurred.	2	2	2	2	2	2	2	1	2	2	2	3	3	3	2
CO4	Construct an electric connection for any domestic appliance like refrigerator as well as to design a battery charging circuit for a specific household application.	3	3	3	3	2	2	2	1	2	1	2	3	3	3	2
CO5	Realize appropriate type of electric supply system and to evaluate the performance of traction unit.	3	3	3	3	2	2	2	1	2	1	2	3	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE22 COMPUTER NETWORKS															
Course Learning Objective	To know about different network architectures and network protocols, data communications and different IEEE standards.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand of the fundamental network issues.	3	2	2	1	1	1	-	-	2	1	2	1	3	1	2
CO2	Analyze the significance of the network layers and their functions.	2	2	1	1	1	-	-	-	2	1	2	2	3	1	2
CO3	Gain knowledge about the basic network protocols.	2	2	1	1	1	-	-	-	2	1	1	1	3	3	2
CO4	Have a basic understanding of TCP / IP.	2	2	1	1	1	-	-	-	2	1	2	2	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE23 / EEOE13 MODERN CONTROL SYSTEMS															
Course Learning Objective	Apply modern control techniques to electrical systems.															
CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the concepts of modern control theory using state-space approach.	3	3	2	2	3	3	-	-	1	1	1	1	3	1	2
CO2	Compare and analyse the classical control system with modern control system.	2	3	1	3	1	2	1	-	-	2	3	0	3	1	2
CO3	Develop advanced controllers to the existing system using modern control design techniques.	3	2	3	1	2	1	1	-	-	1	1	1	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE24 **FUNDAMENTALS OF FACTS**															
Course Learning Objective	Familiarize the students with the basic concepts, different types, scope and applications of FACTS controllers in power transmission.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand various Power flow control issues in transmission lines, for the purpose of identifying the scope and for selection of specific FACTS controllers.	3	2	1	3	3	1	-	-	-	2	3	2	3	-	3
CO2	Apply the concepts in solving problems of simple power systems with FACTS controllers	3	2	2	3	3	1	-	-	-	2	3	2	3	-	3
CO3	Design simple FACTS controllers	3	3	3	3	3	-	3	-	-	3	1	3	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE25 SPECIAL ELECTRICAL MACHINES															
Course Learning Objective	To expose the students to the construction, principle of operation and performance of special electrical machines as an extension to the study of basic electrical machines.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	to understand the construction, principle of operation and performance of Synchronous Reluctance motors	3	1	2	2	1	2	2	-	-	-	-	-	-	-	-
CO2	to understand the construction, principle of operation and performance of Stepping motors	3	1	2	2	1	2	2	-	-	-	-	-	-	-	-
CO3	to understand the construction, principle of operation and performance of Switched Reluctance motors	3	1	2	2	1	2	2	-	-	-	-	-	-	-	-
CO4	to understand the construction, principle of operation and performance of permanent magnet brushless DC motors	3	1	2	2	1	2	2	-	-	-	-	-	-	-	-
CO5	to understand the construction, principle of operation and performance of permanent magnet brushless Synchronous motors	3	1	2	2	1	2	2	-	-	-	-	-	-	-	-

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE26 **WIND AND SOLAR ELECTRICAL SYSTEMS**															
Course Learning Objective	To familiarize the students with basics of solar and wind energy systems and various techniques for the conversion of solar and wind energy into electrical energy.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Describe the solar radiation, measurements and characteristics of solar PV cell.	3	3	1	2	2	-	3	-	1	2	1	2	3	1	2
CO2	Develop the model of a PV system and its applications.	3	3	3	2	2	-	3	-	1	2	3	2	3	1	2
CO3	Describe the basic types and mechanical characteristics and model of wind turbine.	3	3	2	2	2	-	-	-	1	2	1	2	1	3	2
CO4	Analyze the electrical characteristics and operation of various wind-driven electrical generators.	3	3	2	2	2	-	-	-	1	2	1	2	3	1	2
CO5	Understand various power electronic converters used for hybrid system.	3	3	3	3	2	-	3	2	3	2	3	2	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE27 SOLID STATE DRIVES															
Course Learning Objective	• To understand the basic concept of DC and AC Drives. • To understand the various control techniques involved with both DC and AC Drives. • To brief about the working principle of Special Electrical Drives															
CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Learns the fundamental concepts of power electronic converter fed DC and AC machines.	3	2	-	3	-	-	-	2	2	2	2	-	3	-	3
CO2	Can analyze the converter fed motor under different torque/speed conditions.	3	2	-	3	-	2	3	3	2	2	2	3	3	-	3
CO3	Will be able to design converter fed drives with existing/new control techniques.	3	3	1	3	-	2	3	3	3	2	2	3	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE28 EMBEDDED SYSTEM DESIGN															
Course Learning Objective	To enable the learner to design a system with combination of hardware and software for a specific application															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Remember the concepts of process and controllers.	3	3	2	2	1	-	-	-	-	2	3	2	3	-	3
CO2	Apply the concepts for real-time applications.	3	3	3	1	3	-	-	-	-	3	3	3	3	-	3
CO3	Create a real-time system for particular applications	3	3	2	2	2	-	-	-	-	3	3	3	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE29 POWER SYSTEM ECONOMICS AND CONTROL TECHNIQUES															
Course Learning Objective	• To understand the economics of power system operation and planning. • To realize the requirements and methods of real and reactive power control in power system. • To recognize the recent advancements in power system operation.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Calculate various factors such as load factor, demand factor, etc. and interpret different tariff and pricing structures.	2	3	-	-	3	-	2	1	-	2	-	3	3	-	3
CO2	Develop generation dispatching schemes for conventional and restructured power systems.	3	3	-	-	3	-	2	2	-	2	-	3	3	-	3
CO3	Apply frequency, voltage and reactive power control schemes on power system.	2	3	-	-	2	-	2	1	-	1	-	2	3	1	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE30 / EEOE14 DIGITAL CONTROL SYSTEMS															
Course Learning Objective	To learn the digital control design techniques															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the fundamental differences between continuous time control and digital control	3	3	2	2	3	3	-	-	1	1	1	1	3	1	2
CO2	Analyse the advantages of digital control over the continuous time control.	2	3	1	3	1	2	1	-	-	2	3	0	3	1	2
CO3	Develop digital controllers explicitly compared to continuous time controller.	3	2	3	1	2	1	1	-	-	1	1	1	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE31 **OPERATIONS RESEARCH**															
Course Learning Objective	To equip students to identify and formulate real life problems using mathematical modeling; devise a solution procedure; analyze and interpret the results; revise for the process based on the actual results.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Increase the analytical skill of identifying and solving engineering problems.	3	3	3	3	2	2	2	1	2	2	2	2	3	3	**2**
CO2	Optimizing the resources and input-output process	3	3	3	2	2	1	2	1	2	2	2	2	3	2	**2**
CO3	Devising new techniques for the better understanding of real-life situation	3	3	3	3	2	2	2	1	2	2	2	3	3	2	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE32 **ELECTRIC VEHICLE TECHNOLOGY**															
Course Learning Objective	The main objective of this course is to understand the basics of vehicle dynamics, drivetrain control, energy storage technology and vehicle design.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Analyse dynamics, performance and characteristics of electric vehicles.	1	3	2	1	2	-	-	-	2	2	1	2	1	3	2
CO2	Understand the concept of electric traction and drive train topologies.	3	3	1	1	1	-	-	-	-	2	2	1	3	3	1
CO3	Explain the energy storage and drive control techniques used for electric propulsion systems.	1	2	2	2	-	2	2	-	2	2	1	2	1	2	2
CO4	Design electric vehicle drives, controllers and energy storage units	2	2	3	3	2	2	3	1	2	2	2	3	2	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE33 DESIGN THINKING															
Course Learning Objective	To understand the design philosophy of growth-oriented business ideas by creative thinking.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Conceive need for an enterprise	2	1	1	1	1	3	-	2	3	3	2	2	2	1	1
CO2	Carry out strategic planning	3	1	2	2	3	-	2	2	3	1	2	2	3	1	2
CO3	Evolve methodology for innovative implementation	1	2	3	1	-	-	2	3	2	1	2	2	1	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE34 MACHINE LEARNING AND DEEP LEARNING															
Course Learning Objective	• To get familiarized with the introduction to machine learning and deep learning. • To analyse and illustrate various categories of learning schemes. • To develop skills of solving practical applications															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Remember various types of machine learning and deep learning algorithms.	3	3	3	2	3	1	-	-	3	1	1	2	2	3	3
CO2	Analyse various classification and Clustering methods in ML and DL.	3	3	3	2	3	1	-	-	3	1	1	2	3	3	2
CO3	Apply ML and DL algorithms for solving practical applications related to electrical and electronics engineering.	3	3	3	2	3	1	-	-	3	1	1	2	3	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE35 **NANO ELECTRONICS**															
Course Learning Objective	A unique course to explore nano-electronic devices and its applications.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	To enrich the electronic device concepts and operation.	3	1	1	1	1	-	-	-	2	2	1	1	3	1	1
CO2	To understand the devices made for quantum electronics.	3	1	1	1	1	-	-	-	2	2	1	1	3	1	1
CO3	To appreciate the concepts of carbon nanotubes and its application to circuits.	1	2	2	1	2	-	-	-	2	1	2	2	1	2	2
CO4	To apply the nanoelectronics concepts for different applications.	2	2	1	1	1	-	-	-	2	1	2	2	2	2	1
CO5	To enlighten the concepts of spintronics and its use in electronic device.	1	3	2	1	2	-	-	-	2	2	1	2	1	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE36 **COMMUNICATION SYSTEMS**															
Course Learning Objective	• To develop a fundamental understanding on communication systems with emphasis on analog and digital modulation techniques • To get introduced to the basics of error control coding techniques.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand the basics of communication systems, analog and digital modulation techniques.	2	1	2	1	1	2	-	1	2	2	2	1	2	1	2
CO2	Apply the knowledge of digital electronics and understand the error control coding techniques.	2	3	1	2	2	1	-	-	2	3	2	2	2	3	1
CO3	Summarize different types of communication systems and its requirements.	1	2	2	1	2	-	2	2	3	3	2	3	1	2	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE37 **DATA STRUCTURE AND ALGORITHMS**															
Course Learning Objective	To obtain knowledge on data structures, their storage representation, and their usage in an algorithmic perspective															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Knowledge on algorithmic notations and concepts; basic algorithmic complexity and primitive data structures.	3	3	1	3	2	1	1	1	1	1	2	2	2	2	1
CO2	Familiarity with linked linear and non-linear data structures and operations on such data structures.	2	2	1	1	2	1	1	1	1	1	2	2	2	2	1
CO3	Ability to program data structures and use them in implementations of abstract data types.	2	2	1	1	2	1	1	1	1	1	2	2	2	2	1
CO4	Identify appropriate data structures and algorithms for problems and to justify that choice.	2	3	1	2	2	1	1	1	1	1	2	2	2	2	1
CO5	Summarize various sorting, searching techniques and file structures.	2	2	1	1	2	1	1	1	1	1	2	2	2	2	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE38 ELECTRIC POWER QUALITY														
Course Learning Objective	• To impart knowledge about various electric power quality phenomena, causes and consequences. • To familiarize the students to monitoring methods and essential mitigation techniques														
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Understand different types of power quality problems with their source of generation	3	2	2	1	2	1	-	2	2	2	2	2	3	2	2
CO2	Interpret results of power quality monitoring equipment and classify the power quality disturbances	3	3	2	2	2	1	-	2	2	2	2	2	3	3	2
CO3	Recommend viable solutions for mitigation of the power quality problems	3	3	3	3	3	1	1	2	2	2	2	2	3	3	3
CO4	Design active & passive filters for harmonic elimination	3	3	3	3	3	1	-	2	2	2	2	2	3	3	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE39 **VLSI DESIGN**															
Course Learning Objective	To enrich the student with the concepts of VLSI devices and its fabrication and also to develop different electronic circuits.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	To understand the insights of the MOS devices and its characteristics.	3	3	2	2	3	2	3	3	3	3	2	3	3	3	2
CO2	To appreciate the different VLSI process technologies.	3	3	2	2	3	2	3	3	3	3	2	3	3	3	2
CO3	To design the CMOS combinational logic circuits and its layout.	3	3	2	2	3	2	3	3	3	3	2	3	3	3	2
CO4	To develop the sequential circuits and clocking schemes..	3	3	2	2	3	2	3	3	3	3	2	3	3	3	2
CO5	To realize the Design flow of application-specific Integrated circuit.	3	3	2	2	3	2	3	3	3	3	2	3	3	3	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE40 **POWER SYSTEM RESTRUCTURING**															
Course Learning Objective	To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Explain and differentiate the key issues involved in the regulated and de-regulated power markets.	2	1	1	1	-	-	-	-	1	2	2	1	2	1	1
CO2	Describe the operational activities in Generation, Transmission and Distribution system in the restructured environment.	2	2	2	2	1	-	-	-	1	3	2	2	2	2	2
CO3	Illustrate and solve problems in the de-regulated power System.	1	2	2	3	3	-	-	-	1	3	2	1	2	2	3
CO4	Explain and analyze the restructuring activities in Indian Power System.	1	2	3	2	2	-	-	-	1	3	2	3	1	3	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE41 ECONOMIC EVALUATION OF POWER PROJECTS															
Course Learning Objective	To assess the feasibility of power projects from business, financial, and sustainability perspectives															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Do a basic cost-benefit analysis of power projects in generation, transmission, and distribution.	2	1	1	1	-	-	-	-	1	-	1	2	2	1	1
CO2	Study the different business models in power systems.	2	2	1	2	2	2	-	-	2	2	2	1	2	2	1
CO3	Study the different metering techniques.	2	2	1	1	1	-	-	-	-	-	2	2	2	2	1
CO4	Analyze and evaluate the economics of power projects.	2	3	3	2	2	2	-	1	2	2	3	2	2	3	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE42 **INTRODUCTION TO SWITCHED MODE POWER SUPPLIES**															
Course Learning Objective	To understand the concepts and design of switched mode power converters for real world applications															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Realize various ideal switching characteristics from semiconductor switches.	3	3	1	1	1	1	-	-	-	-	2	2	3	3	1
CO2	Analyse various non-isolated and isolated power converters.	2	3	2	2	3	-	-	-	2	1	-	2	2	3	2
CO3	Analyse and design the HF inductor, transformer, gate drivers.	2	3	3	2	-	-	-	2	1	2	2	1	2	3	3
CO4	Apply the knowledge to real world applications.	1	2	3	2	2	2	-	-	2	-	2	2	1	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE43 **OPTIMAL AND ROBUST CONTROL**
Course Learning Objective	• To understand the basic characteristics of system dynamics and control. • To characterize model uncertainties in dynamic systems. • To determine robustness through stability margins. • To parameterize the stabilizing controllers and interpret stabilizing solutions. • To understand standard LQR problems and stability margin.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Perform problem formulation, performance measure and mathematical treatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.	2	2	2	3	2	-	-	-	2	2	2	3	2	2	2
CO2	Solve optimal control design problems by taking into consideration the physical constraints on practical control systems.	1	2	3	3	2	-	-	-	2	1	2	2	1	2	3
CO3	Produce optimal solutions to controller design problems taking into consideration the limitation on control energy and robustness in the real practical worl	2	2	3	3	2	-	-	-	2	2	1	2	2	2	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPE44** **ROBOTICS**
Course Learning Objective	• To introduce the functional elements of robotics. • To impart knowledge on the direct and inverse kinematics. • To introduce the manipulator differential motion and control. • To educate on various path planning techniques. • To introduce the dynamics and control of manipulators.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand basic concept of robotics	3	2	1	1	1	2	1	-	2	2	2	3	3	2	1
CO2	Analyze instrumentation systems and their applications to various robot models.	1	3	2	2	-	-	-	2	2	1	3	2	1	3	2
CO3	choose different sensors and measuring devices according to the applications	2	2	1	1	-	-	-	-	3	1	-	2	2	2	1
CO4	explain about the differential motion add statics in robotics	3	2	1	1	1	2	1	-	2	2	2	3	3	2	1
CO5	model various path planning techniques.	1	2	3	2	-	-	-	-	-	-	2	3	1	2	3
CO6	explain about the dynamics and control in robotics industries	3	2	1	1	1	2	1	-	2	2	2	3	3	2	1

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPE45** **BATTERY MANAGEMENT SYSTEMS**
Course Learning Objective	● To understand the basic operation and parameters associated with a battery. ● To know the functions of Battery Management System. ● To differentiate different types of Battery Management System. ● To analyze the battery performance and fault. ● To understand the protection mechanisms of Battery Management Systems.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Interpret the role of battery management system.	2	1	1	1	-	2	-	-	1	2	2	2	2	1	2
CO2	Identify the requirements of the Battery Management System.	2	3	3	1	2	2	1	-	1	2	2	2	2	1	3
CO3	Interpret the concept associated with the battery charging / discharging process.	3	2	3	1	3	1	-	-	1	2	-	3	1	2	3
CO4	Calculate the various parameters of battery and battery pack.	2	1	1	1	-	-	1	-	1	2	-	2	1	2	2
CO5	Design the model of the battery pack.	2	3	3	1	2	-	-	-	1	2	-	2	1	3	3

3 - High; 2 - Medium; 1 – Low

Course Code & Name	EEPE46 **POWER SYSTEM RELIABILITY**															
Course Learning Objective	To understand theoretical foundations of reliability analysis and to apply them on power system reliability evaluation.															
CO	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	Model and assess reliability of systems undergoing stochastic events.	2	1	1	1	-	-	-	-	1	2	-	2	1	2	2
CO2	Apply probabilistic models to evaluation of power system reliability	2	3	3	1	2	-	-	-	1	2	-	2	2	2	3
CO3	Model variations in load demand and output of renewable energy sources	3	2	3	1	3	-	-	-	1	2	-	2	2	2	2

3 - High; 2 - Medium; 1 – Low

Course Code & Name	**EEPE47** **ELECTRONIC SYSTEM DESIGN**
Course Learning Objective	To equip students with a thorough understanding of the basics of electronic circuit design, with a focus on the design of digital and analog circuits and assembling them on a printed circuit board (PCB) using a computer-aided design (CAD) tool.

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Understand the electronic circuit elements and CMOS inverter.	3	1	1	1	-	-	-	-	1	2	-	2	1	2	2
CO2	Understand the design of CMOS based logical circuits.	3	2	3	1	2	-	-	-	1	2	-	2		2	-
CO3	Realize the importance and various elements of PCB	3	2	3	1	3	-	-	-	1	2	-	2	3	2	2
CO4	Construct a PCB for different applications	3	2	3	3	3	-	-	-	1	2	-	2	-	2	3

3 - High; 2 - Medium; 1 – Low