CURRICULUM AND SYLLABI

B. Tech.

in

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSES

(I to VIII Semesters)

(Applicable to 2017 admission onwards)

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

CALICUT – 673601

KERALA, INDIA

The Program Educational Objectives (PEOs) of B. Tech. in ELECTRICAL & ELECTRONICS ENGINEERING

PEO1	To prepare under graduate students to excel in technical profession/ industry and/or higher education by providing a strong foundation in mathematics, science and engineering.
PEO2	To transform engineering students to expert engineers so that they could comprehend, analyze, design and create novel products and solutions to Electrical and Electronics Engineering problems that are technically sound, economically feasible and socially acceptable.
PEO3	To train students to exhibit professionalism, keep up ethics in their profession and relate engineering issues to address the technical and social challenges.
PEO4	To develop communication skills and team work and to nurture multidisciplinary approach in problem solving.

The Programme Outcomes (POs) of B. Tech. in ELECTRICAL & ELECTRONICS ENGINEERING

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**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.
PO4	**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.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**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.
PO7	**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.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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.
PO12	**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.

The Programme Specific Outcomes (PSOs) of B. Tech. in ELECTRICAL & ELECTRONICS ENGINEERING

PSO1	Identify, formulate and analyze real-life electrical and electronics engineering problems by way of utilising the knowledge of mathematics, science and engineering principles.
PSO2	Design and develop sophisticated equipment and experimental systems for carrying out detailed investigation to multifaceted electrical and electronics engineering problems leading to reliable and feasible solutions for the same utilising all the available tools.
PSO3	Work as an electrical or electronics engineer who is capable of identifying solutions to various local and global problems faced by the society, up keeping a pollution free environment without compromising professional ethics and social values.
PSO4	Think independently, take initiative, lead a team of engineers or researchers, communicate orally as well as in writing with others, participate in various professional activities, take up administrative responsibilities and thus maintain lifelong learning process.

CURRICULUM

The total minimum credits for completing the B. Tech. programme in Electrical & Electronics Engineering is160.

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. programmes shall have the following Course categories:

Sl. No.	COURSE CATEGORY	Number of Courses	Credits
1.	Mathematics (MA)	4	12
2.	Science (BS)	5	10
3.	Humanities (HL)	3	9
4.	Basic Engineering (BE)	6	15
5.	Professional Core (PC)	30	81
6.	Open Electives (OE)	2	6
7.	Departmental Electives (DE)	7	21
8.	Other Courses (OT)	4	6
	TOTAL	61	160

COURSE REQUIREMENTS

1. MATHEMATICS (MA)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MA1001D	Mathematics I	3	1	0	3
2.	MA1002D	Mathematics II	3	1	0	3
3.	MA2001D	Mathematics III	3	1	0	3
4.	MA2002D	Mathematics IV *	3	1	0	3
		Total Credits/Hrs	12	4	0	**12**

* Mathematics IV will be branch specific.

2. SCIENCE (BS)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	PH1001D	Physics	3	0	0	3
2.	PH1091D	Physics Lab	0	0	2	1
3.	CY1001D	Chemistry	3	0	0	3
4.	CY1094D	Chemistry Lab	0	0	2	1
5.	BT1001D	Introduction to Life Science	2	0	0	2
		Total Credits/Hrs	8	0	4	**10**

3. HUMANITIES (HL)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MS1001D	Professional Communication	3	0	0	3
2.	MS3001D	Engineering Economics	3	0	0	3
3.	ME3104D	Principles of Management	3	0	0	3
		Total Credits/Hrs	9	0	0	**9**

4. BASIC ENGINEERING (BE)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1001D	Engineering Mechanics	3	0	0	3

2.	ZZ1003D	Basic Electrical Sciences	3	0	0	3
3.	ZZ1002D	Engineering Graphics	1	0	3	3
4.	ZZ1004D	Computer Programming	2	0	0	2
5.	ZZ1091D	Workshop I	0	0	3	2
6.	ZZ1092D	Workshop II	0	0	3	2
		Total Credits/Hrs	8	0	9	**15**

5. OTHER COURSES (OT)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1093D	Physical Education	0	0	2	1
2.	ZZ1094D	Value Education	0	0	2	1
3.	ZZ1095D	NSS	0	0	2	1
4.	EE2011D	Environmental Studies for Electrical Engineers	3	0	0	3
		Total Credits/Hrs	3	0	6	**6**

6. PROFESSIONAL CORE (PC)

Sl.No.	Course Code	Course Title	Prerequisites	L	T	P	Credits
1.	EE2001D	Circuits & Networks	Nil	3	1	0	3
2.	EE2003D	Logic Design	Nil	3	1	0	3
3.	EE2005D	Electrical Measurements	Nil	3	0	0	3
4.	EE2007D	Basic Electronic Circuits	Nil	3	1	0	3
5.	EE2009D	Applied Electromagnetics	Nil	3	1	0	3
6.	EE2091D	Basic Electrical Engineering Lab	Nil	0	0	3	2
7.	EE2002D	Signals & Systems	Nil	3	1	0	3
8.	EE2004D	Microprocessors & Microcontrollers	Nil	3	1	0	3
9.	EE2006D	Electrical Machines – I	Nil	3	1	0	3
10.	EE2008D	Analog Electronic Circuits & Systems	Nil	3	1	0	3
11.	ME2010D	Mechanical Engineering	Nil	3	0	0	3
12.	EE2092D	Electrical Measurements Lab	Nil	0	0	3	2
13.	EE2094D	Electronics Lab - I	Nil	0	0	3	2
14.	EE3001D	Control Systems -I	Nil	3	1	0	3

15.	EE3003D	Electrical Machines - II	Nil	3	1	0	3
16.	EE3005D	Power Systems - I	Nil	3	1	0	3
17.	EE3007D	Power Electronics	Nil	3	1	0	3
18.	EE3091D	Electrical Machines Lab - I	Nil	0	0	3	2
19.	EE3093D	Electronics Lab - II	Nil	0	0	3	2
20.	EE3002D	Digital Signal Processing	Nil	3	1	0	3
21.	EE3004D	Control Systems - II	Nil	3	1	0	3
22.	EE3006D	Power Systems - II	Nil	3	1	0	3
23.	EE3092D	Electrical Machines Lab - II	Nil	0	0	3	2
24.	EE3050D	Electrical Engineering Drawing	Nil	1	0	2	2
25.	EE4001D	Instrumentation Systems	Nil	3	0	0	3
26.	EE4093D	Power Engineering Lab	Nil	0	0	3	2
27.	EE4095D	Control Systems Lab	Nil	0	0	3	2
28.	EE4094D	Seminar	Nil	0	0	2	1
29.	EE4091D	Project: Part I	Nil	0	0	3	2
30.	EE4092D	Project: part II	Nil	0	0	9	6
Total Credits				55	15	40	81

7. DEPARTMENT ELECTIVES (DE)

Sl.No.	Course Code	Course Title	Prerequisites	L	T	P	Credits
1.	EE3021D	Electrical Engineering Materials	Nil	3	0	0	3
2.	EE3022D	Dynamic System Simulation	EE2002D	3	0	0	3
3.	EE3023D	Network Analysis	EE2001D EE2002D	3	0	0	3
4.	EE3024D	Digital Control Systems	EE3001D	3	0	0	3
5.	EE3025D	Optimization Techniques and Algorithms	Nil	3	0	0	3
6.	EE3026D	Artificial Neural Networks and Fuzzy Logic Systems	Nil	3	0	0	3
7.	EE3027D	Special Machines and Linear Machines	EE2006 D	3	0	0	3

8.	EE3028D	Electrical Machine Design	EE2006D EE3003D	3	0	0	3
9.	EE3029D	Electric Power Utilization	EE3005D	3	0	0	3
10.	EE3030D	Biomedical Engineering	Nil	3	0	0	3
11.	EE3031D	Dynamic Analysis of Electrical Machines	EE2006D EE3003D	3	0	0	3
12.	EE3032D	Illumination Engineering	Nil	3	0	0	3
13.	EE3033D	Linear System Theory	Nil	3	0	0	3
14.	EE3034D	Analog Filters	EE2007D EE2008D EE2001D EE2002D	3	0	0	3
15.	EE3035D	High Voltage Engineering	Nil	3	0	0	3
16.	EE3036D	Power Semiconductor Devices	Nil	3	0	0	3
17.	EE3037D	Non-conventional Energy Systems and Applications	Nil	3	0	0	3
18.	EE3038D	Data Structures and Algorithms	ZZ1004D	3	0	0	3
19.	EE3039D	Applications of Analog Integrated Circuits	EE2007D EE2008D	3	0	0	3
20.	EE3040D	LT & HT Distribution Systems	EE2001D	3	0	0	3
21.	EE3041D	Digital System Design	EE2003D	3	0	0	3
22.	EE3042D	DC Drives	EE2006D EE3007D	3	0	0	3
23.	EE3043D	Embedded Systems	EE2003D EE2004D	3	0	0	3
24.	EE3044D	Electrical System Design for Buildings	Nil	3	0	0	3
25.	EE3045D	Network Synthesis	EE2001D EE2002D	3	0	0	3
26.	EE3046D	Digital CMOS Integrated Circuits	EE2003D EE2007D EE2008D	3	0	0	3

27.	EE3047D	Advanced Processor Architecture and System Organisation	EE2004D	3	0	0	3
28.	EE3048D	Electric Vehicle System Engineering	EE2006D EE3001D EE3003D EE3007D	3	0	0	3
29.	EE4021D	Heuristic Methods for Optimization	Nil	3	0	0	3
30.	EE4022D	Optimal and Adaptive Control	EE3001D	3	0	0	3
31.	EE4023D	AC Drives	EE3003D EE3007D	3	0	0	3
32.	EE4024D	Power System Stability and Control	EE3006D	3	0	0	3
33.	EE4025D	Computer Control of Industrial Processes	EE3001D EE3004D	3	0	0	3
34.	EE4026D	Flexible AC Transmission	EE3005D EE3007D	3	0	0	3
35.	EE4027D	Power System Operation and Control	EE3005D EE3006D	3	0	0	3
36.	EE4028D	Non-linear System Analysis	EE3001D EE3004D	3	0	0	3
37.	EE4029D	Analog MOS Circuits	EE2007D EE2008D	3	0	0	3
38.	EE4030D	Energy Auditing, Conservation and Management	Nil	3	0	0	3
39.	EE4031D	Switched-mode Power Supplies	EE3007D	3	0	0	3
40.	EE4032D	Advanced DC – AC Power Conversion	EE3007D	3	0	0	3
41.	EE4033D	Bio-Signal Processing	Nil	3	0	0	3
42.	EE4034D	System Identification and Parameter Estimation	EE3001D	3	0	0	3
43.	EE4035D	Power System Reliability and Deregulation	Nil	3	0	0	3
44.	EE4036D	Power Quality	EE3005D	3	0	0	3

45.	EE4037D	Control & Guidance Engineering	EE3001D EE3004D	3	0	0	3
46.	EE4038D	Power System Protection and Communication	EE3005D	3	0	0	3
47.	EE4039D	Switchgear and Protection	EE3005D EE3006D	3	0	0	3
48.	EE4040D	Smart Grid Engineering	EE3005D EE3006D EE3007D	3	0	0	3
49.	EE4041D	Analog and Digital Communication	Nil	3	0	0	3
50.	EE4042D	Advanced Digital Signal Processing	EE3002D	3	0	0	3
51.	EE4043D	Static VAR Compensation and Harmonic Filtering	Nil	3	0	0	3
52.	EE4044D	Data Acquisition and Signal Conditioning	Nil	3	0	0	3
Total Credits							**21**

8. OPEN ELECTIVES (OE)

Out of 9 elective courses, to be credited in the curriculum, 2 courses (6 credits) can be of branches other than Electrical & Electronics Engineering as per R.6.4 of 2017 B. Tech rules and regulations.

Course Structure

Semester I

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1001D	Mathematics I	3	1	0	3	MA
2.	PH1001D/CY1001D	Physics/Chemistry	3	0	0	3	BS
3.	MS1001D/ ZZ1003D	Professional Communication/ Basic Electrical Sciences	3	0	0	3	HL/BE
4.	ZZ1001D/ ZZ1002D	Engineering Mechanics/ Engineering Graphics	3/1	0	0/3	3	BE
5.	ZZ1004D/BT1001D	Computer Programming / Introduction to Life Science	2	0	0	2	BS
6.	PH1091D/CY1094D	Physics Lab/ Chemistry Lab	0	0	2	1	BS
7.	ZZ1091D/ ZZ1092D	Workshop I/Workshop II	0	0	3	2	BE
8.	ZZ1093D/ZZ1094D/ZZ1095D	Physical Education /Value Education/ NSS	-	-	-	3*	OT
	Total Credits		14/12	1	5/8	**17+3***	

*Note: Three courses of 1 credit each has to be credited within the first four semesters.

Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1002D	Mathematics II	3	1	0	3	MA
2.	CY1001D/PH1001D	Chemistry/ Physics	3	0	0	3	BS
3.	ZZ1003D/MS1001D	Basic Electrical Sciences/ Professional Communication	3	0	0	3	BE/HL
4.	ZZ1002D/ ZZ1001D	Engineering Graphics/ Engineering Mechanics	1/3	0	3/0	3	BE
5.	BT1001D/ ZZ1004D	Introduction to Life Science./Computer Programming	2	0	0	2	BS
6.	CY1094D/PH1091D	Chemistry Lab / Physics Lab	0	0	2	1	BS
7.	ZZ1092D/ ZZ1091D	Workshop II/ Workshop I	0	0	3	2	BE
8.							
	Total Credits/Hrs		12/14	1	8/5	**17**	

Semester III

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MA2001D	Mathematics III	3	1	0	3	MA
2	EE2001D	Circuits & Networks	3	1	0	3	PC
3	EE2003D	Logic Design	3	1	0	3	PC
4	EE2005D	Electrical Measurements	3	0	0	3	PC
5	EE2007D	Basic Electronic Circuits	3	1	0	3	PC
6	EE2009D	Applied Electromagnetics	3	1	0	3	PC
7	EE2011D	Environmental Studies for Electrical Engineers	3	0	0	3	OT
8	EE2091D	Basic Electrical Engineering Lab	0	0	3	2	PC
	Total Credits/Hrs		21	5	3	**23**	

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MA2002D	Mathematics IV	3	1	0	3	MA
2	EE2002D	Signals & Systems	3	1	0	3	PC
3	EE2004D	Microprocessors & Microcontrollers	3	1	0	3	PC
4	EE2006D	Electrical Machines – I	3	1	0	3	PC
5	EE2008D	Analog Electronic Circuits & Systems	3	1	0	3	PC
6	ME2010D	Mechanical Engineering	3	0	0	3	PC
7	EE2092D	Electrical Measurements Lab	0	0	3	2	PC
8	EE2094D	Electronics Lab - I	0	0	3	2	PC
	Total Credits/Hrs		18	5	6	**22**	

Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	EE3001D	Control Systems -I	3	1	0	3	PC
2	EE3003D	Electrical Machines - II	3	1	0	3	PC
3	EE3005D	Power Systems - I	3	1	0	3	PC
4	EE3007D	Power Electronics	3	1	0	3	PC
5		Elective - 1	3	0	0	3	DE/OE
6		Elective - 2	3	0	0	3	DE/OE
7	EE3091D	Electrical Machines Lab - I	0	0	3	2	PC
8	EE3093D	Electronics Lab - II	0	0	3	2	PC
	Total Credits/Hrs		18	4	6	**22**	

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	EE3002D	Digital Signal Processing	3	1	0	3	PC
2	EE3004D	Control Systems - II	3	1	0	3	PC
3	EE3006D	Power Systems - II	3	1	0	3	PC
4	ME3104D	Principles of Management	3	0	0	3	HL
5		Elective - 3	3	0	0	3	DE/OE
6		Elective - 4	3	0	0	3	DE/OE
7	EE3092D	Electrical Machines Lab - II	0	0	3	2	PC
8	EE3050D	Electrical Engineering Drawing	1	0	2	2	PC
	Total Credits/Hrs		19	3	5	**22**	

List of Electives – Vth & VIth Semesters

1. EE3021D Electrical Engineering Materials
2. EE3022D Dynamic System Simulation
3. EE3023D Network Analysis
4. EE3024D Digital Control Systems
5. EE3025D Optimization Techniques and Algorithms
6. EE3026D Artificial Neural Networks and Fuzzy Logic Systems
7. EE3027D Special Machines and Linear Machines
8. EE3028D Electrical Machine Design
9. EE3029D Electric Power Utilization
10. EE3030D Biomedical Engineering
11. EE3031D Dynamic Analysis of Electrical Machines
12. EE3032D Illumination Engineering
13. EE3033D Linear System Theory
14. EE3034D Analog Filters
15. EE3035D High Voltage Engineering
16. EE3036D Power Semiconductor Devices
17. EE3037D Non-conventional Energy Systems and Applications
18. EE3038D Data Structures and Algorithms
19. EE3039D Applications of Analog Integrated Circuits
20. EE3040D LT & HT Distribution Systems
21. EE3041D Digital System Design
22. EE3042D DC Drives
23. EE3043D Embedded Systems
24. EE3044D Electrical System Design for Buildings
25. EE3045D Network Synthesis
26. EE3046D Digital CMOS Integrated Circuits
27. EE3047D Advanced Processor Architecture and System Organisation
28. EE3048D Electric Vehicle System Engineering

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MS3001D	Engineering Economics	3	0	0	3	HL
2	EE4001D	Instrumentation Systems	3	0	0	3	PC
3		Elective - 5	3	0	0	3	DE/OE
4		Elective - 6	3	0	0	3	DE/OE
5		Elective - 7	3	0	0	3	DE/OE
6	EE4091D	Project: Part I	0	0	3	2	PC
7	EE4093D	Power Engineering Lab	0	0	3	2	PC
8	EE4095D	Control Systems Lab	0	0	3	2	PC
9	EE4094D	Seminar	0	0	2	1	PC
	Total Credits/Hrs		15	0	11	22	

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1		Elective - 8	3	0	0	3	DE/OE
2		Elective - 9	3	0	0	3	DE/OE
3	EE4092D	Project: Part II	0	0	9	6	PC
	Total Credits/Hrs		6	0	9	**12**	

List of Electives – VIIth&VIIIth Semesters

1. EE4021D Heuristic Methods for Optimization
2. EE4022D Optimal and Adaptive Control
3. EE4023D AC Drives
4. EE4024D Power System Stability and Control
5. EE4025D Computer Control of Industrial Processes
6. EE4026D Flexible AC Transmission
7. EE4027D Power System Operation and Control
8. EE4028D Non-linear System Analysis
9. EE4029D Analog MOS Circuits
10. EE4030D Energy Auditing, Conservation and Management
11. EE4031D Switched-mode Power Supplies
12. EE4032D Advanced DC – AC Power Conversion
13. EE4033D Bio-Signal Processing
14. EE4034D System Identification and Parameter Estimation
15. EE4035D Power System Reliability and Deregulation
16. EE4036D Power Quality
17. EE4037D Control & Guidance Engineering
18. EE4038D Power System Protection & Communication
19. EE4039D Switchgear and Protection
20. EE4040D Smart Grid Engineering
21. EE4041D Analog and Digital Communication

22. EE4042D Advanced Digital Signal Processing
23. EE4043D Static VAR Compensation and Harmonic Filtering
24. EE4044D Data Acquisition and Signal Conditioning

Notes:

1. For the successful completion of B. Tech programme, a student must complete the minimum number of courses of each category specified in the curriculum of the specific programme. In addition to the above, the student must have acquired a minimum of 160 credits.
2. Maximum credits that can be registered by a student of any semester is the normal credits of the concerned semester (as per the approved curriculum) plus the credits of one more course or 4 credits only.
3. A student who completes all the course requirements (except the project) before the final semester may be permitted to undertake project at an institute/industry outside with the consent of the department.
4. EED will offer the electives in even or odd semester or in both as per the requirement and availability of faculty.
5. A student at level-4 can credit electives listed at level-3. However, a student at level-3 cannot credit electives listed at level-4.

MA1001D MATHEMATICS I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

Students will be able to:

CO1: Find the limits, check for the continuity and differentiability of functions of a single variable as well as several variables.

CO2: Test for the convergence of sequences and series of numbers as well as functions.

CO3: Formulate different mensuration problems as multiple integrals and evaluate them.

CO4: Use techniques in vector differential calculus to solve problems related to curvature, surface normal and directional derivative.

CO5: Find the parametric representation of curves and surfaces in space and will be able to evaluate the integral of functions over curves and surfaces.

Module 1: (13 Lecture hours)

Real valued function of real variable: Limit, Continuity, Differentiability, Local maxima and local minima, Curve sketching, Mean value theorems, Higher order derivatives, Taylor's theorem, Integration, Area under the curve, Improper integrals.

Function of several variables: Limit, Continuity, Partial derivatives, Partial differentiation of composite functions, Differentiation under the integral sign, Local maxima and local minima, Saddle point, Taylor's theorem, Hessian, Method of Lagrange multipliers.

Module 2: (13 Lecture hours)

Numerical sequences, Cauchy sequence, Convergence, Numerical series, Convergence, Tests for convergence, Absolute convergence, Sequence and series of functions, point-wise and uniform convergence, Power series, Radius of convergence, Taylor series.

Double integral, Triple integral, Change of variables, Jacobian, Polar coordinates, Applications of multipleintegrals.

Module 3: (13 Lecture hours)

Parameterised curves in space, Arc length, Tangent and normal vectors, Curvature and torsion, Line integral, Gradient, Directional derivatives, Tangent plane and normal vector, Vector field, Divergence, Curl, Related identities, Scalar potential, Parameterised surface, Surface integral, Applications of surface integral, Integral theorems: Green's Theorem, Stokes' theorem, Gauss' divergence theorem, Applications of vector integrals.

References:

1. H. Anton, I. Bivensand S. Davis, Calculus, 10th edition, New York: John Wiley & Sons, 2015.
2. G. B. Thomas, M.D. Weirand J. Hass, Thomas' Calculus, 12th edition, New Delhi, India: Pearson Education, 2015.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New York: John Wiley & Sons, 2015.
4. Apostol, Calculus Vol 1, 1st ed. New Delhi: Wiley, 2014.

MA1002D MATHEMATICS II

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes

Students will be able to:

CO1: Test the consistency of system of linear equations and then solve it.
CO2: Test for linear independence of vectors and perform orthogonalisation of basis vectors.
CO3: Diagonalise symmetric matrices and use it to find the nature of quadratic forms.
CO4: Formulate some engineering problems as ODEs and hence solve them.
CO5: Use Laplace transform and its properties to solve differential equations and integral equations

Module 1: (16 Lecture hours)

System of Linear equations, Gauss elimination, Solution by LU decomposition, Determinant, Rank of a matrix, Linear independence, Consistency of linear system, General form of solution.
Vector spaces, Subspaces, Basis and dimension, Linear transformation, Rank-nullity theorem, Inner-product, Orthogonal set, Gram-Schmidt orthogonalisation, Matrix representation of linear transformation, Basis changing rule.
Types of matrices and their properties, Eigenvalue, Eigenvector, Eigenvalue problems, Cayley-Hamiltonian theorem and its applications, Similarity of matrices, Diagonalisation, Quadratic form, Reduction to canonical form.

Module 2: (13 Lecture hours)

Ordinary Differential Equations (ODE): Formation of ODE, Existence and uniqueness solution of first order ODE using examples, Methods of solutions of first order ODE, Applications of first order ODE.
Linear ODE: Homogenous equations, Fundamental system of solutions, Wronskian, Solution of second order non-homogeneous ODE with constant coefficients: Method of variation of parameters, Method of undetermined coefficients, Euler-Cauchy equations, Applications to engineering problems, System of linear ODEs with constant coefficients.

Module 3: (10 Lecture hours)

Gamma function, Beta function: Properties and evaluation of integrals.
Laplace transform, Necessary condition for existence, General properties, Inverse Laplace transform, Transforms of derivatives and integrals, Differentiation and Integration of transform, Unit-step function, Shifting theorems, Transforms of periodic functions, Convolution, Solution of differential equations and integral equations using Laplace transform.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New Delhi, India: Wiley, 2015.
2. G. Strang, Introduction to Linear Algebra, Wellesley MA: Cambridge Press, 2016.
3. R. P. Agarwal and D. O 'Regan, An Introduction to Ordinary Differential Equations, New York: Springer, 2008.
4. V. I. Arnold, Ordinary Differential Equations, New York: Springer, 2006.
5. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, New York: Springer,2014.

PH1001D PHYSICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
Students will be able to:

CO1: To enable students to apply relevant fundamental principles of modern physics to problems in engineering.

CO2: To develop knowledge of basic principles of Quantum Physics

CO3: Acquire knowledge of the basic physics of a collection of particles and the emergent macroscopic properties.

CO4: Apply principles of quantum and statistical physics to understand properties of materials

Module 1: (12 hours):
Particle nature of radiation – Photoelectric effect, Compton effect, Wave nature of matter – matter waves, wave packets description, phase and group velocity, uncertainty principle. Formulation of Schrödinger equation, physical meaning of wave function, expectation values, time-independent Schrödinger equation, quantization of energy for bound particles. Application of time-independent Schrödinger equation to free particle, infinite well, finite well, barrier potential, tunneling.

Module 2: (14 hours):
Simple Harmonic Oscillator, two-dimensional square box, the scanning tunneling microscope. Wave function for two or more particles, indistinguishable particles, symmetry and anti-symmetry under exchange of particles, Pauli's exclusion principle, electronic configurations of atoms. Quantum model of a solid – periodicity of potential and bands, E – k diagram, effective mass, band gap.

Module 3: (13 hours):
Microstates and macrostates of a system, equal probability hypothesis, Boltzman factor and distribution, ideal gas, equipartition of energy, Maxwell speed distribution, average speed, RMS speed, Quantum distributions - Bosons and Fermions, Bose-Einstein and Fermi-Dirac distribution, applications.

References:

1. Kenneth Krane, Modern Physics, 2nd Ed., Wiley (2009)
2. Arthur Beiser, Concepts of Modern Physics, 6th Ed., Tata Mc Graw –Hill Publication (2009)
3. Robert Eisberg and Robert Resnick, Quantum Physics of atoms, Molecules, Solids, Nuclei and Particle, 2nd Ed., John Wiley(2006)
4. David Halliday, Robert Resnick and Jearl Walker, Fundamentals of Physics, 6th Ed., Wiley (2004)

CY1001D CHEMISTRY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
Students will be able to:
CO1: Acquire knowledge about separation strategies, identification and characterization of molecules
CO2: Understand the causes and mechanism of corrosion and understand its prevention methods
CO3: Attain knowledge about electrochemical reactions and their current applications
CO4: Comprehend the principles of industrial catalytic processes and enzyme catalysis

Module 1: (14 hours)

Spectroscopy – General Principles, Infrared, group frequencies, Electronic spectroscopy of conjugated molecules, Woodward-Fieser Rule.
Chromatography – Retention and Separation factors, Theoretical plates, Instrumentation and uses of Gas Chromatography and High Performance Liquid Chromatography
Thermal analysis – Thermogravimetry, Differential Scanning Calorimetry and Differential Thermal Analysis

Module 2: (12 hours)

Electrochemical corrosion – Mechanisms, control and prevention.
Cyclic voltammetry, Switching potentials, Cathodic and anodic peak currents Potentiometry, Fuel cells – Types and applications
Liquid crystals – Phase types, uses in displays and thermography.

Module 3: (13 hours)

Catalysis – Homogeneous and heterogeneous catalysis, Organometallic compounds, 18-electron rule, Oxidative addition, Reductive elimination, insertion and Elimination reactions, Wilkinson's catalyst in alkene hydrogenation, Zeigler-Natta catalysis in polymerization of olefins.
Enzyme catalysis – Mechanisms, significance of Michaelis – Menten constant, Turnover number, Co-enzymes and cofactors

References:

1. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th edition, Tata McGraw Hill, New Delhi, 2010.
2. D. A. Skoog and D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, Brooks Cole, Florence, 2004.
3. H. H. Williard, L. L. Merrit, J. A. Dean and F. A. Settle, *Instrumental Methods of Analysis*, Wadsworth Publishing Company, Belmont, California, 1986.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry,* Vishal Publishing, New Delhi, 2000.
5. J. E. Huheey, E.A. Keiter and R.L. Keiter, *Inorganic Chemistry, Principles of Structure and Reactivity*, 4th Ed, Harper Collins College Publishers, New York, 1993.
6. C. Elschenbroich, *Organometallics*, 3rd edition, Wiley-VCH Verlag GmbH, Weinheim, 2006.

MS1001D PROFESSIONAL COMMUNICATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes
Students will be able to:

CO1: Distinguish the different types of meaning for constructive criticism, by developing a comprehensive understanding of the extensive vocabulary and usage in formal English language.
CO2: Learn and practice principles related to good formal writing.
CO3: Develop competence in group activities such as group discussions, debates, mock interviews, etc. by practicing the integration of unique qualities of nonverbal and verbal styles.
CO4: Deliver clear and effective presentation of ideas in the oral / written medium and to acquire the ability to modify it according to the target audience.

Module 1: (12 hours)

Role and importance of verbal communication, Everyday active vocabulary, Common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension- skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Two types of meaning- literal and contextual. Constructive criticism of speeches and explanations.

Module 2: (15 hours)

Fundamental grammar, Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open –ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships.

Module 3: (12 hours)

Kinesics, Proxemics, Haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same. Different types of interviews, and presentation- oral, poster, ppt. Organizing ideas for group discussions, the difference between GD and debates.

References:

1. Duck, Steve and David T. Macmahan. *Communication in Everyday Life*. 3rd Ed. Sage, 2017.
2. Quintanilla, Kelly M. and Shawn T. Wahl. *Business and Professional Communication*. Sage, 2016.
3. Gamble, Kawl Teri and Michael W. Gamble. *The Public Speaking Playbook*. Sage, 2015.
4. Tebeaux, Elizabeth and Sam Dragga. *The Essentials of Technical Communication*, 3rd Ed. OUP, 2015
5. Raman, Meenakshi and Sangeetha Sharma. *Technical Communication: Principles and Practice*, OUP, 2015
6. MacLennan, Jennifer. *Readings for Technical Communication*. OUP, 2007.

ZZ1001D ENGINEERING MECHANICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
Students will be able to:

CO1: Determine the resultants of a force system
CO2: Solve rigid body statics problems using equations of equilibrium and principle of virtual work
CO3: Perform kinematic analysis of a particle
CO4: Solve particle dynamics problems using Newton's laws, energy methods and momentum methods

Module 1: Basic Concepts (13 hours)

Introduction: idealizations of mechanics, vector and scalar quantities, equality and equivalence of vectors, laws of mechanics, elements of vector algebra.

Important vector quantities: position vector, moment of a force about a point, moment of a force about an axis, the couple and couple moment, couple moment as a free vector, moment of a couple about a line.

Equivalent force systems: translation of a force to a parallel position, resultant of a force system, simplest resultant of special force systems, distributed force systems, reduction of general force system to a wrench.

Module 2: Statics (13 hours)

Equations of equilibrium: free-body diagram, free bodies involving interior sections, general equations of equilibrium, problems of equilibrium, static indeterminacy.

Applications of equations of equilibrium: Trusses: solution of simple trusses using method of joints and method of sections; Friction forces: laws of Coulomb friction, simple contact friction problems; Cables and chains.

Properties of surfaces: first moment and centroid of plane area, second moments and product of area for a plane area, transfer theorems, rotation of axes, polar moment of area, principal axes.

Method of virtual work: principles of virtual work for rigid bodies and its applications.

Module 3: Dynamics (13 hours)

Kinematics of a particle: introduction, general notions, differentiation of a vector with respect to time, velocity and acceleration calculations in rectangular coordinates, velocity and acceleration in terms of path variables and cylindrical coordinates, simple kinematical relations and applications.

Dynamics of a particle: introduction, Newton's law for rectangular coordinates, rectilinear translation, Newton's law for cylindrical coordinates, Newton's law for path variables, energy and momentum methods: introduction, conservative force field, conservation of mechanical energy, alternative form of work-energy equation, impulse and momentum relations, moment-of-momentum equation.

References:

1. I. H. Shames, *Engineering Mechanics—Statics and Dynamics*, 4th Edition, Prentice Hall of India, 1996.
2. F.P. Beer and E.R. Johnston, *Vector Mechanics for Engineers – Statics,* McGraw Hill Book Company, 2000.
3. J.L. Meriam and L.G. Kraige, *Engineering Mechanics – Statics*, John Wiley & Sons, 2002.
4. R.C Hibbler, Engineering Mechanics—Statics and Dynamics, 11th Edition, Pearson, India, 2009

ZZ1002D ENGINEERING GRAPHICS

Pre-requisites: Nil

L	T	P	C
2	0	2	3

Total hours: 52

Course Outcomes:
Students will be able to:
CO1: Make use of the Indian Standard Code of Practice in Engineering Drawing.
CO2: Represent any engineering object by its orthographic views.
CO3: Convert orthographic views of an engineering object into its isometric view.
CO4: Enhance the capacity of visualization of engineering objects.

Module 1: (15 hours)

Introduction; drawing instruments and their uses; lines, lettering and dimensioning; geometrical construction; constructions of plain, diagonal and vernier scales; orthographic projection—first and third angle projections; orthographic projection of points on principal, profile, and auxiliary planes.

Module 2: (17 hours)

Orthographic projection of straight line in simple and oblique positions; application of orthographic projection of line; orthographic projection of planes in simple and oblique position on principal and profile planes; orthographic projection of lines and planes on auxiliary planes.

Module 3: (20 hours)

Orthographic projection of solids in simple and oblique positions on principal and profile planes; orthographic projections of solids in oblique position using auxiliary plane method; orthographic projection of spheres; orthographic projection of solids in section; development of surfaces of solids; method of isometric projection.

References:

1. N. D. Bhatt, Engineering Drawing, 53rd ed. Anand, India: Charotar Publishing House, 2016.
2. Basant Agrawal and C M Agrawal, Engineering Drawing, 2nd ed. New Delhi, India: McGraw Hill Education (India), 2014.

ZZ1003D BASIC ELECTRICAL SCIENCES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

Students will be able to:

CO1: Design simple resistive circuits for various applications in Electrical and Electronics engineering.

CO2: Design simple magnetic circuits and inductive components for signal and power processing.

CO3: Carry out design verification calculations, power and power loss calculations, voltage drop calculations etc. in single phase ac circuits.

CO4: Analyze Amplifiers and Digital Circuits in terms of critical parameters and complexity.

CO5: Design sub modules for systems/ Solutions for real life problems using suitable sensors/transducers, amplifiers, data converters and digital circuits

Module 1: (11 hours)

Analysis of Resistive Circuits:
v-i relationship for Independent Voltage and Current Sources
Solution of resistive circuits with independent sources- Node Voltage and Mesh Current Analysis, Nodal Conductance Matrix and Mesh Resistance Matrix and symmetry properties of these matrices
Source Transformation and Star-Delta / Delta-Star Conversions to reduce resistive networks
Circuit Theorems - Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.
Magnetic Circuits:
MMF, Magnetic Flux, Reluctance, Energy stored in a Magnetic Field, Solution of Magnetic Circuits.
Two Terminal Element Relationships:
Inductance - Faraday's Law of Electromagnetic Induction, Lenz's Law, Self and Mutual Inductance, Inductances in Series and Parallel, Mutual Flux and Leakage Flux, Coefficient of Coupling, Dot Convention, Cumulative and Differential Connection of Coupled Coils.
Capacitance – Electrostatics, Capacitance, Parallel Plate Capacitor, Capacitors in series and parallel, Energy stored in Electrostatic Field, v-i relationship for Inductance and Capacitance

Module 2: (9 hours)

Single Phase AC Circuits:
Alternating Quantities - Average Value, Effective Value, Form and Peak factors for square, triangle, trapezoidal and sinusoidal waveforms.
Phasor representation of sinusoidal quantities - phase difference, Addition and subtraction of sinusoids, Symbolic Representation: Cartesian, Polar and Exponential forms.
Analysis of a.c circuits - R, RL, RC, RLC circuits using phasor concept, Concept of impedance, admittance, conductance and susceptance.
Power in single phase circuits - instantaneous power, average power, active power, reactive power, apparent power, power factor, complex power, solution of series, parallel and series parallel a.c circuits.

Module 3 (11 hrs)

Sensors and Transducers:
principles of piezoelectric, photoelectric, thermoelectric transducers, thermistors, strain gauge, LVDT, etc, Measurement of temperature, pressure, velocity, flow, pH, liquid level, etc.
Basics of Signal Amplification:
(Explanation based on two port models is only envisaged) – voltage gain, current gain and power gain, amplifier saturation, types of amplifiers (voltage, current, transconductance and transresistance amplifiers) and relationship between these amplifier models, frequency response of amplifiers, single time constant networks.
Operational amplifier basics:
Ideal op-amp, inverting, noninverting, summing and difference amplifiers, integrator, differentiator.

Module 4 (8 hrs)
Digital Electronics:
Review of number systems and Boolean algebra, Logic Gates and Truth Tables, Simplification of Boolean functions using Karnaugh map (upto 4 variable K-maps), Implementation of Simple combinational circuits (Adder, Code Converters, 7-Segment Drivers, Comparators, Priority Encoders, etc) - MUX-based implementation of combinatorial circuits , Sequential circuits: SR,JK, T and D filpflops, counters and registers using D flip flops, Basics of data converters (at least one ADC and DAC).

References:

1. J.W. Nilsson and S.A. Riedel, *Electric Circuits*, 8th ed., Pearson, 2002
2. K.S. Suresh Kumar, *Electric Circuits & Networks*, Pearson Education, 2009
3. C. A. Desoer and E. S. Kuh, *Basic Circuit Theory*, McGraw Hill, 2009
4. J. A. Edminister, *Electric Circuit Theory*, Schaum's Outline series: 6th ed., McGraw Hill, 2014
5. A. D. Helfrick and W. D. Cooper, *Modern Electronic Instrumentation and Measurement Techniques*, Prentice Hall of India, 2003
6. A. S. Sedra and K. C. Smith, *Microelectronics*, 6thed.,Oxford University Press, 2013
7. C. H. Roth and L. L. Kinney, *Fundamentals of Logic Design*,7thed., Cengage Learning,2014

ZZ1004D Computer Programming

Pre-requisites: Nil.

L	T	P	C
2	0	0	2

Total hours: 26

Course Outcomes:
Students will be able to:

CO1: Design of algorithms for simple computational problems.
CO2: Express algorithmic solutions in the C programming language.

Module 1: (10 hours)
Data Types, Operators and Expressions: Variables and constants - declarations - arithmetic and logical operators – Assignment operator – Input/Output.
Control Flow: Statements and blocks – if-else, switch, while, for and do-while statements – break and continue – goto and labels.

Module 2: (08 hours)
Functions and Program structure: Basics of functions, Parameter passing – scope rules – recursion.

Module 3: (08 hours)
Aggregate data types: Single and multidimensional arrays, structures and unions – Pointers to arrays and structures – passing arrays and pointers as arguments to functions.

References:
1. B.S. Gottfried, *Programming with C (Schaum's Outline Series)*, 2nd ed. McGraw-Hill,1996.
2. B. W. Kernighan and D. M. Ritchie, *The C Programming Language*, 2nd ed. Prentice Hall, 1988.
3. W. Kernighan, *The Practice of Programming*, Addison-Wesley, 1999.

PH1091D PHYSICS LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

Course Outcomes:
Students will be able to:

CO1: To develop experimentation skills and understand importance of measurement practices in Science & Technology.
CO2: Develop analytical skills for interpreting data and drawing inferences.
CO3: Estimate the nature of experimental errors and practical means to obtain errors in acquired data.
CO4: Develop skills for team work and technical communication and discussions.
CO5: Apply theoretical principles of modern physics to analysis and measurements performed in the laboratory.

LIST OF EXPERIMENTS

1. Magnetic Hysteresis loss - Using CRO
2. Band gap using four probe method
3. Hall effect- determination of carrier density, Hall coefficient and mobility
4. Solar cell characteristics
5. Double refraction – measurement of principle refractive indices.
6. Measurement of N.A & Attenuation
7. Measurement of e/m of electron – Thomson's experiment
8. Determination of Planck's constant
9. Measurement of electron charge – Millikan oil drop experiment
10. Determination of magnetic field along the axis of the coil
11. Newton's rings
12. Laurent's Half shade polarimeter –determination of specific rotatory power
13. Study of P-N junction
14. Study of voltage-current characteristics of a Zener diode.
15. Laser – measurement of angle of divergence & determination of λ using grating
16. Measurement of magnetic susceptibility- Quincke's Method / Gouy's balance.
17. Mapping of magnetic field
18. Temperature measurement by using thermocouple

NOTE: Any 8 experiments have to be done.

References:

1. A.C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press (2003)
2. Avadhanulu, Dani and Pokley, Experiments in Engineering physics, S. Chand & Company ltd (2002).
3. S.L. Gupta and V. Kumar, Practical physics, Pragathi Prakash (2005)

CY1094D CHEMISTRY LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

Course Outcomes:
Students will be able to:
CO1: Acquire practical knowledge on the separation of mixtures and their identification
CO2: Understand chirality and the specific rotation of a compound
CO3: Attain practical experience in the synthesis of new molecules
CO4: Apply different techniques to quantitatively determine the amount of components

List of Experiments:

1. Determination of specific rotation by polarimetry
2. Potentiometric titrations
3. Estimation of ions using complexometry
4. Determination of strength of an acid using pH meter
5. Analysis of organic and inorganic compounds
6. Conductometric titrations using acid or mixture of acids
7. Separation of compounds using chromatography
8. Colorimetric estimations
9. Determine the eutectic temperature and composition of a solid two component system
10. Synthesis of organic/inorganic compounds and their characterizations
11. Determination of molecular weight of polymers

Note: Selected experiments from the above list will be conducted

References:

1. G. H. Jeffery, J. Bassett, J. Mendham and R.C. Denny, *Vogel's Text Book of Quantitative Chemical Analysis*, Longmann Scientific and Technical, John Wiley, New York,1989.
2. A. I. Vogel, *Elementary Practical Organic Chemistry – Small Scale Preparations*, Pearson India, New Delhi, 2011.
3. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and P. W. G. Smith, *Vogel's Text Book of Practical Organic Chemistr*y, Longman and Scientific Technical, New York, 1989.

ZZ1091D WORKSHOP I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

Students will be able to:

CO1: Perform experiments to ascertain the quality requirements and quality testing procedures of selected building material, viz., cement, fine aggregate, coarse aggregate, concrete, timber and steel.

CO2: Identify and evaluate various driver characteristics as driver of a vehicle.

CO3: Acquire knowledge about basic civil engineering practices of brick masonry, plumbing and surveying.

CO4: Perform wiring estimation and costing for simple building/commercial electrical wiring systems.

CO5: Use commonly employed wiring tools and lighting and wiring accessories.

CO6: Adopt electrical safety measures in using and servicing household appliances.

Civil Engineering Workshop (24 hours)

1. Introduction to Surveying – Linear measurements – Hands on session on Setting out of a small residential building.
2. Introduction to Levelling – Hands on sessions using Dumpy level – Levelling exercise.
3. Introduction to Total Station – Hands on sessions - small exercises.
4. Tests on cement and aggregates: Demonstration of standard consistency, initial and final setting time of cement - Hands on sessions - Compressive strength test on cement mortar cubes and sieve analysis for coarse and fine aggregates.
5. Tests on hardened concrete, brick, timber and steel: Demonstrations on hardness tests (Rockwell hardness), impact tests (Charpy and Izod) on steel specimens-demonstration on properties of timber – Hands on sessions - Compression test on concrete cubes, bricks and tension test on mild steel specimen.
6. Masonry: Hands on sessions - English bond, Flemish bond – wall junction – one brick – one and a half brick - Arch construction.
7. Water supply and sanitation: Study of water supply pipe fittings – tap connections – sanitary fittings
8. Various tests on Driver characteristics – Visual acuity and colour blindness, peripheral vision, depth perception, driver reaction time.

Electrical Engineering Workshop (15 hours)

1. (a) Familiarization of wiring tools, lighting and wiring accessories, various types of wiring systems.
   (b) Wiring of one lamp controlled by one switch.
2. (a) Study of Electric shock phenomenon, precautions, preventions, Earthing.
   (b) Wiring of one lamp controlled by two SPDT Switches and one 3 pin plug socket independently.
3. (a) Familiarization of various types of Fuses, MCBs, ELCBs, etc.
   (b) Wiring of fluorescent lamp controlled by one switch with ELCB & MCB.
4. (a) Study of estimation and costing of wiring.
   (b) Wiring, control and maintenance of domestic appliances like Mixer machine, Electric Iron, fan, motor, etc.

References

1. T.P. Kanetkar, S.V. Kulkarni, *Surveying and Levelling - Part1*, Pune Vidyarthi Griha Prakashan, Pune, 1994.
2. B.C. Punmia, *Building Construction*, Laxmi Publications, New Delhi1999.
3. Satheesh Gopi, R. Sathikumar, N. Madh, *Advnaced Surveying*, Pearson Education,2007.
4. M.S. Shetty, *Concrete Technology*, S. Chand & Company, New Delhi,2005.

5. K. B. Raina & S. K. Bhattacharya, *Electrical Design Estimating and costing*, New Age International Publishers, New Delhi, 2005.
6. Khanna, S. K., and Justo, C. E. G., *Highway Engineering*, Nemchand and Bros, Roorkee,2001.
7. Uppal S. L., *Electrical Wiring & Estimating*, Khanna Publishers---5th edition, 2003.
8. John H. Watt, *Terrell Croft American Electricians' Handbook: A Reference Book for the Practical Electrical Man*, 9th ed. McGraw-Hill, 2002.

ZZ1092D WORKSHOP II

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

Students will be able to:

CO1: Ability to select suitable material for a given purpose applying knowledge of material properties and processing.

CO2: Ability to use measuring devices like Vernier Calipers, Micrometers, etc.

CO3: Ability to fabricate simple components using basic manufacturing processes like Casting, Forming, Joining and Machining.

CO4: Ability to sequence various operations so as to execute the task within minimum time.

CO5: Perform diagnostic measurements using analog and digital meters for troubleshooting electronic systems.

CO6: Select appropriate electronic components for a given design task and assemble the prototype on breadboard.

CO7: Troubleshoot electronic boards used in various household appliances.

CO8: Perform cost estimation and costing of PCB soldering and carry out the soldering.

Mechanical Engineering Workshop (24 hours)

The course is intended to expose the student to various manufacturing processes through hands on training in different sections of Central Workshop. During the course, the student learns the properties and selection of different materials and acquires the skill in using various tools and measuring devices.

1. Carpentry: Study of tools and joints – plaining, chiseling, marking and sawing practice, one typical joint- Tee halving/Mortise and Tenon/ Dovetail
2. Fitting: Study of tools- chipping, filing, cutting, drilling, tapping, about male and female joints, stepped joints. Edge preparation for single V joint.
3. Welding: Study of arc and gas welding, accessories, joint preparation. Welding of a single V joint
4. Smithy: Study of tools. Forging of square or hexagonal prism/chisel/bolt
5. Foundry: Study of tools, sand preparation. Moulding practice using the given pattern.
6. Sheet Metal: Study of tools, selection of different gauge sheets, types of joints. Fabrication of a tray or a funnel
7. Machine Shop: Study of the basic lathe operations. Simple step turning exercise.

Electronics Engineering Workshop (15 hours)

1. (a) Familiarization of electronic components, colour code, multimeters.
   (b) Bread board assembling-Common emitter amplifier.
2. (a) Study of soldering components, solders, tools, heat sink.
   (b) Bread board assembling-phase shift oscillator.
3. (a) Soldering practice-Common emitter amplifier.
   (b) Soldering practice-Inverting amplifier circuit.
4. (a) Study of estimation and costing of soldering PCB, 3 phase connections.
   (b) PCB wiring and fault Identification of appliances like Electronic Ballast, fan regulator, inverter, UPS, etc.

References

1. W. A. J. Chapman, Workshop Technology - Parts 1 & 2, 4th ed. New Delhi, India, CBS Publishers & Distributors Pvt. Ltd., 2007.
2. Welding Handbook. 9th ed. Miami, American Welding Society, 2001.

3. J. Anderson, Shop Theory, New Delhi, India, Tata McGraw Hill, 2002.
4. J. H. Douglass, Wood Working with Machines, Illinois, McKnight & McKnight Pub. Co., 1995.
5. W.A. Tuplin, Modern Engineering Workshop Practice, Odhams Press, 1996.
6. P. L. Jain, Principles of Foundry Technology, 5th ed. New Delhi, India, Tata McGraw Hill, 2009.
7. John H. Watt, Terrell Croft, American Electricians' Handbook: A Reference Book for the Practical Electrical Man, 9th ed. McGraw-Hill, 2002.
8. G. Randy Slone, Tab Electronics Guide to Understanding Electricity and Electronics, 2nd ed. McGraw-Hill, 2000.
9. Jerry C Whitaker, The Resource Handbook of Electronics, CRC Press-2001.

ZZ1093D PHYSICAL EDUCATION

L	T	P	C
1	0	1	1

Course Outcomes:

CO1: Select a game/ activity of his/ her choice to pursue on the campus to enjoy/ entertain and thereby develop good health and fitness which he/she would carry over to post-campus life for maintaining health, fitness and wellness.
CO2: Be more proficient in a game, which may lead him/her to a berth in the institute teams.
CO3: Gain exposure to professional training, so as to enable him / her to excel in sports activities.
CO4: Participate in intramural and open mass participation activities.
CO5: Participate and organise in-campus or off-campus sports activities.

Unit I - Introduction, definition, aims & objectives of Physical Education. Health, Physical fitness and wellness. Importance, scope and relevance of Physical Education in NITC curriculum.

Unit II - Physical fitness and components. Health related Physical fitness and components. Benefits of exercise – physical and physiological.

Unit III - Physical exercise and its principles. Activities for developing physical fitness – walking, jogging, running, weight training, stretching, yogasanas. Athletic injuries and their management. Nutritional balance.

Unit IV - Motivation and its importance in sports. Stress, anxiety, tension, aggression in sports. Personality, self-confidence and performance. Team cohesion and leadership in sports.

Unit V - Lifestyle diseases and its management, Diabetes and Obesity, Hypertension, Osteoporosis Coronary heart diseases and cholesterol. Backpain, Postural deformities and their remedies.

Unit VI. - Olympic Values Education. Event & Crisis management.

References

1. Najeeb, A. M., Atul, M., Sumesh, D. and Akhilesh, E. (2015), “Fitness Capsule for university curriculum”.

ZZ1094D VALUE EDUCATION

L	T	P	C
1	0	1	1

Course Outcomes:

CO1: Identify the purpose of education and the problems faced by mankind, in terms of socio economic and environmental issues.
CO2: Describe the social and intellectual needs to transform the society to a better one where everyone meets the basic economic and social security, freedom and atmosphere to live a meaningful life.
CO3: Practise a meaningful life avoiding all kinds of corrupt practices and develop unconditional love, universal brotherhood and simulate international peace and prosperity.
CO4: Persuade others to practise a righteous life, which would stimulate a synergy of universal harmony and peace.
CO5: Create an ideal society where everyone enjoys the fruits of love, peace and harmony.

Unit I (3 hours): Social Justice Definition –need-parameters of social justice –factors responsible for social injustice –caste and gender –contributions of social reformers.
Unit II (5 hours): Human Rights and Marginalized People Concept of Human Rights-Principles of human rights-human rights and Indian Constitution-Rights of Women and children-violence against women –Rights of marginalized People-like women, children, dalits, minorities, physically challenged etc.
Unit III (5 hours): Social Issues and Communal Harmony Social issues–causes and magnitude-alcoholism, drug addiction, poverty, unemployment etc.-communal harmony-concept-religion and its place in public in public domain-separation of religion from politics-secularism role of civil society.

Unit IV (5 hours): Media Education and Globalized World Scenario Mass media-functions-characteristics-need and purpose of media literacy-effects and influence –youth and children-media power-socio cultural and political consequences mass mediated culture-consumerist culture-Globalization-new media –prospects and challenges-Environmental ethics

Unit V (2 hours): Values and Ethics Personal values –family values-social values-cultural values-professional values-and overall ethics-duties and responsibilities

Project: 10 hours

References

1. Sharma, B. K. (2010), 'Human Rights Covenants and Indian Law', PHI Learning Pvt. Ltd.
2. Law Commission of India, (1971), 'Indian Penal code', (http://lawcommissionofindia.nic.in/1-50/report42.pdf), accessed on February 14, 2018.
3. Srivastava, S. S. (2017), 'Central Law Agency's Indian Penal Code along with General Principles (IPC)', Central Law Agency.
4. 'Gandhiji on Communal Harmony', (2003), Mani Bhavan Gandhi Sangrahalaya', Mumbai.
5. 'Social Impact of Drug Abuse', UNDCP, ((https://www.unodc.org/pdf/technical_series_1995-03-01_1.pdf, accessed on February 14, 2018).
6. Bryfonski, D. (2012), 'The Global Impact of Social Media', Green Heaven Publications.
7. Schmidtz, D. & Willott, E. (2012), 'Environmental Ethics: What Really Matters, What Really Works', Oxford University Press.
8. Ranganathanda, S. (1987), 'Eternal Values for a Changing Society: Education for human excellence', Bharatiya Vidya Bhavan.
9. Rokeach, M. (1979), 'Understanding human values: Individual and Societal', The New Free Press.

ZZ1095D NSS

L	T	P	C
0	0	3	1

Course Outcomes:

CO1: Acquire awareness in social and environmental issues thereby improving social consciousness and commitment towards the community.

CO2: Participate in socially relevant activities that are aimed at betterment of the campus and the society, thereby instilling a helpful attitude

CO3: Develop a positive attitude towards dignity of labour, self-help and the need for combining physical work with intellectual pursuits.

CO4: Improve inter-personal skills and contribute to nation building by serving the local community, thereby promoting a healthy and positive attitude towards life.

NSS activities have been divided in two major groups. These are Regular NSS Activities and Special Camping programme.

(a) Regular NSS Activity: NSS volunteers undertake various activities in adopted villages and slums for community service. The NSS units organise the regular activities as detailed below:

i) Orientation of NSS volunteers: To get the NSS volunteers acquainted with the basics of NSS programmes, for their orientation through lectures, discussions, field visits, audio-visuals etc.

ii) Campus Work: The NSS volunteers may be involved in the projects undertaken for the benefit of the institution and students concerned. Such projects cover maintenance of public properties, tree plantation, waste management and Swach Bharat activities, conservation of water and energy sources, social audits, awareness programmes on drug-abuse, AIDS, population education, and other projects

iii) Community service will be in adopted villages/urban slums independently or in collaboration with others in this field.

iv) Institutional work: The students may be placed with selected voluntary organisations working for the welfare of women, children, aged and disabled outside the campus.

v) Rural Project: The rural projects generally include the working of NSS volunteers in adopted villages for e-governance and digital literacy, watershed management and wasteland development, rainwater harvesting, agricultural operations, health, nutrition, hygiene, sanitation, mother and child care, gender equality sensitization programmes, family life education, gender justice, development of rural cooperatives, savings drives, construction of rural roads, campaign against social evils etc.

vi) Urban Projects: In addition to rural projects other include adult education, welfare of slum dwellers, work in hospitals, orphanages, destitute home, environment enrichment, population education, drug, AIDS awareness, and income generation,

vii) National Days and Celebrations: The National Service Scheme programmes also include the celebration of National days. The purpose of such a provision is to celebrate such occasions in a befitting manner,

viii) Blood Donation Activities,

ix) Campus farming activities,

x) Activities for social inclusion such as organizing programmes for differently – abled children.

Students shall volunteer and contribute to the activities of the National Service Scheme for a minimum duration of 45 hours for the award of credit.

(b) Special Camping Programme: Under this, camps of 7 days' duration are organised during vacations with some specific projects by involving local communities. 50% NSS volunteers are expected to participate in these camps.

MA2001D MATHEMATICS III

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Handle application problems involving random variables and functions of random variables.
CO2: Identify statistical problems and make use of statistical inference while handling stochastic systems.
CO3: Apply regression and correlation analysis for studying relationship between variables.
CO4: Identify situations where analysis of variance is appropriate and apply it.
CO5: Use probabilistic and statistical analysis in various applications of engineering.

Module 1: (15 hours)

Probability distributions, Random variables, Expectation of a function of a random variable, Mean, Variance and Moment generating function of a probability distribution, Chebyshev's theorem, Binomial distribution, Poisson distribution, Geometric distribution, Hyper- geometric distribution, Normal Distribution, Uniform distribution, Gamma distribution, Beta distribution and Weibull distribution. Transformation of a random variable, Probability distribution of a function of a random variable, Jointly distributed random variables, Marginal and conditional distributions, Bi-variate Normal distribution, Joint probability distribution of functions of random variables**.**

Module 2: (14 hours)

Population and samples, The sampling distribution of the mean (σ known and σ unknown), Sampling distribution of the variance, Point estimation, Maximum likelihood estimation, Method of moments, Interval estimation, Point estimation and interval estimation of mean and variance. Tests of hypothesis, Hypothesis tests concerning one mean and two means. Hypothesis tests concerning one variance and two variances, Estimation of proportions, Hypothesis tests concerning one proportion and several proportions, Analysis of $r \times c$ contingency tables, Chi – square test for goodness of fit.

Module 3: (10 hours)

Analysis of variance, General principles, Completely randomized designs, Randomized block design. Curve fitting, Method of least squares, Estimation of simple regression models and hypotheses concerning regression coefficients, Correlation coefficient- Estimation of correlation coefficient, Hypothesis concerning correlation coefficient. Estimation of curvilinear regression models.

References:

1. R. A. Johnson, Miller and Freund's, *Probability and Statistics for Engineers*, 8th ed, PHI New Delhi, 2011.
2. W. W. Hines, D. C. Montgomery, D. M. Goldsman and C. M. Borror*, Probability and Statistics in Engineering*, 4th ed, John Wiley & Sons Inc., 2003.
3. S. M. Ross, *Introduction to Probability and statistics for Engineers and Scientists*, 5th ed., Academic Press (Elsevier) New Delhi, 2014.

EE2001D CIRCUITS & NETWORKS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Perform design validation of electronic amplifiers and such two-port systems by applying two-port network modeling.

CO2: Perform design verification calculations for voltage-drop, current loading, power and efficiency in three-phase transmission and distribution systems, three-phase generation and utilization equipment etc.

CO3: Design simple first-order and second-order circuits for basic signal processing applications from given transfer function or impulse response.

CO4: Conduct design evaluation/verification of pulse transformers, potential transformers and current transformers.

CO5: Design simple first-order and second-order RC, RL and RLC circuits to perform basic signal processing tasks like averaging, filtering, signal coupling, signal bypassing, supply decoupling, current smoothing, tuned filtering etc., employing frequency response approach.

Module 1: Analysis of Circuits with Dependent Sources (9 hours)

Circuits with Linear Dependent Sources: VCVS, VCCS, CCVS and CCCS - node analysis and mesh analysis of circuits containing resistors, independent sources and linear dependent sources - effect of dependent sources on the symmetry of nodal admittance matrix and mesh impedance matrix - determination of Thevenin's and Norton's equivalent for circuits containing dependent sources.

Two Port Networks: Two port networks-characterization in terms of impedance, admittance, hybrid and transmission parameters - inter relationships among parameter sets - Reciprocity Theorem-Interconnection of Two port networks: Series, Parallel and Cascade - Input impedance, output impedance and gain of terminated two-ports in terms of two-port parameters and termination impedance – Application of y, z, g and h parameters in the analysis of negative feedback systems – Application of *ABCD* parameters in the power frequency analysis of transmission lines – T and Π models for a line.

Module 2: Steady-state Analysis of Three-phase Balanced and Unbalanced Circuits (10 hours)

Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem for a.c circuits - Polyphase working - 3 phase a.c systems - balanced system - phase sequence - Star Delta Transformation Theorem - Balanced 3 phase a.c source supplying balanced 3 phase star connected and delta connected loads - 3 wire and 4 wire systems - neutral shift - neutral current.

Power in three phase circuits: active power, reactive power, complex power, apparent power and power factor in balanced and unbalanced three phase systems.

Steady-state analysis of three-phase balanced loads excited by three-phase unbalanced sources – symmetrical transformation – sequence components – sequence impedances – sequence decoupling – power in sequence components.

Dependent source equivalent circuits for coupled coils – ac steady-state analysis of circuits containing coupled coils – the perfectly coupled two-winding transformer and the ideal two-winding transformer.

Module 3: Circuit Analysis in Time-domain and *s*-domain (10 hours)

*Time Domain Analysis of Circuits***:** Solution of multi-mesh and multi-node circuits (containing RLCM and linear dependent sources) by differential equation method - Determination of initial conditions – Obtaining step response and ramp response of circuits from impulse response

[*Review of Laplace Transforms* **-** Laplace Transform - Transform Pairs-Gate Functions-Shifting Theorem - Solution of Differential Equations by Laplace Transforms - Initial and Final Value Theorems – Laplace Transforms of periodic signals-Inversion of transforms by partial fractions - Convolution Theorem and Convolution Integral. *(Review to be done by students. No class hour will be spent for this review. Home assignments will be given.)*]

s-domain Analysis of Circuits - Transformed equivalent of inductance, capacitance and mutual inductance -Impedance and admittance in the transform domain – concept of the transformed circuit in *s*-domain –

Node Analysis and Mesh Analysis of the transformed circuit - Nodal Admittance Matrix and Mesh Impedance Matrix in the s-domain

Solution of transformed circuits with mutual inductance – step response of an ideal transformer – step response of a non-ideal transformer – flux expulsion by short circuited winding – instantaneous change in current in coupled coil systems.

Generalization of Circuit theorems – Input and transfer immittance functions - Transfer functions - Impulse response and Transfer function - Poles and Zeros - Pole Zero plots – Stability and poles

Module 4: Sinusoidal Steady - State Frequency Response and Fourier Analysis (10 hours)

Sinusoidal steady - state and frequency response function – frequency response function as a complex function of ω as evaluated from phasor equivalent circuit - frequency response function from s-domain transfer and immittance functions - explanation for substituting $s = j\omega$ in s-domain transfer function to get frequency response function – Properties of frequency response function of LTI circuits.

Frequency response of first order circuits – concept of cut-off frequencies and bandwidth – Series and parallel RC circuits as an averaging filter (for current signal and voltage signal), low-pass filter, high-pass filter, integrator, differentiator, signal coupling circuit, signal bypassing circuit etc.

Graphical evaluation of frequency response function from pole-zero plots : introduction to filtering and illustration of graphical evaluation of frequency response function from pole-zero plots in the case of standard second order filter functions using Series RLC and Parallel RLC Circuits – frequency response specifications for second order functions – correlation between time-domain specs and freq-domain specs in the case of first order and second order circuits.

Frequency response and bandwidth of cascaded first order circuits with interaction between stages and without interaction between stages.

Fourier Series representation of non-sinusoidal periodic waveforms : [*(revision)* - Fourier Coefficients-Determination of Coefficients-Waveform Symmetry-Exponential Fourier Series - Discrete Amplitude and Phase Spectra - *(Review to be done by students. No class hour will be spent for this review. Home assignments will be given.)*]

Steady State Solution of Circuits with non-sinusoidal periodic inputs: by Fourier Series and frequency response function, power and rms value of non-sinusoidal waveforms, Discrete Power Spectrum, THD measure for waveforms. – Application of tuned series LC and parallel LC structures in Power Systems – Application of parallel RLC circuit in Communication circuits – Application of LC circuits in power supply filtering – Application of RLC circuit in power supply decoupling.

References:

1. K. S. S. Kumar, *Electric Circuits and Networks*, Pearson Education, New Delhi, 2009.
2. M. E. Van Valkenburg, *Network Analysis*, 3rd ed, PHI, 2010.
3. W. H. Hayt, J. E. Kemmerly, *Engineering Circuit Analysis*, 6th ed., Mcgraw- Hill, 2012.
4. John D. Ryder, *Networks, Lines and Field*s , 2nd ed, Prentice-Hall India, 1989.
5. K. V. V. Murthy, M.S. Kamath, *Basic Circuit Analysis*, Tata McGraw-Hill, 1989.
6. C. A. Desoer, E. S. Kuh, *Basic Circuit Theory*, McGraw-Hill, New York, 1969.

EE2003D LOGIC DESIGN

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Formulate Combinational Logic Problems and perform Logic Optimization
CO2: Design combinational logic applications using standard SSI and MSI gates and state of the art MUX, ROM, PLA and PAL units
CO3: Perform design verification/validation of synchronous and asynchronous sequential circuit designs.
CO4: Design synchronous and asynchronous sequential circuits for simple applications

Module 1: Combinational Logic Design (10 hours)

Review of topics covered in Module 4 of ZZ1003 Basic Electric Sciences:

Boolean functions : - canonical and standard forms - simplification of Boolean functions by Karnaugh map up to five variable map - NAND, NOR, EX-OR & EX-NOR implementation - multi level NAND circuits - multi level NOR circuits
Binary Number Operations: Binary representations, Binary Arithmetic, Binary codes, Octal and Hexadecimal codes
MSI and LSI Combinational circuits and their applications: Arithmetic Circuits, Comparators and parity generators, multiplexers and demultiplexers, decoders and encoders AND-OR-INVERT gates, Wired logic, Tri-State Bus systems
Combinational circuit design using Multiplexer
Practical aspects: Fan-in and Fan-out, propagation delay, glitches

Module 2: Introduction to Sequential circuits (10 Hours)

Need for sequential circuits, basic architectural difference between combinational and sequential logic, concept of memory, the binary cell, switch debouncing using binary cell,
Asynchronous versus synchronous sequential machines, basics of sequential machine operation, classification of sequential machines
Latches and flip-flops (RS, JK, D, T and Master Slave) - Design of a clocked flip-flop – Flip-flop conversion – clocks and oscillators –
Practical clocking aspects concerning flip-flops – timing and triggering considerations – clock skew
Shift registers – parallel & serial, serial transfer – universal shift register- study of IC-74LS95 and IC-74LS195
Counters: - Binary Ripple Counter, Binary Synchronous UP/DOWN Counter, Binary Counter with Parallel Load, BCD Counters, Modulo-n counters, Ring Counter, Johnson Counter – cascading of counters – study of ICs 74LS90, 74LS93, 74192, 74193

Module 3: Analysis and Design of Sequential Circuits (10 Hours)

General model of sequential networks - State diagrams – Analysis and design of Synchronous sequential Finite State Machine – Exact State reduction – State reduction with don't cares -Minimization and design of the next state decoder.
Design of counters with arbitrary count sequence and unused states, design of sequence detectors.
Asynchronous sequential logic: Analysis and Design – Race conditions and Cycles – Hazards in combinational circuits – Hazard free realization.
Practical design aspects: Timing and triggering considerations in the design of synchronous circuits – Set up time - Hold time – Clock skew - Static timing analysis - Dynamic analysis.

Module 4: Memory and Programmable Logic (9 Hours)

Random Access Memory, Memory decoding, Error detection and correction, Read-Only Memory, ROMs PROMs and applications, PLA, PAL -Combinational circuit implementation using ROM, PAL and PLA – Introduction to Sequential Programmable Devices.

References:

1. M. M. Mano and M. D. Ciletti, *Digital Design*, 5th ed., Pearson, 2013.
2. C. E. Strangio, *Digital Electronics : Fundamental Concepts and Applications*, PHI, 1987.
3. C. H. Roth, *Fundamentals of Logic Design*, 4th ed., Jaico Publishers, 2006.
4. W. I. Fletcher, *An Engineering Approach to Digital Design*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1980.
5. R. J. Tocci, and N. S. Widmer, Digital *Systems - Principles and Applications*, 8th ed., Prentice Hall, 2010.
6. J. F. Wakerly, *Digital Design: Principles and Practices*, 3rd ed.,Prentice-Hall, 1999
7. D.D. Givone, *Digital Principles and Design*, Tata McGraw-Hill, 2003
8. R. Katz, *Contemporary Logic Design,* Addison Wesley, 1993.
9. D. Lewin and D. Protheroe, *Design of Logic Systems*, 2nd ed., Chapman & Hall, University and Professional Division, 1992.
10. T. L. Floyd, *Digital Fundamentals*, 9th ed., Prentice Hall, 2006.

EE2005D ELECTRICAL MEASUREMENTS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Perform the measurement of various electrical engineering parameters like voltage, current, power, energy etc in industry as well as in power generation, transmission and distribution sectors.

CO2: Analyze and solve varieties of problems and issues coming up in the vast field of electrical measurements and design the measuring instruments of new generation needed for industry and R and D organizations by implementing latest scientific inventions and technologies.

CO3: Propose and create innovative ideas to improve the existing technology and methodology in the field of measurements in terms of accuracy, cost, durability and user friendliness rising to the level of societal needs.

Module 1: Indicating Instruments (10 hours)

Concepts of measurement- static and dynamic characteristics of instruments-definitions relating to measuring instruments –errors in measurement- calibration- –classification and selection of instruments-essential features of indication instruments- Galvanometers-analog volt meters, ammeters and Ohm meters- moving coil instruments-principle, construction and working- moving iron instruments-principle construction and working –hot wire instruments-thermo couple instruments- electrostatic volt meter

Module 2: Measurement of Power and Energy (10 hours)

Measurement of power- power in DC and AC circuits-Dynamometer type watt meters-principle. Construction and working – errors and calibration –measurement of power in single phase without watt meters and with watt meter- measurement of power in three phase balanced and un balanced systems-Blondel's theorem-measurement of reactive volt amperes- Dynamo meter type watt meter- principle construction and working – induction type single phase energy meters-errors, compensation and adjustments-testing of energy meters- phantom loading –measurement of kVA.

Module 3: Measurement of Resistance and Inductance (10 hours)

Potentiometers- - slide wire potentiometer-direct reading potentiometer-Crompton potentiometer-measurement of emf, current and resistance using DC potentiometer-calibration of volt meter, ammeter and watt meter- AC potentiometer- measurement of self inductance – Wheatstone bridge – Kelvin double bridge-measurement of low, medium and high resistances-location of cable faults- Murray loop test-Varley loop test- Megger and insulation test

Module 4: Capacitance measurement, Magnetic measurements and Photometry (9 hours)

AC bridges- Maxwell bridge-Hay bridge-Schering bridge-Wein bridge-Wgner earthling device – Ballistic galvanometer and flux meter-magnetic measurements-BH curve and BH loop-Lloyd-Fischer square-potential and current transformer- Photometry and illumination- units and standards- Lummer-Brodhun photo meter head-determination of MHI and MSI-

References:

1. Golding E.W *Electrical Measurements & Measuring Instruments*, 5th ed., Reem Publications,2009.
2. Cooper W.D, *Modern Electronics Instrumentation*, PHI, 1996.
3. Stout M.B, *Basic Electrical Measurements*, Prentice Hall, 1986.
4. Oliver & Cage, *Electronic Measurements & Instrumentation*, McGraw Hill, 1979.
5. Sawhney A. K., *Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai & Co.,2007

EE2007D BASIC ELECTRONIC CIRCUITS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Design biasing circuits as per specification for BJTs, JFETs and MOSFETs
CO2: Design single-stage and multi-stage amplification systems with specified mid-band performance and specified frequency response using BJTs, JFETs and MOSFETs.
CO3: Design simple Class B and Class AB power stages using BJTs.
CO4: Conduct performance evaluation of prototype amplifier designs by small signal analysis procedure.
CO5: Perform comparative evaluation of various standard logic families in simple digital circuits with power supply current, propagation delay, rise and fall times etc., as basis of comparison.

Module 1: Semiconductors Devices and Small Signal Models (9 hours)

Revision of principles of operation of diodes and bipolar junction transistors - transition capacitance of a diode - minority carrier storage-diffusion capacitance-breakdown diodes -schottky diode – forward and reverse recovery processes in a diode.
Transistor capacitances – Transistor ratings – Biasing a BJT – Thermal stability of bias.
Concept of small signal operation of semiconductor devices – small equivalent circuit for diodes including capacitances – h-parameter equivalent circuit for a BJT – hybrid-π equivalent for a BJT – determination of small signal parameters from static characteristics.
Construction and characteristics of JFETs – capacitances of a JFET – biasing a JFET - small signal model for a JFET
Construction and characteristics of depletion type and enhancement type MOSFETs – MOSFET capacitances – biasing a MOSFET – small signal model of a MOSFET

Module 2: BJT, JFET and MOSFET Amplifier Circuits – Midband Analysis (9 hours)

Amplification in a CE amplifier - CE , CB and Emitter Follower Analysis and Comparison using h parameters as well as hybrid-π parameters - considerations in cascading transistor amplifiers -CS and CD Amplifiers using JFETs and MOSFETs – comparison of BJT, FET and MOSFET amplifiers - Class B and Class AB Power Amplifiers using BJT.

Module 3: Frequency Response of BJT/FET/MOSFET Amplifiers (phasor equivalent circuit approach is envisaged) (10 hours)

Distortion in amplifiers – Non-linear distortion – linear distortion due to frequency response – conditions for distortionless amplification.
Low Frequency response of BJT and FET Amplifiers-Dominant Time Constant-Selection of Coupling and Bypass Capacitors.
High Frequency Response of CE current gain- α-cut off and β cut off frequencies - Gain-Bandwidth product-Miller Effect-Emitter Follower at high frequencies - FET and MOSFET amplifiers at high frequencies.
Cascode Amplifier – BJT discrete version, BJT IC version, MOSFET IC version

Module 4: Digital Electronic Circuits (11 hours)

Transistor as an inverter – switching delays – various components of switch-off and switch-on delays – calculation of switching time components – comparison between high frequency transistor and switching transistor.

Charging and discharging a capacitive load by a BJT and MOSFET – rise time and fall time calculations for capacitive load switching
Analysis of basic DTL gate, propagation delay, rise and fall times, fan-in and fan out – power supply current versus frequency of operation
Analysis of basic TTL gate, propagation delay, rise and fall times, fan-in and fan out, ratings, power supply current versus frequency of operation
Different variants of TTL gates.
Analysis of basic ECL gate, propagation delay, rise and fall times, fan-in and fan out.
Analysis of basic CMOS gate, propagation delay, rise and fall times, fan-in and fan out – power dissipation in the gate and effect of (i) supply voltage (ii) frequency of operation and (iii) load capacitance on gate dissipation.
Comparison of various digital logic families – speed-power product as a figure of merit.

References:

1. A.S Sedra and K.C Smith, *'Microelectronic Circuits*', 5th ed., Oxford University Press,2009
2. Taub & Schilling, '*Digital Integrated Electronics*', McGraw-Hill, Singapore, 1997
3. Millman J, '*Microelectronic',* 2nd ed., McGraw-Hill, New Delhi, 2005.
4. Schilling & Belove, '*Electronic Circuits – Discrete and Integrated*', 3rd ed., McGraw-Hill, New Delhi, 2006
5. Boylestad & Nashelsky , *Electronic Devices and Circuit Theory*, 10th ed., Pearson Education, New Delhi, 2009.

EE2009D APPLIED ELECTROMAGNETICS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Determine electric and magnetic field due to various charge and current distributions.
CO2: Electromagnetic Design of the various devices which are working based on the forces generated by electric and magnetic fields.
CO3: Derive the Maxwell's equation in Differential and Integral forms.
CO4: Analyse the propagation of electromagnetic energy through transmission lines and design the propagation medium based on the requirements.
CO5: Determine the parameters involved in the propagation of electromagnetic energy through space.

Module 1: The Co-ordinate Systems and Electrostatics (11 hours)

The Co-ordinate Systems; Rectangular, Cylindrical, and Spherical Co-ordinate System. Co-ordinate transformation. Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field. Their Physical interpretation. The Laplacian. Divergence Theorem, Stokes' Theorem. Useful Vector identities. Electrostatics : Electric field intensity. Field due to a line charge, Sheet Charge and Continuous Volume Charge distribution. Electric Flux and Flux Density; Gauss's law. Application of Gauss's law. Energy and Potential . The Potential Gradient. The Electric dipole. The Equipotential surfaces. Energy stored in an electrostatic field. Boundary Conditions. Capacitors and Capacitances. Poisson's and Laplace's equations. Solutions of Simple Boundary value problems. Method of Images.

Module 2: Steady magnetic field (9 hours)

Steady Electric Currents: Current densities , Resistance of a Conductor; The Equation of Continuity , Joules law. Boundary Conditions for Current densities. The EMF. Magnetostatics : The Biot-Savart law. Amperes' Force Law , Torque exerted on a current carrying loop by a magnetic field. Gauss's law for magnetic fields. Magnetic Vector Potential . Magnetic Field Intensity and Ampere's Circuital law, Boundary conditions., Magnetic Materials , Energy in magnetic field.

Module 3: Time varying electromagnetic field and waves (10 hours)

Faraday's Law of Induction; Self and Mutual inductance . Maxwell's Equations from Ampere's and Gauss's Laws. Maxwell's Equations in Differential and Integral forms; Equation of Continuity. Concept of Displacement Current, Electromagnetic Boundary Conditions. Poynting's Theorem , Time – Harmonic EM Fields , Application to Transformer. Plane wave Propagation : Helmholtz wave Equation. Plane wave solution., Plane wave propagation in lossless and lossy dielectric medium and conducting medium . Plane wave in good conductor, surface resistance , depth of penetration.

Module 4: Transmission lines and waves (9 hours)

The TEM wave and the transmission line limit - Transmission Lines: The high-frequency circuit. Time domain reflectometry. LCR ladder model for transmission lines. The transmission line equation. Analogy with wave equation. Solution for lossless lines. Wave velocity and wave impedence. Reflection and Transmission coefficients at junctions. VSWR. Introduction to electromagnetic interference and compatibility

References:

1. NN Rao, *"Elements of Engineering Electromagnetics*", 6th ed., Pearson Education, 2004.
2. Mathew N. O. Sadiku , *Elements of Electromagnetics,* 7th ed., Oxford University Press, 2018.
3. David K. Cheng , *Fields and Wave Electromagnetics*, , 2nd ed., Pearson Education, 2002
4. JD Kraus & KR Carver*, Electromagnetics*, 2nd ed., Mcgraw-Hill, 1973

EE2011D ENVIRONMENTAL STUDIES FOR ELECTRICAL ENGINEERS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1: Instill the spirit of environmental enthusiasm and environmentalism

CO2: Understand the environmental problems faced by the modern man in terms of pollution, deforestation and in general the environmental degradation

CO3: Think in terms of sustainable envelopment based on the knowledge they have in different subjects of science and engineering

CO4: Think in terms of scientific and technological advancement in the spirit of a sustainable earth

CO5: Understand the relationships between natural resources, consumption, population, economics of consumerism, etc in an environmental context.

Module 1: Multidisciplinary Nature of Environmental Studies (2 hours)

Definition, scope and importance, Need for public awareness.

Module 2: Natural Resources: Renewable and Non-renewable Resources (6 hours)

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

Module 3: Ecosystems (5 hours)

Concept of an ecosystem. - Structure and function of an ecosystem - Producers, consumers and decomposers Energy flow in the ecosystem - Ecological succession - Food chains, food webs and ecological pyramid Introduction, types, characteristic features, structure and function of the following ecosystem :- (a) Forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Module 4: Biodiversity and its Conservation (6 hours)

Introduction – Definition : genetic, species and ecosystem diversity. - Biogeographically classification of India Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values Biodiversity at global, National and local levels - India as a mega-diversity nation - Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. - Endangered and endemic species of India - Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Module 5: Environmental Pollution (5 hours)

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

Module 6: Social Issues and the Environment (5 hours)

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

Module 7: Human Population and the Environment (5 hours)

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

Module 8: Field work (5 hours)

Visit to a local area to document environmental assets- river/forest/grassland/hill/mountain - Visit to a local polluted site-Urban/Rural/Industrial/Agricultural - Study of common plants, insects, birds -Study of simple ecosystems-pond, river, hill slopes, etc.

References:

1. Agarwal, K.C, *Environmental Biology*, 2nd ed., Nidhi Publishers, 2008.
2. Erach B, *The Biodiversity of India*, Mapin Publishing Pvt. Ltd., Ahmedabad, 2002
3. Brunner R.C., *Hazardous Waste Incineration*, McGraw Hill Inc, 1989.
4. Clark R.S., *Marine Pollution*, 5th ed., Clarendon Press Oxford, 2001.
5. Cunningham, W.P. Cooper, T.H. Gorani, E, Hepworth, M.T, *Environmental Encyclopedia*, Jaico Publ. House, Mumbai, 2001.
6. De A.K., *Environmental Chemistry*, 8th ed., New Age International Ltd., 2017
7. Down to Earth, *Centre for Science and Environment* (Magazine)
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9. Hawkins R.E., *Encyclopedia of Indian Natural History*, Bombay Natural History Society, 1987
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11. Jadhav, H & Bhosale, V.M., *Environmental Protection and Laws*. Himalaya Pub. House, Delhi, 1995.
12. Mckinney, M.L. & School, R.M., *Environmental Science systems & Solutions*, Web enhanced edition. 1996.
13. Mhaskar A.K., *Matter Hazardous*, Techno-Science Publication
14. Miller T.G. Jr., *Environmental Science*, 16th ed., Wadsworth Publishing Co.
15. Odum, E.P., *Fundamentals of Ecology*. W.B. Saunders Co. USA, 1971.
16. Rao M N. & Datta, A.K., *Wastewater Treatment*. Oxford & IBH Publ.Co. Pvt. Ltd., 1987.
17. Sharma B.K., *Environmental Chemistry*. Geol Publ. House, Meerut, 2001.
18. *Survey of the Environment*, The Hindu
19. Townsend C., Harper J, Michael Begon, *Essentials of Ecology*, Blackwell Science

20. Trivedi R.K., *Handbook of Environmental Laws, Rules Guidelines,Compliances and Standards, (Vol 1 and 2)*, Enviro Media
21. Trivedi R. K., P.K. Goel, *Introduction to air pollution*, Techno-Science Publication, 2010
22. Wagner K.D., *Environmental Management*. W.B. Saunders Co. Philadelphia, USA , 1998

EE2091D BASIC ELECTRICAL ENGINEERING LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:
CO1: Use different meters and instruments for measurement of electrical quantities

CO2: Estimate power and current requirements of a composite load comprising various linear and nonlinear different types of loads.
CO3: Design potential divider circuits for given specifications.
CO4: Experimentally verify the basic circuit theorems
CO5: Measure power and power factor in single-phase and three-phase ac circuits
CO6: Measure earth resistance and insulation resistance
CO7: Select fuse for a given load circuit branch

List of Experiments:

1. a) Study of Analog/Digital meters/Multimeters/CROs. Interfacing a C.R.O with a PC.
   b) Verification of Kirchhoff's laws in D.C circuits.
2. Study of Linear and Non- linear characteristics of loads – Determination of voltage – current Characteristics of linear resistor and linear inductor, incandescent and CFL lambs, iron cored solenoid
3. a) Potential divider connection and study of the dependence of output voltage upon the value of the loading resistance.
   b) Methods of measurement for low- medium-high resistance using voltmeter and ammeter.
4. Verification of Superposition Theorem and Maximum Power Transfer theorem.
5. Verification of Thevenin's Theorem and Generalized Reciprocity theorem.
6. a) Study of Fuse, MCB, ELCB – Selection of Fuse rating for circuits.
   b) Determination of fuse characteristics and fusing factor of different specimens (open, enclosed, HRCfuses and MCB).
7. a) Single phase power measurement (fan load) – study of variation of speed, input power and power factor with supply voltage.
   b) Determination of thermal efficiency of an electric kettle.
8. Measurement of power and power factor in R-L-C series and parallel circuits and design of P.F compensator.
9. Three phase power measurement of balanced and unbalanced loads.
10. Experiments and Analysis of Resonance in the RLC circuits and design of an RF circuits to receive an RF signal and verifying it experimentally.
11. Measurement of Self-inductance, Mutual inductance and Coupling coefficient of windings.
12. Measurement of Earth Resistance and Insulation Resistance.

Note: Normally the practical classes are administered in two cycles. Depending on the availability of equipments and time, class coordinators may choose the experiments for each cycle.

References:

1. H Cotton, *Advanced Electrical Technology*, Wheeler Publications.
2. Suresh Kumar K.S, *Electrical Circuit and Networks*, Pearson Education, New Delhi, 2009
3. EW. Golding *Electrical Measurements and Measuring Instruments*, 5th ed., Reem publications, 2011.
4. Hughes, *Electrical Technology*, 10th ed., Pearson, 2011

MA2002D MATHEMATICS IV

Pre-requisites: MA1001D Mathematics - I
MA1002D Mathematics - II

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Find solutions of linear differential equations using power series method and Frobenius series method.
CO2: Formulate various engineering problems as partial differential equations and hence solve them.
CO3: Identify analytic functions and find harmonic conjugates.
CO4: Find images of regions under complex transformations.
CO5: Evaluate line integrals in the complex plane.
CO6: Use techniques of complex analysis to evaluate integrals of real valued functions

Module 1: Series Solutions and Special Functions (11 hours)

Power series solutions of differential equations, Theory of power series method, Legendre Equation, Legendre Polynomials, Frobenius Method, Bessel's Equation, Bessel functions, Bessel functions of the second kind, Sturm- Liouville's Problems, Orthogonal eigenfunction expansions.

Module 2: Partial differential Equations (10 hours)

Basic Concepts, Cauchy's problem for first order equations, Linear Equations of the first order, Nonlinear Partial Differential Equations of the first order, Charpit's Method, Special Types of first order equations, Classification of second order partial differential equations, Modeling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: Solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, Solution of a Partial Differential Equations by Laplace transforms.

Module 3: Complex Numbers and Functions (9 hours)

Complex functions, Derivative , Analytic function, Cauchy- Reimann equations, Laplace's equation, Geometry of Analytic functions: Conformal mapping, Linear fractional Transformations, Schwarz - Christoffel transformation, Transformation by other functions.

Module 4: Complex Integration (9 hours)

Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions.Power series, Functions given by power series, Taylor series and Maclaurin's series. Laurent's series, Singularities and Zeros, Residue integration method, Evaluation of real Integrals.

References:

1. Kreyszig E, *'Advanced Engineering Mathematics'*, 8th ed., John Wiley & Sons, New York, 1999.
2. I.N. Sneddon, '*Elements of Partial Differential Equations'*, Dover Publications, 2006.
3. Wylie C. R. & Barrett L. C., *'Advanced Engineering Mathematics'*, 6th ed., Mcgraw-Hill, New York,1995.
4. Donald W. Trim, *'Applied Partial Differential Equations'*, PWS – KENT publishing company, 1994.

EE2002D SIGNALS & SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Perform design verification/validation of simple first order and second order continuous-time linear systems in various domains by analytical as well as experimental methods.
CO2: Carry out performance evaluation of multi-order LTI System designs by Impulse Response Test
CO3: Evaluate stability and stability margins of a proposed CT-LTI Design by transfer function approach.
CO4: Design simple first-order and second-order systems for basic signal/energy processing applications from given transfer function/ impulse response/ steady-state requirements in electrical and thermal domains.
CO5: Evaluate the signal distortion characteristics of a given transmission channel.
CO6: Perform design verification/validation of simple first order and second order discrete-time linear systems by analytical methods.

Module 1: First Order CT- LTI Systems in Time-domain (8 hours)

Signals and Systems - System as interconnection of elements – electrical system elements, thermal system elements, translational and rotational mechanical system elements.
Signal definition – Size of a signal - Classification of signals – Basic signal operations – Commonly used signal models (impulse, step, ramp, complex exponential etc), even and odd components of a signal.
Linearity of system elements – element relation – superposition principle – Time-invariance - Bilateral versus unilateral elements
Independent source elements – voltage, current, force, velocity, heat, temperature sources-
Interconnection of elements – interconnection laws for electrical, mechanical and thermal systems

Formulation of System Differential Equation –
Formulation of differential equation for Series and Parallel RC circuits, Series and Parallel RL circuits, mass-damper system, single body heating and cooling system – need for initial condition specification - equivalence between impulse excitation and initial conditions

First-Order Dynamics –
Source-free response of RC circuit – time constant – Source-free response of RL circuit – time constant – Source-free response of first order mechanical system and thermal system – mechanical time constant, thermal time constant – DC switching problem in RC and RL Circuits with and without initial energy storage– Natural response and forced response – transient response – Rise time and fall time in first order systems – Difference between DC switching and applying step input - Complete Solution for step/impulse/sinusoid inputs – First order mechanical system impulse and step response - First order thermal system impulse and step response, generalisations for all first order systems – zero-input response and zero-state response – relation between them to natural response and transient response – superposition principle as applied to various response components –
Concept of steady-state – DC steady-state in RC and RL Circuits – Sinusoidal steady-state in first order systems - sinusoidal steady-state frequency response function of first order systems – periodic steady-state in first order systems.

Module 2: Higher Order CT - LTI Systems in Time-domain – Impulse Response Description (9 hours)

Time-domain analysis of second-order systems – The mass-spring-damper system (for example, an ammeter or voltmeter) - series and parallel RLC –initial conditions – zero-state and zero-input response components - impulse response – step response – undamped and damped natural frequencies – damping

factor – quality factor – undamped spring-mass system and LC system – weakly damped spring-mass system and LC system – Q factor versus rate of decay in stored energy in a weakly damped system - time-domain specifications for a second order system.

Time-domain analysis of higher order systems – Formulation of differential equation for multi-mesh circuits – determination of initial conditions - solution of nth order Linear ODE using material learnt from Maths Courses - natural frequencies – natural frequencies versus stability – frequency response function in terms of coefficients of differential equation - generalisations for nth order linear time-invariant system - Instability in circuits involving dependent sources.

Convolution Integral – Impulse decomposition of an arbitrary input– convolution integral for zero-state response of a LTI system – importance of impulse response – scanning function – depth of memory of an LTI system and duration of impulse response – relation between DC steady-state output and impulse response – relation between AC steady-state frequency response function and impulse response –
Properties of systems – linearity, time-invariance, causality and stability in terms of impulse response – cascading LTI systems with and without inter-stage interaction –
Zero-state output of an LTI System for complex exponential input – condition of 'dominance' - eigen function – eigen value versus system function – system function H(s) of a nth order LTI system

Module 3: CT- LTI Systems in Frequency-domain - with Arbitrary Inputs (10 hours)

[Revise Fourier Series and analysis of LTI Systems for periodic inputs using Fourier Series and Frequency Response Function – No class time allotted.]

Signal Expansion in terms of est kind of signals – Fourier Transforms (FT)
Aperiodic inputs – Fourier Transform from Fourier Series – interpretation of Fourier transform – revise what was learnt in MathsI (properties and theorems)– frequency response function and its role in LTI system solution for aperiodic inputs – band-limiting versus time-limiting of signals – continuity of Fourier transform – convolution theorem – modulation theorem –
Linear distortion in signal transmission context – amplitude and phase distortion – conditions for distortion-free transmission – why such conditions cannot be met in practice – Practical distortion criterion for pulse transmission in terms of energy content of output.

Sampling of CT signals and reconstruction – Nyquist's Theorem on sampling – ideal interpolation versus practical interpolation.

Signal Expansion in terms of est kind of signals – Laplace Transforms (LT)
Laplace transform from Fourier transform – LT as signal expansion in terms of complex exponential functions – ROC – revise what was learnt in Maths – Unilateral Laplace Transform – Shifting theorem - use of LT for solving complete response of LTI system – transfer function and its relation with what was called system function earlier – poles, zeros- impulse response from pole-zero plot – relation between transfer function and frequency response

Module 4: Introduction to Discrete-time Signals and Systems (12 hours)

Discrete-time signals - sequences – Basic DT Test Signals – Unit Sample Sequence and Unit Step Sequence, Accumulator system, Unit Ramp, DT Sinusoids and their properties, Comparison with CT Sinusoids, Generalised DT Complex Exponential , Signal point, signal plane, z-plane, Unit Circle in z-plane, Basic Signal Operations **-** basic signal operations –
Discrete-time systems- Linearity of DT System, Time Invariance, LTI-DTS System elements, Finite Difference Equation (FDE) description of LTI-DTS, Memory less systems, Finite Impulse Response Systems, Impulse and Step responses of FIR Systems, IIR Systems, Need for initial conditions, Interpretation of initial conditions as the output due to unknown input applied in distant past – Consistency between initial condition specification and input specification

Impulse response (IR) as the primary and sufficient response of a LTI-DTS – Representation of an arbitrary input sequence $x[n]$ in terms of weighted and shifted impulses – Convolution summation and its properties – geometrical interpretation of convolution summation – stability, causality from convolution point of view –

LTI-DTS in Time-domain : Decomposition of the analysis problem stated by $\sum_{i=0}^{N} a_i y[n-i] = \sum_{i=0}^{M} b_i x[n-i]; n \geq 0 \text{ and } a_o = 1,$ with $y[-1] = y_{-1}; y[-1] = y_{-2}; \cdots\cdots y[-N] = y_{-N}$ into Zero-input problem + Zero-state problem format suitable for applying superposition principle – Zero-input response (ZIR) and Zero-state response (ZSR) – Interpretations of ZIR and ZSR – Principle of superposition as applied to ZSR, ZIR and Total Response.

ZIR of LTI-DTS – Solution and properties of ZIR – Characteristic equation of a FDE – Natural frequencies, Location of natural frequencies in signal plane – stability of LTI-DTS and Unit Circle in signal plane –

ZSR of LTI-DTS for standard inputs of type $x[n]$ for $n \geq 0$ - Forced response and natural response components in ZSR – viewing forced response as the right side of solution assuming that $x[n]$ is applied from infinite past instead of from $n = 0$. – steady-state response and its interpretation for step, sinsoidal , complex exponential functions and periodic sequences – relation between forced response component of ZSR and steady-state response - determination of forced response for $\delta[n], u[n], \cos \omega n, e^{j\omega n} \text{ and } z^n$ - Total ZSR for these inputs -concept of eigen functions of an FDE - z^n as eigen function of a LTI-DTS – ac sinusoidal steady-state frequency response function (FRF) – Determination of FRF from FDE coefficients – Properties of FRF

Sinusoidal steady-state response from convolution summation – relation between FRF and IR - sinusoidal steady-state response as the primary and sufficient response of a LTI-DTS

References:

1. Lathi,, B.P., *Signal Processing and Linear Systems*, Oxford University Press, New Delhi, 2006
2. Lathi,, B.P., *Signals, Systems and Communication*, BS Publications, Hyderabad, 2008
3. K.S. Suresh Kumar*, Electric Circuits and Networks* , Pearson Education, New Delhi, 2009
4. Alan V . Oppenheim, Ronald W. Schafer, *.Discrete-Time Signal Processing*., Prentice-Hall of India Pvt. Ltd., New Delhi, 1997
5. Sanjit K Mitra, *.Digital Signal Processing: A computer-based approach*, Tata McGraw-Hill edition .1998
6. Charles L. Phillips, John M. Parr & Eve A. Riskin, *Signals, Systems and Transforms*, Pearson Education, New Delhi, 2008
7. Simon Haykin, Barry Van Veen, *Signals and Systems*, 2nd ed., Wiley India, 2009

EE2004D MICROPROCESSORS AND MICROCONTROLLERS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Use the knowledge about the basics of digital realm in designing a Digital Systems.
CO2: Evaluate microprocessor/controllers from its architecture and assess its suitability in a particular engineering application.
CO3: To make the student capable of programming a processor using assembly language.
CO4: Acquire the competence on configuring and using different peripherals in a digital system.
CO5: Develop the skill to compile, debug as well as generate an executable file from a program and burn in the system memory to execute it.
CO6: Design, assemble and test a digital system hardware using microcontroller / processor to solve engineering problems.

Module 1: Basics of computer (10 hours)

Number systems – Computer languages of different levels – compilers – cross compilers- History of Microprocessors – Computer architecture (Block diagram) – Memory types, Addressing concept.

Module 2: Microcontrollers, Hardware using PIC (12 hours)

Microchip PIC 18F 452 Microcontroller - Introduction - Architecture – Memory organization –CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture. Assembly Language programming – simulation using MPLAB IDE - Programming of I/O ports – Addressing modes -Example Programs.
PIC (Cont.) Bank switching – Table processing – Timers and its programming – Interrupt programming. Concept of development of single board computers - Hard ware.

Module 3: Introduction to MSP430 family (2 hours)

Low power RISC architecture and block diagram eg. MSP430 - Variants of the MSP430 family viz. MSP430x2x, MSP430x4x, MSP430x5x and their targeted applications. Low Power aspects of MSP430: low power modes, Active vs Standby current consumption, FRAM vs Flash for low power & reliability.

Module 4: Intel 8086 processor (8 hours)

Pin configuration of 8086 – Architecture. 8086 Vs Low power RISC processor e.g. MSP430 - Comparison of Serial communication capabilities of 8086 CISC and MSP430 RISC processor - I2C, SPI, UART.— 8086 addressing modes – 8086Instruction set – Assembly Language Programming. Intel 8086 processor (Contd.) - Interrupts– Timing diagrams – Minimum and maximum mode –address decoding.

Module 5: Interfacing chips (7 hours)

Programmable Peripheral Interface (8255) - Programmable timer (8253) - Serial communication interface (8251) –DMA controller (8257) - Programmable Interrupt Controller (8259).

References:

1. Muhammad Ali Mazidi, - Rolin D.Mckinlay, Danny Causey. *PIC microcontroller and Embedded Systems*, 1st ed., Pearson Education, 2008
2. Lyla B Das - *The x86 Microprocessors,* 1st ed., Pearson Education, 2010

3. T R Padmanabhan - *Introduction to Microcontrollers and their applications,* 1st ed., Narosa Publishing House Pvt Ltd., 2007.
4. Hall D V , *Microprocessors & Interfacing* , 2nd ed., McGraw Hill, 2001
5. Brey B B , *The Intel Microprocessors, Architecture , Implementation & Programming*,7th ed., McGraw Hill, 2005
6. Peter Norton - *Peter Norton's Intro to Computers*, 6th ed., McGraw Hill, 2006
7. Dr Badri Ram - *Fundamentals of Microprocessors and Microcomputers*, 3rd ed., Dhanpat Rai & Sons, 1989

EE2006D ELECTRICAL MACHINES I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire knowledge about the fundamental principles and classification of electromagnetic machines.

CO2: Acquire knowledge about the constructional details and principle of operation of dc machines.

CO3: Acquire knowledge about the operation, testing and applications of dc generators and motors.

CO4: Acquire knowledge about the constructional details and principle of operation of transformers.

CO5: Acquire knowledge about the testing and applications of transformers.

Module 1: Electromagnetic Machines (8 hours)

Fundamental principles - classification - generators, motors and transformers - elements of electromagnetic machines - armature windings - single layer winding and double layer winding - lap winding and wave winding - commutator winding - phase winding - single phase winding and three phase winding - MMF of a winding - space harmonics - torque developed in a winding - emf developed in a winding - distribution factor - chording factor.

Module 2: DC Machines (7 hours)

Construction - principle of operation - magnetic circuit - flux distribution curve in the air-gap - emf equation - armature reaction - demagnetising and cross magnetising ampere turns - commutation - methods of excitation - generators and motors.

Module 3: DC Generators and Motors (10 hours)

Generators - power flow diagram - circuit model - magnetisation characteristics - process of voltage build up - terminal characteristics - control of terminal voltage - parallel operation - motors - power flow diagram - circuit model - back emf - torque and speed equations - performance characteristics - starting methods - design of starters - methods of speed control - testing - Swinburne's test - Hopkinson's test - separation of losses - retardation test - permanent magnet dc motor - applications.

Module 4: Transformers (14 hours)

Types and construction - principle of operation - magnetising current - harmonics - ideal and real transformer - dot convention - current and voltage ratio - equivalent circuit - phasor diagram - per unit impedance - losses - efficiency and regulation - all day efficiency - OC and SC tests - Sumpner's test - Parallel operation - tap changing - switching transients - auto transformers - voltage and current relationships - saving of copper - different connections of three phase transformers - notations - Scott connection - cooling methods.

References:

1. Clayton A E & Hancock N N, *Performance and Design of DC Machines*, ELBS, 1971.
2. Langsdorf A S, *Theory of DC Machinery*, McGraw Hill, 1999.
3. Nagrath I J & Kothari D P, *Electric Machines*, 3rd ed., Tata McGraw Hill, 2004.
4. Say M G, *The Performance and Design of AC Machines*, CBS, 1983.
5. Chapman S J, *Electric Machinery Fundamentals*, McGraw Hill, 1999.
6. Toro V D, *Electrical Machines and Power Systems*, Prentice Hall, 1988.

EE2008D ANALOG ELECTRONIC CIRCUITS & SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Design standard linear signal processing circuits using Opamps.
CO2: Apply various fixed and adjustable voltage regulator ICs for power supply design.
CO3: Design audio frequency amplitude stabilized sinusoidal oscillators using Opamps.
CO4: Apply non-linear ICs as building blocks in designing non-linear signal processing and timing applications.
CO5: Design basic filters for signal conditioning employing Opamps and Filter Building Block ICs.
CO6: Apply standard ADC and DAC ICs for data conversion.

Module 1: Linear Opamp Circuits (9 hours)

BJT and MOSFET Differential Amplifiers-Common Mode and Differential Mode gains-CMRR-Current Source Biasing-Offset behaviour. Current Sources for biasing inside an IC.
Operational Amplifier - ideal opamp properties-properties of practical opamps (LM741, LM324, LM358, LF351, OP07, TL082)-different stages in an opamp-internally compensated and externally compensated opamps-slew rate - offsets.
Various types of Opamps and their application, Power supply configuration for Opamps, Interpretation of Opamp data sheet – Comparison of LM714 and TL082
CMOS Operational Amplifiers – basic two-stage CMOS Opamp – Folded Cascode Opamp

Analysis of opamp circuits using ideal opamp model- Concept of Feedback-Negative and Positive Feedback- Loop Gain- Closed Loop Gain - concept of virtual short and its relation to negative feedback – Offset model of a practical opamp-
Linear Applications of Opamps: Non inverting Amplifier-Gain bandwidth product-Voltage Follower-Inverting Amplifier-Summing Amplifier-Offset analysis of Non inverting and inverting amplifiers-Subtracting Circuit-Instrumentation Amplifier-Voltage to Current Converter for floating and grounded loads-Opamp Integrator-Opamp Differentiator.
Series Voltage Regulators-Monolithic Regulators-Three terminal regulators., Fixed and adjustable Voltage Regulators, Dual Power Supply, Basic switching regulator and characteristics of standard regulator ICs – TPS40200, TPS40210

Module 2: Feedback Amplifiers, Stability and Oscillators (s-domain approach is envisaged) (9 hours)

Voltage Series Feedback on a single time constant voltage to voltage amplifier - Advantages of negative feedback in a single time constant voltage to voltage amplifier - gain, input and output resistances, rise time, bandwidth, nonlinearity etc- stability and positive feedback in the above amplifier - Voltage Shunt, Current series and Current Shunt topologies and properties.
Voltage Series feedback on a second order amplifier - Closed Loop poles and loop gain - Transient Response of Closed Loop Amplifier vs Loop Gain - Voltage Series Amplifier with third order open loop amplifier - pole migration to right half of s-plane – Bode Plots of Loop Gain - Barkhausen's criterion for stability of feedback amplifiers - Gain Margin and Phase Margin - Introduction to amplifier compensation-dominant pole compensation- Oscillators- Phase Shift Oscillator & Wein's Bridge Oscillator using Opamps – Amplitude stabilization of oscillators.

Module 3: Nonlinear IC Applications (11 hours)

Regenerative Comparator Circuits using Opamps-Comparator IC LM311 and its applications-Square, Triangle and Ramp Generator Circuits using Opamps and Comparator ICs-Effect of Slew Rate on waveform generation- Zero crossing detector, Scmitt Trigger, Voltage Limiters, Study of Function Generator IC ICL8038- Principles of VCO circuits-
Opamp TL082 based Astable and Monostable Circuits, Sweep circuits, Timer ICs – 555 Applications
Precision half wave and full wave rectification using opamps-
Log and antilog amps and applications.
Analog Multiplier MPY634 and applications, AGC and AVC using TL082 and MPY634
Phase Locked Loops-Principles-Lock and Capture Ranges-Capture Process-Loop Filter-PLL dynamics under locked condition-study of NE564 and CD 4046-Applications of PLL in signal reconstruction, noise rejection, frequency multiplication, frequency synthesis, FSK demodulation, FM demodulation, line synchronization etc.

Module 4: Signal Conditioning and Signal Conversion (10 hours)

Active Filtering-Butterworth Low Pass Filter Functions-Low Pass Filter Specifications-order and cut off frequency of Butterworth Function from Low Pass Specifications-Sallen and Key Second Order LP Section-Gain Adjustment in Butterworth LP filters-Butterworth High Pass Filters-Second Order Wide Band and Narrow Band Bandpass Filters. Multiple Feedback Single OPAMP LPF,HPF & BPF – Universal Active Filter topology and design of various filters.
Analog Switches-Sample and Hold Amplifier-Data Conversion Fundamentals-D/A Conversion-Weighted Resistor DAC- R/2R Ladder DAC-Current Switching DAC-Multiplying DAC-Bipolar DACs-A/D conversion-Quantiser Characteristics-Single Slope and Dual Slope ADCs-Counter Ramp ADC-Tracking ADC - Successive Approximation ADC-Simultaneous ADC.

References:

1. A.S Sedra and K.C Smith,*Microelectronic Circuits*, 5th ed., Oxford University Press,2009
2. Millman J, *Microelectronic,* 2nd ed., McGraw-Hill, New Delhi,2005.
3. Schilling & Belove, *Electronic Circuits – Discrete and Integrated*, 3rd ed., McGraw-Hill, New Delhi,2006
4. D.H. Sheingold, .*Nonlinear Circuits Handbook*., Analog Devices Inc. 1976
5. Sergio Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, Tata McGraw-Hill, New Delhi, 2005
6. M.E Van Valkenburg, *Analog Filter Design*, Oxford University Press 2001
7. National Semiconductor, *Linear Applications Handbook*, 1994
8. Anvekar D.K. & Sonde B.S, *Electronic Data Converters*, Tata McGraw Hill,1994
9. Gayakwad R.A, *OP AMPS & Linear Integrated Circuits*, 3rd ed., Prentice Hall of India, 1995.
10. Clayton G.B, *Operational Amplifiers*, 5th ed., Oxford ,2004
11. Frederiksen T.M, *Intuitive Operational Amplifiers*, McGraw Hill, 1996.

ME2010D MECHANICAL ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes:

CO1: Acquire knowledge about various thermodynamics concepts and enable students to approach real life engineering problems like engines compressor etc.
CO2: Acquire knowledge about fluid mechanics concepts and its applications to various real life engineering problems like notches, flow-measuring devices etc.
CO3: Discuss the various fluid machineries such as pumps turbines etc.
CO4: Explain the working of various power plants.

Module 1: (10 hours)

Thermodynamics: Thermodynamic systems, Properties, Processes, Heat and work, Zeroth law of thermodynamics, First law of thermodynamics -- concept of internal energy and enthalpy -- steady flow energy equation -- applications, Second law of thermodynamics -- concept of entropy -- absolute zero – heat engine -- refrigerator -- heat pump.

Module 2: (9 hours)

Engineering applications of thermodynamics: Carnot cycle, Otto cycle, Diesel cycle – applications, Principle of operation of two stroke and four stroke engines, Spark ignition and compression ignition engines – applications, Rankine cycle, Brayton cycle -- their applications. Refrigeration -- methods of producing cold, Refrigeration cycle -- vapour compression system – vapour absorption system – applications, Psychrometric properties, Psychrometric processes, Purity of air and Human comfort, simple A/c load estimation

Module 3: (11 hours)

Fluid mechanics and fluid machinery: Fluid properties – viscosity -- surface tension -- fluid pressure -- measurement of viscosity and pressure, Centre of pressure, Buoyancy, Classifications of flow, Continuity equation, Bernoulli's equation, Momentum equation – applications, Friction in flow passages, Flow measuring instruments. Fluid machinery: Air compressors -- working principles – loads -- characteristics and electric power requirement. Hydraulic turbines – classifications -- performance characteristics – governing -- cavitation, Hydraulic pumps – classification -- performance characteristics – cavitation -- electric power requirements.

Module 4: (9 hours)

Power plant Engineering: Conversion technology of conventional and non-conventional energy sources. Steam power plant: Layout -- steam generators -- types of boilers for power station. Hydel power plants: Layout -- classifications and study of various components – operation Gas turbine power plant and combined power plants. Internal Combustion engine power plants. Layout -- schemes -- study of various components – operation. Nuclear power plants, New generation power producing systems.

References:

1. Zemansky, M.W., *Basic Engineering Thermodynamics*, 2nd ed., McGraw hill, 2002
2. Michel A. SAAD, *Thermodynamics for engineers*, Prentice-Hall, 1966

3. Spalding, D.B., and Cole, B.H., *Thermodynamics,* 3rd ed., Arnold, 1987
4. Gordon F.C. Rogers & Yon R. Mayhew, *Engineering Thermodynamics Work and Heat Transfer*, 4th ed., Pearson Prentice-Hall, 1996.
5. Jones I.B. & Dugan R.E., *Engineering Thermodynamics*, Prentice Hall,1995
6. P.K. Nag, *Engineering Thermodynamics*, 3rd ed., Tata McGraw Hill, 2003
7. Gordon F.C. Rogers and Yon R. Mayhew, *Thermodynamic and Transport Properties of Fluids*, Blackwell Publishers, 1995
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9. Gill, P.W., and Smith J.H., *Internal combustion engines*, 4th ed., United States Naval Institute, 2010
10. Joseph Heitner, Automotive systems, 2nd ed., D. Van Nostrand company Inc, 1984
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12. Stoecker, W.F. and Jones, *Refrigeration & Air conditioning*, 2nd ed., McGraw Hill, New York,1987
13. Modern air conditioning practice, Norman C. Harris, McGraw-Hill, 1974
14. Streeter, V.L., Fluid Mechanics, 8th ed., McGraw Hill 1985
15. F. M. White, *Fluid Mechanics*, 5th ed., McGraw Hill New York, 2005.
16. R.L. Daugherty, J.B. Franzini, *Fluid Mechanics with Engineering Applications*, 7th ed., McGraw Hill, New York, 1977.
17. Cengel, Y.A., and Cimbala, J.M., *Fluid mechanics,* 2nd ed., McGraw Hill, 2010
18. Krivchenko, G.I., *Hydraulic Machinery*, 2nd ed., Lewis Publishers, 1994
19. Jagdish Lal, *Hydraulics and fluid mechanics* 9th ed., Metropolitan, 1987
20. El-Wakil, M.M., *Power Plant Engineering*, 1st ed., McGraw Hill, New York, 1985
21. Rogers GFC, Cohen H. and Saravanamuttoo HIH, *Gas Turbine Theory*, 5th ed., Pearson 2001
22. Ganesan V, *Gas Turbines*, Tata McGraw-Hill, 1999
23. Skrotsky, B., Vopat, H., *Power Plant Engineering*, 2nd ed., McGraw hill, 1985.
24. Frederick, T. Morse, *Power Plant Engineering*, 3rd ed., Van Nostrand Company,1994

EE2092D ELECTRICAL MEASUREMENTS LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total Hours: 39
Total Hours: 39

Course Outcomes:
CO1: Use different electrical calibration and measurement devices.
CO2: Determine loss characteristics of a magnetic material.
CO3: Design measuring devices employing range extension principles.
CO4: Measure characteristics of electrical elements employing DC and AC Bridge technique.
CO5: Use various potentiometers for calibration of electrical measurement devices.

List of Experiments:

1. Determination of B-H curve μr -H curve and μr -B curve of an iron ring specimen.
2. Calibration of magnetic flux meter using standard solenoid, search coil and Hibbert's magnetic standard.
3.
    a. Measurement of low/medium resistance using Kelvin's double bridge and wheat stone's bridge.
    b. Measurement of various cable resistance as per ISI specifications.
4.
    a. Measurement of Capacitance and Inductance using AC bridges.
    b. Measurement of Inductive and capacitive reactance at HF, VHF and UHF ranges.
5. Calibration of dynamometer type wattmeter using slide wire potentiometer.
6. Extension of range of ammeter/voltmeter using shunt/series resistance and calibration of the extended meter using standard ammeter/voltmeter.
7. Extension of range of a dynamometer type wattmeter using CT/PT and calibration of the extended meter using a standard wattmeter.
8. Calibration of single – phase energy meter by direct loading and phantom loading at various power factors.
9. Calibration of 3-phase energy meter using standard wattmeter.
10. Determination of hysteresis loop of an iron ring specimen using 6- point method and CRO.
11. Measurement of branch and node voltage of a given R-L-C circuit using AC potentiometer.
12.
    a. Measurement of candle power of given light sources. Determine the illumination levels at different working planes and verify laws of illumination.
    b. Determination of MSCP of an Incandescent lamp/CFL.
    c. Determination of the polar curve of candle power distribution and hence find MHCP/MSCP of light sources.

Note: Normally the practical classes are administered in two cycles. Depending on the availability of equipments and time, class coordinators may choose the experiments for each cycle.

References:

1. Golding E.W, *Electrical Measurements & Measuring Instruments*, 5th ed., Reem publications, 2009.
2. Cotton.H, *Advanced Electrical Technology*, Wheeler Publications, 2011.
3. Suresh Kumar K.S *Electric Circuit and Networks,* Pearson education, 2009.
4. Cooper W.D, *Modern Electronics Instrumentation*, Prentice Hall of India, 1986.

EE2094D ELECTRONICS LAB - I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:
CO1: Use different meters and instruments for measurement of electronic quantities
CO2: Study the characteristics of different semiconductor devices like diode, BJT, FET, UJT etc. experimentally
CO3: Design and test various application circuits using diodes
CO4: Design and test various signal and power amplifier circuits using BJTs and FETs
CO5: Design voltage regulation circuits for given specifications.

List of Experiments:

1. Use of CRO: a) Measurement of current, voltage, frequency and phase shift.
2. Semiconductor diodes: V-I and transfer characteristics of Si, Ge and zener diodes.
3. Characteristics of clipping and clamping circuits using diodes and zener diodes.
4. Rectifiers and filters with and without shunt capacitors- Characteristics of half-wave, full wave and bridge rectifiers- Ripple factor, Rectification efficiency, and % regulation.
5. Transistor characteristics in CB and CE configurations - Identification of cut off, active and saturation regions.
6. JFET characteristics in the common source configuration- determination of equivalent circuit parameters.
7. Characteristics of voltage regulators- Design and testing of:
   a. Simple zener voltage regulator
   b. Zener regulator with emitter follower output.
8. UJT Characteristics and UJT relaxation oscillator- Design for a particular frequency.
9. RC coupled amplifier using BJT in CE configuration- measurement of gain, input and output impedance and frequency response
10. BJT emitter follower- Measurement of voltage gain, current gain, input impedance, output impedance and load characteristics
11. FET amplifier- Measurement of voltage gain, current gain, input and output impedance.
12. Power amplifiers - Class AB (complementary symmetry).

Note: Normally the practical classes are administered in two cycles. Depending on the availability of equipments and time, class coordinators may choose the experiments for each cycle.

References:

1. Boylestad and Nashelsky , *Electronic Devices and Circuit Theory,* 10th ed., Pearson Education, New Delhi, 2009.

EE3001D CONTROL SYSTEMS - I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Represent models of dynamic systems in transfer function and state space forms
CO2: Describe the common control schemes
CO3: Analyze the system response and stability in both time-domain and frequency domain
CO4: Identify the structure of different types of compensators and design the compensators using time-domain and frequency domain specifications
CO5: Analyze the system response with and without compensators so as to assess the effect of compensators on system performance. Evaluate system performance using software tools.

Module 1: System Modelling and System Response (10 hours)

Dynamic Systems Modelling - Differential equation model and Transfer function model of LTI SISO and MIMO systems - Development of models for Electrical, Mechanical, Electromechanical, Pneumatic and Thermal systems. Control actuators and sensors for Electrical, Mechanical, Electromechanical, Pneumatic and Thermal systems

Open loop and Closed loop Transfer function- Block diagram representation- Block diagram reduction - Signal flow graphs – Mason's gain formula.

Time domain analysis - Transient response analysis- First order systems- Initial condition response - Impulse response- Step input response-Time constant- Second order system response- Transient response specifications- Response of Higher order systems - Steady state error and error constants - dynamic error constants.

Module 2: Conventional Controllers and System Stability (10 hours)

Conventional control laws - P, PI, PD and PID controllers - Effect of P, PI, PD and PID controllers on system response of First order and Second order systems

Concept of stability of LTI systems -BIBO stability- Characteristic equation - Effect of feedback on closed loop stability - Routh Hurwitz criterion - Root locus techniques for stability analysis and controller design - Root locus techniques for Compensator design.

Module 3: Frequency domain Analysis (10 hours)

Frequency domain methods - Sinusoidal transfer function – Frequency response - Frequency domain specifications - peak resonance and resonant frequency- correlation with time domain parameters-

Polar plot, Nyquist plot and Bode plot for stability analysis - relative stability - concept of gain margin and phase margin - Bandwidth and cut off frequency- Compensator design using Frequency domain techniques.

Module 4: State Space Analysis and Controllability (9 hours)

Dynamic Systems Modelling in State Space - State space models from Transfer function - Transfer function from state space model- Eigen values and system stability - Diagonal form of state equations - Jordan canonical form - Solution of state equations of LTI systems- State transition matrix - Controllability and Observability from state space models.

References:

1. Katsuhiko Ogata, *Modern Control Engineering*, Pearson Prentice Hall, 2006
2. William J. palm III, *Control Systems Engineering*, John Wiley & Sons Inc., 1986
3. M Gopal, *Control Systems*, 3rd ed., Tata McGraw Hill, 2006
4. Benjamin C Kuo, *Digital Control Systems*, Oxford University Press, 1992.

EE3003D ELECTRICAL MACHINES - II

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire knowledge about the constructional details and principle of operation of alternators.

CO2: Acquire knowledge about the working of synchronous machines as generators and motors.

CO3: Acquire knowledge about the constructional details and principle of operation of induction motors.

CO4: Acquire knowledge about the speed control, testing and applications of induction motors.

CO5: Acquire knowledge about the generalized machine theory and simulation methods.

Module 1: Alternators (8 hours)

Construction - principle of operation - type and selection - armature reaction - voltage regulation - predetermination of voltage regulation - EMF method - synchronous reactance and short circuit ratio - MMF method - Potier method - phasor diagrams - two reaction theory - modified phasor diagram - analysis by two reaction theory - sudden short circuit - current waveforms - transient and sub transient reactance - slip test - DC excitation - static excitation - brush less excitation and self excitation - measurement of losses.

Module 2: Synchronous Machines (12 hours)

Power angle characteristics of cylindrical rotor and salient pole machines - reluctance power - active and reactive power control - load sharing upon parallel operation - effect of armature reactance - automatic synchronizing - effect of change in fuel supply and excitation - alternator connected to infinite bus - governor characteristics - synchronizing power and torque - phasor diagram for two identical generators in parallel - locus of generated voltage for constant real power and variable excitation - automatic voltage regulators - synchronous motor - principle of operation - equivalent circuit - phasor diagram - torque and power relations - effect of load changes on synchronous motor - mechanical load diagram - armature current as function of power developed and excitation - V curves - inverted V curves - minimum excitation for given power - hunting - periodicity of hunting - suppression - different starting methods.

Module 3: Induction Machines (14 hours)

Three phase induction motors - construction - principle of operation - rotor MMF and production of torque - slip and frequency of rotor current - phasor diagram - equivalent circuit - mechanical power developed - maximum torque - torque slip characteristics - losses and power flow - single phasing - no-load and blocked rotor tests - circle diagram - effect of deep bar and double cage rotors - effects of air gap flux harmonics - cogging and crawling - starting methods for three phase induction motors - direct on line starting - auto transformer starting - star delta starting - rotor resistance starting - starters and contactors - speed control - basic methods - voltage control - frequency control - rotor resistance control - pole changing - static frequency conversion and slip power recovery scheme - line excited and self excited induction generators - single phase induction motors - double revolving field theory - equivalent circuit - starting methods of single phase induction motors - applications of all types of induction motors.

Module 4: Generalised Machine Theory (5 hours)

Generalised machine theory - machine as a circuit - model parameters - conventions - models for dc machines, synchronous machines, induction machines and transformers - introduction to digital simulation of systems comprising of machines.

References:

1. Langsdorf A S, *Theory of DC Machinery*, McGraw Hill, 1999.
2. Nagrath I J & Kothari D P, *Electric Machines*, Tata McGraw Hill, 1999.
3. Say M G, *The Performance and Design of AC Machines*, CBS, 1983.
4. Chapman S J, *Electric Machinery Fundamentals*, McGraw Hill, 1999.
5. Toro V D, *Electrical Machines and Power Systems*, Prentice Hall, 1988.

EE3005D POWER SYSTEMS – I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Describe the general structure of modern power systems, microgrid and smart grid
CO2: Design electrical and mechanical parameters of power system
CO3: Analyze different types of distribution systems, power quality issues and power conservation measures
CO4: Discuss and design various protection schemes

Module 1: Power Generation and Economics (9 hours)

Conventional sources of electrical energy - renewable energy sources - power plant economics - operating costs - load factor - demand factor - diversity factor - plant factor - tariffs- case study- distributed generation - microgrid - smartgrid – simulation of models and case study.

Module 2: Mechanical Design of Transmission Lines (9 hours)

Overhead transmission systems - arrangement of conductors - sag and tension - transmission line supports choice of transmission voltage - line insulators - failure of insulation - corona - underground cables - different types - capacitance of single core and three core cables - grading of cables – Performance of transmission lines - calculation of transmission line inductance and capacitance - GMD and GMR - bundled conductors - transposition - ABCD constants – Ferranti effect- computer based estimation of system parameters.

Module 3: Distribution system Design (10 hours)

Distribution systems - classification and arrangement of distribution systems - distribution substation layout and arrangement - economic loading of distribution transformers - Kelvin's law - considerations in primary and secondary distribution system design - current distribution and voltage drop calculation-design of feeders and distributors - improvement of existing distribution systems - LT capacitor installation – System and equipment earthing - Energy Conservation Measures- Power quality issues and mitigation techniques- distribution system planning and automation-traction-heating-welding-lighting.

Module 4: Switchgear and protection (11 hours)

Circuit breaker – Types - rating - Selection - Neutral earthing - Lightning and protection - Protective Relays – Functions - Types of Relays - protection schemes - case study - NEC and importance of relevant IS/IEC Specifications

References:

1. I.J. Nagrath and D.P. Kothari, *Power System Engineering*, Tata McGraw-Hill, 2005
2. A.T. Starr, *Generation, Transmission & Utilization of Electric Power*, 4th ed., Sir Issac Pitman and Sons, 1973
3. Turan, Gonen, *Electric Power Transmission System Engineering*, John Wiley, 1988
4. S.L. Uppal*, Electric Power*, Khanna Publishers, 1992.
5. A.S. Pabla*, Electric Power Distribution System*, Tata McGraw Hill, 1992.
6. M N Bandyopadhyay, *Electrical Power Systems- Theory and Practice*, Prentice Hall of India, 2006.
7. Weedy B M, Cory B J*, Electric Power Systems*, 4th ed., John Wiley Publication, 1998.
8. Sunil S Rao, *Switchgear Protections*, Khanna Publications, Delhi 1999
9. T S Madhav Rao, *Power system protection static relays with microprocessor Applications*, Tata McGraw hill Publication,1998.
10. Badri Ram, D N Vishwakarma, *Power System Protection and Switchgear*, Tata Mc Graw Hill, 2005.

EE3007D POWER ELECTRONICS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Choose the appropriate power semiconductor switches for a power electronic circuit.
CO2: Analyse and design Phase Controlled rectifiers.
CO3: Design and choose Cycloconverter, DualConverter, and Inverters suitable for an application.
CO4: Illustrate and explain the Choppers and Switching Regulators.
CO5: Select proper power electronic converter for an application.

Module 1: Power Semiconductor Switches (10 hours)

Power diodes - Basic structure and V-I characteristics - various types - DIACs – Basic structure and V-I characteristics – TRIACs - Basic structure and V-I characteristics -Thyristors - basic structure - static and dynamic characteristics - device specifications and ratings - methods of turning on - gate triggering circuit using UJT - methods of turning off - commutation circuits. IGBTs - Basic structure and V-I characteristics. MOSFETs - Basic structure and V-I characteristics

Module 2: Rectifiers (11 hours)

Line frequency phase controlled rectifiers using SCR - Single Phase – Half wave rectifier with R and RL loads – Full wave half controlled and fully controlled converters with continuous and constant currents - Input side harmonics and power factor - Effect of source inductance. Three Phase - Half wave rectifier with R and RL loads - Full wave fully controlled converters with continuous and constant currents.

Module 3: Inverters & Cycloconverters (9 hours)

Inverters – Single phase inverters – series, parallel and bridge inverters. Single Phase Pulse Width Modulated (PWM) inverters – Basic circuit and operation. AC regulators - single phase ac regulator with R and RL loads - sequence control of ac regulators - single phase to single phase cycloconverters - basic principle of operation.

Module 4: DC – DC Converters (9 hours)

Choppers - principle of operation - step-up and step-down choppers. Switching regulators - Buck regulators - Boost regulators - Buck-boost regulators - Switched mode power supply - principle of operation and analysis.

References:

1. Ned Mohan, *Power Electronics*, 2nd ed., John Wiley and Sons, 1995.
2. Rashid, *Power Electronics, Circuits Devices and Applications,* 3rd ed., Pearson Education, 2004.
3. G.K.Dubey, *Thyristorised Power Controllers*, Wiley Eastern Ltd, 1993.
4. Straughen and Dewan, *Power Semiconductor Circuits*, John Wiley & Sons, 1975.
5. Cyril W Lander, *Power Electronics*, 3rd ed., McGraw Hill, 1993.

EE3091D ELECTRICAL MACHINES LAB - I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

CO1: Acquire hands on experience of conducting various tests on dc machines and obtaining their performance indices.

CO2: Acquire hands on experience of conducting various tests on transformers and obtaining their performance indices.

CO3: Acquire knowledge about the standard analytical as well as graphical methods for the performance analysis of dc machines and transformers.

List of Experiments:

1. Determination of open circuit characteristic of a dc shunt generator and its analysis.
2. Load test on a dc shunt generator, determination of internal/ external characteristics and analysis.
3. Break test on dc shunt and series motors, determination of performance characteristics and analysis.
4. Swinburne's test on a dc shunt motor and predetermination of efficiency of the machine.
5. Hopkinson's test on a pair of dc shunt machines and predetermination of their efficiencies.
6. Retardation test on a dc shunt machine and separation of losses.
7. No load test on a dc machine and separation of losses.
8. OC and SC tests on a single-phase transformer and predetermination of efficiency/ regulation.
9. Separation of losses in a single-phase transformer.
10. Sumpner's test on a pair of single-phase transformers and predetermination of efficiency/ regulation.
11. Scott connection of two single-phase transformers and performance evaluation.
12. Polarity test on single phase transformers and three phase connections of the same.

References:

1. Clayton A E & Hancock N N, *Performance and Design of DC Machines*, ELBS,1971.
2. Nagrath I J & Kothari D P, *Electric Machines*, Tata McGraw Hill, 1999.
3. Say M G, *The Performance and Design of AC Machines*, CBS, 1983.
4. Toro V D, *Electrical Machines and Power Systems*, Prentice Hall, 1988.

EE3093D ELECTRONICS LAB - II

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:
CO1: Design and test various basic linear application circuits using Opamps
CO2: Design and test various signal comparison operation circuits using Opamps and Comparators
CO3:Design and test various waveform generation circuits using Opamps, Comparators and IC packages
CO4: Design and test various Opamp based Active Filter Circuits
CO5: Design and test PLL application circuits including FM Demodulation
CO6: Design and test various combinational logic circuits and systems
CO7: Design and test various sequential logic circuits and systems

List of Experiments:

1. OPAMP circuits - design and set up of inverter - scale changer - adder - non-inverting amplifier integrator and differentiator using TL082
2. OPAMP comparator - design and set up of Schmitt trigger - window comparator
3. Phase shift and Wein's bridge oscillator with amplitude stabilization using OPAMPs
4. Waveform generation - square, triangular and saw tooth wave form generation using OPAMPs
5. Precision rectification - absolute value and averaging circuit using OPAMPs
6. Second order LP, HP and BP filters using Universal Active Filter Topology
7.
    a. Study the operation of a PLL constructed using TL082 and MPY634
    b. Using CD 4046 (PLL), set up and study the dynamics of
        i. A Frequency multiplier
        ii. A FSK MOD/DEMOD.
8. Set up analog to digital converter
    a. Successive approximation method
    b. Dual slope method
9. Using UP DOWN COUNTER and a DAC Ics, generate triangular waveform
    a. Using CD 4047 IC, design and set up gated/ungated astable and monostable multivibrators
    b. Using CD 4093 Schmitt NAND IC, design and set up astable and monostable multivibraors
10. Design of Half adder and half subtractor circuits with NAND gates using mode control
    a. Design and realization of ripple counter using JK flip-flop
    b. Cascading of synchronous counters
11. Design and realization of Johnson & Ring counter using
    a. JK flip flop
    b. shift register
12. Synchronous UP/DOWN counter design and realization
13.
    a. Design a Function Generator and VCO using TL082 and MPY634.
    b. Design a AGC and AVC using TL082 and MPY634 for a given peak amplitude of sine wave.

14.
    a. Design a low drop out regulator using TL082 for a given voltage regulation characteristics and compare the characteristics with TPS7250 IC.
    b. Design a switched mode power supply that can provide a regulated output for a given input range using the TPS40200 IC.

Note: Normally the practical classes are administered in two cycles. Depending on the availability of equipments and time, class coordinators may choose the experiments for each cycle.

References:

1. A.S Sedra and K.C Smith, *Microelectronic Circuits*, 5th ed., Oxford University Press,2009
2. M. M. Mano and M. D. Ciletti, *Digital Design*, 5th ed., Pearson, 2013.

EE3002D DIGITAL SIGNAL PROCESSING

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:

CO1: Formulate mathematical description for a given digital filter design and carry out performance evaluation of the design by analytical methods
CO2: Carry out performance evaluation of a digital filter prototype design by impulse response testing.
CO3: Design and validate linear phase FIR systems for various digital signal processing tasks.
CO4: Design IIR and FIR Filter structures for common filtering applications.
CO5: Carry out spectral analysis of periodic CT waveforms using Digital Spectrum Analyzer and interpret the results.
CO6: Implement Digital Filters by Block Convolution

Module 1: Fourier Analysis of DT Signals and Systems (10 hours)

[*Review of Discrete-time (DT) signals and LTI-DT Systems – description by finite difference equations, decomposition of the analysis problem stated by* $\sum_{i=0}^{N} a_i y[n-i] = \sum_{i=0}^{M} b_i x[n-i]; n \geq 0 \text{ and } a_o = 1,$ *with* $y[-1] = y_{-1}; y[-1] = y_{-2}; \cdots\cdots y[-N] = y_{-N}$ *into Zero-input problem + Zero-state problem format suitable for applying superposition principle – Zero-input response (ZIR) and Zero-state response (ZSR) – Interpretations of ZIR and ZSR – Principle of superposition as applied to ZSR, ZIR and Total Response. ZIR of LTI-DTS – Solution and properties of ZIR – Characteristic equation of a FDE – Natural frequencies, Location of natural frequencies in signal plane – stability of LTI-DTS and Unit Circle in signal plane – (1 hr) ZSR of LTI-DTS for standard inputs of type* $x[n]$ *for n ≥ 0*]

Eigen functions of an FDE - z^n as eigen function of a LTI-DTS – condition of dominance - sinusoidal steady-state frequency response function (FRF) – Determination of FRF from FDE coefficients – Properties of FRF Sinusoidal steady-state response from convolution summation – relation between FRF and Impulse Response coefficients - sinusoidal steady-state response as the primary and sufficient response of a LTI-DTS

Review of Fourier Transform theory for CT Signals – Sampling – Sampling Theorem – Aliasing – Band limiting – Interpolation – Ideal Interpolator – Practical interpolators – ZOH and First Order Hold - Realization of a CT frequency response by CT to DT + DT frequency response + DT to CT chain –

Expansion of an arbitrary $x[n]$ in terms of DT Sinusoids– Periodic sequences – Discrete Fourier Series (DFS) and properties, solution of LTI-DTS with periodic inputs using DFS and FRF –

Expansion of a Finite Duration Sequence (FDS) $x[n]$ in terms of DT Sinusoids - periodic replication of an FDS – DFS of periodic replication of an FDS – Limit of DFS as period of replication is sent to ∞ - Discrete-Time Fourier Transform (DTFT) – Properties of DTFT – Extension for general aperiodic $x[n]$ - conditions for existence of DTFT – Use of DTFT in solving LTI-DTS with aperiodic inputs.

Module 2: Z-Transforms and Transfer Function (9 hours)

Expansion of an arbitrary $x[n]$ in terms of generalized complex exponential sequences of z^n type – Z-transform and its interpretation – Inverse Integral and Convergence – Inverting Z-transforms -Properties of Z-transform –

Use of unilateral Z-transform in solving FDE with initial conditions – System Transfer Function – Poles and Zeros – Stability and Unit Circle in z-plane – FRF from transfer function – Geometrical determination of FRF from z-domain pole-zero plot –
All-pass systems, Minimum phase systems, FIR systems and generalized linear phase frequency response – Type-1, Type-2, Type-3 and Type-4 Linear Phase FIR Systems and applications.

Module 3: IIR and FIR Filter Design (10 hours)

IIR Filter design by transformation of Analog filter functions – Butterworth functions for LPF, HPF , BPF and Notch filters –
Transforming analog function to discrete transfer function – Forward and backward difference transformations – Impulse invariant transformation – Bilinear transformation – pre-warping –
Properties of FIR filters – FIR filter design by Windowing – comparison between IIR and FIR filters
Basic structures for IIR and FIR Systems – Direct forms – Cascade forms – Parallel forms.
Finite word length effects in DSP – zero-input limit cycles in fixed point implementations – limit cycles due to overflow

Module 4: DFT, FFT and Applications (10 hours)

Sampling of DTFT of a Finite Duration Sequence– Discrete Fourier Transform (DFT) – Inverse DFT (IDFT) – properties of DFT and IDFT –
Sampling of DTFT of a Infinite duration sequence – IDFT of these samples – aliasing– Linear Convolution and Circular Convolution – Relation between them for different combinations of sequences –
Evaluation of Linear Convolution through Circular Convolution using DFT – Implementation of LTI-DTS by DFT –Block Convolution and latency - Overlap-save and Overlap-add methods –
Computation of DFT – FFT Algorithm – Radix-2 DIT FFT – Radix-2 DIF FFT – Butterfly computations – bit reversed order – in-place computations –
Spectral Analysis of a periodic CT signal by FFT – resolution – leakage – picket-fence effect - interpretation of reported spectral data and pitfalls

References:

1. John G. Proakis , Dimitris G. Manolakis, *Digital Signal Processing*, 4th ed., Pearson, 2007
2. Oppenheim, Schafer, *Discrete-Time Signal Processing*, PHI, 1997
3. Sanjit K Mitra, *Digital Signal Processing : A Computer-based Approach*, TMH, 1998

EE3004D CONTROL SYSTEMS - II

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the mathematical model of discrete time control systems
CO2: Evaluate the stability of digital control systems and nonlinear systems
CO3: Test the controllability and observability of dynamical systems
CO4: Design of controllers and observers for dynamical systems using state feedback
CO5: Describe the characteristics of nonlinearities and types of nonlinear systems
CO6: Analyse nonlinear systems using phase plane method and describing function

Module 1: Introduction to sampled data and discrete time systems (10 hours)

Data conversion and quantization - Sampling process - Mathematical modeling - Data reconstruction and filtering of sampled signals - Hold devices - z transform and inverse z transform - Relationship between s plane and z-plane - Digital control systems - Pulse transfer function - z transform analysis of closed loop and open loop systems - Difference equation - Solution by z-transform - Stability of linear digital control systems - Stability tests.

Module 2: State space design and elements of optimal control (10 hours)

State Space Design: Controllability and Observability - state variable design, state feedback, pole placement - Ackerman's formula – design of full order and reduced order observers – Interrelations between z- transform models and state variable models - Controllability and Observability of digital control systems - Pole placement using state feedback for digital control systems
Optimal control problem: Different performance measures and constraints - Optimal control using quadratic performance measures - State feedback regulator problem.

Module 3: Nonlinear systems (11 hours)

Characteristics - different types of nonlinearities and their occurrence Phase plane analysis - Isocline method - limit cycles in phase plane - stability of limit cycles – existence of limit cycle – Nonlinear feedback systems - Filter hypothesis - Describing functions - describing function for single valued and double valued nonlinear elements - amplitude and frequency of limit cycles.

Module 4: Stability of nonlinear Systems (8 hours)

Linearization and equilibrium points - stability of equilibrium points - Lyapunov's First method - Stability of non-linear systems - Lyapunov method for nonlinear systems – Variable Gradient Method for generation of Lyapunov function.

References:

1. M. Gopal, *Digital Control & State Variable Methods*, Tata McGraw Hill, 1992.
2. Benjamin C Kuo, *Digital Control Systems*, Oxford University Press, 1992.
3. Katsuhiko Ogata, *Modern Control Engineering*, Pearson Prentice Hall, 2006.
4. M Gopal, *Control Systems*, 3rd ed., Tata McGraw Hill, 2006.
5. K P Mohandas, *Modern Control Engineering*, Revised Edition, Sanguine Pearson, 2010.
6. Hassan K Khalil, *Nonlinear Systems*, Prentice Hall International (UK), 1996.
7. Alberto Isidori, *Nonlinear Control Systems*, Springer Verlag, 1995.
8. S. Wiggins*, Introduction to Applied Nonlinear Dynamical Systems and Chaos*, Springer Verlag, 1990.

EE3006D POWER SYSTEMS – II

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Course Outcomes:
CO1: Model individual power system components like transmission lines and generators
CO2: Formulate and solve load flow and analyze faulted power systems
CO3: Analyze economics of power supply systems, economic dispatch and unit commitment
CO4: Create computational models for power system operation and control
CO5: Analyze power system stability, security and reliability
CO6: Explain deregulation of power system

Module 1: Transmission Line Modelling and Load Flow Studies (11 hours)

Transmission line model - Nominal T and π methods of calculations -power flow through a transmission line - Methods of voltage control
Representation of power systems - per unit quantities - Y-bus and Z-bus matrices - load flow studies:- GaussSeidal- Newton Raphson and fast decoupled methods - line loss computation – HVDC Transmission and AC-DC load flow – computer simulations.

Module 2: Short circuit studies (9 hours)

Faults on power systems - short circuit capacity of a bus and circuit breaker ratings-current limiting reactor-sequence impedances and sequence network - symmetrical component methods of analysis of unsymmetrical faults at the terminals of an unloaded generator – Z bus building algorithm-Digital techniques in fault analysis – computer simulations.

Module 3: Economic dispatch, AGC & AVR (9 hours)

Economic dispatch of thermal plants - B-coefficient - optimal load flow solution –unit commitment-speed governing of turbo generator –- load sharing and governor characteristics-load frequency control of single and multi area systems - implementation of Economic Dispatch and Automatic Generation Control - automatic voltage regulation – EMS,SCADA, hydro thermal scheduling – computer simulations.

Module 4: Power system stability studies, Security and Reliability (10 hours)

Electrical stiffness - swing equation - inertia constant - equal area criterion - multi machine stability analysis –case study on standard test systems- factors affecting stability-Voltage stability problem: causes and improvement methods-introduction to power system security and reliability-deregulated power systems.

References:

1. Stevenson J V, William D, *Elements of Power System Analysis*, McGraw Hill, 1988.
2. John J. Grainger and William D. Stevenson, Power System Analysis, Tata McGraw-Hill, 2003
3. D.P. Kothari & I.J. Nagrath, *Modern Power System Analysis*, Tata McGraw Hill, 2007.
4. A.K. Mahalanabis, *Computer Aided Power System Analysis & Control*, Tata McGraw Hill, 1991
5. Arthur R Bergen, Vijay Vittal, *Power system Analysis*, Pearson Education (Singapore) PTE Ltd., 2004
6. Hadi Saadat, *Power System Analysis*, Tata Mcgraw Hill, 2003.
7. J Arrillaga, C P Arnold, B J Harker, *Computer Modelling of Electric Power Systems,* Wiley, 2001.
8. O. Elgerd , *Electric Energy Systems Theory- An Introduction*, 2nd ed., Tata Mcgraw Hill, 1995.

9. Wadhwa C L, *Electrical Power Systems*, 3rd ed., New Age Publication, 2002
10. Loi Lei Lai, *Power system restructuring and deregulation*, John Wiley & sons, 2002.
1. Antonio Gomez-Exposito, Antonio j.conejo & Claudio canizares, *Electric Energy systems analysis and operation*, CRP press, 2009.

ME3104D PRINCIPLES OF MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Explain the characteristics and functions of management in the contemporary context
CO2: Demonstrate ability in decision making process
CO3: Summarize the functional areas of management
CO4: Comprehend the concept of entrepreneurship and create business plans

Module 1: (15 hours)

Introduction to management, classical, neo-classical and modern management theories, Levels of managers and skill required. Management process – planning – mission – objectives – goals – strategy – policies – programmes – procedures. Organizing, principles of organizing, organization structures, Directing, leadership, motivation, Controlling.

Module 2: (11 hours)

Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.

Module 3: (13 hours)

Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, entrepreneurship, business plans, corporate social responsibility, patents and Intellectual property rights.

References:

1. H. Koontz, and H. Weihrich, *Essentials of Management: An International Perspective.* 8th ed., McGraw-Hill, 2009.
2. R. W. Griffin, *Management: Principles and Applications,* Cengage Learning, 2008.
3. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, *Marketing Management: A South Asian Perspective.* 14th ed., Pearson, 2012.
4. M. Y. Khan, and P. K. Jain, *Financial Management*, Tata-McGraw Hill, 2008.
5. R. D. Hisrich, and M. P. Peters, *Entrepreneurship: Strategy, Developing, and Managing a New Enterprise*, 4th ed., McGraw-Hill Education, 1997.
6. E. B. Roberts, *Entrepreneurs in High Tech-Lessons from MIT and beyond,* Oxford University Press, 1991
7. D. J. Sumanth, *Productivity Engineering and Management*, McGraw-Hill Education, 1985.

EE3092D ELECTRICAL MACHINES LAB - II

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

CO1: Acquire hands on experience of conducting various tests on alternators and obtaining their performance indices.

CO2: Acquire hands on experience of conducting various tests on induction machines and obtaining their performance indices.

CO3: Acquire knowledge about the standard analytical as well as graphical methods for the performance analysis of alternators and induction machines

List of Experiments:

1. No load and blocked rotor tests on a 3-phase squirrel cage induction motor, determination of its equivalent circuit and performance analysis by drawing the circle diagram.
2. No load and blocked rotor tests on a 3-phase slip ring induction motor, determination of its equivalent circuit and performance analysis by drawing the circle diagram.
3. No load and blocked rotor tests on a single phase induction motor, determination of its equivalent circuit and performance analysis.
4. Load tests on a 3-phase squirrel cage induction motor and its performance analysis.
5. Load tests on a 3-phase slip ring induction motor and its performance analysis.
6. Operation of a dc machine coupled induction machine as an induction generator and its performance analysis.
7. Speed control of an Induction motor by pole changing method.
8. Speed control of an Induction motor by variable frequency method.
9. Predetermination of voltage regulation of a 3-phase alternator by EMF/ MMF methods.
10. Predetermination of voltage regulation of a 3-phase alternator by ZPF method.
11. Slip test on a salient pole alternator and predetermination of voltage regulation.
12. Synchronization of a 3-phase alternator to the supply mains and plotting of V-curves/ inverted V-curves.
13. Energy saving comparison of delta-connected and star-connected induction motors.
14. Performance comparison of 3-phase energy efficient induction motor with other induction motor.

References:

1. Nagrath I J & Kothari D P, *Electric Machines*, Tata McGraw Hill, 1999.
2. Say M G, *The Performance and Design of AC Machines*, CBS, 1983.
3. Toro V D, *Electrical Machines and Power Systems*, Prentice Hall, 1988.

EE3050D ELECTRICAL ENGINEERING DRAWING

Pre-requisites: Nil

L	T	P	C
1	0	2	2

Total hours: 39

Course Outcomes:

CO1: Acquire experience to design and draw different types of AC and DC armature windings and familiarization with auto cad.
CO2: Acquire experience to design, visualize and draw the sectional plan and elevation of different aspect of transformer structure and to know the relative position of its components.
CO3: Acquire experience to design, visualize and draw the sectional plan and elevation of different type of DC machines, alternator and induction motor.
CO4: Acquire knowledge of layout of schematic representation of outdoor and indoor substations.

Module 1: Familiarization of CAD and preparation of Armature Windings (10 hours)

1. Introduction to AutoCAD. Preparation of simple 2D AutoCAD drawings using the commands/tools of AutoCAD (Draw, Edit, View, Modify, dimension style, plotting, object and layer selection).
2. Drawing of Electrical symbols and introduction to symbol libraries and icons of Electrical CAD.
3. Simplex lap/ wave dc armature windings with end connections, indicating the brush positions.
4. Preparation of Simplex lap/wave DC armature windings with equalizer rings/ dummy coils in AutoCAD.
5. Simplex lap/ wave, integral/ fractional slot, double layer three phase ac armature windings with full pitched/ short chorded coils.
6. Preparation of Mush type and concentric bifurcated/ unbifurcated 2 tier/ 3 tier single layer three phase ac armature winding in AutoCAD.

Module 2: Transformers (8 hours)

1. Sectional plan and elevation of a transformer limb with windings.
2. Sectional plan and elevation of the core assembly of a power transformer.
3. Sectional plan and elevation of a distribution transformer tank with its accessories.
4. Sketches of capacitor and oil filled type transformer bushings.

Module 3: Rotating Machines (17 hours)

A. DC Machines

1. Half sectional Elevation and side view of armature with commutator including the connections.
2. Preparation of Sectional Elevation and side view of yoke and pole assembly with main field winding and interpole windings in Autocad.
3. Preparation of Half Sectional Elevation of a DC machine with field, armature and commutator including connections in Autocad.

B. Alternators

1. Sketches of the methods of pole fixing and slot details of turbo & water wheel alternators.
2. Sectional Elevation and side view of water wheel rotor assembly with winding.
3. Sectional Elevation and side view of salient pole alternator.
4. Sectional Elevation and side view of turbo alternator.

C. Induction Motors

1. Preparation of Half Sectional elevation of slip ring induction motor with slip rings and brushes in Autocad.
2. Half sectional front and side elevation of squirrel cage induction motor.

Module 4: Substations (4 hours)

Preparation of the following substation drawings and layouts in Autocad

1. Layouts and single line diagrams of 3Φ, 11kV HT outdoor and indoor substations.
2. Layout of a 3Φ, 220kV outdoor substation with duplicate bus bar/ tie bar, all accessories and switchgears.
3. Layout of a captive power substation.
4. Single line diagram of a distribution center.

References:

1. Clayton & Hancock, *Performance and Design of DC Machines*, ELBS, 1992.
2. Say M.G, *Performance and Design of AC machines*, Pitman, ELBS, 1991.
3. A.K. Sawhney, *Electrical Machine Design*, Dhanpat Rai, New Delhi, 1991.
4. Narang K.L., *A Text Book of Electrical Engineering Drawing*, Tech India Publications, 2016.
5. Bhattacharya S.K, *Electrical Engineering Drawing*, 2nd ed., Wiley Eastern., 2009

EE3021D ELECTRICAL ENGINEERING MATERIALS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Describe the characteristics and electrical properties of various materials, used in the electrical appliances, devices, instruments and in various applications electrical engineering.
CO2: Apply the fundamental science and engineering principles relevant to electrical engineering materials.
CO3: Design and select suitable materials for applications associated with generation, transmission and distribution of electric power.

Module 1: (11 hours)

Conducting materials: Review of metallic conduction on the basis of free electron theory-electrical and thermal conductivity-Wiedemann-Franz law-drawback of classical theory-quantum free electron theory-Fermi-Dirac distribution - variation of conductivity with temperature and composition, Materials for electric resistances general electric properties: brushes of electrical machines, lamp filaments ,fuses and solder.
Semiconductors: Mechanism of conduction in semiconductors. density of carriers in intrinsic semiconductors the energy gap - types of semiconductors. Hall Effect - compound semiconductors - basic ideas of amorphous and organic semiconductors
Magnetic materials: Classification of magnetic materials - origin of permanent magnetic dipoles ferromagnetism - hysterisis curve-magnetostriction - hard and soft magnetic materials- magnetic materials used in electrical machines instruments and relays

Module 2: (11 hours)

Dielectrics: Dielectric polarization under static fields - electronic, ionic and dipolar polarizations - behavior of dielectrics in alternating fields - mechanism of breakdown in gases, liquids and solids- factors influencing dielectric strength- capacitor materials-Ferro and piezo electricity
Insulating materials-complex dielectric constant - dipolar relaxation .dielectric loss insulator materials used inorganic materials (mica, glass, porcelain, asbestos) - organic materials (paper, rubber, cotton silk fiber, wood, plastics, bakelite) - resins and varnishes - liquid insulators(transformer oil) - gaseous insulators (air, SF6, and hydrogen) – ageing of insulators.

Module 3: (9 hours)

Special purpose materials and processes: Thermo couple materials-soldering materials- fuse materials-contact materials-structural materials-fluorescent and phosphorescent materials- galvanizing and impregnation process -
Super conductors – effect of magnetic field- Meissner effect-type I and type II superconductors –London equations –Josephson effect –applications of superconductors

Module 4: (8 hours)

Materials for electronic components – resistors –insulated moulded resistors-Cracked carbon resistors-alloy resistors-metallic oxide thin film resistors-High value resistors-wire wound resistors-non linear resistors – varistors –capacitors-mica- dielectric capacitors-glass-dielectric capacitors-plastic-dielectric capacitors etc – inductors –air cored coils –cored coils-ferrite core-relays- Applications of nano materials.

References:

1. Indulkar C.S. and Thiruvengadam S, *An Introduction to Electrical Engineering Materials*, 6th ed., S. Chand & Co Pvt Ltd, 2011.
2. P.K. Palanisamy, *Solid State Physics*, Scitech Publications, Hyderabad, 2011.
3. A.J. Dekker, *Electrical Engineering Materials,* 1st ed., Prentice Hall of India, 1963.
4. Yu Koritsky, *Electrical Engineering Materials*., Moscow MIR, 1970.
5. Arumugam M., Materials Science., Anuradha Publishers, 1990.
6. Kapoor P.L., *Electrical Engineering Materials*, Khanna Publications, 2014.
7. Hutchison T.S. and Baird D.C, *The Physics of Engineering Solids*, 2nd ed., John Wiley Publications, 1968.
8. S.O.Kasap, *Principles of Electrical engineering Materials and Devices*, Tata McGraw Hill. 2000
9. R.K. Rajput, *Electrical Engg. Materials*, 2nd ed., Laxmi Publications, 2015.
10. T. K. Basak, *Electrical Engineering Materials*, New age International, 2008.
11. Solymar, *Electrical Properties of Materials*, 9th ed., Oxford University Press, 2014.
12. I. P. Jones, *Material Science for Electrical and Electronic Engineering*, Oxford University Press, 2000.
13. TTTI Madras, *Electrical Engineering materials*, Tata McGraw Hill, 2004.

EE3022D DYNAMIC SYSTEM SIMULATION

Pre-requisites: EE2002D Signals & Systems

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Explain the modelling of dynamic systems for digital computer simulation
CO2: Describe the use of various computer based tools for simulation and analysis
CO3: Simulate continuous time, discrete time and discrete event systems system using digital computer
CO4: Simulate electrical machines, drives and controls using digital computer
CO5: Explain the system performance using simulation results and suggest improvements

Module 1: Basics of System Simulation (12 hours)

Review of mathematical methods for computer based simulation of dynamic systems-numerical methods for solution of differential equations-numerical integration-matrix methods-random number generation-random processes-stochastic processes-discrete time models-event driven systems-queues- effect of sampling time on proper results-connection between simulation time and real time-transient responses for first order systems, second order systems-continuous time and discrete time systems-simulation of feedback control systems-text based programming and block set based programming-introduction to hardware in the loop simulation-exercises for simulation of first order and second order systems using popular programming languages-familiarization of custom software tools.

Module 2: Simulation of electrical machines (13 hours)

Modeling and simulation of electrical machines- Transfer function modeling-for DC machines and AC machines- Modeling of special machines-generalized machine modeling-transformations used in generalized modeling-simulation of various machines for various working conditions. Simulation of multi-machine dynamics.

Module 3: Simulation of Converters (14 hours)

Modeling & simulation of power converters and drives-Halfwave controlled rectifiers, full bridge controlled rectifier, Three phase converters, cyclo-converters, inverters-inverter fed Squirrel cage motor, Chopper fed DC motor. UPS circuits-Harmonic analysis of outputs of power converters-determination of conversion efficiency.

Textbooks:

1. Chee-MunOng, *Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK*, Prentice Hall, 1998.

References:

1. Karnopp, Dean C, Donald L. Margolis, Ronald C. Rosenberg, *System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems*, John Wiley & Sons, 2012.
2. Fabien, Biran, *Analytical System Dynamics: Modeling and Simulation*, Springer, 2009.
3. Argyris, J., Faust, G., Haase, M, Friedrich, R, *An Exploration of Dynamical Systems and Chaos*, Springer 2015.

EE3023D NETWORK ANALYSIS

Pre-requisites: EE2001D Circuits & Networks
EE2002D Signals & Systems

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Analyze linear electrical circuits using graph theory
CO2: Apply computer based methods for solutions for simple networks using graph theory
CO3: Analyze two passive networks and derive network parameters
CO4: Derive parameters for passive two port filters using given specifications
CO5: Analyze three phase power circuits for various operating conditions

Module 1: Linear Graph Theory & Networks (13 hours)

Linear Oriented Graphs - incidence matrix – Kirchoff's Laws in incidence matrix form – nodal analysis (with independent and dependent sources) – Circuit matrix of linear oriented graph – Kirchoff's laws in fundamental circuit matrix form - Loop analysis of networks (with independent and dependent sources) – Planar graphs – Mesh analysis- Duality – Cut set matrix - Fundamental cut set matrix – Relation between circuit, cut set and incidence matrices – Kirchoff's laws in fundamental cut set form – Node pair analysis – Analysis using generalized branch model (node, loop and node pair analysis) – Tellegen's theorem for lumped parameter network in topological form.

Module 2: Two Port Networks & passive filters (13 hours)

Modeling Two-port networks-examples-amplifiers, transmission lines, passive filters-describing equations and parameter sets for two-port networks-equivalent circuit for a two port network-inter-relationship between parameters- driving point and transfer impedance- determination of parameters for T and Phi networks-reciprocity and symmetry- characteristic impedance-propagation constant—derivation of characteristic impedance and propagation constant for T and Phi networks under sinusoidal steady state-constant k and m-derived filters-low pass, high pass and band pass filters-effect of cascading multiple sections-switched capacitor filter.

Module 3: Steady state analysis of Three phase Circuits (13 hours)

Three phase circuits- balanced star-delta-circuits-purely resistive circuits- RL and RLC balanced conditions-derivation of voltage, current and power- unbalanced star-delta-circuits-purely resistive circuits- RL and RLC unbalanced conditions-derivation of voltage, current and power- neutral shift-open delta connections-analysis-power invariant transformations- star-delta and delta-star transformations-Analysis of phase voltage and current for harmonic input voltage-fundamental plus even harmonic-fundamental plus odd harmonics-for star and delta connection-finding neutral current for star and circulating current for delta for balanced conditions of phase impedances. Three phase transformer connections. Symmetrical components- per unit representations.

Textbooks:

1. Sureshkumar K.S, *Electric Circuits and Networks*, Pearson, 2009.
2. Hayt, William H(Jr), Jack E Kemmerly, Steven M Durbin, *Engineering Circuit Analysis*, McGraw-Hill Higher Education, 2007.

3. Van Valkenburg M E, *Network Analysis,* Prentice Hall India, 3rd ed., Indian Reprint 2014.

References:

1. Ramakalyan A, *Linear Circuits: Analysis & Synthesis*, Oxford University Press, 2005.
2. Chen, W.K, *Graph Theory and Its Engineering Applications*, World Scientific, 1997.
3. Bakshi U.A, Bakshi A.V, Electrical *Networks*, Technical Publications, 2008.

EE3024D DIGITAL CONTROL SYSTEMS

Pre-requisite: EE3001D Control Systems - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Able to describe and apply the basic principles and modeling of digital control system in transfer function and state-space domain.
CO2: Able to describe and apply the Laplace and Z-transforms and its correlation to digital control system.
CO3: Able to analyze different aspect of time response like steady state analysis, transient response analysis with system pole location, disturbance rejection, robustness and sensitivity analysis
CO4: Able to describe and apply the analysis techniques like Root locus, Bode and Nyquist plots, Jury stability criteria, Routh stability criteria, Bilinear transformation
CO5: Able to demonstrate the design procedure for controller for digital control system using root locus method, Bilinear transformation.
CO6: Able to apply the knowledge of fundamentals and design procedures of deadbeat controllers for digital control system.

Module 1: Fundamentals and Modelling (10 hours)

Basic digital control system- Examples - D/A and A/D conversion,quantization and delay effects, principles of discretization,mathematical model,Data reconstruction-ZOH and FOH- choice of sampling rate--Mapping between s-domain and z-domain-Pulse transfer function- Different configurations for the design- Modified z-transform- Multi-rate discrete data systems.Sampled signal flow graph

Module 2: Time and Frequency domain Analysis (10 hours)

Time responses of discrete data systems**-** Correlation between time response and root locations in the z-plane - Steady state performance- Disturbance Rejection- Robustness and Sensitivity -Jury's stability test – Routh stability criterion on the r-plane -Root locus- Polar plots-Nyquist stability criterion- Bode plot-Bilinear transformation method .

Module 3: Controller Design and Realization (10 hours)

Cascade compensators using Root Locus- Design of PID controllers by using bilinear transformation-Digital controller design using bilinear transformation- Dead-beat response design- Deadbeat controller without and with prescribed manipulated variable-Choice of sample time for deadbeat controller-Realization of Digital controllers- Computer based simulation.

Module 4: State-Space Analysis (9 hours)

State variable model of discrete data systems with S/H devices- State transition equations- state diagrams-Transfer function- Transformation to Jordan canonical form and phase variable form- Computation of state transition matrix using Cayley-Hamilton theorem and z-transform method- Response between sampling instants, Controllability, Observability, stabilizability and reachability- Loss of controllability and observability due to sampling- Pole placement design using state feedback for SISO systems- Computer based simulation.

Text books:

1. M.Gopal, *Digital control and State Variable methods*, Tata McGraw –Hill , 1997
2. B.C.Kuo, *Digital Control Systems*, 2nd ed., Oxford University Press,1992.
3. Constantine H. Houpis and Gary B. Lamont, *Digital control systems: Theory, hardware, software,* Mcgraw-Hill Book Company, 1985.
4. R.Isermann, *Digital control systems, Volume 1: Fundamentals, Deterministic control*, Springer Verlag, 2nd revised ed., 1989.
5. R.G.Jacquot, *Modern digital control systems*, 2nd ed., Marcel Dekker, Inc., 1995.
6. Phillips and Nagle, *Digital control system analysis and design*, Prentice Hall, 1984.
7. G.F.Franklin, J.David Powell and M.Workman, *Digital Control of Dynamic Systems,* 3rd ed., Addison Wesley, 2000.

EE3025D OPTIMIZATION TECHNIQUES & ALGORITHMS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Solve optimization problems using linear programming and apply for solving engineering optimization problems

CO2: Solve optimization problems using nonlinear programming (Hessian and gradient) and apply for solving engineering optimization problems

CO3: Solve optimization problems using descent methods and apply for solving engineering optimization problems

CO4: Solve constrained optimization problems using direct and indirect methods and apply for solving engineering optimization problems

CO5: Solve optimization problems using dynamic programming and genetic algorithm and apply for solving engineering optimization problems

Module 1: Linear programming (13 hours)

Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem.-Classical Optimization Techniques: Single and multi variable problems-Types of Constraints Semi definite case-saddle point- Linear programming: Standard form-Geometry of LP problems-Theorem of LP-Relation to convexity formulation of LP problems - simplex method and algorithm -Matrix form- two phase method-Duality- dual simplex method- LU Decomposition-.Sensitivity analysis-Artificial variables and complementary solutions-QP- Engineering Applications: Minimum cost flow problem, Network problems-transportation, assignment & allocation, scheduling .Karmarkar method-unbalanced and routing problems.

Module 2: Nonlinear programming (13 hours)

Non linearity concepts-convex and concave functions- non-linear programming gradient and Hessian-Unconstrained optimization: First & Second order necessary conditions-Minimization & Maximization-Local & Global convergence-Speed of convergence.-Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method-Lagrange multiplier method - Kuhn-tucker conditions .Quasi-Newton method- separable convex programming - Frank and Wolfe method, Engineering Applications-Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods-SLP, SQP Indirect methods-Transformation techniques-penalty function-Lagrange multiplier methods-checking convergence-Engineering applications

Module 3: (13 hours)

Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality-Computational procedure- Engineering applications.

Genetic algorithms-Gene formation-Cross over, mutation, etc.- Simulated annealing methods- modern developments in heuristic techniques like fiefly algorithm, cuckoo search, particle swarm optimization, etc. Optimization programming, tools and Software: MATLAB- SIMULINK, FSQP, SOLVER, LINDO etc

Text books:

1. S.S.Rao, *Engineering Optimization*, 3rd ed., New Age International (P) Ltd, New Delhi, 2004.
2. Shashi Kant Mishra, Bhagwat Ram, *Introduction to Linear Programming with MATLAB*, Chapman & hall (CRC Press),2017.

References:

1. W.L.Winston, *Operation Research-Applications & Algorithms*, Thomson publications, 2003.
2. Kalyanmoy Deb, *Optimization for Engineering Design-Algorithms and Examples*, Prentice Hall India-1998
3. Vanderbei, Robert J, *Linear Programming: Foundations and Extensions*, Springer, 2013
4. M. S. Bazaraa, J. J. Jarvis, H. D. Sherali, *Linear Programming & Network Flows*, John Wiley & Sons, 2010.
5. Luenberger, David G, *Linear and Nonlinear Programming*, Springer,2015
6. Winker, Peter, *Optimization Heuristics in Econometrics: Applications of Threshold Accepting*, John Wiley & Sons, 2000.

EE3026D ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Describe the concepts of Artificial Neural Networks
CO2: Explain the concept of fuzzy logic and adaptive fuzzy systems
CO3: Apply the concept of Artificial Neural Network and fuzzy logic methods in real time application
CO4: Visualize the applications of Artificial Neural Network and fuzzy logic methods using computer simulation

Module 1: Artificial Neural Networks (9 hours)

Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, types of Neuron Activation function, ANN Architectures, Learning strategy, supervised, and unsupervised learning, reinforcement learning rules, Perceptron Models, training Algorithms, Limitations of the Perceptron Model and Applications, Computer based simulation

Module 2: Multilayer Feed forward Neural Networks (10 hours)

Multilayer Feed forward Neural Networks:
Back propagation Algorithm, Limitations of Back propagation Algorithm, RBF network structure - covers theorem and the separability of patterns - RBF learning strategies, Applications in forecasting and pattern recognition and other engineering problems, Computer based simulation

Module 3: Fuzzy Logic Systems (11 hours)

Fuzzy Logic Systems:
Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions., Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods, Computer based simulation

Module 4: Fuzzy Inference Systems and applications (9 hours)

Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models, Adaptive Neuro-Fuzzy Inference Systems, Applications, function Approximation, control and process, Monitoring, fault diagnosis and load forecasting, other engineering applications, Computer based simulation

References:

1. Simon Haykin, *Neural Networks Comprehensive Foundation*, 2nd ed., Pearson Education, 2005.
2. James A. Freeman, David M. Skapura, *Neural Networks Algorithms, Applications, and Programming Techniques*, Pearson Education India, 1991.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications*, Prentice-Hall of India Pvt. Ltd., 2006
4. S.N.Sivanandam and S.N.Deepa, *Principles of Soft Computing*, Wiley India Pvt. Ltd, 2011.
5. Timothy J. Ross, *Fuzzy logic with engineering applications*, McGraw Hill, New York, 2010.
6. Stamatios V Kartalopoulos, *Understanding neural networks and fuzzy logic basic concepts and applications*, Prentice Hall of India (P) Ltd., New Delhi, 2000.

EE3027D SPECIAL MACHINES AND LINEAR MACHINES

Prerequisite: EE2006D Electrical Machines - I

L	T	P	C
3	0	0	3

Total Hours: 39 Hours

Course Outcomes:

CO1: Acquire knowledge about the fundamental principle and classification of servomotor.

CO2: Acquire knowledge about the fundamentals of systematical components for the analysis of AC servomotor leading to the design of its equivalent circuit and evaluation of its performance.

CO3: Acquire knowledge about the constructional features, method of operation and applications of stepper motor and understand the design procedure of drive amplifier and transistor logic for stepper motor.

CO4: Acquire knowledge about the fundamentals, construction details and classification of universal motors and synchronous motor like reluctance motors, hysteresis motors.

CO5: Acquire the knowledge of fundamentals, construction details and classification of linear machines.

Module 1: Servo Motors (11 hours)

Servo motors -Requirement of a good servomotor, Types of servomotors: DC servomotor: Basic working principle and its classification, Field controlled and Armature controlled DC servomotor, Application: servo stabilizer and position control system. AC servo motor: construction, operating principle and Application. Symmetrical components applied to two - phase servo motors -equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves.

Module 2: Stepper Motors (8 hours)

Stepper motors - construction features - method of operation - drive - amplifiers and transistor logic -Drive Circuits - half stepping and the required switching sequence - the reluctance type stepper motor – ratings. Characteristics of Stepper Motor- Stepper motor application.

Module 3: Reluctance motors & Universal motors (10 hours)

Reluctance motors - General types of synchronous motors - Reluctance motors - definitions - construction - polyphase and split phase reluctance motors - capacitor type reluctance motors.

Hysteresis motors - Construction - polyphase - capacitor type and shaded pole hysteresis motors –Methods of reversing direction of rotation in shaded pole motor. Advantage over reluctance motors, Torque develop and slip

Universal motors – Applications - torque characteristics - essential parts of universal motors - EMF due to main field and cross field - Transformer and rotational emf - circuit model and Phasor Diagram.

Module 4: Linear Machines (10 hours)

Linear machines - basic difference between LEMS and rotating - machine – classification of LEMS, linear motors and levitation machines - linear induction motors - linear synchronous motors - DC linear motors – linear levitation machines, edge Effect, MMF wave and its velocity, air gap flux density

References:

1. Toro.V.D, *Electric Machines and Power Systems*, Prentice Hall of India, 1985.
2. Veinott, *Fractional Horsepower Electric Motors*, McGraw-Hill, 1948

3. Nasar.S.A,Boldeal, *Linear Motion Electric Machines*, John Wiley,1976
4. V.U.Bakshi, U.A.Bakshi, *Electrical Circuits and Machines*, Technical Publication, Pune, 2008.
5. V. V. Athani, *Stepper Motors: Fundamentals Applications and Design*, New Age International 2007.
6. Fitzgerald, Charles Kingsley, Stephen D. Umans, *Electric machinery*, Tata McGraw-Hill 2002.

EE3028D ELECTRICAL MACHINE DESIGN

Pre-requisites: EE2006D Electrical Machines - I
EE3003D Electrical Machines - II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Acquire knowledge about the design of dc machines with performance estimation.
CO2: Acquire knowledge about the design of dc machines with performance estimation.
CO3: Acquire knowledge about the design of alternators with performance estimation.
CO4: Acquire knowledge about the design of induction machines with performance estimation.

Module 1: DC Machines (11 hours)

Output equation - main dimensions - choice of specific electric and magnetic loadings - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system, commutator, interpoles, compensating winding and brushes - Carter's coefficient - real and apparent flux density - design examples.

Module 2: Transformers (10 hours)

Output equation - single phase and three phase power transformers - main dimensions - choice of specific electric and magnetic loadings - design of core, LV winding, HV winding, tank and cooling tubes - prediction of no load current, forces on winding during short circuit, leakage reactance and equivalent circuit based on design data - design examples.

Module 3: Alternators (9 hours)

Output equation - salient pole and turbo alternators - main dimensions - choice of specific electric and magnetic loadings - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system and damper winding - prediction of open circuit characteristics and regulation of the alternator based on design data - design examples.

Module 4: Induction Machines (9 hours)

Output equation - main dimensions - choice of specific electric and magnetic loadings - design of stator and rotor windings, stator and rotor slots and air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor - calculation of equivalent circuit parameters and prediction of magnetising current based on design data - design examples.

References:

1. Clayton A E & Hancock N N, *Performance and Design of DC Machines*, ELBS,1971.
2. Say M G, *The Performance and Design of AC Machines*, CBS, 1983.
3. Sawhney A K, *A Course in Electrical Machine Design*, Dhanpat Rai & Co., 2016.

EE3029D ELECTRIC POWER UTILIZATION

Pre-requisites: EE3005D Power Systems - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire the knowledge of Electric Traction, Electric heating, Electric welding and Illumination
CO2: Analyze and solve variety of problems and issues in electric power utilization
CO3: Acquire the knowledge to design interior and exterior lighting systems- illumination levels for various purposes light fittings- factory lighting- flood lighting-street lighting
CO4: Create awareness of energy conservation.
CO5: Acquire knowledge about the air conditioning and refrigeration systems.
CO6: Study and apply technology of electric and hybrid electric vehicles

Module 1: (11 hours)

Electric Traction: Features of an ideal traction system-systems of electric traction- mechanism of train movement- speed-time curve, Power and Power Measurement, traction supply system- transmission line to feed substation- feeding and distributing system on an ac traction- system of current collection-traction motors tractive effort and horse power- Speed control Schemes-Electric braking

Module 2: (10 hours)

Electric heating: classification- heating element-losses in oven and efficiency- resistance furnace- radiant heating- induction heating- high frequency eddy current heating-Dielectric heating- arc furnace- heating of buildings- electric ovens, domestic water heaters and other heating appliances and thermostat control circuit. Electric welding:- methods and equipments- Electrolysis and Electroplating applications, Heating of Bare Conductors.

Module 3: (9 hours)

Illumination: radiant energy-terms and definitions- laws of illumination- polar curves- photometry- MSCP integrating sphere- luminous efficacy- electrical lamps- Color values of illuminates and color effects: colorimeter, artificial daylight, design of interior and exterior lighting systems- illumination levels for various purposes- light fittings- factory lighting- flood lighting-street lighting-energy conservation in lighting. National Lighting Code, Energy Conservation Building Code, Bureau of Energy Efficiency star- rating for lamps.

Module 4: (9 hours)

Air conditioning and refrigeration: function of complete air conditioning system - types of compressor motor. Cool storage - estimation of tonnage capacity and motor power. Water Coolers- Control of temperature. Protection of motors - simple heat load calculations. Technology of electric and hybrid electric vehicles.

Text book:

1. Taylor E Openshaw, *Utilisation of Electric Energy*, Orient Longman,1986.

References:

1. J B Gupta, *Utilization of electric power and electric traction*, S K Kataria & Sons, 2002.
2. Wadhwa. C.L., *Generation, Distribution and utilization of electrical energy*, Wiley Eastern Limited, 1993.
3. Soni, Gupta, Bhatnagar, *A course in electric power*, Dhanpat Rai & sons, 2001.
4. S.L.Uppal, *Electrical Power*, Khanna publishers, 1988.

5. Partab H., *Art and Science of Utilisation of Electrical Energy*, 2nd ed., Dhanpat Rai and Sons, New Delhi, 2004.
6. Tripathy S.C., *Electric Energy Utilization And Conservation*, Tata McGraw Hill, 1993.
7. Bureau of Energy Efficiency. [Online]. Available: https://beeindia.gov.in/
8. US Energy Information Administration. [Online]. Available: www.eia.doe.gov/
9. IRFCA. [Online]. Available: www.irfca.org/
10. IEEE bronze book-IEEE press
11. William Edward Barrows, *Light, Photometry and Illumination*, Biblio Bazaar, LLC, 2009.

EE3030D BIOMEDICAL ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Identify and describe the fundamental concepts in human physiology for learning the application of technology for the benefit of mankind.
CO2: Explain the engineering applications in the field of health- care system which includes the principles of various medical devices and equipments.
CO3: Illustrate the applications of physical, engineering and chemical laws in devising instruments in the field of health – care system.
CO4: Evaluate the human needs in the area of diagnosis and therapy and consider the need for better designs in the area of biomedical engineering in general.

Module 1: Introduction to Physiological Signals (10 hours)

Introduction to electrophysiology – action potential – transducers for biomedical applications -electrodes – mono polar and bipolar recording - heart and cardiovascular system –blood pressure measurement – characteristics of blood flow-electromagnetic and ultrasonic blood flow meters- indicator dilution technique plethysmography - sounds of the heart – blood pumps – heart lung machine - ECG – Eindhoven 's law - 12 lead system – cardiac pace maker –defibrillator -EMG – introduction to nervous system and brain - EEG

Module 2: Diagnostic and Therapeutic Equipment (10 hours)

Introduction to intensive care monitoring –patient monitoring instruments –organization of hospital for patient care monitoring – respiratory physiology – measurements in respiratory system –respiratory therapy equipments – instrumentation for sensory measurement and behavioral studies – ultrasonics in medicine

Module 3: Laser and X-Ray Applications (10 hours)

Lasers in medicine - X- ray and radio isotopes – radio therapy equipment -safety and dosage-medical linear accelerator machine

Module 4: Analytical Measurements and Dialysis (9 hours)

Renal physiology – membranes for haemodialysis – haemodialysis machines- lithotriptors – Measurement of p^H, p^{CO_2} and p^{O_2}

Text Books:

1. R.S.Khandpur, *Handbook of Biomedical instrumentation*, 3rd ed., Tata McGraw-Hill, 2014.
2. Leslie Cromwell, Fred J Weibell, Erich A Pfeiffer, *Biomedical instrumentation and measurements*, 2nd ed., Pearson Education, 2008.
3. Geddes & Baker, *Principles of Applied biomedical instrumentation*, 3rd ed., John Wiley & Sons, 1989.

EE3031D DYNAMIC ANALYSIS OF ELECTRICAL MACHINES

Pre-requisites: EE2006D Electrical Machines - I
EE3003D Electrical Machines - II

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes:
CO1: Formulate electrodynamic equations of all electric machines and analyze the performance characteristics.
CO2: Formulate unified theory for all electrical machines
CO3: Formulate machine equations in various reference frames
CO4: Determine stability of the machines under small signal and transient conditions.

Module 1: (11 hours)

Electro dynamical Equations and their Solution . A Spring and Plunger System- Rotational Motion System, Mutually Coupled Coils. Solution of Electrodynamical Equations by Euler's method and Runge-Kutta method. Linearisation of the Dynamic Equations and Small Signal Stability . Differential Equations of a smooth air-gap two winding machine. Conditions for Conversion of Average Power in such a Machine . A two phase machine with current excitation - Interpretation of the Average Power Conversion Conditions in terms of air-gap Magnetic Fields. The Primitive 4 Winding Commutaor Machine- The Brush Axis and its Significance . Self and Mutually induced voltages in the stationary and commutator windings . Speed e.m.f induced in Commutator Winding . Rotational Inductance Coefficients . Sign of Speed e.m.f terms in the Voltage Equation . The Complete Voltage Equation of Primitive 4 Winding Commutator Machine . The Torque Equation . Analysis of Simple DC Machines using the Primitive Machine Equations.

Module 2: (10 hours)

The Three Phase Induction Motor . Equivalent Two Phase Machine by m.m.f equivalence . equivalent two phase machine currents from three phase machine currents . Power Invariant Phase Transformation . Voltage Transformation. Voltage and Torque Equations of the Equivalent Two Phase Machine . Commutator Transformation and its interpretation . Transformed Equations . Different Reference Frames for Induction Motor Analysis. Nonlinearities in Machine Equations . Equations under Steady State - Solution of Large Signal Transients in an Induction Machine . Linearised Equations of Induction Machine . Small Signal Stability. Eigen Values. Transfer Function Formulation. Simulation of variable frequency drive (applying DQ transformation) using MATLAB.

Module 3: (9 hours)

The Three Phase Salient Pole Synchronous Machine . Three Phase to Two Phase Transformation . Voltage and Torque Equations in stator, rotor and air-gap field reference frames. Commutator Transformation and Transformed Equations . Parks Transformation . Suitability of Reference Frame Vs kind of Analysis to be Carried out . Steady State Analysis . Large Signal Transient Analysis . Linearisation and Eigen Value Analysis . General Equations for Small Oscillations . Small Oscillation Equations in State Variable form, Damping and Synchronizing Torques in Small Oscillation Stability Analysis .Application of Small Oscillation Models in Power System Dynamics.

Module 4: (9 hours)

Dynamical Analysis of Interconnected Machines . Machine Interconnection Matrices . Transformation of Voltage and Torque Equations using Interconnection Matrix . Large Signal Transient Analysis using

Transformed Equations . Small Signal Model using Transformed Equations . The DC Generator/DC Motor System . The Alternator /Synchronous Motor System . The Ward-Leonard System . Hunting Analysis of Interconnected Machines Selection of proper reference frames for individual machines in an Interconnected System.

References:

1. Sengupta D P & J.B. Lynn, *Electrical Machine Dynamics*, The Macmillan Press Ltd, 1980.
2. Jones C V, *The Unified Theory of Electrical Machines*, Butterworth, London,1967.
3. Woodson & Melcher, *Electromechanical Dynamics*, John Wiley & Sons, 1968.
4. P.C. Kraus O. Wasynczuk and S.D. Sudhoff, *Analysis of Electric Machinery and Drive Systems*, Wiley Interscience, 2002.
5. Ned Mohan, *Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB / Simulink*, Wiley, 2014.

EE3032D ILLUMINATION ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Identify the need for good illumination and criteria for the selection of lamps and lighting systems for an indoor or outdoor space.
CO2: Distinguish various Electric light sources and their operating characteristics.
CO3: Measurement of illumination, determination of total luminous flux emitted by different sources.
CO4: Design of lighting systems. Maintenance of lighting system and lighting calculations considering day light. Design of Energy efficient lighting systems

Module1: (9 hours)

Introduction: State the need for Illumination, Define good Illumination, Radiation - Eye and Vision -The Purkinje effect- Laws of Illumination –Candela- Frechner's law - Inverse Square Law - Lambert's Cosine Law of Incidence Photometry and spectrophotometry.

Module 2: (10 hours)

Electric light sources and their operating characteristics: Incandescent lamps: ratings, operating characteristics vapor lamps- mercury vapor lamps- sodium vapor lamps-Fluorescent lamps: fundamentals, ratings, cathode types- starters- ballasts- operating characteristics- CFL- Bulb Temperature Vs Light output - Lumen Maintenance Curve.

Module 3: (10 hours)

Entities in the illumination systems and their units: Illumination, intensity, brightness, solid angle relationships, luminous flux-luminosity-measurement of illumination- determination of total luminous flux emitted by a plane source, circular disc source, rectangular source, strip source.

Module 4: (10 hours)

Design of lighting systems- Interior Lighting -Sports Lighting -Road Lighting -Street lighting-Factory outdoor lighting- Flood lighting -Maintenance of lighting system and Lighting Calculations considering day light. Design of Energy efficient lighting systems.

References:

1. Partab H, *Art and Science of Utilization of Electrical Energy*, Dhanpat Rai & Sons, Delhi, 2017.
2. Steffy G, *Architectural Lighting Design*, 3rd ed., John Wiley & Sons, 2008
3. Boast W.B, *Illumination Engineering*, McGraw-Hill Book Company, 1953.
4. Cotton H, *Principles of Illumination*, John Wiley and Sons, 1960.
5. Jack L. Lindsey*, Applied Illumination* Engineering ,PHI,1991
6. IS CODE 3646
7. IS CODE 6665

EE3033D LINEAR SYSTEM THEORY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Construct models of dynamic systems
CO2: Apply linearization techniques on nonlinear system models
CO3: Analyze the system stability by transfer function approach
CO4: Analyze the system response in both time-domain and frequency domain
CO5: Evaluate performance of standard dynamical systems through computer simulations

Module 1: Concepts of dynamic systems modelling and analysis (10 hours)

Introduction to the concepts of dynamic systems modelling and analysis design and development-Definition of system –System Dynamics--Feedback-Classification of systems- static, dynamic, linear, non-linear, time varying, time invariant, distributed, lumped, continuous time, discrete time, discrete event, systems etc. Modelling of electrical systems- passive networks- dc and ac motors linear models –Concept of transfer function – transfer functions for simple electrical and electromechanical systems. Impulse response and transfer function- convolution –block diagrams and signal flow graphs- Mason's gain formula.

Module2: Modelling of non-electrical systems (10 hours)

Modelling of non-electrical systems- Examples of simple pneumatic, hydraulic and thermal and liquid level systems-control valves - Translational and rotational systems- D'Alembert's principle-Modelling of electromechanical systems, force-voltage and force-current analogy- Comparison of RLC Circuits and Mass Spring-Damper system- Development of linearised models- Superposition principle-Linearized model for Inverted Pendulum. Introduction to Time delay systems.

Module 3: Signals and Systems in Frequency Domain (10 hours)

Fourier representation of a periodic signals- Fourier transform and inverse Fourier transform pairs- Properties of Fourier transforms. Continuous amplitude and phase spectra - Relation between Laplace transforms and Fourier transforms. Concepts of attenuation, amplification and filtering of signals - Stability of linear systems – open loop and closed loop stability – bounded input bounded output stability -Routh Hurwitz criterion – limitations.

Module 4: Time domain and Frequency domain analysis of SISO LTI Systems (9 hours)

Time domain and Frequency domain analysis of single input-single output linear time invariant systems Determination of Impulse response**-**Analysis of response to other standard inputs- step, ramp ,acceleration and sinusoidal inputs- Time domain performance measures for first order and second order systems- under-damped and over-damped systems- Significance of damping factor. Definition of order and type of dynamical systems - steady state and dynamic error - Determination of error constants from transfer functions- Analysis of response of higher order systems- Effect of poles and zeros. Frequency response – Bode plots – performance criteria in frequency domain – band width – cut off frequency – gain margin – phase margin. Computer simulation of systems.

References:

1. David K Cheng, *Analysis of Linear Systems*, Narosa Publishers, 1998.
2. Gene F Franklin, J David Powell and Abbas Emami Naeini, *Feedback Control of Dynamic Systems*, 4th ed., Pearson Education Asia, 2002.
3. M. Gopal, *Control Systems Engineering*, Tata McGraw Hill, 2008.
4. John J D'Azzo, Constantine H Houpis and Stuart N. Sheldon, *Linear Control System Analysis & Design with MATLAB*, 5th ed., Marcel Dekker, 2003.

5. Burton T.D, *Introduction to Dynamic Systems*, McGraw-Hill, 1994.
6. John Dorsey, *Continuous & Discrete Control Systems*, McGraw-Hill, 2002.
7. Wayne H Chen, *The Analysis of Linear Systems*, McGraw-Hill, 1963.
8. Benjamin Kuo, *Automatic Control Systems*, 7th ed., Prentice Hall India, 1995.
9. Norman S. Nise, *Control Systems Engineering*, 4th ed., John Wiley, 2004.
10. Chi-Tong Chen, *Linear System Theory and Design*, Oxford University Press, 1999

EE3034D ANALOG FILTERS

Pre-requisites: EE2002D Signals & Systems
EE2007D Basic Electronic Circuits
EE2001D Circuits & Networks
EE2008D Analog Electronic Circuits & Systems

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes:
CO1: Draw up specifications for a filter design problem and design a realizable transfer function to satisfy the specifications.
CO2: Design custom-made Single Opamp Biquad cascade filters to satisfy given specifications
CO3: Employ standard Universal Active Filter ICs to design filters for various signal processing tasks.
CO4: Design electronically tunable filters using OTA ICs and capacitors
CO5: Design high-performance high-order active filters by Ladder Emulation

Module 1: (10 Hours)
Review of continuous time LTI systems – frequency domain representation of continuous time signals. Laplace transform- inverse Laplace transform- properties.
Categories of Filters- LP, HP, BP, BE and All Pass Filters- Second Order s-domain equations in each case and their pole-zero plots.
The Filter approximation problem: - Butterworth Approximation- Chebyshev and Inverse Chebyshev Approximations- Elliptic Approximation- Bessel approximation- Phase and Group delay characteristics of approximation functions-delay equalizer functions

Module 2: (8 Hours)
Passive filters Realization of first order First Order LP, HP, BP, All Pass Filters- frequency transformation. Higher order filters- network functions-synthesis of higher order passive filters. Singly and doubly terminated LC ladders. Limitations of Passive filters

Module 3: (11 Hours)
Active Filters Single OPAMP Biquads : First Order LP,HP,BP, All Pass Filters- Biquad Topologies, Analysis and Design of Single OPAMP Biquads with finite gain . Analysis and design of LP, HP and BP Filter with second order response. Sensitivity Analysis of Single OPAMP Filters. Analysis and design of various multiple OPAMP filters. Universal Active Filter, Compensation.

Module 4: (10 hours)

OTA-C Filters.Inductor Simulation, Antoniou Gyrators, LP,HP,BP and BE Filters using Antoniou Gyrators**.** Structure for LP, HP, BP and BE SC Filters, Basic ideas of method of realization of higher order filters. Synthesis of LC ladder Networks using gyrators

References:

1 G. Daryanani, *Digital and Analog Communication Systems*, John Wiley and Sons, 1976
2 M.E Van Valkenburg, *Analog Filter Design*, Prentice Hall of India, 2004.
3 M.E Van Valkenburg , *Design of Analog Filters*, Oxford University Press,2001
4 L.P Huelsman, *Introduction to the Theory and Design of Active Filters*, McGraw Hill, 1980
5 Roubik Gregorian and Gabor C, *Analog MOS Integrated Circuits for Signal Processing*, John Wiley and Sons, 1986
6 Kendall L. Su, *Analog Filters*, Kluwer academic publishers, 1996
7 Wai-Kai Chen, *Passive and active filters*, John Wiley & Sons, 1986

EE3035D HIGH VOLTAGE ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course outcomes:

CO1: Acquire the knowledge of testing methods of various apparatus in power system.
CO2: Acquire the knowledge of various circuits for generating high voltages for testing various apparatus and their measurement method.
CO3: Acquire the knowledge of the various reasons of overvoltage in power system and protection methods.
CO4: Acquire the knowledge of insulation coordination and design of insulation levels of various parts of power system.

Module 1: (9 hours)

Generation of High voltages and currents: AC voltages: cascade transformers-series resonance circuits, Tesla coils. DC voltages: voltage doubler-cascade circuits-electrostatic machines, Impulse voltages: single stage and multistage circuits-wave shaping-tripping and control of impulse generators Generation of switching surge voltage and impulse currents. Simulation of voltage doubler, Cockroft Walton voltage multiplier and Marx impulse voltage generation circuits.

Module 2: (10 hours)

Measurement of high voltages and currents-DC, AC and impulse voltages and currents-DSO-electrostatic and peak voltmeters-sphere gaps-factors affecting measurements-potential dividers (capacitive and resistive)-series impedance ammeters-rogowski coils-hall effect generators.

Module 3: (10 hours)

High voltage testing of materials and apparatus-preventive and diagnostic tests-dielectric loss measurements Schering bridge-inductively coupled ratio arm bridge-partial discharge and radio interference measurement, different types of sensors used for PD measurement-testing of circuit breakers and surge diverters

Module 4: (10 hours)

Introduction to Insulation materials: Classification, insulating materials used in various power equipments. Breakdown in gas and gas mixtures-breakdown in uniform and non uniform fields-Paschen's law, Townsends criterion-streamer mechanism-corona discharge-breakdown in electro negative gases-Breakdown in liquid dielectrics-Breakdown in solid dielectrics.
Natural causes of over voltages- lightning phenomena - over voltages due to switching surges - system faults and other abnormal conditions for different voltage levels- principles of insulation co-ordination

References:

1. Kuffel and Zaengl , *High Voltage Engineering Fundamentals*, 2nd ed., Newness, 2002
2. M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, 3rd ed., McGraw-Hill,1995.
3. M. Khalifa, *High Voltage Engineering: Theory and Practice*, Dekker, 1990.
4. H. M. Ryan, *High Voltage Engineering and Testing*, IEE 2001.
5. Kuffel and Abdullah.M, *High Voltage Engineering*, Pergamon press,1978
6. Wadhwa C L, *High Voltage Engineering*, New Age International, New Delhi,1994
7. Relevant IS standards and IEC standards
8. Haddad A , Warne D F, *Advances in High Voltage Engineering*, IEE publication,2004
9. Standard techniques for high voltage testing, IEEE Publication 1978.

EE3036D POWER SEMICONDUCTOR DEVICES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Choose the appropriate power semiconductor switches for an application.
CO2: Analyse and design different types of power electronic converters.
CO3: Designing the driver circuits for various power semiconductor devices.
CO4: Learn to model the converters and semiconductor switches.
CO5: Analyse and design the protection circuit of various power semiconductor switches.
CO6: Select the pertinent power electronic system suitable for an application.

Module 1: (10 hours)

Power diode and Thyristor:
Power Diode: Basic Structure and 1-V Characteristics . Breakdown Voltages and Control . On State Losses .
Switching Characteristics . Turn on Transient . Turn off Transient . Reverse Recovery Transient . Schottky Diodes . Snubber Requirements for Diodes and Diode Snubbers.
Thyristor: Basic Structure . V-1 Characteristics . Turn on Process . On State operation . Turn off process . Switching Characteristics .Turn on Transient and di/dt limitations . Turn off Transient . Turn off time and reapplied dv/dt limitations . Ratings of Thyristors . Snubber Requirements and Snubber Design.

Module 2: (9 hours)

DIAC, TRIAC and GTO:
DIAC: Basic Structure and operation . V-1 Characteristics . Ratings
TRIAC: Basic Structure and operation . V-1 Characteristics . Ratings . Snubber Requirements.
Gate Turnoff Thyristor (GTO): Basic Structure and Operation . GTO Switching Characteristics . GTO Turn on Transient . GTO Turn off Transient . Minimum ON and OFF State times .Maximum Controllable Anode Current . Overcurrent protection of GTOs

Module 3: (11 hours)

Power BJT and Power MOSFET
Power BJT: Basic Structure and 1-V Characteristics . Breakdown Voltages and Control . Second Breakdown
and its Control- FBSOA and RBSOA Curves - On State Losses . Switching Characteristics . Resistive Switching
Specifications . Clamped Inductive Switching Specifications . Turn on Transient . Turn off Transient . Storage
Time .Base Drive Requirements . Switching Losses . Device Protection- Snubber Requirements for BJTs and
Snubber Design - Switching Aids.
Power MOSFET: Basic Structure . V-1 Characteristics . Turn on Process . On State operation . Turn off process. Switching Characteristics . Resistive Switching Specifications . Clamped Inductive Switching Specifications -
Turn on Transient and di/dt limitations . Turn off Transient . Turn off time . Switching Losses . Effect of Reverse
Recovery Transients on Switching Stresses and Losses - dv/dt limitations . Gating Requirements . Gate Charge -Ratings of MOSFETs. FBSOA and RBSOA Curves . Device Protection -Snubber Requirements.

Module 4: (9 hours)

Insulated Gate Bipolar Transistor (IGBT):
Basic Structure and Operation .Latch up IGBT Switching Characteristics . Resistive Switching Specifications . Clamped Inductive Switching Specifications - IGBT Turn on Transient . IGBT Turn off Transient- Current Tailing - Ratings of MOSFETs. FBSOA and RBSOA Curves . Switching Losses - Minimum ON and OFF State times - Switching Frequency Capability – Overcurrent protection of IGBTs. Short Circuit Protection . Snubber Requirements and Snubber Design. New power semiconductor devices.

References:

1. Ned Mohan et.al ,*Power Electronics*,John Wiley and Sons,2006
2. G. Massobrio, P. Antognet, *Semiconductor Device Modeling with Spice*, McGraw-Hill, Inc.,1988.
3. B. J. Baliga, *Power Semiconductor Devices*,Thomson, 2004.
4. V. Benda, J. Gowar, D. A. Grant, *Power Semiconductor Devices. Theory and Applications*, John Wiley & Sons 1999

E3037D NON-CONVENTIONAL ENERGY SYSTEMS AND APPLICATIONS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the concepts of different renewable energy sources
CO2: Explain the concepts of solar energy conversion systems
CO3: Explain the concepts of wind energy based electricity generation systems
CO4: Describe the utilization of different storage technologies
CO5: Describe the concepts of renewable energy sources like biomass, ocean energy and hydro power generation system

Module 1: (11 hours)

Introduction to renewable energy various aspects of energy conversion-Principle of renewable energy systemsenvironment and social implications.
Solar energy: Solar radiation components- measurements-estimation-solar collectors-solar water heatersCalculation-Types-analysis-economics-Applications, Solar thermal power generation.
Solar Photovoltaics- energy conversion principle-classifications-equivalent circuit-characteristics-Cell efficiency- Limitations-PV modules-MPPT algorithms.

Module 2: (9 hours)

Wind energy: Basics of wind-wind turbines-power and energy from wind turbine-characteristics-types of electric generators for wind power generation, Single fed and doubly fed Induction generator, PMSM generator, Dynamics matching- performance of wind generators - applications- economics of wind power

Module 3: (10 hours)

Storage Devices: Super capacitor-SMES- Battery storage-flywheel storage- compressed air storage- Fuel cells–types and applications; MHD generators – backup -System design-industrial and domestic applications of storage devices.

Module 4: (9 hours)

Bioenergy, Bio fuels-classification-biomass conversion technologies-applications; Ocean Energy, tidal energy-wave energy-ocean thermal energy conversion systems applications - mini, micro and pico-hydro power generation

References:

1. Godfrey Boyle, *Renewable Energy: Power for a sustainable future*, 2nd ed., Oxford University press,2004.
2. Rai G D, *Solar Energy Utilization*, Khanna Publishers, 1997.
3. B H Khan, *Non-Conventional Energy Resources,* 2nd ed., The McGraw-Hill Companies,2009.
4. Sukhatme, S.P, *Solar Energy -Principles of Thermal Collection and Storage*, 2nd ed., Tata McGraw-Hill, 1997.
5. Sammes, Nige, *Fuel Cell Technologies-State and Perspectives*, Springer publication, 2005
6. Kreith, F., and Kreider, J.F., *Principles of Solar Engineering*, Mc-Graw-Hill Book Co, 1978.
7. S.L.Soo , *Direct Energy Conversion* , Prentice Hall Publication, 1968
8. James Larminie, Andrew Dicks, *Fuel Cell Systems*, 2nd ed., Wiley & Sons Ltd, 2003.
9. E.J. Womack, *MHD power generation engineering aspects* , Chapman, Hall Publication, 1969.

EE3038D DATA STRUCTURES & ALGORITHMS

Pre-requisites: ZZ1004D Computer Programming

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Explain the various applications of data structures in computations including database systems
CO2: Explain operations like search, insertion, deletion, traversing mechanism etc. on various data structures
CO3: Analyze algorithms and data structures in terms of time and memory complexity of basic operations.
CO4: Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphsand writing programs for these solutions.
CO5: Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, and branch and bound and writing programs for these solutions.

Module 1: Computer Application & Algorithm Complexity Types (13 hours)

Information and Data-Review of field applications of structured data in programming languages-embedded systems- database management systems-Data abstraction for Database Systems- Types of Database Systems-Relational & Distributed systems-data modeling using entity-relationship criteria-Normal forms-Examples of Database Management Systems**-**Data Analytics**-** Basics of Complexity of algorithms: Time and space complexity- Complexity notations- Complexity Analysis-Examples of polynomial complexity-NP and NP Hard Problems.

Module 2: Data Structures (13 hours)

Data structures: Stacks, Queues, Lists, Dictionary- Linked list Data Structures-implementation using pointers- Sets, Trees-Graphs-implementation using arrays and linked list- Binary tree - In-order, pre-order and post-order traversals-Polish notations-Expression tree-Height balance trees-AVL Tree & Red Black Tree- Trees for external search-B Trees-Basics of File Structures-Hashing and hash tables-Implementation of Data Structure using C and Python-Exercises.

Module 3: Design & Analysis of Algorithms (13 hours)

Algorithms-Divide & Conquer-Greedy Methods-Searching Algorithms: Sequential Search – Searching arrays and linked lists. Binary Search – Searching arrays and binary search trees-Sorting Algorithms: n^2 Sorts – Bubble sort, insertion Sort, selection sort. nlogn sorts – quick sort, heap sort, merge sort. External sort – merge files- Recursion: Recursive algorithms, Analysis of recursive algorithms-Travelling Salesman Problem-Dynamic programming-Approximation algorithms- Randomized Algorithms-Design for reentrant and thread safe computations.

Textbooks:

1. Richard Johnsonbaugh, *Discrete Mathematics*, 5th ed., Pearson Education, 2001.
2. Cormen T.H., Leiserson C.E, Rivest R.L and Stein C, *Introduction to Algorithms*, Prentice Hall India, New Delhi, 2004.
3. Kleinberg John, Eva Tardos, *Algorithm Design*, (Pearson) Dorling Kindersley(India) Pvt Ltd, 2014.
4. Kruse, Robert, C.L. Tondo, Bruce Leung and Shashi Mogalla, *Data Structures and Program Design in C,* Pearson Education, 2007(2013).

References:

1. Jeffrey A. Hoffer, Mary Prescott, Fred McFadden, *Modern Database Management Systems*, Eight Edn, Prentice Hall, 2006.

2. Elmasri, Ramez, Shamkant B Navathe, *Database Systems,* Pearson Education, 2013.
3. Mott, Joe L, Abraham Kandel, Theodore P Baker, *Discrete Mathematics for Computer Scientists & Mathematicians*, Prentice Hall India, 2003.
4. Mark Allen Weiss*, Data Structures and Algorithm Analysis in C++*, 3rd ed., Addison Wesley, 2006.
5. Goodrich, Michael T, Roberto Tamassia, *Algorithm Design*, John Wiley & Sons, 2013 reprint.
6. Aho A.V., Hopcroft J.E and Ullman J.D, Data *Structures and Algorithms*, Pearson Education, New Delhi, 1983.
7. Chow, Randy, Theodore Johnson, *Distributed Operating Systems and Algorithm Analysis*, Pearson Education, 2009.

EE3039D APPLICATIONS OF ANALOG INTEGRATED CIRCUITS

Pre-requisites: EE2007D Basic Electronic Circuits
EE2008D Analog Electronic Circuits

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes:
CO1: Select the right Opamp for a given linear or non-linear application problem.
CO2: Design Opamp and OTA based linear and non-linear application circuits to meet various kinds of signal processing objectives.
CO3: Draw up specifications for a filter design problem and design custom-made Single Opamp Biquad cascade filters to satisfy the specifications.
CO4: Employ standard Universal Active Filter ICs to design filters for various signal processing tasks.
CO5: Design electronically tunable filters using OTA ICs and capacitors
CO6: Apply analog building blocks like PLL, Multiplier ICs, RMS-DC Converters etc., to build signal processing subsystems.

Module 1: (10 hours)

Various Stages of an Operational Amplifier, Active Load, Current Mirror –
Simplified Schematic Circuit of a typical BJT Opamp, Bias and Small Signal Analysis of a typical BJT Opamp, Bias and Small Signal Analysis of a typical two-stage CMOS Opamp, Bias and Small Signal Analysis of a typical folded cascode CMOS Opamp
Ideal and practical characteristics of Opamps, Compensating an Opamp, Offset model of opamp and offset analysis of simple application circuits, special design opamps, auto-zero amplifiers, single supply opamps and applications. Noise Dynamics and Properties. Sources of Noise and Low-Noise Op Amps

Module 2: (10 hours)

Applications : Amplifiers for Signal Conditioning, Schmitt Triggers, analog switches, comparator ICs, precision rectifiers, precision clipping circuits,Sine, Triangular, Sawtooth, and Monolithic Wave Generators, Multivibrators , V-F and F-V Converters, VCO Circuits, Timers.Voltage References and Regulators. Switching, linear, and monolithic switching regulators. Switching Regulator Control ICs , Battery Charging Control ICs.Operational Transconductance Amplifiers . Applications

Module 3: (10 hours)

Active Filters: Categories of Filters, LP,HP,BP,BE and All Pass Filters, Second Order s-domain equations in each case and their pole-zero plots. The Filter approximation problem - Butterworth Approximation, Chebyshev and Inverse Chebyshev Approximations, frequency transformations. Biquad Topologies, Analysis and Design of Single OPAMP Biquads with finite gain . Analysis and design of LP,HP and BP Filter with second order response KHN (Universal Active Filter) Filter, Tom-Thomas Biquad, Analysis and Design for various categories of filters.- OTA .C Tunable Filters.
SC Filters, SC Resistor, First and second Order SC Filters, Structure for LP, HP, BP and BE SC Filters

Module 4: (9 hours)

Applications and Design Techniques: Log/Antilog Amplifiers and Applications, Analog Multipliers . Log / Antilog , Transconductance Type and TDM Type .Applications of Multipliers - True RMS to DC Converters -Phase-Locked Loops, Monolithic PLLs, PLL Applications- Direct Digital Synthesis of Waveforms.

Hardware Design Techniques. Grounding and Shielding, Power Supply Filtering and Noise reduction, Grounding in Mixed Signal Systems, EMI/RFI considerations.

References:

1. A.S Sedra and K.C Smith, *Microelectronic Circuits*., 3rd ed., Holt Saunders International,1989
2. D.H. Sheingold, *Nonlinear Circuits Handbook*., Analog Devices Inc. 1976
3. Clayton , *Operational Amplifiers*, Butterworth Publications,1979
4. Sergio Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, Mc Graw Hill, 1988
5. M.E Van Valkenburg, *Analog Filter Design*, Oxford University Press 2001
6. National Semiconductor, *Linear Applications Handbook*, 1994
7. Analog Devices Inc, *Practical Design Techniques for Thermal and Power Management*, 2004
8. Analog Devices Inc , *RMS to DC Conversion Application Guide*.
9. Analog Devices Inc., *A Designers. Guide to Instrumentation Amplifiers*.
10. Analog Devices Inc., *Practical Design Techniques for Sensor Signal Conditioning*.

EE3040D LT & HT DISTRIBUTION SYSTEMS

Pre-requisites: EE2001D Circuits & Networks

L	P	T	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Describe and apply general concepts of Power system, Load and Energy forecasting
CO2: Analyze power system and carry out optimization of distribution system network cost modelling
CO3: Analyze economic loading of distribution transformers, Distribution system reliability
CO4: Describe about Consumer services, Tariffs costing and pricing, overhead and underground lines optimum design considerations
CO5: Describe and apply the knowledge of Power capacitors HT and LT capacitor installation
CO6: Acquire the knowledge of Electrical Safety standards and distribution system design aspect and implement Earthing Practices and Lightning protection
CO7: Describe and apply general concepts of Distribution Automation System –SCADA systems and Automation

Module 1: Concept of Distribution System and its components (10 hours)

Power system-general concepts-distribution of power, load and energy forecasting-factors in power system loading, Power system analysis-load flow-fault studies-voltage control, Optimization of distribution system network cost modeling-economic loading of distribution transformers. Distribution system reliability - reliability assessment techniques.

Module 2: Distribution System parameters and design considerations (10 hours)

Consumer services-maximum demand, diversity and load factor-consumer load control for power shortages, Tariffs-costing and pricing –economically efficient tariff structure. Overhead and underground lines-optimum design considerations, Power capacitors-size of capacitor for power factor improvement- HT and LT capacitor installation requirements.

Module 3: Distribution System Design and Safety Practices (9 hours)

Distribution System Design- Electrical Design Aspects of Industrial, Commercials Buildings Design, estimation and costing of outdoor and indoor Substations, Electrical Safety and Earthing Practices at various voltage levels- Lightning protection.-Regulations and standards.

Module 4: Distribution Automation System and its Communication Systems (10 hours)

Distribution Automation System: Necessity, System Control Hierarchy- Basic Architecture and implementation Strategies for SCADA and DAC systems -Basic Distribution Management System Functions. Communication Systems for Control and Automation- Wireless and wired Communications- SCADA and DAC communication Protocols, Architectures and user interface

References:

1. Turan Gonen, *Electric Power Distribution system Engineering*, McGraw-hill ,Inc,1987
2. A.S. Pabla, *Electric Power Distribution systems,* Tata McGraw-hill Publishing company limited, 4th ed., 1997.
3. Alexander Eigeles Emanuel, *Power Definitions and the Physical Mechanism of Power Flow*, John Wiley & Sons, October 2009.
4. *Handbook of International Electrical Safety Practices*, John Wiley & Sons, PERI June 2009.

5. Ali A. Chowdhury and Don O. Koval, *Power distribution system reliability- Practical methods and applications,* John Wiley & sons Inc., IEEE Press 2009
6. Richard E. Brown, *Electric power distribution reliability*, Taylor & Francis Group, LLC,2009.
7. James Northcote - Green, Robert Wilson, *Control and automation of electrical power distribution system*, Taylor & Francis Group, LLC, 2007.
8. S. Sivanagaraju, V. Sankar, Dhanpat Rai & Co, *Electrical Power Distribution and Automation*, 2006.
9. Pansini, Anthony J, *Guide to electrical power distribution system*, Fairmont press, Inc., 6th ed., 2006.
10. Stuart A. Boyer, *SCADA-Supervisory Control and Data Acquisition*, Instrument Society of America Publication, 2004
11. Leveque, Francois, *Transport Pricing of Electricity Networks*, Springer 2003
12. Lakervi & E J Holmes, *Electricity distribution network design*, Peter Peregrimus Ltd. 2nd ed., 2003.
13. William H. Kersting, *Distribution system modeling and analysis*, CRC press LLC, 2002.
14. Michael Wiebe, *A Guide to Utility Automation: AMR, SCADA, and IT Systems for Electric Power*, PennWell, 1999.
15. IEEE Press: *IEEE Recommended practice for Electric Power Distribution for Industrial Plants*, published by IEEE, Inc., 1993

EE3041D DIGITAL SYSTEM DESIGN

Pre-requisites: EE2003D Logic Design

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes
CO1: Analyze and design a synchronous sequential machine.
CO2: Analyze and design an asynchronous sequential machine
CO3: Apply hardware description language in real life situations.
CO4: Identify the working of various programmable devices and to program them for real life examples.

Module 1: Synchronous Sequential circuit Design (12 hours)

Basic Synchronous sequential circuit, Moore and Mealy state machines, Analysis of clocked sequential circuit. Design steps of synchronous sequential circuit, Example problems –sequence detector, parity checker etc. Analysis of sequential circuit implemented with JK and other Flip-flops, Sequential circuit design using JK flip flops and D Flip-flops, State Reduction, State assignment. Algorithmic state machine charts, Conversion of ASM chart into hardware, clock skew, clock timing constraints.

Module 2: Asynchronous sequential circuit design (12 hours)

Design procedure for asynchronous sequential circuit, stable and unstable states, Examples , Races, race free assignment, State reduction for incompletely specified machines, Determination of compatible pairs, state reduction procedure, Circuit hazards, Gate delays, Generation of static hazards in combinational networks, Design of hazard free combinational network, Hazard-free asynchronous circuit design. Dynamic hazards, Function hazards and Essential Hazards.

Module 3: System Design using VHDL (9 hours)

Introduction to Verilog, Description of combinational circuits, VHDL model for multiplexers, Signals and Constants, Arrays, VHDL Operators. VHDL for Sequential Logic, Modeling Flip flops , Registers, counters using VHDL, Modeling a Sequential Machine**.**

Module 4: Synchronous design using programmable devices (6 hours)

Programming logic device families – Designing a synchronous sequential circuit using PLA/PAL – Realization of finite state machine using PLD – FPGA – Xilinx FPGA-Xilinx 4000.

Text books:

1. Charles H Roth,L Kinney, *Fundamentals of Logic Design*, Cengage Learning, 2010.
2. Brian Holdsworth, Clive Woods, *Digital Logic Design*, 4th ed., Newness, 2002.
3. Givone Donald, *Digital Principles and Design*, 2nd ed., Tata McGraw Hill, 2012.

References:

1. Nripendra N Biswas, *Logic Design Theory*, Prentice Hall of India, 2001.
2. Parag K.Lala, *Fault Tolerant and Fault Testable Hardware Design*, B S Publications, 2002.
3. Parag K.Lala*, Digital system Design using PLD*, B S Publications, 2003.
4. M.D.Ciletti, *Modeling, Synthesis and Rapid Prototyping with the Verilog HDL*, Prentice Hall, 1999.
5. M.G.Arnold, *Verilog Digital – Computer Design*, Prentice Hall (PTR), 1999.
6. S. Palnitkar, *Verilog HDL – A Guide to Digital Design and Synthesis*, Pearson, 2003.

EE3042D DC DRIVES

Pre-requisites: EE2006D Electrical Machines – I
EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Model and analyze DC Motor drives and their sub-systems.
CO2: Select a suitable rotating DC machine for an electrical drive.
CO3: Select a suitable power electronic converter for an electrical drive.
CO4: Select a suitable control structure and control parameters for an electrical drive
CO5: Solve engineering problems associated with electric drive systems and DC machines.

Module 1: (8 hours)

Introduction to Drives:
Characteristic matching of the load and the motor - Criteria for selection of subsystems of the Drive - Thermal consideration – considerations in the match between the Power Electronics converter and the motor - Characteristics of mechanical systems - stability criteria.

Module 2: (8 hours)

Modelling of DC Machine:
Theory of operation – Induced EMF – Equivalent circuit and electromagnetic torque – Elecrtomechanical modeling – state space modeling – Block diagram.

Module 3: (13 hours)

Phase controlled DC motor Drives:
Field Control – Armature Control – Four quadrant operation – Single phase controlled convertors - Three phase controlled convertors – half controlled convertor – Converters with freewheeling – Converter configuration for a four quadrant DC motor drive – Steady state analysis of Three phase converter controlled DC motor drive – Two quadrant, Three phase converter controlled DC motor drive. Two quadrant DC motor drive with field weakening- Harmonics and Associated problems – Effect of field weakening.

Module 4: (10 hours)

Chopper Controlled DC motor Drive:
Principle of operation of chopper – Four quadrant chopper circuit and its operation in all quadrants - Model of chopper – Steady state analysis of chopper controlled DC motor drive- Torque pulsations.

References:

1. Ned Mohan, *Power Electronics*, Wiley 2011
2. Gopal K Dubey, *Fundamentals of Electrical Drives*, 2nd ed., Narosa 2001
3. R Krishnan, *Electric Motor Drives, Modeling, Analysis, and Control*, Pearson Education, 2001
4. G.K.Dubey and C.R.Kasaravada, *Power Electronics & Drives*, Tata McGraw Hill, 1993.
5. W. Shepherd, L N Hulley, *Power Electronics & Control of Motor*, Cambridge University Press, 2005.
6. Dubey, *Power Electronics Drives*, Wiley Eastern, 1993.
7. Chilikin, M, *Electric Drives*, Mir publications, 2nd ed., 1976
8. Vedam Subrahmanyam, *Electric Drives Concepts and applications*, 1st ed., Tata McGraw Hill, 1994.

EE3043D EMBEDDED SYSTEMS

Pre-requisites: EE2003D Logic Design
EE2004D Microprocessor & Microcontrollers

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Evaluate the nature of embedded systems from the basic idea regarding it.
CO2: Design and evaluate the hardware and software aspects of modern embedded systems.
CO3: Interface various components such as processors / controllers, sensors, actuators and other electronic components to the embedded system.
CO4: Design and develop an embedded system as it is done in a product design industry.
CO5: Develop the Operating Systems, including RTOS, and design and evaluate various features of the OS used in the embedded systems for practical applications.
CO6: Acquire the competence to develop embedded systems using modern processors such as ARM family processors.

Module 1: Introduction to Embedded Systems (12 hours)

Application Areas, figures of merit, Categories of embedded systems, Overview of embedded system architecture, desirable features and history. Specialties of embedded systems, recent trends in embedded systems, Architecture of embedded systems, Hardware architecture, Software architecture, Application Software, Communication Software, Embedded System Development Environment and debugging Tools – - IDE, Compilers, Simulators /Emulators

MCU internals - Reset types, Timers, Stacks, Interrupts, DMA, Serial Communication etc. Memory: EPROM, Flash, OTP, SRAM, DRAM, SDRAM etc., Pull up, Pull down and High Z connections , A brief introduction to sensors and actuators and examples of embedded systems

Module 2: The ARM Processor (12 hours)

Background of ARM Architecture, Architecture Versions, Processor Naming, Instruction Set Development, Thumb-2 and Instruction Set Architecture.
ARM Assembly language- Programming using the ARM Instruction Set in Keil Microvision IDE, Data Transfer Instructions, Arithmetic instructions, Branch Instructions, Multiple register instruction Programming the peripherals of ARM using C and Keil Microvision IDE.
Features of a typical ARM 7 processor –Bus structure Peripherals: GPIO, Timers, Interrupts, Serial Communication New ARM processors –Introduction to the Cortex Series.

Module 3: Embedded System Design (3 hours)

Embedded System Product Development Life cycle (EDLC), Hardware development cycles- Specifications. Hardware testing methods like Boundary Scan, In Circuit Testing (ICT) etc. Networks for embedded systems - I2C, SPI, AMBA, CAN etc.

Module 4: Operating Systems (12 hours)

Operating System Fundamentals, Concept of firmware, Operating system basics, General Linux Architecture, Linux Kernel, Linux file systems, Embedded Linux: Booting Process in Linux, boot loaders,

U-boot, Kernel Images, Real Time Operating systems, Basics of RTOS: Real-time concepts, Hard Real time and Soft Real-time, Differences between General Purpose OS & RTOS, Basic architecture of an RTOS, Tasks, Processes and Threads, Multiprocessing and Multitasking, Task scheduling, Task communication and synchronisation, Device Drivers.
GNU Tools: gcc, gdb, gprof, Makefiles, Free RTOS/ Chibios-RT

References:

1. Lyla B. Das., *Embedded Systems-an integrated approach*, Pearson Education ,2013
2. Shibu K.V. , *Introduction to Embedded Systems*, Tata McGraw Hill ,2010.
3. Michael J. Pont , *Embedded C*, Addison Wesley, 2002.
4. Tim Wilmshurst*, An introduction to the design of small-scale embedded systems*, Palgrave, 2001.
5. Venkateswaran Sreekrishnan, *Essential Linux Device Drivers*, Prentice Hall, 2007.
6. Raj Kamal, *Embedded Systems Architecture Programming and Design*, Tata McGraw Hill, 2001.
7. Jane Liu, *Real-time Systems*, Prentice Hall, 2000
8. Laplante, Phillip, *Real-Time Systems Design and Analysis: An Engineer's Handbook*, 4th ed., IEEE Press, 2012.
9. Simon, David E*, Embedded Software Primer*, Pearson 2012.
10. Lyla B Das: *Architecture, Programming and Interfacing of Low-power Processors – ARM7, Cortex-M* ; Cengage publishers, 2017.
11. J. Cooperstein, *Writing Linux Device Drivers: A Guide with Exercises*, 3rd ed., O'Reilly, 2005.

EE3044D ELECTRICAL SYSTEM DESIGN FOR BUILDINGS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire knowledge of fundamentals of Electrical Installations like general requirements, design considerations, testing, estimating and costing.
CO2: Design of electrical installations Acquire knowledge of fundamentals of National Electrical Code –
CO3: Acquire knowledge of fundamentals of various schemes of illumination, energy conversion methods used in it and design of lighting for various purposes
CO4: Design, estimation and costing of electrical installation in a commercial building, hospitals, cinema theatres, small industries, high rise building, etc
CO5: Design, estimation and costing of outdoor and indoor substations
CO6: Design earthling systems and lightning protection schemes

Module 1: (10 hours)

Electrical Installations: general requirements, design considerations, testing, estimating and costing - symbols, standards – National Electrical Code – design of panel boards – design and estimation of service connections – design and safety aspects of residential buildings

Module 2: (7 hours)

Illumination schemes – types of light sources and lighting arrangements – energy efficiency in lamps and illumination – design of lighting for various purposes.

Module 3: (12 hours)

Electrical system design, estimation and costing of commercial buildings, hospitals, recreational and assembly buildings, cinema theatres, small industries, Design of electrical installations of high rise buildings: electrical aspects of lifts, escalators services, stand by generators.

Module 4: (10 hours)

Design, estimation and costing of outdoor and indoor Substations - Layouts and single line diagrams of outdoor and indoor substations in AutoCAD –Design of earthing system, earth mat, plate and pipe earthing – Safety of electrical installations – Lightning protection.

References:

1. K.B. Raina, S.K. Bhattacharya, *Electrical Design, Estimating and Costing*, New Age International (p) Ltd. Publishers, New Delhi, 2002.
2. Surjit Singh. *Electrical Estimating and Costing*, Dhanpat Rai & Co., Delhi, 2005.
3. ISI, *National Electrical Code*, Bureau of Indian Standard Publications.
4. G. Ramamurthy, *Hand book of Electrical Power Distribution*, Universities Press (India) Private Ltd., New Delhi, 2004.
5. N Alagappan,S Ekambaram, *Electrical estimating and Costing*, McGraw-Hill,1999.
6. Narang K.L., *A Text Book of Electrical Engineering Drawing*, Tech India Publications, 1963

EE3045D NETWORK SYNTHESIS

Pre-requisites: EE2001D Circuits & Networks
EE2002D Signals & Systems

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Derive network functions for one port and two port networks
CO2: Develop one port networks in CauerI & II forms through synthesis
CO3: Develop one port networks in Foster I& II forms through synthesis
CO4: Develop the realizations of two port networks through synthesis
CO5: Apply synthesis techniques for developing networks with given transfer functions

Module 1: Network Functions (13 hours)

Network functions for one port and two port networks – calculation of network functions for ladder and general networks-poles and zeros for network functions-pole zero location for driving point and transfer functions-Hurwitz polynomials – properties - Brune's positive real functions – Properties of positive real functions –passivity- necessary and sufficient conditions for positive real functions-physical realizability.

Module 2: Synthesis of one port networks (13 hours)
Synthesis of reactive one-ports by Foster's and Cauer's methods - Synthesis of LC, RC and RL driving-point functions – RLC one terminal-pair network synthesis – Minimum positive real functions – Brune's method of RLC synthesis – Series Parallel realization – Chop- chop method -

Module 3: Synthesis of two port networks (13 hours)

Constant k filter-m-derived filters-synthesis of two port networks- method of Bolt and Duffin –Two terminal–pair synthesis –The LC ladder development –The RC ladder development – lattice networks-Gulleiman's transfer admittance synthesis. Introduction to synthesis of active networks and filters.

Text books:

1. Sureshkumar K.S, *Electric Circuits & Networks*, Pearson, 2009.
2. Ramakalyan A, *Linear Circuits: Analysis & Synthesis*, Oxford University Press, 2005.

References:

1. Van Valkenburg M.E., *Introduction to Modern Network Synthesis*, Wiley Eastern, 1960 (reprint 1986).
2. Van Valkenburg M.E, *Network Analysis*, Prentice Hall India, 2014.
3. Bakshi U.A, Bakshi A.V, *Network Analysis & Synthesis*, Technical Publications, 2005.

EE 3046D DIGITAL CMOS INTEGRATED CIRCUITS

Pre-requisites: EE2003D Logic Design
EE2007D Basic Electronic Circuits
EE2008D Analog Electronic Circuits & Systems

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Acquire basic knowledge on digital circuits using CMOS
CO2: Develop design capability in Combinational logic circuits using CMOS
CO3: Develop design capability in synchronous and asynchronous sequential CMOS circuits
CO4: Develop capability to design state-of-the art of memory unit, PLL, DLL circuits
CO5: Develop knowledge on design trade-offs in various digital CMOS circuits towards speed of operation and power consumption and power optimization design approach
CO6: Develop knowledge in data paths in digital processor architectures

Module 1: (9 hours)

The static behavior of CMOS inverter-evaluating the robustness of the CMOS inverter in terms of switching threshold, noise margins. The dynamic behavior of CMOS inverter- computing the capacitances, propagation delay-first order analysis, dynamic power consumption, energy and energy-delay. Analyzing power consumption using SPICE. Combinational logic Gates in static CMOS- Complementary CMOS, Ratioed logic, pass transistor logic, transmission logic. Dynamic CMOS logic design-basic principle, speed and power dissipation of dynamic logic, VTC, fan-in, fan-out , cascading dynamic logic gates.

Module 2: (11 hours)

Design of sequential logic circuits using CMOS – timing metrics for sequential circuits, classification of memory elements. Static latches and registers- bistability principle, multiplexer-based latches, master-slave edge-triggered register. Dynamic latches and register – dynamic transmission-gate edge-triggered registers, basic approaches-C2MOS approach, TSPCR approach. Pipelining - An approach to optimize sequential circuits, latch vs, register based pipelines, pipeline structures. Non-bistable sequential circuits-Schmitt trigger, monostable sequential circuits, astable circuits.

Module 3: (9 hours)

Timing issues in digital circuits – classification of timing in digital circuits, synchronous timing basics, sources of skew and jitter, clock distribution technique, latch based clocking. Self- timed logic-an asynchronous technique, completion signal generation, practical example of self timed logic. Clock synthesis and synchronization using phase-locked loop. Distributed clocking using DLLs. Synchronous vs. Asynchronous design.

Module 4: (10 hours)

Data paths in digital processor architectures- the adder- the binary adder- definitions, logic and design considerations, the multiplier-definitions, logic and design considerations, partial-product generation, accumulation, final addition, the shifter- barrel shifter, logarithmic shifter. Power and speed trade-offs in datapath structures. Design time power reduction techniques, run-time power management, reducing the power in standby mode.

References:

1. E. Elmasry, ed., *Digital MOS Integrated Circuits II*, IEEE Press, 1992.
2. A. Kang and Leblebici, *CMOS Digital Integrated Circuits*, 2nd ed., McGraw-Hill, 1999.
3. M. Annaratone, *Digital CMOS Circuit Design*, Kluwer, 1986.
4. M. Shoji, *High-Speed Digital Circuits*, Addison-Wesley, 1996
5. A. Chandrakasan and R. Brodersen, *Low-Power Digital CMOS Design*, IEEE Press, 1998.
6. Rabaey, *Digital Integrated Circuits- A design perspective,* 2nd ed., Pearson Education, 2003

EE3047D ADVANCED PROCESSOR ARCHITECTURE & SYSTEM ORGANISATION

Pre-requisites: EE2004D Microprocessors & Microcontrollers

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:
CO1: Describe the history of development of the processors.
CO2: Explain the working of a modern processor.
CO3: Develop a processor based system by programming the processor in assembly language.
CO4: Describe the architecture of a modern processor and latest trends in processor industry.

Module 1: (10 hours)

Basic Concepts of Microprocessors, Different Architectures of Microprocessors. 8051 Microcontroller Hardware, 1/O Pins, Ports and Circuits, External Memory, Counters and Timers, Serial Data Input/ Output, Interrupts, Assembly Language Programming of 8051.

Module 2: (10 hours)

8086 Hardware Details, Memory Organization and Addressing Modes, System Bus Structure – Minimum Mode and Maximum Mode, Interrupt Priority Management, System Bus Timing, Multiprocessor Configuration.

Module 3: (10 hours)

Design of 8086 based system, Architecture of 80286, 80386, Development of Personal Computers.

Module 4: (9 hours)

Processor Types and Instruction Sets , Microcode , Protection and Processor Modes, Physical Memory , Virtual Memory, Caches, Bus Architecture , Parallelism and Pipelining , Performance Assessing of processors.

References:

1. Brey B.B, *The Intel Microprocessors - Architecture, Programming & Interfacing*, 6th ed., Prentice Hall, , 2004.
2. Liu Y.C. & Gibsen G.A, *Microcomputer System: The 8086/8088 Family, Architecture Programming and Design*, 2nd ed., Prentice Hall of India, 2004 .
3. Ayala K.J., *The 8051 Micro controller, Architecture, Programming and Applications*, 2nd ed., Penram International Publishing (India), 1996.
4. Ayala K.J, *The 8086 Microprocessor: Programming and Interfacing The PC*, Penram International Publishing (India), 1995.
5. Trebel, Walter A Singh, Avtar, *8088 and 8086 microprocessors, Programming Interfacing, Software, Hardware and Aplications*, 4th ed., Pearson Education , 2004.
6. Douglas E Comer, *Essentials of Computer Architecture*, Pearson Education, 2005.
7. Pattersen D.A. & Hennesy J.L, *Computer Organization and Design: The Hardware/ Software Interface*, 2nd ed,, Harcourt Asia Pvt Ltd (Morgan Kaufman), 2002.
8. Heuring V.P. & Jordan H.F, *Computer System Design and Architecture*, Addison Wesle Hamacher, Vranesic & Zaky, Computer Organisation, McGraw Hill,2002.

EE3048D ELECTRIC VEHICLE SYSTEM ENGINEERING

Pre-requisites: EE3007D Power Electronics
EE2006D Electrical Machines - I
EE3003D Electrical Machines - II
EE3001D Control System - I

L	T	P	C
3	1	0	3

Total hours: 39

Course outcomes:
CO1: Acquire knowledge about the necessity of electric vehicle and study its building blocks.
CO2: Study and understand various power electronics and storage technologies applied to electric drive system
CO3: Understand various possible drive train system for electrical vehicle
CO4: Model and simulate electric vehicle systems and analyse the performance

Module 1: Introduction to Electric Vehicles (9 hours)

Introduction to EVs, Configuration of EVs, Performance of EVs, Energy Flow Analysis, Concept of Regenerative Braking, Introduction to Traction Batteries. Drive cycle and its importance in system analysis. Component selection for a given drive cycle for a BEV. Single Phase and Three Phase Inverter, VSI and CSI topologies, PWM Techniques- Space Vector PWM- Hysteresis Control, Comparison of PWM techniques.

Module 2: Energy Storage System (10 hours)

Battery Types and battery pack, Basic battery operation , Battery Chemistry -Li Ion, Electric Vehicle Battery Efficiency and Effects on Performance, Calculation of Electric Vehicle Battery Capacity, Chemical and electrical analysis during charging and discharging – Governing equations and Waveforms, Battery parameters and comparisons, BEV – battery sizing, Modelling of Battery -RC equivalent network Model, Concept of cell balancing , Basic battery management systems
Battery Chargers- Basic requirements for charging systems, Classification of Charging Architectures, Charging Controls, Current Regulations, charging standards and technologies.

Module 3: Electric Drive Train Systems (12 hours)

Electric Drive train Overview, Systems with Linear Motion and Rotating Systems, Types of loads, Four Quadrant Operation,
Induction Motor for EV power train - Steady State Analysis of Induction Drive, Direct & Indirect Vector Control, Direct Torque Control, Field Oriented Control, Machine Model with Leakage Inductance,.
Permanent magnet synchronous machine for EV power train , Non-Salient & Salient Drives, Generic Model, Steady State Analysis, Field Oriented Control.
Switched Reluctance Machine for EV power train. Operating principles, Single phase and
3 phase machines, Control of SRM machines

Module 4: EV Modelling & Simulation (8 hours)

Modelling of BEV-Forward looking Model-Driver Perspective, Backward Looking Model-Drive Cycle Perspective, Modelling of Driver, Modelling of Brake Control Unit, Modelling of Vehicle Control Strategy, Modelling of Vehicle Chassis

Sizing of Components- Steady State Energy Balance Equation, Powertrain Dimensioning-Peak vs Continuous performance, Type of Drive cycles, Types of Control Strategy, Analysis-Performance, Range, Consumption Prediction

References:

1. Goodarzi, Gordon A., Hayes, John G, *Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles*, Wiley 2018
2. RiK De Doncker, *Advanced Electric Drives – Analysis , Modeling ,Control*, Springer publications
3. Mehradad Eshani, Yimin Gao, Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory and Design*, Second Edition, CRC Press, Taylor and Francis Group, 2010.
4. Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, Second Edition, CRC Press, Taylor and Francis Group, 2011.
5. James Larminie John Lowry, *Electric Vehicle Technology Explained*, Second Edition, Wiley, 2012.
6. Wei Liu, *Introduction of Hybrid Vehicle system Modelling and Control*, Wiley student edition 2013.
7. Ned Mohan, *Power Electronics Convertor, Applications, and Design*, Third Edition, Wiley, 2002.
8. De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, *Advanced Electrical Drives*, First Edition, CRC Press, Taylor and Francis Group, 2011.

Note :-

The topic is shared between experts from M/s Robert Bosch and faculty NITC.

As a laboratory work during tutorial hours, initial simulations are done in EED Simulation Lab. On due course, Bosch Pvt Ltd will set up a state of art Advanced EV simulation lab to equip and train the students in industrial software/modules to bridge the gap between industry and academia and to carry out course assignment.

MS3001D ENGINEERING ECONOMICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: To evaluate the economics of the management, operation, and growth and profitability of engineering firms and analyze operations of markets under varying competitive conditions

CO2: The course equips a student to carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives

CO3: To analyze cost/revenue data and carry out make economic analyses in the decision making process to justify or reject alternatives/projects on an economic basis.

CO4: Produce a constructive assessment of a social problem by drawing the importance of environmental responsibility and demonstrate knowledge of global factors influencing business and ethical issues.

CO5: Helps to use models to describe economic phenomena; analyze and make predictions about the impact of government intervention and changing market conditions on consumer and producer behavior and well-being.

Module 1: (9 hours)

General Foundations of Economics; Forms of organizations-Objectives of firms-Opportunity principle-Discounting, Marginalism versus Incrementalism-Production Possibility frontier-Central problems of an economy- Two sector, Three sector and Four sector circular flow of income. Demand analysis-Individual, Market and Firm demand, Determinants of demand and supply, Shifts and changes in demand and supply, Market equilibrium, Shortages versus surpluses, Price ceiling ,Price floor- Elasticity of demand and business decision making.

Module 2: (17 hours)

Production functions in the short and long run-Cost concepts- Short run and long run costs- economies and diseconomies of scale-economies and diseconomies of scope-Break even analysis-Vertical & horizontal integration-Product markets- Market structure-Competitive market-Imperfect competition (Monopoly, Monopolistic competition and Oligopoly) and barriers to entry; Pricing in different markets; Price discrimination-Dead weight loss-consumer's surplus ; Game Theory-Prisoner's Dilemma-Maximin, Minimax, Saddle point, Nash Equilibrium.

Module 3: (13 hours)

Macroeconomic Aggregates-Gross Domestic Product; Gross national product, net domestic product, Transfer payments, Depreciation, Economic Indicators; Models of measuring national income; Fiscal deficit, primary deficit, Inflation and deflation ; Fiscal and Monetary Policies ; Monetary system; Indian stock market; Development Banks; NBFIs, role of Reserve Bank of India, Money Market, Capital market; NIFTY, SENSEX, Financial ratios.

References:

1. R. S. Pindyck, D. L. Rubinfeld and P. L. Mehta, *Microeconomics*, 9th ed., Pearson Education, 2018.
2. P. A. Samuelson and W. D. Nordhaus, *Economics*, 19th ed., Tata McGraw Hill, 2015.
3. N. G. Mankiw, *Principles of Microeconomics*, 7th ed., Cengage Publications, 2014.
4. S. B. Gupta, *Monetary Economics: Institutions, Theory & Policy*, New Delhi: S. Chand & Company Ltd., 2013.
5. K. E. Case, R. C. Fair and S. Oster, *Principles of Economics*, 10th ed., Prentice Hall, 2011.

Note: Supplementary materials would be suggested / supplied for select topics on financial markets and Indian economy.

EE4001D INSTRUMENTATION SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Summarize the different types of errors in measurement, calibration process and standards.
CO2: Discuss the different methods for measurement of various electrical quantities.
CO3: Recognize the dynamics of instrument systems.
CO4: Discuss various methods for measurement of non-electrical quantities like Temperature, Pressure, Force, Torque, Density, Liquid level, Viscosity, Flow, Displacement etc.
CO5: Illustrate various signal processing circuits.
CO6: Outline various sensors, DCS and PLC.

Module 1: Instrumentation and Calibration, Signals and their representation (10 hours)

Measurement, Instrumentation and Calibration - Introduction to Instrumentation systems - performance characteristics, static and dynamic characteristics – Errors in measurement - gross Errors, systematic Errors – statistical Analysis of Random Errors – Calibration and Standards -Process of calibration, classification of standards, standards for calibration.
Signals and their representation. Electrical Measuring Systems- Dynamics of Instrument systems – generalized performance of systems – electrical Networks – Mechanical systems - Electromechanical systems –Thermal systems – Fluidic systems – Filtering and Dynamic Compensation.

Module 2: Amplifiers, measurement of non-electric quantities and Signal processing Circuits (10 hours)

Electronic Amplifiers- difference or Balanced Amplifiers, Electrometer Amplifier, operational Amplifiers, feedback amplifiers, Isolation Amplifiers, charge Amplifiers, power Amplifiers. Measurement of phase Angle- Frequency Measurement – Time – Interval measurement - Basics of Temperature, pressure, Force, Torque, Density, Liquid level, Viscosity, Flow, Displacement measurement.
Signal processing Circuits – Data Display and recording systems – Data Transmission and Telemetry.

Module 3: Classification of transducers (9 hours)

Classification of transducers –Mechanical Transducers- Passive Electrical Transducers – resistive, Inductive and capacitive Transducers, Active Electrical Transducers – Thermoelectric, piezoelectric, magnetostrictive, Hall Effect, Electromechanical, Electro Chemical- Photoelectric and Ionization Transducers, Digital Transducer, Feedback Transducers Systems.

Module 4: Sensors, PLC and DCS (10hours)

Recent Developments in sensor technology – Semiconductor sensors- Smart Sensors-Microsensors – IR Radiation Sensors – Ultrasonic Sensors –Fibre Optic Sensors – Chemical Sensors – Biosensors. Programmable Logic controllers- Introduction to PLC Programming-Distributed Control Systems and Computer Based Systems.

References:
1. D.V.S Murty, *Transducers & Instrumentation*,1st ed., Prentice Hall of India (pvt ltd), 2012
2. Ernest O. Doebelin and Dhanesh N, Manik, *Measurement Systems Application & design*, 5th ed., Tata McGraw Hill, 2007.
3. Klaas B Klaassen, *Electronic Measurement and Instrumentation*, Cambridge University Press, 1996.

4. A.D. Helfrick and W.D. Cooper, *Modern Electronics Instrumentation and Measurement Techniques*, Pearson Education India,2016.
5. Alan S. Morris and Reza Langari, 2nd ed., *Measurement and Instrumentation*, *Theory and Application*, Academic Press, 2015
6. Bela G. Liptak, *Instrument Engineers' Handbook Process Control and Optimisation,*, 3rd ed., vol. 2, CRC Press, 2012.

EE4091D PROJECT: Part I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

CO1: Identify a topic of interest relevant to industry or society in the field of Electrical Engineering or interdisciplinary field

CO2: Formulate and develop a design proposal and to effectively communicate the same and complete the preliminary work by undertaking literature survey, case studies, data collection and feasibility studies

CO3: Develop a design or model or algorithm for a new idea/product through simulated or theoretical and experimental approach.

The project work will be of a design and/or experimental approach in the electrical engineering discipline or interdisciplinary field. An individual student or group of students from electrical engineering department or other department(s) of the institute can do project work under a supervisor, towards the innovative idea/social/product development. In case of interdisciplinary project, the faculty member(s) from the concerned department(s) are also the supervisor(s) for the students. A faculty coordinator will coordinate the project work of all students and will decide the maximum number of students in a project group.

The assessment of the project will be done at the end of the semester by a project review committee consisting of three or four faculty members from the concerned field. After completing the work to the satisfaction of the supervisor(s), the project report will have to be submitted by the student(s) to the project review committee. The project supervisor(s) and project review committee will award the grades to the individual student based on the performance and contribution by an individual.

EE4093D POWER ENGINEERING LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

CO1: Examine and evaluate the characteristics of different relays
CO2: Design and evaluate the characteristics of phase controlled rectifiers
CO3: Design and evaluate the characteristics ac voltage controller and inverter
CO4: Obtain and evaluate the characteristics of various semiconductor devices and choose the proper device for particular application.
CO5: Conduct load flow and short circuit analysis on power system

List of Experiments:

1. IDMT Over current relay: plot the IDMT characteristics of the inverse over current relay, identify PSM and settings required for a 3 phase 5 hp induction motor with 120% overload limit, Determine the tripping time for 50*I.
2. Under voltage and Over voltage relay: Plot the inverse characteristics of the relay in under and over voltage operation zone. Determine the tripping time for 150*V and 50*V.
3. Design and setup a single-phase full-converter and study its performance for R and RL loads.
4. Solar PV Module: Plot I-V characteristics of a P-V Module. Determine the maximum power point and power transferred for a lamp load.
5. Design and setup a single-phase semi-converter and study its performance for R and RL loads.
6. Design and set up a Single Phase half wave rectifier and study its performance for R and RL loads.
7. Design and set up a Single Phase AC voltage controller using Triac.
8. Design and set up a Single Phase square wave inverter and study the effect of variation is DC Bus voltage and duty cycle.
9. Study of V-I characteristics of Thyristor.
10. Study of V-I characteristics of IGBT.
11. Study of V-I characteristics MOSFET.
12. Study of switching characteristics of IGBT.
13. Study of switching characteristics of MOSFET.
14. Determination of sequence Impedance of Transformer.
15. Short circuit analysis on a power system using PSCAD software
16. Load flow analysis on a power system using ETAP software
17. Cable Testing: Determine the IR value, conductor resistance and calculate the leakage current. Conduct HV test on 415V grade cable.

References:

1. Ned Mohan et.al ,*Power Electronics,*John Wiley and Sons,2006
2. Rashid*, Power Electronics, Circuits Devices and Applications*, 3rd ed., Pearson Education, 2004.
3. G.K.Dubey, *Thyristorised Power Controllers*, Wiley Eastern Ltd, 1993.
4. Dewan&Straughen, *Power Semiconductor Circuits*, John Wiley & Sons, 1975.
5. Cyril W Lander, *Power Electronics*, 3rd ed., McGraw Hill, 1993.
6. Hadi Saadat, *Power System Analysis*, Tata Mc Graw Hill, 2003.

EE4095D CONTROL SYSTEMS LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Course Outcomes:

CO1: Development of mathematical model of dynamic systems
CO2: Design of controllers for single input single output systems
CO3: Design of controllers for multi input multi output systems
CO4: Development of controllers for dynamical systems using PLC
CO5: Design of controllers for dynamical systems using MATLAB
CO6: Real time implementation of controllers for dynamical systems using dSPACE board

List of Experiments:

1. To obtain the moment of inertia and develop the transfer function of the given DC Motor for
   a. Armature controlled.
   b. Field controlled cases. Draw the relevant block diagrams.
2. To conduct experiments on the given amplidyne for
   a. To obtain the transfer function.
   b. To obtain the load characteristics under different levels of compensation.
   c. To obtain the characteristics of a metadyne.
3. To Study the FEEDBACK ®MS150 DC Modular Servo System and to obtain the characteristics of the constituent components. Also to set up a closed loop position control system and to study the system performance.
4. To design Lead, Lag and Lead-Lag compensators and to obtain the characteristics by experiment and simulation using MATLAB®.
5. To set up a system for closed loop voltage regulation for a dc separately excited generator using amplidyne and to obtain its characteristics.
6. To obtain the model of the Inverted pendulum and study the closed loop performance using experiments on Bytronic® Inverted Pendulum
7. To obtain the characteristics of the synchro systems and to set up a synchro link position control system using FEEDBACK® MS150 AC Modular Servo.
8.
   a. To familiarize the twin rotor MIMO system (TRMS)
   b. To develop the state space model of the TRMS from the given dynamic equations
   c. To obtain the linearized model of the TRMS
   d. To develop the transfer matrix and obtain the decoupled system.
   e. To study the effect of PID controller on the performance of the system
   f. To simulate the real-time system for step input and sinusoidal input.
9. To conduct experiments on the Level Process Control Station and to study the working of a level control loop.
10.
    a. To study the Digital Input / Output operation of PLC
    b. To study the On delay and Off delay Timer operation using PLC
    c. To study the UP and DOWN Counter operation using PLC
    d. To study the performance of automatic water level control system using PLC
    e. To study the control of Bottle filling system using PLC
    f. To control the speed of the PMDC motor using Versamax Micro PLC
    g. To study the water level control
    h. To study the performance of a conveyor control system using PLC
11. To use the MATLAB package for design of controllers for a dynamical system.
12.
    a. To familiarize the dSPACE Control-Desk for the real time control of systems
    b. To design a state feedback controller to be implemented in real time using DS1103 to perform the closed loop speed control of DC Motor

References:

1. K. Ogata, *Modern Control Engineering*, Pearson Prentice Hall, 2006.
2. M. Gopal, *Control Systems*, 3rd ed., Tata McGraw-Hill, 2006.
3. K. P. Mohandas, *Modern Control Engineering*, Sanguine Pearson, Revised Edition, 2010.
4. G. F. Franklin, J. D. Powell and A. E. Naeini, *Feedback Control of Dynamic Systems*, 4th ed., Pearson Education Asia, 2002.
5. G. C. Goodwin, S. F. Graebe and M. E. Salgado, *Control System Design*, Prentice Hall India, 2003.
6. J. J. D'Azzo, C. H. Houpis, S. N. Sheldon, *Linear Control System Analysis & Design with MATLAB*, 5th ed., Marcel Dekker, 2003.

EE4094D SEMINAR

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

Course Outcomes:

CO1: Identify promising new directions of various cutting edge technologies
CO2: Study research papers for understanding of a new field, in the absence of a textbook, summarize and review them
CO3: Prepare detailed report describing the project and results
CO4: Effectively communicate by making an oral presentation before an evaluation committee

Individual students will be asked to choose a topic in Engineering field and/or relevant to industry or society, however, the main focus shall be in Electrical Engineering field, preferably from outside the B.Tech syllabus. Give an open seminar and submit a report on the topic after detailed study of the topic. A committee consisting of at least three faculty members specialized on different fields of Engineering will assess the presentation and report of the seminar. The marks will be assessed by the committee based on the seminar presentation and report.

EE4092D PROJECT: Part II

Pre-requisites: Nil

L	T	P	C
0	0	9	6

Total hours: 117

Course Outcomes:

CO1: Implement the design or model or algorithm developed under EE4091D Project: Part I or Identify and implement the design or model of a topic of interest relevant to industry or society in the field of Electrical Engineering or interdisciplinary field

CO2: Synthesize the results of the detailed analytical studies conducted, lay down validity and design criteria and interpret the result for application to the problem.

CO3: Develop the concept and detailed design solution and effectively communicate the thesis rationale.

Students are encouraged to do Project: Part II in a reputed industry/ R&D organization/ institute, if they had completed EE4091D Project: Part I satisfactorily, in their seventh semester. The Project: Part II may also be a continuation of EE4091D Project: Part I of seventh semester. The Project: Part II can be done by an individual and / or by a group of students from electrical engineering department or other department(s) of the institute. The type of the project can be analytical / simulation/ design or/and fabrication related to Electrical Engineering or interdisciplinary field. A faculty coordinator will coordinate the project work of all students and will decide the maximum number of students in a project group.

Evaluation will be done by a project review committee consisting of the concerned supervisor(s) and two/three faculty members in the concerned area of the project nominated by the HOD. The faculty coordinator of the project will be a member of the evaluation committee for all the projects. The mode of presentation, submission of the report, method of evaluation, award of grades etc will be decided by the project review committee. The students shall submit both soft and hard copies (required number of copies) of project report in the prescribed format to the department and library after incorporating all the corrections and changes suggested by the project review committee.

EE4021D HEURISTIC METHODS FOR OPTIMIZATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the concepts of genetic algorithms and apply the knowledge in engineering problem
CO2: Explain the concept of Particle Swarm Optimization with examples
CO3: Evaluate Simulated Annealing and Tabu Search method in the engineering applications
CO4: Apply Ant colony optimization to solve the optimization problem
CO5: Construct the optimization method for the real-time applications with computer simulation

Module 1: (10 hours)

Genetic algorithm:
Introduction to Optimization, types of optimization problem, optimization algorithms, classification, History of evolutionary, Advantages of evolutionary computation, Introduction to genetic algorithms, The genetic computation process-natural evolution-parent selection-crossover-mutation-properties - classification - Application to engineering problems, Computer simulation practices.

Module 2: (10 hours)

Particle Swarm Optimization:
Introduction, background of Particle Swarm Optimization, Discrete PSO, PSO for MINLPs, Hybrid PSO, Adaptive PSO, Evolutionary PSO, Application to engineering problems, Computer simulation practices.

Module 3: (11 hours)

Simulated Annealing: Introduction - Algorithm - Applications, Computer simulation practices
Tabu Search: Overview of Tabu Search -Problem formulation, basic Tabu Search Algorithm - Applications, Computer simulation practices.

Module 4: (8 hours)

Ant colony optimization:
Introduction, behavior of real ants, Ant colony algorithms, Characteristics, distributed computations, positive feedback, use of greedy search and constructive heuristic information, Applications, Computer simulation practices.

References:

1. K. Y. Lee, M. A. El-Sharkawi, *Modern Heuristic Optimization Techniques: Theory and Applications to Power Systems*, IEEE Press, 2008.
2. D.E. Goldberg, *Genetic Algorithms in Search Optimization and Machine Learning*, Addison Wesley, 1989.
3. M. Gen, R. Cheng and L. Lin, *Network Models and Optimization: Multiobjective Genetic Algorithm Approach*, Springer, 1994.
4. M. Clerc, *Particle Swarm Optimization*, ISTE ltd, 2006.

EE4022D OPTIMAL AND ADAPTIVE CONTROL

Pre-requisite: EE3001D Control Systems - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Describe basic concepts of optimization of functionals with and without constraints using Calculus of variations
CO2: Formulate performance index, define optimal control problems and solve optimal control problems
CO3: Apply Pontryagin's minimum principle to optimal control problems for constrained optimization
CO4: Solve linear regulator, minimum time and minimum control effort problems
CO5: Apply dynamic programming for solution to optimal control problems
CO6: Describe concept of model following control and controller design for model reference adaptive systems

Module 1: Calculus of variations approach for Minimization of functionals (10 hours)

Basic mathematical concepts - Calculus of variations approach- Maximization of functionals of a single and several independent functions - Euler-Lagrange Equation - Constrained extremals - extremal of functionals with dependent functions - differential equation constraints – isoperimetric constraints.

Module 2: Variational Approach to Optimal Control (10 hours)

Optimal control problem –performance measure - Optimal control problem formulation - Open loop and closed loop form of optimal control - the variational approach to solving optimal control problems - necessary conditions and boundary conditions for optimal control using *Hamiltonian* – closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle - state inequality constraints - minimum time problems - minimum control effort problems.

Module 3: Dynamic programming (10 hours)

Dynamic programming - principle of optimality - application to multi stage decision making – application to optimal control problem recurrence relation of dynamic programming - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation - continuous linear regulator problem.

Module 4: Model reference adaptive control (9 hours)

Model following control – Model reference adaptive control - Design method based on the use of Liapunov function - Adaptive variable structure model following control

References:

1. E. Kirk, *Optimal Control Theory: An Introduction*, Prentice-Hall, 2004.
2. B. D. O. Anderson and J. B. Moore, *Optimal Control: Linear Quadratic Methods*, Prentice-Hall, 2007.
3. M. Krstic, P. V. Kokotovic and I. Kanellakopoulos, *Nonlinear and Adaptive Control Design*, John Wiley and Sons, 1995.
4. K. J. Astrom and B. Wittenmark, *Adaptive Control*, 2nd ed., Dover, New York, 2008.
5. G. Feng and R. Lozano, *Adaptive Control Systems*, Oxford University Press, 1999.

EE4023D AC DRIVES

Pre-requisites: EE3003D Electrical Machines – II
EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Model and analyze AC Motor drives and their sub-systems.
CO2: Select a suitable rotating AC machine for an electrical drive.
CO3: Select a suitable power electronic converter for an IM drive.
CO4: Select the suitable control structure and control parameters for an IM drive
CO5: Solve engineering problems associated with electric drive systems and AC machines.

Module 1: (8 hours)

AC Machines for Drives:
Induction machine – Synchronous machine – Permanent magnet machines – Synchronous reluctance and variable reluctance machine – Principle of operation, Equivalent circuit, Modeling and characteristics of all these machines.

Module 2: (12 hours)

Phase Controlled Induction Motor Drives:
Cycloconverters - Phase controlled cycloconverters – Circuits and operation principle – Circulating and noncirculating current mode – load and line harmonics – Line displacement power factor - Stator voltage control – Slip energy recovery scheme.

Module 3: (9 hours)

Frequency Controlled Induction Motor Drives:
Voltage Source Inverter (VSI) – VSI fed Induction motor - constant V/F control – Constant Flux control – Constant Slip-speed control – Torque pulsation – Effect of harmonics and its control - PWM control – Flux weakening operation.

Module 4: (10 hours)

Current Source Inverter (CSI) fed Induction motor Drives - CSI - Operation - Modeling - Steady state performance of CSI motor drive. Vector controlled Induction motor Drives - Principle and operation. Permanent Magnet Motor drives – PMSM and BLDC drives

References:

1. N. Mohan, *Power Electronics*, Wiley, 2011.
2. G. K. Dubey, *Fundamentals of Electrical Drives*, 2nd ed., Narosa, 2001.
3. R. Krishnan, *Electric Motor Drives, Modeling, Analysis, and Control*, Pearson Education, 2001.
4. G.K.Dubey and C. R. Kasaravada, *Power Electronics & Drives*, Tata McGraw-Hill, 1993.
5. W. Shepherd, L. N. Hulley, *Power Electronics & Control of Motor*, Cambridge University Press, 2005.
6. Dubey, *Power Electronics Drives*, Wiley Eastern, 1993.
7. M. Chilikin, *Electric Drives*, 2nd ed., Mir publications, 1976.
8. V. Subrahmanyam, *Electric Drives Concepts and applications*, 1st ed., Tata McGraw-Hill, 1994.

EE4024D POWER SYSTEM STABILITY AND CONTROL

Pre-requisite: EE3006D Power systems - II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Model and analyze of power system components - generators, transmission lines, excitation and prime mover controllers and interpret power system stability problems
CO2: Analyze stability of single machine and multi-machine systems using digital simulation and small-signal analysis techniques.
CO3: Analyze Sub Synchronous Resonance and Counter measures
CO4: Assess Voltage Stability using PV Curves

Module 1: (10 hours)

Generation Control Loops, AVR Loop, Performance and Response, Automatic Generation Control of Single Area and Multi Area Systems, ALFC loop-tie line bias control, Static and Dynamic Response of AGC Loops, Economic Dispatch and AGC.

Module 2: (10 hours)

Transient Stability Problem, Modeling of Synchronous Machine, Loads, Network, Excitation and Systems, Turbine and Governing Systems, Trapezoidal rule of Numerical Integration Technique for Transient Stability Analysis, Data for Transient Stability Studies, Transient Stability Enhancement Methods, Equal area criterion to asses stability of a SMIB system, limitations of classical model of synchronous machines.

Module 3: **(10 hours)**

Low Frequency Oscillations, Power System Model for Low Frequency Oscillation Studies, Improvement of System Damping with Supplementary Excitation Control, Introduction to Sub Synchronous Resonance, and Counter measures, power system stabilizers.

Module 4: (9 hours)

Voltage Stability Problem, Real And Reactive Power Flow in Long Transmission Lines, Effect of ULTC and Load Characteristics on Voltage Stability, Voltage Stability Limit, Voltage Stability Assessment Using PV Curves QV curve – PQ curve – analysis with static loads – loadability limit, Voltage Collapse Proximity Indices, Voltage Stability Improvement Methods.

References:

1. O. I. Elgerd, *Electric Energy System Theory: An Introduction,* 2nd ed., McGraw Hill, New York, 1982.
2. A. J. Wood and B. F. Wollenberg, *Power Generation, Operation And Control*, 2nd ed., John Wiley And Sons, New York, 1996.
3. J. Arrillaga, C. P. Arnold and B. J. Harker*, Computer Modeling Of Electrical Power Systems*, Wiley, New York, 1983.
4. I. J. Nagrath and D. P. Kothari, *Power System Engineering*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1994.
5. Yao-Nan Yu, *Electric Power System Dynamics,* Academic Press, 1983.

6. P. Kundur, *Power System Stability and Control*, McGraw Hill, New York, 1994.
7. K. R. Padiyar, *Power System Dynamics, Stability And Control*, Interline Publishing (P) Ltd., Bangalore, 1999.
8. C. Van Cutsem, T. Vournas, *Voltage Stability of Electric Power Systems*, Rlever Academic Press (U.K.), 1999.
9. B. R. Gupta, *Power System Analysis and Design*, 3rd ed., A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. T. J. E. Miller, *Reactive Power Control in Electric Power Systems*, John Wiley and Sons, New York, 1982.

EE4025D COMPUTER CONTROL OF INDUSTRIAL PROCESSES

Pre-requisites: EE3001D Control Systems – I
EE3004D Control Systems – II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Identify the characteristics of MIMO systems and calculate system norms
CO2: Analyze robustness and robust stability using $\mathcal{H}_2$ and $\mathcal{H}_\infty$ theory
CO3: Construct man-machine interface using programmable logic controllers
CO4: Describe large scale control systems like SCADA
CO5: Explain real time systems and inter task communication
CO6: Explain supervisory control, distributed control and PC based automation

Module 1: Multivariable Control (12 hours)

Basic expressions for MIMO systems - Singular values- Stability norms- Calculation system norms- Robustness- Robust stability- H_2 / H_∞ Theory- Solution for design using H_2 / H_∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances Decoupling- Introduction to batch process control.

Module 2: Programmable Logic Controllers (9 hours)

Organization of Programmable logic controllers- Hardware details- I/O- Power supply- CPU- Standards Programming aspects- Ladder programming- Sequential function charts- Man- machine interface- Detailed study of one model- Case studies.

Module 3: Large Scale Control System (10 hours)

Introduction- SCADA Architecture- Different Communication Protocols- Common System Components- Supervision and Control- HMI, RTU and Supervisory Stations- Trends in SCADA- Security Issues – Introduction to distributed control systems- DCS Architecture- Local Control (LCU) architecture- LCU languages- LCU - Process interfacing issues- communication facilities- configuration of DCS- displays- redundancy concept - case studies in DCS.

Module 4: Real Time Systems (8 hours)

Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control- direct digital control- Distributed control- PC based automation.

References:

1. F. G. Shinskey, *Process control systems: application, Design and Tuning*, McGraw Hill International Edition, Singapore, 1988.
2. P. Belanger, *Control Engineering: A Modern Approach*, Saunders College Publishing, USA, 1995.
3. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, Addison Wesley Longman Inc., 1999.
4. P. A. Laplante, *Real Time Systems: An Engineer's Handbook*, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. C. H. Houpis and G. B. Lamont, *Digital Control systems*, McGraw-Hill Book Company, Singapore, 1985.

6. S. A. Boyer, *SCADA-Supervisory Control and Data Acquisition*, Instrument Society of America Publications, USA, 1999.
7. G. Clarke and D. Reynders, *Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*, Newnes Publications, Oxford, UK, 2004.
8. E. N. Rosenwasser and B. P. Lampe, *Multivariable computer-controlled systems: a transfer function approach*, Springer, 2006.

EE4026D FLEXIBLE AC TRANSMISSION

Pre-requisites: EE3005D Power Systems - I
EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Discuss the power flow control in AC systems and FACTS Devices.
CO2: Analyze static series compensation, static shunt compensation and different types of compensators in each category.
CO3: Analyze the operation and control of Unified Power Flow Controller and Demonstrate through simulation.
CO4: Analyze and Demonstrate Special purpose FACTS controllers and custom power devices through simulation.

Module 1: (9 hours)

FACTS concepts and general system considerations: Power flow in AC systems - Real and Reactive Power flow control Definition of FACTS - Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

Module 2: (10 hours)

Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM - characteristics and control, Compensator control - Comparison between SVC and STATCOM. Static series compensation: GCSC, TSSC, SSSC -Static voltage and phase angle regulators - TCVR and TCPAR Operation and Control –Applications- Modeling and Simulation.

Module 3: (10 hours)

Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic Principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller- comparison with other FACTS devices -Applications-Modeling and Simulation.

Module 4: (**(10 hours)**

Special purpose FACTS controllers - Thyristor controlled voltage limiter - Thyristor controlled voltage regulator - Thyristor controlled braking resistor - Thyristor controlled current limiter Custom Power - Compensation Devices - STS - SSC - SVR -Backup energy supply devices, DVR, D-STATCOM and UPQC.

References:

1. N. G. Hingorani and L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 2000.
2. T.J.E Miller, *Reactive Power Control in Electric Systems*, John Wiley & Sons, 2010.
3. N. Mohan et.al., *Power Electronics*, 3rd ed., John Wiley and Sons, 2002.
4. K. R. Padiyar, *FACTS controllers in power transmission and distribution*, New Age International (P) Ltd, 2008.

EE4027D POWER SYSTEM OPERATION AND CONTROL

Pre-requisites: EE3005D Power systems – I
EE3006D Power systems – II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Formulate and implement control objectives and operational constraint for optimal power flow
CO2: Analyze and solve economic dispatch of thermal units, unit commitment
CO3: Discuss automatic generation control and voltage regulation during normal operation of power system augmented with FACTS devices
CO4: Analyze economic interchange of power and energy between interconnected utilities
CO5: Estimate the system states and analyze the security of power system

Module 1: (10 hours)

Economic dispatch of thermal units and methods of solution- Optimal power flow solution- Transmission losses- B matrix loss formula- Take-or-pay fuel supply contract- Composite generation production cost function solution by gradient search techniques, Dynamic programming methods.

Module 2: **(9 hours)**

Unit commitment - Solution methods-Hydrothermal coordination - Scheduling problems - Short term hydrothermal scheduling problem – Pumped storage hydro plants - Hydro scheduling using linear programming - Short term hydro scheduling - load model - Prime mover model - governor model - tie-line model - generation control.

Module 3: (10 hours)

AGC - Single and multi area system - Speed governing – Generation allocation. AGC with optimal dispatch - TG response - ALFC loop - tie line bias control – AVR: Exciter types - Modeling - AVR loop. Methods of system voltage control-Tap changing transformer-Shunt reactors - Shunt capacitors - Series capacitors - Synchronous condensers - Static VAR Systems - introduction to FACTS devices - simulation exercise.

Module 4: **(10 hours)**

Interchange of power and energy- Economy interchange between interconnected utilities- inter - utility economy energy evaluation- capacity interchange - diversity interchange - energy banking- emergency power interchange –Inadvertent power Exchange- power pools-Transmission Effects and issues- Power system security - Contingency Analysis Using Network Sensitivity Method And AC Power Flow Method - security constrained optimal power flow - state estimation – case study on standard test system

References:

1. A. J. Wood and B. F. Wollenberg, *Power Generation Operation and Control*, 2nd ed., John Wiley & Sons, ICN, 2005.
2. A. Gomez-Exposito, A.J. Conejo and C. Canizares, *Electric Energy systems analysis and operation*, CRP press, 2009.
3. P. Kundur, *Power System Stability And Control*, McGraw Hill, New York, 1994.
4. A. K. Mahalanabis, *Computer Aided Power system analysis and control*, Tata McGraw-Hill, 1991.
5. O. I. Elgerd, *Electric Energy Systems Theory*, McGraw Hill, 2nd ed., 1982.

EE4028D NONLINEAR SYSTEM ANALYSIS

Pre requisites: EE3001D Control Systems - I
EE3004D Control Systems - II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the characteristics of nonlinearities and types of nonlinear systems
CO2: Analyse nonlinear systems using phase plane method
CO3: Analyse stability of nonlinear systems
CO4: Analyse nonlinear feedback systems using describing function, Popov's criterion and Circle criterion
CO5: Design of controllers for nonlinear systems using feedback
CO6: Apply feedback linearization for stabilization and control of nonlinear systems

Module 1: (10 hours)

Introduction and classical techniques- Characteristics of nonlinear systems – Types of nonilearities and their occurrence- classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis.

Module 2: (12 hours)

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method - Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability.

Module 3: (8 hours)

Harmonic Linearisation and Describing Function Method-Harmonic linearization - filter hypothesis - Sine Input describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using SIDF- Dual Input Describing function - study of sub-harmonic oscillations- Popov.s' criterion - Circle criterion

Module 4: (9 hours)

Feedback Control and Feedback Stabilisation- Analysis of feedback systems- Concepts of Inverse control- Feedback linearization- Simultaneous Feedback control- Design via linearization- stabilization - regulation via integral control - gain scheduling - Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.

References:

1. H. K. Khalil, Nonlinear *Systems*, Prentice-Hall International (UK), 1996.
2. J. J. E. Slotine and W. Li, *Applied Nonlinear Control*, Prentice Hall, New Jersey, 1991.
3. A. Isidori, *Nonlinear Control Systems*, Springer Verlag, 1995.
4. K. P. Mohandas, *Modern Control Engineering*, Revised Edition, Sanguine Pearson, 2010.

EE4029D ANALOG MOS CIRCUITS

Pre-requisites: EE2007D Basic Electronic Circuits
EE2008D Analog Electronic Circuits & Systems

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Select the optimum model for MOS transistors, resistors and capacitors for Spice Simulation of a proposed Analog MOS System design.
CO2: Acquire knowledge on basic analog MOS application structures in order to use them as building blocks in designing analog MOS subsystems.
CO3: Employ CMOS Opamps to design common signal processing subsystems.
CO4: Apply mixed-signal CMOS building blocks designing analog MOS subsystems.

Module 1: (9 hours)

Basic MOS Device:
Analog MOS models – Device construction, Principle of operation, static characteristics, Body effect on static characteristics and DC biasing, VVR explanation and use, channel length modulation – Early Voltage, low frequency model – MOS in saturation –high frequency model – MOS resistors and resistor circuits

Module 2: (9 hours)

Single-Stage Amplifiers-– common source –common gate – common drain amplifiers, cascode and folded cascode structures
Current sources and sinks – regulated cascode current source/sink, Wilder current source
Passive and Active current mirrors – Basic Current mirrors-cascode current mirror – Wilson current mirror – Active Current mirror

Module 3: (10 hours)

Differential amplifiers – Basic differential pair, common mode response.
Frequency response of amplifiers- General considerations of Miller effect, common source, common gate, common drain amplifiers, cascade and differential pair.
CMOS Operational amplifiers – Basic one and two stage CMOS OAs, folded cascade type.

Module 4: (11 hours)

Mixed signal circuits – CMOS comparator design – analog multiplier – dynamic analog circuits – charge injection and capacitive feed through in
Introduction to switched capacitor circuits- MOSFET as switch – sample and hold circuits– switched capacitor filters
Ring Oscillator, LC oscillator, VCO - PLL, Charge pump PLL, delay locked loops and applications.

References:

1. A. S. Sedra and K.C. Smith, *Microelectronic circuits,* Oxford University Press*, 2003.*
2. J. R. Baker, H.W. Li and D.E. Boyce, *CMOS - Circuit Design, Layout & Simulation*, PHI,2005.
3. B. Razavi, *Design of Analog CMOS Integrated Circuit*, Tata McGraw-Hill, 2002.
4. R. Gregorian and G. C. Temes, *Analog MOS Integrated Circuits for Signal Processing*, John Wiley, 1986.

EE4030D ENERGY AUDITING, CONSERVATION & MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire the knowledge of basic principles of energy auditing types and objectives, instruments used
CO2: Apply energy efficient control methods and schemes for improvement of starting efficiency in Electrical Motors.
CO3: Explain efficient control strategies, optimal selection, sizing, operation of variable speed drives like pumps and fans.
CO4: Analyze Transformer loading and Evaluate Feeder/ cable losses
CO5: Discuss reactive power management scheme and Peak Demand control Methodologies
CO6: Acquire the knowledge of different types and schemes of cogeneration.
CO7: Apply Energy conservation measures and optimal operation methods for electric load like air conditioning, refrigeration, gysers-solar water heaters, compressors, electrolytic process.

Module 1: (8 hours)

Electrical Systems: Supply & Demand Side, Economic operation, Input-Output curves, Load profiling, Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods specific energy analysis

Module 2: (10 hours)

Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors.
Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study

Module 3: (11 hours)

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor Sizing-Degree of Compensation, Peak Demand controls Methodologies-Types of Industrial loads-Optimal Load scheduling-case study; Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study;

Module 4: (10 Hrs)

Cogeneration-Types and Schemes; Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage .Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- softwares-EMS

References:

1. R. DeGunther, *Alternative energy for dummies*, John Wiley & Sons, 2010.
2. P. A. Lynn, *Electricity from sunlight*, John Wiley & Sons, 2010.
3. L. K. Kirchmayer, *Economic Operation of power system*, Wiley India Pvt Ltd, 2010.

4. Jean-Claude Sabonnadiere, *Low emission power generation technologies and energy management*, John Wiley & Sons, 2010.
5. U. Eicker, *Low energy cooling for sustainable buildings*, John Wiley & Sons, 2010.
6. A. J. Wood, *Power generation Operation and Control*, 2nd ed., Wiley, 2010.
7. T. J. E. Miller, *Reactive power control in electric systems*, Wiley, 2010.
8. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, *Analysis of electric machinery and drive system*, 2nd ed., Wiley, 2010.
9. M. Pagliaro, G. Palmisano and R. Ciriminna, *Flexible Solar Cells*, John Wiley & Sons, 2009.
10. A. Mitsos, P. I. Barton, *Microfabricated Power Generation Devices*, John Wiley & Sons, 2009.
11. A. Thumann and S. Dunning, *Plant Engineers and Managers Guide to Energy Conservation*, 9th ed., TWI Press Inc., Terre Haute, 2008.
12. Roland Wengenmayr, *Renewable Energy*, John Wiley & Sons, 2004.
13. Francois and Leveque, *Transport pricing of electricity networks*, Springer 2003.
14. F. Parasiliti and P. Bertoldi, *Energy Efficiency in motor driven systems*, Springer, 2003.
15. Turner and C. Wayne, *Energy Management Handbook*, The Fairmont Press, 2001.
16. R. W. Donald, *Energy Efficiency Manual*, Energy Institute Press, 2000.
17. G. Petrecca, *Industrial Energy Management:Principles and Applications*, The Kluwer international series -207, Springer, 2000.
18. A. J. Pansini, K. D. Smalling, *Guide to Electric Load Management*, Pennwell Pub., 1998.
19. A. Thumann, *Handbook of Energy Audits*, 5th ed., Fairmont, 1998.
20. H. E. Jordan, *Energy-Efficient Electric Motors and Their Applications*, 2nd ed., Plenum Pub. Corp., 1994.
21. Petrecca and Giovanni, *Industrial Energy Management*, Springer, 1993.
22. IEEE Bronze Book, *Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities*, IEEE Inc, USA, 1985.
23. H. Partab, *Art and Science of Utilisation of Electrical Energy*, 2nd ed., Dhanpat Rai and Sons, 2014.
24. S. C. Tripathy, *Electric Energy Utilization And Conservation*, Tata McGraw-Hill, 1991.

EE4031D SWITCHED MODE POWER SUPPLIES

Prerequisite: EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Acquire knowledge on operation of non-isolated and isolated DC-DC Converters
CO2: Develop analytical competence required for modeling and simulation of these converters
CO3: Develop competence in design of power circuit (including magnetics) and closed-loop control systems for DC-DC Converters
CO4: Develop design competence in analysis, modeling and design of Off-line Switched Mode Power Supplies

Module 1: Introduction (9 hours)

Linear regulator Vs. Switching regulator – Topologies of SMPS – isolated and non isolated topologies – Buck – Boost – Buck boost – Cuk – Polarity inverting topologies – Push pull and forward converters half bridge and full bridge – Fly back converters Voltage fed and current fed topologies. EMI issues.

Module 2: Design Concepts (10 hours)

Magnetic Circuits and design – Transformer design - core selection – winding wire selection – temperature rise calculations - Inductor design. Core loss – copper loss – skin effect - proximity effect. Power semiconductor selection and its drive circuit design – snubber circuits – EMI and RFI considerations – Layout principles.

Module 3: Large Signal and Small Signal Modeling of Switched Mode Power Supplies (10 hours)

Switched model of Buck and Boost Converters – State Space Averaged Model – Various averages in a Power Electronic System – Local Average Model of a SMPS – Relation between State space average model and Local average model – conditions of validity of state space model – Small signal LTI model for Buck and Boost converters – various transfer functions – poles and zeros of control to output transfer function – effect of operating point and esr of capacitor on dynamics of small signal model – the right-half zero of a boost converter – Input admittance function of a converter – input filter stability- extension of state space model for transformer isolated SMPS designs.

Module 4: Control Modes (10 hours)

Voltage Mode Control of SMPS.. Transfer Function and Frequency response of Error Amp. Transconductance Error Amps . PWM Control ICs (SG 3525,TL 494,MC34060 etc.)
Current Mode Control and its advantages. Current Mode Vs Voltage Mode. Current Mode PWM Control IC(eg. UC3842).
Closing the loop – feedback isolation -

References:

1. A. I. Pressman, *Switching power supply design*, 2nd ed., McGraw-Hill, 1998.
2. K. H. Billings, *Switch mode power supply handbook*, 1st ed., McGraw-Hill, 1989.
3. S. Maniktala, *Switching power supplies A to Z*, 1st ed., Elsevier Inc., 2006.
4. D.M. Mitchell, *DC-DC Switching Regulator Analysis*, McGraw-Hill, 1988.
5. N. Mohan et.al., *Power Electronics*, 3rd ed., John Wiley and Sons, 2002.
6. O. Kilgenstein, *Switched Mode Power Supplies in Practice*, John Wiley and Sons, 1991.
7. M.J. Nave, *Power Line Filter Design for Switched-Mode Power Supplies*, Van Nostrand Reinhold, New York, 1991.

EE4032D ADVANCED DC – AC POWER CONVERSION

Pre-requisites: EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the concepts of Modulation Techniques for DC-AC Power Conversion
CO2: Explain the concept of Voltage and current source Inverters
CO3: Analyze the working of Special type inverters and Soft switching DC-AC inverters
CO4: Evaluate the applications of DC-AC Power Convertors using computer simulation

Module 1: Modulation Techniques for DC-AC Power Conversion (10 hours)

Evolution of topologies for DC-AC power conversion, Purpose of pulse width modulation, Over modulation, Square wave operation of voltage source inverter, Selective harmonic elimination, THD optimized PWM, Space vector concept and transformation, Per-phase methods from a space vector perspective, Space vector based modulation, Conventional space vector PWM, Simulation practice.

Module 2: Voltage and Current Source Inverter (10 hours)

Voltage source inverters, Single phase half bridge inverters, Single phase full bridge inverters, Three phase full bridge VSI, Current source inverters, Three phase full bridge current source inverters, Boost type CSI, Comparison between VSI and CSI, Filter design for inverters, Applications and simulation practices.

Module 3: Special type inverters (11 hours)

Impedance source inverters, Quasi-impedance source inverters, Equivalent circuit and operations, Circuit analysis and calculations, Simulation practice, Multilevel DC-AC inverters, Diode-clamped capacitor clamped multilevel inverters, Multilevel inverters using H-Bridges, Generalized multilevel inverters, Mixed level multilevel inverters, Applications and simulation practices.

Module 4: Soft switching DC-AC inverters (8 hours)

Notched DC link inverters, Resonant circuits, Design considerations, Resonant pole inverter, Operating, principle, Transformer based resonant DC link inverters, Applications and simulation practices

References:

1. F. L. Luo and H. Ye, *Advanced DC/AC Inverters: Applications in Renewable Energy*, CRC Press, 2013.
2. Seguier, Guy, Labrique and Francis, *Power Electronic Converters- DC-AC Conversion*, Springer, 1993.
3. E. dos Santos, E. R. da Silva, *Advanced Power Electronics Converters: PWM Converters Processing AC Voltages*, Wiley, 2014.
4. A. Yazdani, *Voltage–Sourced Converters in Power Systems: Modeling, Control, and Applications,* Wiley, 2010.
5. D. O. Neacsu, *Switching Power Converters: Medium and High Power*, CRC Press, 2017.

EE4033D BIO-SIGNAL PROCESSING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course outcomes:

CO1: Apply mathematical principles of digital signal processing.
CO2: Apply methods to extract relevant information from biomedical signal measurements.
CO3: Design suitable algorithms for the analysis of ECG signal with characteristic feature points.
CO4: Assess the appropriateness of various biomedical signal processing techniques for the benefit of clinical diagnostics

Module 1: Discrete Signals and Transforms (11 hours)

Discrete time signals and systems –classification and representation of discrete –time signals
Classifications of sequences –basic operation of sequences – discrete time systems – Discrete Time Fourier Transform - Discrete Fourier Transform – computation of DFT –Mathematical derivation of unilateral z Transform– properties of z- Transform –the inverse z – Transform – bilateral z –Transform -power series - region of convergence

Module 2: Physiological Signal Processing (12 hours)

The brain and it's potentials – electrophysiological origin of brain waves –EEG signal and it's characteristics –EEG analysis – linear prediction theory – recursive estimation of AR parameters
Spectral error measure – transient detection and elimination (the case of epileptic patents)-review of Wiener Filtering Problem – principle of adaptive filter –the Steepest -Descent Algorithm -50Hz interference and it's cancellation –cancellation of ECG signal from the electrical activity of the chest muscles

Module 3: ECG Data Acquisition and Processing (8 hours)

Basic electrocardiography- ECG data a acquisition-ECG lead systems – steps in ECG analysis -ECG parametersand their estimation – QRS detection algorithm -arrhythmia analysis and monitoring - long term ECG recording

Module 4: Compression Techniques for ECG Signals (8 hours)

Direct ECG data compression techniques – Transformation compression Techniques –other data compression techniques – Prony's method – clinical applications

Text books:

1. D. C. Reddy*, Biomedical signal processing: principle and techniques*, 1st ed., TMH, 2005.
2. W. J. Tompkins, *A Biomedical signal processing*, PHI, 2009.

References:

1. R. M. Rangayyan, *Biomedical signal analysis*, IEEE Press, 2002.
2. L. Sornmo and Pablo, *Bioelectrical signal processing in cardiac and neurological applications*, Laguna, Elsevier Academic Press, 2005.
3. R. U. Acharya, J. S. Suri, J. A. E. Spaan, S. M. Krishnan, *Advances in Cardiac Signal Processing*, Springer, 2007.

EE4034D SYSTEM IDENTIFICATION & PARAMETER ESTIMATION

Pre-requisites: EE3001D Control System - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Solve minimum mean square estimation problems
CO2: Solve maximum likelihood estimation problems
CO3: Develop the Kalman Filter Equations for the given estimation problem
CO4: Solve stochastic estimation problems using Kalman Filter

Module 1: Mean Square Estimation (13 hours)

Formulation of models for linear estimation problems-Statistical framework for parameter estimation-guiding principles behind MSE parameter estimation methods-minimizing prediction errors-linear regression and least squares methods-examples- correlating prediction errors with past data-Instrumental variable method-consistency and identifiability-Recursive methods- Matrix inversion lemma-RLS Algorithm-Weighted RLS-Application in parameter estimation-feature extraction-data analytics. AR and ARMA process modeling and estimation of model parameters.Spectral methods.

Module 2: Maximum Likelihood estimation (13 hours)

Statistical framework for parameter estimation- Stochastic processes- Ergodicity- Stationarity-univariate processes-multivariate processes-Wiener process- Markov process-guiding principles behind MLE parameter estimation methods -maximum likelihood estimation-derivations-examples-simulation-identification of closed loop systems –identification of multivariable systems- examples

Module 3: State Estimation & Kalman Filter (13 hours)

Derivation of the stochastic estimation problem-Wiener Hopf equation- realizability-examples of realizable filters- stochastic state estimation problem- optimal filtering-derivation of Kalman filter- Simulation-calculation of memory requirements for digital implementation- -study of literature in control, guidance and communication on Kalman filter applications.-Extended Kalman Filter.

Text books:

1. Ljung and Lennart, *System Identification: Theory for the user*, Prentice Hall Information Systems Science Series, 1987.

References:

1. J. Schoukens, R. Pintelon and Y. Rolain, *Mastering System Identification in 100 Exercises*, Wiley-IEEE Press, 2012.
2. L. Wang and K. C. Tan, *Modern Industrial Automation Software Design*, Wiley-IEEE Press, 2012.
3. R. V. Jategaonkar, *Flight Vehicle System Identification: A Time-Domain Methodology,* 2nd ed., Aerospace Research Central, American Institute of Aeronautics & Astronautics, USA, 2015.

EE4035D POWER SYSTEM RELIABILITY AND DEREGULATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the basic reliability concepts and reliability measures.
CO2: Develop analytical models for power system reliability analysis.
CO3: Implement and use algorithms for power system reliability analysis
CO4: Conduct reliability studies of typical system using simulation tools
CO5: Explain power system deregulation and its social impacts

Module 1: (8 hours)

Generator System Models- State Load Model- Probability Methods- Unit Unavailability- Outage Probability, Generating Capacity Limits- Recursive Techniques- Capacity Expansion Analysis - Scheduled Outages - Reliability Indices- Frequency Duration Method. Power quality issues. Load forecasting: Classification of loads-Forecast methodology- Energy forecasting

Module 2: (11 hours)

Reliability analysis of isolated and Interconnected Systems - Two Systems with Tie- Probability Array Methods- Reliability Indices- Variable Reserve and Maximum Peak Load Reserve- Multi Connected Systems. Distribution System- Interruption Indices- System Performance- risk prediction- Radial Systems- Effect of Load Transfer- Line Failures- Parallel And Mesh Networks- Industrial Systems.
Capacity state classification- Average –Interruption rate method – LOLP method

Module 3: (10 hours)

Deregulated Systems: Need and conditions for deregulation-Introduction of Market structure-Market Architecture-Spot market-forward markets and settlements. -deregulation in Indian power sector - Operations in power markets -Review of Concepts- marginal cost of generation least-cost operation-incremental cost of generation.

Module 4: (10 hours)

Reconfiguring Power systems- Unbundling of Electric Utilities- Competition and Direct access. Transmission network and market power - Power wheeling transactions and marginal costing - transmission costing. Framework and methods for the analysis of Bilateral and pool markets.

References:

1. Dong, Z., Zhang, P. Ma, J., Zhao, J., Ali, Meng, K., Yin, *Emerging Techniques in Power System Analysis*, 1st ed., Springer, 2010.
2. S.C. Savulescu, *Real-Time Stability assessment in modern power system control centres*, John Wiley & Sons, January 2009
3. Eric Monmasson, *Static Converters*, John Wiley & Sons, September 2009.
4. Bo Bergman, Jacques de Mare, Thomas Svensson, Sara Loren, *Robust Design methodology for reliability*, John Wiley & Sons, October 2009
5. Ali A. Chowdhury, Don O. Koval, *Power distribution system reliability-Practical methods and applications* , John Wiley & sons Inc., IEEE Press 2009
6. Richard E.Brown, *Electric power distribution reliability*, Taylor & Francis Group, LLC, 2009.

7. Elmakias, David (Ed.) *New Computational Methods in Power System Reliability*, Studies in Computational Intelligence, Springer 2008
8. Leveque, Francois , *Transport Pricing of Electricity Networks*, Springer 2003
9. Steven Stoft , *Power System Economics-Designing markets for electricity*, IEEE Pres,2002
10. M. Shahidehpour, H. Yamin and Zuyi Li, *Market operations in electric power systems-Forecasting, scheduling and risk management*, John Wiley & sons Inc., 2002
11. Kankar Bhattacharya, Math H.J. Bollen, and Jaap E. Daalder, *Operation of restructured power systems*, Kluwer international series,2001
12. Loe lei lai, *Power system restructuring and deregulation- trading, performance and information technology*, John Wiley and sons,Ltd,2001
13. Wilson K. Kazibwe and Musoke H Semdaula. *Electric Power Quality Control Techniques*, Van Nostarand Reinhold New York.2001
14. Yong-Hua Song, *Modern Optimisation Techniques in Power Systems* , Intelligent Systems, Control and Automation: Science and Engineering, Vol. 20, Springer 1999
15. Roy Billinton, Ronald N. Allan, *Reliability Assessment of Large Electric Power Systems*, IEEE Press 1995
16. R.Ramakumar, *Reliability Engineering: Fundamentals and Applications*, Prentice Hall, 1993
17. Roy Billinton, *Power System Reliability Evaluation*, Plenum Press, New York,1991
18. J. Endrenyi, *Reliability Modeling in Electrical Power Systems*, Wiley New York, 1978

EE4036D POWER QUALITY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:
CO1: Explain different power quality issues and its mitigation techniques
CO2: Discuss about the harmonic sources and effect of harmonics on power system equipment and loads.
CO3: Explain harmonic elimination, isolation techniques and power factor correction methods
CO4: Measure voltage sag, swell and harmonics and analyze the measured data.

Module 1: (7 hours)

Power Quality –overview of power quality phenomena -Basic terminologies –Power Quality Issues – Causes for reduction in Power Quality — Power Quality Standards and indices.

Module 2: (10 hours)

Voltage sags-Causes of voltage sags – magnitude & duration of voltage sags – effect on drives and peripherals– monitoring & mitigation of voltage sags.
Interruptions -Origin of Long & Short interruptions – influence on various equipments – monitoring & mitigation of interruptions.
Harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

Module 3: (11 hours)

Power factor improvement- Passive Compensation- Passive Filtering- Harmonic Resonance - Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End-Control Methods for Single Phase APFC Three Phase APFC and Control Techniques- PFC Based on Bilateral Single Phase and Three Phase Converter static var compensators-SVC and STATCOM

Module 4: (11 hours)

Active Harmonic Filtering-Shunt Injection Filter for single phase , three-phase three-wire and three-phase four wire systems-d-q domain control of three phase shunt active filters -UPS-constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag , swell and flicker problems.
Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.

References:

1. G. T. Heydt, *Electric Power Quality*, Stars in a Circle Publications, 1991.
2. M. H. Bollen, *Understanding Power Quality Problems*, 1st ed., IEEE Press, 2001.
3. J. Arrillaga, *Power System Quality Assessment*, John Wiley, 2000.
4. J. Arrillaga, B. C. Smith, N. R. Watson & A. R. Wood, *Power system Harmonic Analysis*, Wiley, 1997.
5. W. E. Kazibwe, M. H. Sendaula, *Electric Power quality control techniques*, Van Nostrand Reinhold, New York, 1993.
6. J. Schlabbach, D. Blume and T. Stephanblome , *Voltage quality in Electrical Power Systems*, No. 36. IET, 2001.

7. R. C. Dugan, M. F. McGranaghan, S. Santoso and H. W. Beaty, *Electrical power systems quality*, 3rd ed., Tata McGraw-Hill, 2012.
8. G. J. Walkilesh, *Power Systems Harmonics*, Springer, 2007.
9. R. S. Vedam and M. S. Sarma, *Power Quality VAR Compensation in Power Systems*, CRC press, 2009.
10. A. Baggini, *Handbook of Power Quality*, Wiley, 2008.

EE4037D CONTROL & GUIDANCE ENGINEERING

Pre-requisites: EE3001D Control Systems - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Identify the features of satellite based navigation systems, GPS and GNSS
CO2: Summarize the guidance system components: gyros and accelerometers
CO3: Construct dynamic models of space vehicles and missiles
CO4: Design guidance and control schemes for space vehicles and missiles

Module 1: Navigation Systems (11 hours)

General principles of early conventional navigation systems - Geometric Concepts of navigation-Reference frames-Direction cosine matrix-Euler angles-Transformation of angular velocities-Quaternion representation in co-ordinate transformations-Comparison of transformation methods. Inertial platforms-Stabilized platforms-Gimbaled and Strap down INS and their mechanization-Gyro compassing for initial alignment- Externally aided inertial navigation systems- TACAN, TERCOM, LORAN, OMEGA, DECCA, VOR, DME, JTIDS, FLIR -Basics of satellite based navigation systems- Global Positioning Systems (GPS) and Global Navigation of Satellite Systems (GNSS).

Module 2: Guidance Systems (9 hours)

Guidance information requirements-Energy Conservation Methods-Time Conservation Methods-Collision Warning and Avoidance-Rendezvous - Satellite Orbit maintenance-Inertial navigation-block diagram representation of essential components-Inertial sensors, Gyros: Principle of operation-TDF and SDF- gyro precession-Nutation-gimbal - lock-gimbal flip-gyro transfer function- rate gyro-integrating gyro-Constructional details and operation of floated rate integrating gyro-Dynamically tuned gyro-Ring laser gyro-Fiber optic gyro -gyro performance parameters-Accelerometers-transfer function-Pendulous gyro integrating accelerometer Vibrating String accelerometer-Accelerometer performance parameters-Navigation equations-Schuler principle and mechanization.

Module 3: Space vehicle dynamics and control (9 hours)

Powered flight-unpowered flight-Orbital mechanics- Orbital parameters- circular, elliptical, parabolic, hyperbolic and rectilinear orbits- energy of the orbit- orbital transfer and rendezvous- LEO, SSPO,GSO,GTO orbits- impulse transfer between circular orbits- Hoffmann transfer- other co-planar and non-coplanar transfers- N-body problem- two-body problem- Re-entry of space vehicle- re-entry dynamics-ballistic re-entry- skip re-entry- double-dip re-entry- aerobraking- lifting body re-entry- entry corridor-equilibrium glide- thermal and structural constraints- commanded drag guidance.

Module 4: Missile guidance and Control (10 hours)

Guided missile - surface to surface, surface to air, air to surface and air to air missiles-Tactical and strategic missile- Subsystems of a missile – airframe, flight control and guidance, warhead, data link, fuze, propulsion, telemetry- Control – Canad, wing and tail control- Steering policy – skid to turn (STT), preferred orientation control (POC), bank to turn (BTT) and hybrid- Aerodynamic and Ballistic missiles-Auto pilots-Types of fuze, warhead and propulsion systems-Guidance sequence- different schemes of guidance during launch, midcourse and terminal phases- Collision avoidance.

References:

1. M. H. Kaplan, *Modern Spacecrafts dynamics and control*, John Wiley & Sons, 1976.
2. H. Schaub and J. L. Junkins, *Analytical Mechanics of Space Systems*, AIAA, USA, 2003.
3. E. V. B. Stearns, *Navigation and Guidance in Space*, Prentice Hall, 1983.
4. M. Fernandez and G.R. Macomber, *Inertial Guidance Engineering*, Prentice Hall, 1962.
5. C. F. Lin, *Modern Navigation, Guidance, and Control Processing*, Prentice-Hall, 1991.
6. M. J. Zucrow, *Aircraft & Missile Propulsion*, John Wiley & Sons, 1958.
7. D. B. Newman, *Space Vehicle Electronics*, D. Van Nostrand Co., 1964.
8. A. C. Kermode, *Mechanics of Flight*, Pearson Education, 2004.
9. P. Zarchan, *Tactical and Strategic Missile Guidance*, AIAA, 2007.

EE4038D POWER SYSTEM PROTECTION AND COMMUNICATION

Pre-requisites: EE3005D Power Systems - I

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Introduce signal processing concept to power system protection.

CO2: Assimilate concept of different types of relay, including differential relay, ohm relay, mho relay, directional relay, distance relay, reactions relay etc. and their selection for each protection scheme design.

CO3: Understand the basic principles of communication systems used in modern power systems operation and control.

CO4: Introduce the concept of wide area measurement system based on SCADA and PMUs.

Module 1: (9 hours)

Protective Relaying concepts - Qualities of relaying- schemes and design-factors affecting performance – zones and degree of protection; Numerical relaying algorithms; signal conditioning- conversion subsystems- relay units sequence networks- Relaying Transducers, CTs and PTs-Guidance in applications- fault sensing data processing units -Travelling wave relays; Adaptive relaying.

Module 2: (9 hours)

Relay Schematics and Analysis- Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types Characteristics. Testing of Relays, Simulation studies with different relaying schemes.

Module 3: (10 hours)

Protection of Power System Equipment - Generator, Transformer, Transmission Systems, Bus bars, Motors; Pilot wire and Carrier Current Schemes. Relay coordination. Case studies and simulations for different protection paradigms.

SCADA system and RTUs-configurations, PMU and implementation strategies.

Module 4: (11 hours)

Communication in power systems: Different standards, Terminologies and architectures; Protocols, Networks and Information Technology Applications in Power Systems-Wide Area Communication Infrastructure, Time data communication, Challenges, Security Implications

References:

1. Dong, Z., Zhang, P. Ma, J., Zhao, J., Ali, Meng, K., Yin, *Emerging Techniques in Power System Analysis*, 1st ed., Springer, 2010.
2. Clark W Gellings, *The smart grid, enabling energy efficiency and demand side response*- CRC Press, 2009
3. Janaka Ekanayake, Kithsiri Liyanage , Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, *Smart Grid: Technology and Applications,* Wiley 2012.
4. James Momoh, *Smart Grid: Fundamentals of Design and Analysis* - Wiley, IEEE press, 2012
5. Shahidehpour, Mohammad, and Yaoyu Wang. *Communication and control in electric power systems: applications of parallel and distributed processing*, John Wiley & Sons, 2004
6. Yong-Hua Song *Modern Optimisation Techniques in Power Systems,* Intelligent Systems, Control and Automation: Science and Engineering, Vol. 20, Springer 1999.
7. Badri Ram , D.N. Vishwakarma, *Power system protection and switch gear*, Tata McGraw Hill, 2001

8. Singh L.P, *Digital Protection, Protective Relaying from Electromechanical to Microprocessor*, John Wiley & Sons, 1994
9. Wright, A. and Christopoulos, C, *Electrical Power System Protection*, Chapman & Hall, 1993,
10. Walter A. Elmore, J. L. Blackburn, *Protective Relaying Theory and Applications*, ABB T&D Co.Marcel Dekker, Inc. 2004
11. Arun G. Phadke, James S. Thorp, *Computer Relaying for Power Systems*, Marcel Dekker, Inc 2009.
12. Kalam, Akhtar, and D. Kothar., *Power system protection and communications,* New Age Science Ltd, 2010.

EE4039D SWITCHGEAR AND PROTECTION

Pre-requisites: EE3005D Power Systems - I
EE3006D Power Systems - II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Analyze the various abnormal conditions that could occur in power system.
CO2: Design various protective devices in power system for protecting equipment and personnel
CO3: Analyze various types of existing circuit breakers, their design and constructional details.
CO4: Analyze various conventional relays, their design and latest developments
CO5: Knowledge of standards and specifications related to switchgear and protection

Module 1: (9 hours)

Circuit breakers - principles of operation – RRRV-Current chopping. Constructional features and Selection of LT breakers (MCB/MCCB/ELCB) and HT Breakers (ABCB - OCB – SF6CB– VCB); Circuit breaker ratings Testing of circuit breakers.

Module 2: (10 hours)

Overvoltages – Surges and travelling waves – Wave propagation on transmission lines - reflection and attenuation- Lightning strokes- protection against lightning - earth wires- lightning diverters - surge absorbers - arcing ground - neutral earthing - basic concepts of insulation levels and their selection - BIL – Co-ordination of insulation-Simulation of overvoltages using EMTP software.

Module 3: (12 hours)

Protective relays - protective zones - requirement of protective relaying- definitions-Codes-Standards - Types – Over current Relays - Earth fault relays- Directional relays- Differential relays- Distance relays- Under voltage/ Frequency relays. Static, digital and numerical relays-PC based relays-Construction-Characteristic Functions -Converter Elements-Comparators-Relay Schematics, Analysis. Design of a numerical over current relay.

Module 4: (8 hours)

Protection Scheme for Generators-Power Station & DG sets, Power & Distribution Transformers, Transmission lines and Busbars, Motors. NEC and importance of relevant IS/IEC specifications related to switchgear and protection.

References:

1. S. S. Rao, *Switchgear Protections*, Khanna Publications, Delhi, 1999.
2. A. Greenwood, *Electrical Transients in Power Systems*, 1991.
3. A. R. van C. Warrington, *Protective Relays*, vol. 1 & 2, Chapman & Hall, 1998.
4. T. S. M. Rao, *Power System Protection Static Relays with Microprocessor Applications*, Tata McGraw-Hill, 1998.
5. B. Ram, D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw-Hill, 2005.
6. P. M. Anderson, *Power System Protection*, IEEE Press, 1999.
7. W. A. Elmore, *Protective Relaying Theory and Applications*, 2nd ed., CRC Press, 2003.

EE4040D SMART GRID ENGINEERING

Pre-requisites: EE3005D Power Systems – I
EE3006D Power Systems - II
EE3007D Power Electronics

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Determine conceptual ideas of Smart Grid with a thorough understanding of various communication technologies and power management issues with smart grid.
CO2: Analyze issues related with integration of various distributed energy sources to smart grid.
CO3: Analyze the operation and importance of demand side management, power market scenarios in deregulated scenarios.
CO4: Cross link various inter-disciplinary topics such as policy, control, communication, instrumentation and core power systems for better operability of smart grid.

Module 1: Overview of Smart grid (9 hours)

Introduction to Smart Grids – Today's Grid versus the Smart Grid, Key functions of smart grid, smart grid elements and control layers. Policies and infrastructures. Concept of Resilient & Self-Healing Grid. Demand Side Management (DSM) and transactive energy models.

Module 2: Metering and Interoperability (6 hours)

Introduction to Smart Meters, Real Time Pricing, Pricing Models, Automatic Meter Reading (AMR), Smart Sensors, Home & Building Automation. Standards and case studies.

Module 3: Communications in Smart Grid (10 hours)

Communication aspects - Elements of communication and networking: architectures, standards and adaptation of power line communication (PLCC). Communication models- Home area networks (HAN) and neighborhood area networks (NAN). IP Protocols, Big data analytics and CLOUD computing, Security for Smart Grid.
Wide area Monitoring Systems (WAMS), PMU and PDCs. Special relaying schemes for Smart Grid

Module 4: Operations on Smart Grid (14 hours)

The economics of supply and demand in energy markets - Energy market deregulation.
Technology Drivers, Smart energy resources- Plug-in hybrid vehicles, Smart substations, Substation and Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management. Grid Data Management. – Case studies and test beds for the smart grid.

Text books:

1. James Momoh, *Smart Grid: Fundamentals of Design and Analysis,* Wiley-IEEE Press, 2012.
2. Lars T. Berger and Krzysztof Iniewski, *Smart Grid Applications, Communications, And Security*, Wiley, New Delhi, Aug 2015.
3. Takuro Sato, Daniel M. Kammen,Bin Duan, Martin Macuha, Zhenyu Zhou, and Jun Wu, *Smart Grid Standards: Specifications, Requirements, and Technologies*, Wiley-Blackwell, Apr 2015.

4. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, and Nick Jenkins, *Smart Grid: Technology And Applications*, Wiley, New Delhi, Aug 2015.
5. Budka, Kenneth C., Jayant G. Deshpande, and Marina Thottan. *Communication networks for smart grids,* Springer London Limited, 2016.
6. Relevant and Latest IEEE/IEC Standards

References:

1. Sioshansi, Fereidoon P. ed., *Smart grid: integrating renewable, distributed and efficient energy*, Academic Press, 2011.
2. Keyhani, Ali. *Design of smart power grid renewable energy systems*, John Wiley & Sons, 2016.
3. Jayaweera, Dilan ed., *Smart power systems and renewable energy system integration*. Vol. 57. Springer, 2016.
4. Borlase, Stuart ed., *Smart grids: infrastructure, technology, and solutions*, CRC press, 2017
5. Elahi, Ata, and Adam Gschwender, *ZigBee wireless sensor and control network*, Pearson Education, 2009.
6. Uslar, Mathias, Michael Specht, Christian Dänekas, Jörn Trefke, Sebastian Rohjans, José M. González, Christine Rosinger, and Robert Bleiker. *Standardization in smart grids: Introduction to it-related methodologies, architectures and standards,* Springer Science & Business Media, 2012
7. Shahidehpour, Mohammad, and Yaoyu Wang. *Communication and control in electric power systems: applications of parallel and distributed processing,* John Wiley & Sons, 2004.
8. Ali Keyhani, Mohammad N. Marwali, Min Dai, *Integration of Green and Renewable Energy in Electric Power Systems*, Wiley, 2009.
9. Clark W. Gellings, *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press, 2009.
10. A.G. Phadke and J.S. Thorp, *Synchronized Phasor Measurements and their Applications*, Springer, 2010.
11. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.

EE4041D ANALOG AND DIGITAL COMMUNICATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Formulate Communication subsystem requirements in an electrical system and communicate the requirements effectively to the Design Team.
CO2: Carry out initial evaluation of analog versus digital communication subsystem alternatives in the context of electrical system design.
CO3: Outline preferred communication subsystem structures in an electrical system to the multi-disciplinary design team.
CO4: Evaluate the need for error correction in communication subsystems in the target electrical system design and report effectively to the Design Team.
CO5: Design simple analog/pulse communication systems for non-critical signal transmission and telemetering applications over wire in Electrical Systems.

Module 1: (8 hours)

[*Review : Frequency domain representation of finite energy signals and periodic signals - energy spectral density and power spectral density - convolution theorem - response of linear time invariant system - sampling and reconstruction - Nyquist sampling theorem*]
Rrandom processes - ensemble and time averages - Stationarity - correlation theory for wide sense stationary processes - wiener-Khinchin-Einstein theorem - properties of Gaussian random processes - white noise - response of LTI system to white Gaussian noise

Module 2: (10 hours)

Amplitude modulation - spectrum - power relations - modulator and demodulator circuits - AM transmitter block diagram - tuned radio frequency and superheterodyne receivers - calculation of signal to noise ratio for envelope detection and coherent detection of AM - principle of single side band suppressed carrier modulation - frequency modulation - deviation - modulation index - spectrum of FM signal - relationship between phase modulation and FM - JFET reactance modulator - FM transmitter block diagram - foster Sceley discriminator - SNR calculation - pre-emphasis and de-emphasis

Module 3: (10 hours)

Analog modulation scheme - PAM - PWM - PPM - digital pulse modulation scheme - PCM - DPCM and delta modulation - base band data transmission - base band transmission model - additive white gaussian noise channel - matched filter receiver - inter symbol interference - basic ideas of pulse shaping - equalization - synchronization - scrambling and line coding - digital pass band transmission - elements of digital pass band transmission - pass band transmission model - coherent binary modulation schemes: ASK - PSK and FSK - multilevel signaling schemes - average probability of error - bit error rate - concept of an optimal receiver

Module 4: (11 hours)

Elements of information theory - measure of information – Shanon's source coding and channel coding theorems - discrete memory - less channel - Shanon-Hartley theorem - error control strategies - principles of forward error correction and ARQ - linear block codes and syndrome decoding - elements of data communication - transmission impairments - synchronous and asynchronous transmission - multiple access - FDM - synchronous and statistical TDM - CDMA - frequency hopped and direct sequence CDMA - computer networks - network topologies - circuit switching - packet switching - basic concepts of network protocols - OSI

References:

1. S. Haykin, *Communication Systems*, 2nd ed., John Wiley, 2007.
2. R. E. Ziemer and W.H.Tranter *, Principles of Communications*, JAICO Publishing House, 2001.
3. D. Roddey and J. Coolen, *Electronics Communications*, Prentice Hall of India, 1995.
4. K. S. Shanmugam*, Digital and Analog Communications*, John Wiley, 1994.
5. A. Bateman, *Digital Communication: Design for The Real world*, Addison Wesley, 1999.
6. B. P. Lathi, *Modern Digital and Analog Communication Systems*, 4th ed., Oxford University Press, 2009.
7. S. Haykin*, An Introduction to Analog and Digital Communication Systems*, 2nd ed., John Wiley, 2006.

EE4042D ADVANCED DIGITAL SIGNAL PROCESSING

Pre-requisite: EE3002D Digital Signal Processing

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Apply optimization methods for IIR and FIR filter design in time domain and frequency domain and algorithms for filter implementation.
CO2: Model and analyze speech signals and speech signal processing
CO3: Describe two dimensional signal processing and its application in image processing
CO4: Explain about digital signal processors and their architecture.

Module 1: Optimisation Methods for IIR and FIR filter Design (10 hours)

Deczky's method for IIR filter design in the frequency domain, Pade approximation method, Least- squares design method in time domain; Frequency sampling method for FIR filters, Parks and McClellan Algorithm for design, Remez exchange algorithm for implementation.

Module 2: Speech signal processing (10 hours)

Digital models for speech signal, Mechanism of speech production, Acoustic theory, Lossless tube models , Formulation of LPC equation, Solution of LPC equation, Levinson Durbin algorithm, Schur algorithm, Spectral analysis of speech, Short time fourier analysis, Speech coding, subband coding, Transform coding, Channel vocoder,Formant vocoder, Cepstral vocoder, Vector quantisation coder.

Module 3: Two dimensional signal processing (Image Processing) (10 hours)

Digital image representation; 2-D DFT. properties; DCT; Image enhancement, Spatial and frequency domain filtering methods; colour image processing; Image restoration- Degradation model, Inverse filtering; Fundamentals of image compression.

Module 4: Digital signal processors (9 hours)

Introduction to DSP processors- common features, fixed point versus floating point; Memory architecture Harvard architectures, multiple access memories, multi-processor support, addressing modes; instruction set; An example DSP architecture- Analog Devices/Motorola/Texas Instruments.

References:

1.Alan V Oppenheim, Ronald W. Schafer, *Discrete-Time Signal Processing*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997.
2.John G. Proakis, and Dimitris G. Manolakis, *Digital Signal Processing*, 3rd ed., Prentice-Hall of India Pvt. Ltd, New Delhi, 1997.
3.L.R. Rabiner and R.W Schafer, *Digital processing of speech signals*, Prentice Hall, New Jersey, 1978.
4.R. C. Gonzalez and R.E. Woods, *Digital Image processing*, Addison Wesley, 1992.
5.Jae S. Lim, *Two Dimensional signal and image processing*, Prentice Hall Inc., Englewood Cliffs, New Jersey,1990.
6.Lapsley P, Jeff Bier, Amit Shoham and Lee E. A., *DSP Processor Fundamentals ,Architectures and features*, IEEE Press.

EE4043D STATIC VAR COMPENSATION AND HARMONIC FILTERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Explain the shunt compensation of Power Systems
CO2: Describe in detail the various Power Quality issues
CO3: Explain the operation and design control systems for of Satic VAr Compensators and STATCOMS.
CO4: Analyze and Design various power electronic converters used static reactive power compensation units
CO5: Analyze and Design single-phase and three-phase shunt/series active harmonic filters and their control systems

Module 1: (10 hours)

Fundamentals of Load Compensation, Steady-State Reactive Power Control in Electric Transmission Systems , Reactive Power Compensation and Dynamic Performance of Transmission Systems .
Power Quality Issues . Sags, Sweels, Unbalance, Flicker, Distortion, Current Harmonics - Sources of Harmonics in DistributionSystems and Ill Effects.

Module 2: (10 hours)

Static Reactive Power Compensators and their control. Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control, Sub-Synchronous Resonance and damping, Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems.

Module 3: (10 hours)

Converters for Static Compensation. Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM) . GTO Inverters . Multi-Pulse Converters and Interface Magnetics. Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM). Multi-level inverters of Cascade Type and their modulation .Current Control of Inverters.

Module 4: (9 hours)

Passive Harmonic Filtering. Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling . Three-phase four-wire shunt active filters. Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode. Series Active Filtering in Harmonic Isolation Mode . Dynamic Voltage Restorer and its control . Power Quality Conditioner.

References:

1. T.J.E Miller, *Reactive Power Control in Electric Systems*, John Wiley & Sons,1982.
2. N.G. Hingorani & L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 2000.
3. Ned Mohan et.al, *Power Electronics*, John Wiley and Sons 2006

4. R. Sastry Vedam & Mulukutla S. Sarma, *Power quality VAR compensation in power systems*, CRC press, 2009.
5. Hirofumi akagi, Edson hirokazu watanabe, Mauricio aredes, *Instantaneous power theory and applications to power conditioning*, Wiley Inter Science,2007.
6. K.R. Padiyar, *FACTS controllers in power transmission and distribution*, New age international publications, 2008.

EE4044D DATA ACQUISITION & SIGNAL CONDITIONING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:
CO1: Describe the fundamentals of data acquisition systems
CO2: Explain various transducers and signal conditioning circuits
CO3: Discuss on different first order and second order filter circuits and sample and hold devices
CO4: Explain different signal conversion (analog to digital and digital to analog converters)
CO5: Explain various analog and digital data transmission systems, modulation and telemetry systems

Module 1: Transducers & Signal Conditioning (10 hours)

Data Acquisition Systems (DAS)- Introduction – Fundamentals of signals acquisition, conditioning and processing. -Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors) – Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers. Noise Reduction Techniques in Signal Conditioning- Transmitters, Optical Fiber Based Signal Transmission Piezoelectric Couplers- Intelligent transmitters.

Module 2: Filtering and Sampling: (10 hours)

Review of Nyquist's Sampling Theorem - Aliasing. Need for Prefiltering - First and second order filters classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters. Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers.

Module 3: Signal Conversion: (10 hours)

Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion. Conversion Processes, Speed, Quantization Errors. Successive Approximation ADC. Dual Slope ADC. Flash ADC. Digital-to-Analog Conversion (DAC). Techniques, Speed, Conversion Errors, Post Filtering-Weighted Resistor, R-2R, Weighted Current type of DACs- Multiplying Type DAC-Bipolar DACs.

Module 4: Data Transmission: (9 hours)

Data transmission systems- Analog transmission system, Digital transmission system, Analog encoding of analog information, Analog encoding of digital Information, Digital encoding of analog information, Digital encoding of digital information, Schmitt Trigger-Pulse code formats- Modulation techniques and systems-Telemetry systems.

References:

1. Ernest O Doeblin., *Measurement Systems: Application and Design*, Int. ed., McGraw Hill, 1990.
2. George C.Barney, *Intelligent Instrumentation*, Prentice Hall of India Pvt Ltd., New Delhi, 1988.

3. Ibrahim, K.E., *Instruments and Automatic Test Equipment*, Longman Scientific & Technical Group Ltd., UK, 1988.
4. G.B. Clayton, *Operational Amplifiers*, Butterworth &Co, 1992.
5. Oliver Cage, *Electronic Measurements and Instrumentation*, Int. ed., McGraw-Hill, 1975.