GOVERNMENT COLLEGE OF ENGINEERING: : SALEM – 636011

Regulations 2018A

B.E. Electrical and Electronics Engineering- Full Time

Course Code	Course Title	Category	Contact periods	Hours/week				Maximum Marks		
				L	T	P	C	CA	FE	Total
FIRST SEMESTER										
THEORY										
18EN101	Professional English	HS	2	2	0	0	2	40	60	100
18MA102	Matrices, Calculus and Differential Equations	BS	4	3	1	0	4	40	60	100
18CY101	Chemistry	BS	4	3	1	0	4	40	60	100
18CS101	Fundamentals of Problem Solving and C Programming	ES	3	3	0	0	3	40	60	100
PRACTICAL										
18EN102	Professional English Laboratory	HS	2	0	0	2	1	60	40	100
18CS102	Computer Practice Laboratory	ES	4	0	0	4	2	60	40	100
18ME102	Workshop/Manufacturing Practices	ES	5	1	0	4	3	60	40	100
18MC102	Induction Programme	MC					0	100	-	100
	Total						**19**			
SECOND SEMESTER										
THEORY										
18MA204	Fourier Series and Transforms	BS	4	3	1	0	4	40	60	100
18PH202	Physics- Waves & Optics and Quantum Mechanics	BS	4	3	1	0	4	40	60	100
18ME101	Engineering Graphics and Design	ES	5	1	0	4	3	40	60	100
18CM201	Basic Civil and Mechanical Engineering	ES	4	4	0	0	4	40	60	100
PRACTICAL										
18PH103	Physics Laboratory	BS	3	0	0	3	1.5	60	40	100
18CY102	Chemistry Laboratory	BS	3	0	0	3	1.5	60	40	100
18EN103	Professional Communication Laboratory	HS	2	0	0	2	1	60	40	100
18CE201	Basic Civil Engineering Laboratory	ES	2	0	0	2	1	60	40	100
	Total						**20**			

THIRD SEMESTER										
THEORY										
18MA302	Statistics and Numerical Methods	BS	4	3	1	0	4	40	60	100
18EE301	Electric Circuit Analysis	PC	4	3	1	0	4	40	60	100
18EE302	Electromagnetic Fields	PC	4	3	1	0	4	40	60	100
18EE303	DC Machines and Transformers	PC	3	3	0	0	3	40	60	100
18EE304	Electron Devices and Circuits	PC	4	3	1	0	4	40	60	100
PRACTICAL										
18EE305	DC Machines and Transformers Laboratory	PC	3	0	0	3	1.5	60	40	100
18EE306	Electron Devices and Circuits Laboratory	PC	3	0	0	3	1.5	60	40	100
18CYMC01	Environmental Science	MC	1	0	0	1	0	100	-	100
	Total						**22**			
FOURTH SEMESTER										
THEORY										
18EE401	Signals and Systems	PC	3	2	1	0	3	40	60	100
18EE402	Synchronous and Induction Machines	PC	3	3	0	0	3	40	60	100
18EE403	Measurements and Instrumentation	PC	3	3	0	0	3	40	60	100
18EE404	Analog and Digital Integrated Circuits	PC	3	3	0	0	3	40	60	100
18ME408	Engineering Mechanics	ES	3	2	1	0	3	40	60	100
PRACTICAL										
18EE405	Synchronous and Induction Machines Laboratory	PC	3	0	0	3	1.5	60	40	100
18EE406	Measurements and Instrumentation Laboratory	PC	3	0	0	3	1.5	60	40	100
18EE407	Analog and Digital Integrated Circuits Laboratory	PC	3	0	0	3	1.5	60	40	100
18MC301	Indian Constitution	MC	1	1	0	0	0	100	-	100
	Total						**19.5**			

FIFTH SEMESTER										
THEORY										
18EE501	Power Generation, Transmission and Distribution System	PC	3	3	0	0	3	40	60	100
18EE502	Control Systems	PC	4	3	1	0	4	40	60	100
18EE503	Power Electronics	PC	3	3	0	0	3	40	60	100
18EE504	Microprocessor and Microcontroller	PC	3	3	0	0	3	40	60	100
18EEPXX	Program Elective – 1	PE	3	3	0	0	3	40	60	100
18EE0EXX	Open Elective-1	OE	3	3	0	0	3	40	60	100
18MCIN01	Ideation Sprits	EEC	3	2	2	0	1	100		100
PRACTICAL										
18EE505	Control SystemLaboratory	PC	3	0	0	3	1.5	60	40	100
18EE506	Power Electronics Laboratory	PC	3	0	0	3	1.5	60	40	100
18EE507	Microprocessor and Microcontroller Laboratory	PC	3	0	0	3	1.5	60	40	100
	Total						**24.5**			
SEMESTER VI (Regular Stream)										
THEORY										
18EEPXX	Program Elective- 1	PE	3	3	0	0	3	40	60	100
18EEPXX	Program Elective- 2	PE	3	3	0	0	3	40	60	100
18EEPXX	Program Elective- 3	PE	3	3	0	0	3	40	60	100
18EEPXX	Program Elective- 4	PE	3	3	0	0	3	40	60	100
18EEPXX	Program Elective- 5 (Dropped)	PE	3	3	0	0	3	40	60	100
18EE0EXX	Open Elective - 2	OE	3	3	0	0	3	40	60	100
18EE0EXX	Open Elective - 3	OE	3	3	0	0	3	40	60	100
	Naan Muthalvan						2			
Total							**21**			
SEMESTER VI (protosem stream)										
	THEORY									
18MEPS11	Applied Design Thinking (Open Elective-I)	PE	3	3	0	0	3	100	-	100
18MEPS12	Startup Fundamentals (Open Elective-II)	PE	3	3	0	0	3	100	-	100
18MEPS13	Computational Hardware (Professional Elective-I)	PE	3	3	0	0	3	100	-	100
18MEPS14	Coding for Innovators(Profession Elective-II)	OE	3	3	0	0	3	100	-	100
18MEPS15	Industrial Design & Rapid Prototyping Techniques (Professional Elective-III)	OE	3	3	0	0	3	100	-	100
18MEPS16	Industrial Automation/ Data Life Cycle Management (Professional Elective-IV)	OE	3	3	0	0	3	100	-	100
18MEPS17	Robotics /ML& MLOps (Professional Elective-V)	EEC	3	3	0	0	3	100	-	100
Total							**21**			

SEVENTH SEMESTER										
THEORY										
18EE701	Power System Protection and SwitchGear	PC	3	3	0	0	3	40	60	100
18EE702	Industrial Management and Economics	HS	3	3	0	0	3	40	60	100
18EE601	Power System Analysis and Stability (6th Sem Course)	PC	3	3	0	0	3	40	60	100
18EE602	Electrical Drives and Control (6th Sem Course)	PC	3	3	0	0	3	40	60	100
18EE606	Professional Ethics and Human Values (6th Sem Course)	HS	3	3	0	0	3	40	60	100
PRACTICAL										
18EE703	Power Systems Laboratory	PC	3	0	0	3	1.5	60	40	100
18EE704	Electrical Drives and Control Laboratory	PC	3	0	0	3	1.5	60	40	100
18EN504	Communication Skills Laboratory	HS	3	3	0	0	1	60	40	100
18EE604	Mini Project	EEC	4	0	0	4	2	60	40	100
	Total						**21**			
EIGHTH SEMESTER										
THEORY										
18EEPXX	Program Elective –6	PE	3	3	0	0	3	40	60	100
PRACTICAL										
18EE801	Project Work	EEC	16	0	0	16	8	80	120	200
	Total						**11**			
Total Number of Credits 158										

B.E. Electrical and Electronics Engineering - Full Time

Programme Electives

S.No	Course Code	Course Title	Cat.	Hours/week & Credits				Maximum Marks			Preferred Semester
				L	T	P	C	CA	FE	Total	
1	18EEP01	Electrical Machine Design	PE	3	0	0	3	40	60	100	V
2	18EEP02	Biology for Electrical Engineers	PE	3	0	0	3	40	60	100	V
3	18EEP03	Digital Signal Processing	PE	3	0	0	3	40	60	100	V
4	18EEP04	Discrete Control Systems	PE	3	0	0	3	40	60	100	V
5	18EEP05	High Voltage Engineering	PE	3	0	0	3	40	60	100	VI
6	18EEP06	HVDC Transmission Systems	PE	3	0	0	3	40	60	100	VI
7	18EEP07	EHVAC Transmission Systems	PE	3	0	0	3	40	60	100	VI
8	18EEP08	FACTS Controllers	PE	3	0	0	3	40	60	100	VI
9	18EEP09	Power Quality	PE	3	0	0	3	40	60	100	VI
10	18EEP10	Utilization of Electrical Energy	PE	3	0	0	3	40	60	100	VI
11	18EEP11	Electrical Energy Conservation and Auditing	PE	3	0	0	3	40	60	100	VI
12	18EEP12	Power System Operation and Control	PE	3	0	0	3	40	60	100	VI
13	18EEP13	Distributed Generation and Micro Grid	PE	3	0	0	3	40	60	100	VII
14	18EEP14	Wind and Solar Energy Systems	PE	3	0	0	3	40	60	100	VII
15	18EEP15	Electrical and Hybrid Vehicles	PE	3	0	0	3	40	60	100	VII
16	18EEP16	Soft Computing and Machine Learning	PE	3	0	0	3	40	60	100	VII
17	18EEP17	Advanced Electric Drives	PE	3	0	0	3	40	60	100	VIII
18	18EEP18	Computational Electromagnetics	PE	3	0	0	3	40	60	100	VIII

19	18EEP19	Special Electrical Machines	PE	3	0	0	3	40	60	100	VIII
20	18EEP20	Electrical Wiring Estimation and Costing	PE	3	0	0	3	40	60	100	VIII
21	18EEP21	Total Quality Management	PE	3	0	0	3	40	60	100	VIII
22	18EEP22	Restructured Power System	PE	3	0	0	3	40	60	100	VIII
23	18EEP23	Industrial Electrical Systems	PE	3	0	0	3	40	60	100	VIII
24	18EEP24	Smart Grid	PE	3	0	0	3	40	60	100	VIII

Open Electives

S.No	Course Code	Course Title	Category	Contact Hrs	Hours/week & Credits				Maximum Marks		
					L	T	P	C	CA	FE	Total
1	18EEOE1	Renewable Energy Sources	PE	3	3	0	0	3	40	60	100
2	18EEOE2	Smart Grid Technology	PE	3	3	0	0	3	40	60	100
3	18EEOE3	Energy Conservation and Management	PE	3	3	0	0	3	40	60	100
4	18EEOE4	Electric Vehicles	PE	3	3	0	0	3	40	60	100

18EN101	PROFESSIONAL ENGLISH	L	T	P	C
		2	0	0	2

Course Objectives:

1.	Master basic reading skills such as phonics, word recognition and meaningful division of sentences.
2.	Read fast, decode accurately and remove oral reading errors that affect text meaning.
3.	Acquire and develop writing skills for academic, social and professional purposes.
4.	Gain skills in academic and functional writing tasks.

Writing

1. Word Formation with Prefix and Suffix, Synonyms and Antonyms, Tenses, Parts of Speech, Common Errors in English (Subject –Verb Agreement, Noun-Pronoun Agreement, Prepositions, Articles, Conditional statements, Redundancies, Clichés etc), Voices.
2. Email – Training Programme and related details, paper submission for seminars and conferences, Fixing an appointment, Arranging and Cancelling a meeting with team members, conference details, hotel accommodation, Reminder mails, Raising queries with team members, Congratulatory mails at work, arranging for a meeting with a foreign client, personal emails.
3. Letter Writing – Business and need based communication – Formats of official, personal and business letters, official leave and request applications (Bonafide certificate, course completion, conduct certificate, permission to arrange industrial visits) complaints, replies to queries from business customers, inviting dignitaries, accepting and declining invitations, placing orders, cover letter for a job application with resume.
4. Technical Report Writing – status reports – Work Done in the Project, Feasibility Reports on Office Accommodation, Introduction of New Products, Sales Promotion, Customers Feedback, Starting a New Company, Event Reports- Seminars, Conferences, Meeting, Recommendations and Checklists.
5. Charts- interpreting pie charts, graphs etc.,

READING:

1. Understanding notices, messages, timetables, adverts, graphs, etc.- understanding meaning and purpose of short texts
2. Gapped sentences – Meanings, collocations and meanings of individual words.
3. Reading passage with multiple choice questions – reading for gist and reading for specific information – skimming for general idea of and meaning and contents of the whole text.
4. Short reading passage; gap-filling – Grammar, especially prepositions, articles, auxiliary verbs, modal verbs, pronouns, relative pronouns and adverbs.
5. Short reading passages; sentence matching – Scanning – ability to pick out specific information in a short text.

METHODOLOGY:

Objective Type:

1. Vocabulary of business communication.
2. Collocations related to technical and business.
3. Coherence in paragraphs – use of sequence clues.
4. Conversations and appropriate responses.
5. Tenses with time makers.
6. Verbal phrases
7. Description of objects in a sentence or two
8. Products and likely slogans
9. Tone, vocabulary, expressions in formal and informal letters.
10. Email writing- tone, vocabulary, expressions, mail ID., creation, CC, BCC.

Descriptive Writing:

1. Skimming and scanning to look for specific information.
2. Spotting Errors.
3. Email writing in different work place/ profession based contexts with hints.
4. Letter writing in different business based contexts with hints.
5. Report writing: feasibility report, progress in project reports, accident reports and event reports.

6. Checklists in business, office and profession based context. 7. Recommendations in business, office and profession based context. 8. Resume and Cover letter. 9. Mind mapping visuals on social and environmental issues – essay writing based on the given mind map visual.		
Total (30+0)=30 Periods		
Course Outcomes:		
Upon completion of this course, the students will be able to		
CO1	:	Read and summarize the main ideas, key details and inferred meanings from a passage.
CO2	:	Internalize the grammar items such as prepositions, articles, tenses,verbs, pronouns, and adverbs adjectives through contexts andapply them to spot errors.
CO3	:	Develop the ability to classify, check information and prepare reports.
CO4	:	Apply the academic and functional writing skills in new contexts.
CO5	:	Interpret pictorial representation of data and statistic.

Text Books:

1.	Norman Whitby. Business Benchmark –Pre - Intermediate to Intermediate, Students Book, Cambridge University Press, 2014.

Reference Books:

1	M. Ashraf Rizvi, Effective Technical Communication, McGraw Hill.2017 ,2nd edition
2	Farhathullah, T.M. Communication Skills for Technical Students.2002
3	Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice, Oxford University Press, New Delhi, 2015,3rd edition.
4	David F. Beer and David McMurray, Guide to Writing as an Engineer, John Willey. New York, 2019.
5	Collins Cobuild- Student's Grammar: Self-Study Edition with Answers (Collins Cobuild Grammar) paperback- 6 May 1991.
6	. Essential English Grammar paperback Raymond Murphy CUP 2015,3rd edition.
7	Speak Better Write Better English paperback – Nov 2012, Norman Lewis, Goyal Publishers and Distributors. Essential English Grammar Paperback Raymond Murphy CUP 2019.
8	English Reading Comprehension RPH Editorial Board.2020
9	Proficiency in Reading Comprehension Simplifying the 'Passage' for you, 2020 Ajay Singh.6

E-Reference

1	https://play.google.com/store/apps/details?id=com.zayaninfotech.english.grammar.
2	http://www.onestopenglish.com/grammar/

CO/PO Mapping

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

18MA102	MATRICES, CALCULUS AND DIFFERENTIAL EQUATIONS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To know the use of matrix algebra needed by engineers for practical applications.
2.	To understand effectively the geometrical application of differential calculus and integral calculus.
3.	To familiarize the solutions of ordinary differential equations of higher order.
4.	To obtain the knowledge of solving partial differential equations of higher order with constant coefficients.
5.	To acquire the knowledge of vector differentiation and integration and its applications

Unit I	MATRICES	9	+	3

Symmetric, Skew Symmetric and Orthogonal Matrices – Characteristic equation of a Matrix – Eigen values and Eigen vectors – Properties – Cayley-Hamilton theorem (excluding proof) – Diagonalization of Matrices - Reduction of quadratic form to canonical form by orthogonal transformation.

Unit II	MULTI VARIABLE CALCULUS	9	+	3

Maxima, Minima and Saddle point- – Method of Lagrangian multipliers- Multiple integrals- Double integrals – Change of order of integration in double integrals – Change of variables (Cartesian to Polar) – Application to Areas – Evaluation of Triple integrals – Application to volumes.

Unit III	ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDER	9	+	3

Second order linear differential equations with constant and variable coefficients –Cauchy-Euler equation and Cauchy- Legendre's linear equation - Method of variation of parameters –Simultaneous first order linear equations with constant coefficients

Unit III	PARTIAL DIFFERENTIAL EQUATIONS	9	+	3

Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions – Solution of standard types of first order partial differential equations – Lagrange's linear equation – Linear partial differential equations of second and higher order with constant coefficients.

Unit V	VECTOR CALCULUS	9	+	3

Vector differentiation- Gradient- Directional derivative - Divergence - Curl , Vector integration- Line integration- work done – Surface and Volume integrals - Green's theorem , Gauss divergence and Stokes theorem (without proof) – Simple applications involving cubes and rectangular parallelopipeds.

Total (45+15)=60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Learn the fundamental knowledge of Matrix theory.
CO2	:	Familiar with the concept of the differentiation and integration and its applications.
CO3	:	Acquire skills in applications of Vector Calculus.

Text Books:

1.	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, (2015).
2.	Veerarajan T., "Engineering mathematics for first year", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009

Reference Books:

1	James Stewart, "Essential Calculus", Cengage Learning, New Delhi, 2nd edition, 2013.
2	P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year B.E., B.Tech)", Nineth Edition, S. Chand & Co. Ltd. New Delhi, 2010.
3	Srimanta pal and Subath.C.Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015
4	Ewinkreyzig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2006.

5	Sivaramakrishnadas.P, Ruknmangadachari.E. “Engineering Mathematics”, Pearson, Chennai & Delhi, 2nd edition, 2013

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	1	2	1	1	1	1	1
CO2	3	2	2	2	1	1	2	1	2	1	1	2
CO3	3	2	2	2	1	1	2	1	1	1	1	2

18CY101	CHEMISTRY	L	T	P	C
		3	1	0	4

Course Objectives:

1	Analyze microscopic chemistry in terms of atomic and molecular orbitals.
2	Rationalize periodic properties of elements and the knowledge of acids and bases.
3	Analyze the stereo chemical aspects of organic molecules and chemical reactions that are used in the synthesis of organic molecules
4	Rationalize bulk properties and processes in thermodynamic aspects and its extension in electrochemical processes.
5	Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques

Unit I	MOLECULAR STRUCTURE	9	+	3

Formation of molecular orbitals of diatomic molecules - energy level diagrams of – H2, He2, N2, O2, CO and NO-bond order, bond length, bond energy, magnetic behavior and relative stability ;
Aromaticity- Huckel rule - concept of aromaticity - aromatic, non-aromatic and anti-aromatic molecules-benzenoid, non-benzenoid and annulenes only;
Crystal field theory – postulates-d-orbital splitting in octahedral and tetrahedral complexes-strong field and weak field ligands-spectrochemical series-high spin and low spin complexes-magnetic properties of complexes-crystal field stabilization energy(CFSE) and its calculations for octahedral and tetrahedral complexes

Unit II	PERIODIC PROPERTIES & ACID-BASE CONCEPTS	9	+	3

Effective nuclear charge – shielding effect, penetration of orbitals - variations of s, p, d and f orbital energies of atoms –Aufbau principle - electronic configuration of elements – periodic properties - atomic and ionic size, ionization energy, electron affinity and electro negativity - anomalous properties of second period elements - diagonal relationship;
Acids and bases - Bronsted-Lowry concept - Lewis concept - pH and pKa – problems – HSAB - buffer solutions – types- mechanism of buffer action- Henderson–Hasselbalch equation- derivation and problems.

Unit III	STETEROCHEMISTRY & ORGANIC REACTIONS	9	+	3

Stereoisomerism – geometrical isomerism – cis-trans and E-Z nomenclature – optical isomerism – symmetry, chirality, optical activity, enantiomer and diastereomers – absolute configuration - R-S notation - conformational analysis – Ethane, butane, cyclohexane;
Addition reaction – hydrogenation, halogenations - Markovnikov rule – Kharasch effect - hydration, hydrohalogenation, hydroboration;
Aliphatic nucleophilic substitution reaction –SN_1, SN_2 and SN_imechanism – electrophilic substitution reaction in benzene– mechanism - nitration, halogenations, sulfonation, alkylation and acylation;
Elimination reaction –E_1, E_2 and E_1CB- mechanism- Saytzeff rule – examples.

Unit IV	USE OF FREE ENERGY IN CHEMICAL EQUILIBRIA	9	+	3

Thermodynamic functions- internal energy, enthalpy, entropy and free energy- first and second law of thermodynamics - partial molar properties - Gibbs Duhem equation – variation of chemical potential with temperature and pressure – Third and Zeroth law of thermodynamics – definition only;
Free energy and EMF relation - single electrode potential - electrochemical series and its significance.- cell potential and its measurement (Poggendorff method only) - Nernst equation-derivation and problems-Standard cell potential and equilibrium constant relation- problems.

Unit V	SPECTROSCOPY TECHNIQUES & APPLICATIONS	9	+	3

Beer-lambert's law (problem)- UV visible spectroscopy: principle, chromophores, auxochrome, electronic transitions and instrumentation (no application);
IR Spectroscopy: principles-instrumentation and applications of IR in H_2O,CO_2 and NH_3;
Flame photometry-principle-instrumentation-estimation of sodium by flame photometer;
Atomic absorption spectroscopy-principles-instrumentation-estimation of nickel by atomic absorption spectroscopy.

		Total (45+15)=60 Periods
Course Outcomes:		
Upon completion of this course, the students will be able to		
CO1	:	Understand in-depth knowledge of atomic and molecular orbitals based chemical aspects.
CO2	:	Realize the nature of periodic properties of elements and the knowledge of acids and bases.
CO3	:	Grasp the knowledge of 3D structural aspects of organic molecules and chemical reactions that are used in the synthesis of organic molecules.
CO4	:	Substantiate the various processes involved in thermodynamic considerations and its involvement in electrochemical aspects.
CO5	:	Aware of spectroscopic techniques in the field of molecular identification of materials.

Text Books:

1.	P.R. Puri, L.R.Sharma and Madan S. Pathania,"Principle of physical chemistry" 47th Vishal Publishing Co, Jalandhar-8
2.	C. N. Banwell and E. M. Mccash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2009.
3	Raj. K. Bansal – "A Text Book of Organic Chemistry" Revised 4th Ed.,(2005), New Age International Publishers Ltd., New Delhi.
4	P.S. Kalsi – "Stereochemistry conformation and Mechanism", 6th Ed., (2005), New Age International Publishers Ltd., New Delhi.
5	J.D. Lee – "A New Concise Inorganic Chemistry", 5th Edn., Oxford University Press, 2011.
6	Wahid Malik, G.D.Tuli and R.D.Madan, "Selected Topic in Inorganic Chemistry",S.Chand& Co., Ltd (2011).

Reference Books:

1	David.W.Ball, Physical Chemistry, Cengage Learning India Pvt. Ltd., New Delhi, 2009.
2	G.Aruldhas, Molecular structure and spectroscopy, second edition, PHI learning Pvt. Ltd., New Delhi, 2008.
3	Cotton and Wilkinson – "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons, New York-2004.
4	James E. Huheey, Ellen A. Keiter and Richard L. Keiter – "Inorganic Chemistry-Principles of Structure and Reactivity", 4 thEdn., Pearson Education, 11th Impression, 2011.
5	F.A. Carey and R.J. Sund berg – "Advanced organic chemistry" Vol. I and II– 3rd Ed.,(1984), Plenum Publications.
6	Ernest. Eliel and Samuel H. Wilen – "Stereochemistry of Organic Compounds" – Wiley Student Ed., (2006). John Wiley and Sons Pvt. Ltd., Singapore.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3							2			
CO2	3	3							2			
CO3	3	3								2		
CO4	3	3										
CO5	3	3			2					2		

18CS101	FUNDAMENTALS OF PROBLEM SOLVING AND C PROGRAMMING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To express problem solving through programming.
2.	To practice the basic concepts of C programming language.
3.	To provide the basics knowledge about array and strings to solve simple applications.
4.	To use pointers and functions in the simple applications.
5.	To review the elementary knowledge of structures and unions.

Unit I	**Introduction to Computer and Problem Solving**	**9**	**+**	**0**

Problem formulation, Problem Solving methods, Need for logical analysis and thinking – Algorithm – Pseudo code – Flow Chart- Need for computer languages, Generation and Classification of Computers- Basic Organization of a Computer.

Unit II	**C Programming Basics and Control Statements**	**9**	**+**	**0**

C Character set- Identifies and Keywords- Data Type- Declarations-Expressions-Statements and Symbolic constants- Operators – Arithmetic Operators – Unary operators – Relational and Logical Operators – Assignment operators – Conditional operators- Managing Input and Output operations- Decision Making- Branching and Looping statements.

Unit III	**Arrays and Strings**	**9**	**+**	**0**

Pre-processor directives-Storage classes-Arrays – Initialization – Declaration – one dimensional and two dimensional arrays. Strings - String operations – String handling functions-Simple programs-sorting-searching.

Unit IV	**Functions and Pointers**	**9**	**+**	**0**

Function – Library functions and user-defined functions – Function prototypes and function definitions – Call by value –Call by reference – Recursion – Pointers - Definition – Initialization – Pointers arithmetic – Pointers and arrays.

Unit V	**Structures, Unions and File**	**9**	**+**	**0**

Introduction – need for structure data type – structure definition – Structure declaration – Structure within a structure – Passing structures to functions – Array of structures – Pointers to structures-Union-basic file operation.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Formulate and apply logic to solve basic problems.
CO2	:	Write, compile and debug programs in C language.
CO3	:	Apply the concepts such as arrays, decision making and looping statements to solve real time applications.
CO4	:	Solve simple scientific and statistical problems using functions and pointers.
CO5	:	Write programs related to structures and unions for simple applications.

Text Books:

1.	Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011. (Unit-I).
2.	E.Balagurusamy, "Programming in ANSI C" fourth Edition, Tata McGraw-Hill, 2008. (Unit II-V).

Reference Books:

1.	Byron S Gottfried, "Programming with C", Schaum's Outlines, Second Edition, Tata McGraw-Hill,2006.
2.	Kernighan,B.W and Ritchie,D.M, "The C Programming language", 2nd Edition, Pearson Education, 2006.
3.	Yashavant P. Kanetkar. "Let Us C", BPB Publications, 2011.

CO/PO Mapping

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

18EN102	PROFESSIONAL ENGLISH LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

1.	To acquire and develop listening skills for academic, social and professional purposes.
2.	To understand short conversations or monologues
3.	To master basic reading skills such as phonics, word recognition, and fluency
4.	Acquire and develop pre-intermediate level fluency in oral skills such as discourse management, grammar and vocabulary, pronunciation and interactive communication for academic, social and professional purposes
5.	Address an audience and present a topic.
6.	Express an opinion and justify it

Exercises

Methodology - Listening

1. Job Responsibilities
2. Conversation between two employees on company culture
3. Emails
4. Description of gadgets
5. Interview with a leading industrialist
6. Office procedures – applying for permission, placing an order for office equipment,
7. Enquiries about orders and deliveries
8. Conversation between two people on general topics
9. Telephone Messages
10. Fixing and Cancelling appointments
11. Asking for directions
12. Rescheduling a travel plan
13. Tones : Rude and Polite
14. Conversation : Statements, Discussions, Debating, Accepting, Negotiating
15. Conferences ; Announcements about changes in schedules andsessions
16. Motivational Speech
17. TED Talk on Team Work
18. Describing charts and data
19. Presentation at an office
20. Short self-descriptions

METHODOLOGY: - Speaking

1. Self-Introduction – Personal information –Name, Home background, study details, area of interest, hobbies, strengths and weaknesses, projects and paper presentations if any, likes and dislikes in food, clothes, Special features of home town, Personal role models in life, goals and dreams, favorite inspirational quote.
2. Situational Role Play between Examiner and Candidate – Customer and Sales Manager, Hotel Manager and Organiser, Team Leader and Team member, Bank Manager and Candidate, Interviewer and Applicant, Car Driver and Client, Industrialist and Candidate, Receptionist and Appointment Seeker, New Employee and Manager, Employee and Employee, P.A. and Manager Schedule for training, Asking for directions, Seeking help with office equipment, Clarifying an error in the bill, Quality of Products, Buying a Product, Selling a Product, cancelling and fixing appointments, hotel accommodation, training facilities, dress code, conference facilities, faculty advisors and student, student and student, college Office personnel and student.

Total (0+30)= 30 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Infer, interpret and correlate routine, classroom-related conversation.
CO2	:	Use a range of common vocabulary and context based idioms.
CO3	:	Comprehend native speakers when they speak quickly to one another, although the student might still have trouble.
CO4	:	Identify the most important words in a story/article.
CO5	:	Summarize the main ideas, key details, and inferred meanings from listening passages of up to five minutes.
CO6	:	Vocalize words without the aid of pictures

CO7	:	Make effective self-introductions.
CO8	:	Study options, compare and contrasts the options.
CO9	:	Exercise a choice, justify it by giving examples and illustrations.
CO10	:	Construct a situation and to participate in conversations

Text Book:

1.	Norman Whitby. Business Benchmark – Pre-Intermediate to Intermediate, Students book,Cambridge University Press, 2014.

Reference Books:

1	Spoken English: A Self-Learning Guide. V.Sasikumar and P V Dhamija
2	English Conversation Practice: Grant Taylor Paperback 1976ly. Krishna Mohan, N P Singh
3	Discussions that Work. Penny Ur.CUP, 1981.
4	Speak Better Write Better English Paperback – November 2012 Norman Lewis, GoyalPublishers and Distributors.

CO/PO Mapping

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

18CS102	COMPUTER PRACTICE LABORATORY	L	T	P	C
		0	0	4	2

Course Objectives:

1.	To provide basic knowledge of creating Word documents and also producing mail merge.
2.	To make use of basic functions, formulas and charts in Spread sheet.
3.	To implement problem solving techniques.
4.	To promote the programming ability to develop applications for real world problems.

List of experiments

A	**Word Processing** 1. Document creation, Text manipulation with Scientific notations, Table creation, Table formatting and Conversion 2. Letter preparation using Mail merge and Draw flow Charts using tools
B	**Spread Sheet** 3. Chart - Line, XY, Bar and Pie. 4. Formula - formula editor, Sorting and Import and Export features. 5. Spread sheet - inclusion of object, Picture and graphics, protecting the document and sheet.
C	**Simple C Programming** 6. Program using Control statements. 7. Program using Looping. 8. Program using Array. 9. Program using String. 10. Program using Function. 11. Program using Structures. 12. Program using Pointers. 13. Program using Files. *** For programming exercises Flow chart and pseudo code are essential**

Total (0+60)=60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Demonstrate the basic mechanics of Word documents and working knowledge of mail merge.
CO2	:	Demonstrate the use of basic functions and formulas in Spread sheet.
CO3	:	Apply good programming methods for program development.
CO4	:	Implement C programs for simple applications.

CO/PO Mapping

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

18ME102	WORKSHOP MANUFACTURING PRACTICES	L	T	P	C
		1	0	4	3

Course objectives:

1.	To provide an exposure of basic engineering practices to the student
2.	To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering

Experiments

1.	Introduction to Safety measures and First aid.
2.	Study of Lathe -Welding methods and equipment's- Casting process and tools- Sheet metal and fitting tools- Carpentry tools and joints.
3.	Fitting: V-fitting, Square fitting, Curve fitting.
4.	Lathe: Facing, turning, taper turning and knurling.
5.	Welding: BUTT, LAP and T- joints.
6.	Foundry: Green sand preparation- mould making practice.
7.	Sheet metal: Cone, tray, cylinder.
8.	Carpentry: CROSS, T and DOVETAIL joints.
9.	Drilling: simple exercises.

Total (15+60)=75 Periods

Course outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Prepare fitting of metal and wooden pieces using simple fitting and carpentry tools manually.
CO2	:	Prepare simple lap, butt and tee joints using arc welding equipment.
CO3	:	Prepare green sand moulding.
CO4	:	Prepare sheet metal components.
CO5	:	Prepare simple components using lathe and drilling machine.

Reference books:

1.	Bawa, H.S, "Work shop Practice", Tata McGraw Hill Publishing Company Limited, 2007.
2.	Jeyachandran, K, Natarajan, K and Balasubramanian, S, "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3.	Jeyapoovan, T, SaravanaPandian, M and Pranitha, S, "Engineering Practices Lab Manual", VikasPuplishing House Pvt. Ltd, 2006.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2							1		2
CO2	1		2			2						2
CO3	2	1	2			2						1
CO4	1		1			2						1
CO5	1	1				1						1

18MA204	FOURIER SERIES AND TRANSFORMS	L	T	P	C
		3	1	0	4
Course Objectives:					
1.	To obtain the knowledge with expansion of a function as a Fourier series.				
2.	To impact analytical skills in the areas of boundary value problems and transform techniques.				
3.	To familiarize with the techniques of Laplace transform for solving second order differential equations.				
4.	To understand the concepts of Fourier transform and its applications				
5.	To obtain the solution of difference equation by Z-transform technique.				
Unit I	**FOURIER SERIES**		**9**	**+**	**3**
Drichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity – Harmonic Analysis.					
Unit II	**BOUNDARY VALUE PROBLEMS**		**9**	**+**	**3**
Classification of second order quasi linear partial differential equations – Solutions of onedimensional wave equation – One dimensional heat equation – Steady state solution of twodimensionalheat equation (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates					
Unit III	**LAPLACE TRANSFORM**		**9**	**+**	**3**
Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties– Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- solutions of linear ODE of second order with constant coefficients using Laplace transformation techniques- statement and application of convolution theorem					
Unit IV	**FOURIER TRANSFORM**		**9**	**+**	**3**
Statement of Fourier integral theorem – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem - Parseval's Identity					
Unit V	**Z -TRANSFORM AND DIFFERENCE EQUATIONS**		**9**	**+**	**3**
Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem -Formation of difference equations – Solution of difference equations using Z – transform technique.					
					Total (45+15)= 60 Periods
Course Outcomes:					
Upon completion of this course, the students will be able to:					
CO1	: Acquire the knowledge about Fourier series.				
CO2	: Learn the techniques of solving boundary value problems				
CO3	: Familiar with the transform techniques.				
Text Books:					
1.	Veerarajan T, "Engineering Mathematics (For Semester III)" , 3rd Edition, Tata McGraw Hill Education Pvt.Ltd. , New Delhi, 2009.				
2.	P.Kandasamy, K.Thilagavathy and K.Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company ltd., New Delhi, 1996.				
Reference Books:					
1.	Grewal, B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi,2014				
2.	Wylie C. Ray and Barrett Louis, C., "Advanced Engineering Mathematics", Sixth Edition, McGraw-Hill, Inc., New York, 1995.				
3.	Srimanta pal and Subath.C.Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015				
4	Ewinkreyzig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2006				
5	Narayanan, S., Manicavachagom Pillai, T.K. and Ramaniah, G., "Advanced Mathematics for				

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	1	1	2	1	2
CO2	3	3	2	2	2	1	1	1	1	2	1	1
CO3	3	3	2	2	2	1	1	1	1	2	1	2

18PH202	PHYSICS – WAVE & OPTICS AND QUANTUM MECHANICS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To make the students to understand Simple harmonic motion and Waves
2.	To understand the Propagation of light
3.	To get clear idea of wave optics
4.	To understand the Principle and working of laser with applications
5.	To know the basic concepts of quantum Mechanics and Matter Waves

Unit I	SIMPLE HARMONIC OSCILLATION AND WAVES	9	+	3

Simple harmonic motion ; Damped Simple harmonic motion ; Forced vibrations – resonance; Wave motion- types and characteristics - velocity of a transverse wave along a stretched string -frequency of a vibrating string – harmonics and overtones - progressive waves & stationary waves – wave equation for progressive and Stationary waves

Unit II	THE PROPAGATION OF LIGHT AND GEOMETRIC OPTICS	9	+	3

Fermats Principle - laws of reflection and refraction ; Mirage effect ; Total internal reflection ; Matrix method - imaging by a spherical refracting surface - imaging by a coaxial optical system; Optical Instruments - simple and compound microscope - astronomical telescope.

Unit III	WAVE OPTICS	9	+	3

Huygens Principle ; Principle of superposition ; Interference of Light – Youngs double slit experiment - Newtons rings - experimental arrangement to determine the wavelength of sodium light ; Michelson Interferometer ; Fraunhofer diffraction from a single slit ; Diffraction grating –determination of wavelength of light and dispersive power ; Polarisation - Polarisation by reflection - Brewsters Law

Unit IV	LASERS	9	+	3

Properties of Laser beams - monochromacity , coherence , directionality and brightness ; Einstiens theory of matter radiation interaction and A&B coeffiecients - amplification of light by population inversion - pumping methods ; Different types of laser - Ruby , Nd-YAG , He-Ne, CO_2 laser - Energy level diagrams ; Applications of lasers in science ,engineering and medicine.

Unit V	QUANTUM MECHANICS	9	+	3

Introduction - matter waves - Debroglie’s equation - Davisson-Germer experiment-G.P.Thomson experiment; Time independent and dependent Schroedinger equation; Wave packet; Uncertainity Principle; Schroedinger equation for Particle in a one dimensional box; Physical Significance of wavefunction.

Total (45+15)= 60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand Simple harmonic oscillation and propagation of waves.
CO2	:	Apply matrix method to analyse system of reflecting and refracting surfaces.
CO3	:	Know various experimental techniques in wave optics.
CO4	:	Understand the concept of laser and its applications.
CO5	:	Gain knowledge in the basics of quantum mechanics.

Text Books:

1.	AjoyGhatak,‘Optics’, Tata Mc Graw Hill Publishing Co.Ltd, Fourth Edition,2009
2.	Gupta Kumar Sharma, ‘Quantum Mechanics’, Jai Prakash Nath & co, 25th Edition, 2005
3	Gaur R.K and Gupta S.L,‘Engineering Physics’, Dhanpat Rai Publishers,2009

Reference Books:

1.	PalanisamyP.K,‘Engineering Physics’, Scitech Publications,2011
2.	Rajendran V and Marikani A, ‘Engineering Physics’, PHI learning PVT, India, 2009

CO/PO Mapping

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

18ME101	ENGINEERING GRAPHICS AND DESIGN	L	T	P	C
		1	0	4	3

Course objectives:

1.	To impart knowledge on concepts, ideas and design of engineering products and to provide an exposure to CAD Modelling.
2.	Standards of Engineering Drawing: Size, layout and folding of drawing sheets, lettering - Use of drafting instruments

UNIT I	PROJECTION OF POINTS, LINES AND PLANE SURFACES	3	+	12

General principles of orthographic projection- Projection of points, located in all quadrants – Projection of straight lines located in first quadrant – Determination of true lengths and true inclinations – Projection of polygonal surface and circular lamina inclined to both reference planes.

UNIT II	PROJECTION OF SOLIDS	3	+	12

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is perpendicular to one reference plane and also inclined to one reference plane by change of position method.

UNIT III	SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES	3	+	12

Sectioning of above solids in simple vertical position by cutting planes inclined to one reference plane and perpendicular to other – solids inclined position with cutting planes parallel to one reference plane- Obtaining true shape of section.

Development of lateral surfaces of simple and truncated solids – Prisms, pyramids cylinders and cones- Development of lateral surfaces of solids with square and cylindrical cutouts, perpendicular to the axis.

UNIT IV	ISOMETRIC PROJECTION	3	+	12

Principles of isometric projection –isometric scale - isometric projections of simple solids, truncated prisms, pyramids, cylinders and cones.

UNIT V	PERSPECTIVE PROJECTION	3	+	12

Perspective projection of prisms, pyramids and cylinders by visual ray and vanishing point methods.

Total (15+45)= 60 Periods

Note: Study of drafting software – Auto CAD – Coordinate System (Absolute, relative and polar)
Creation of simple figures like polygon, Drawing a plan of residential building, Creation of 3-D Models
of simple objects and obtaining 2-D multi view drawing from 3-D model. (**Internal Assessment only)**

Course outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the conventions and the methods of engineering drawing.
CO2	:	Understand the fundamental concepts of theory of projection.
CO3	:	Understand the development of different surfaces.
CO4	:	Develop the relationships between 2D and 3D environments.
CO5	:	Demonstrate computer aided drafting.

Text books:

1.	Bhatt N.D, “Engineering Drawing”, Charotar publishing House, 2003
2.	Natarajan, K.V, “A Text book of Engineering Graphics”, Dhanalakshmi Publishers, 2006.

Reference books:

1.	Gopalakrishnana K.R, “Engineering Drawing", Vol. I and II, Subhas Publications, 1999.
2.	Dhananjay A. Jolhe, “Engineering Drawing with an Introduction to AutoCAD”, Tata McGraw Hill Publishing Company Limited, 2008.
3.	Venugopal, K and Prabhu Raja, V., “Engineering Graphics”, New Age International (P) Ltd, 2008.
4.	Gill, P.S, “Engineering Drawing-Geometrical Drawing”, S.K Kataria and Sons, 2008.
5.	CAD Software Theory and User Manuals

CO/PO Mapping

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

18CM 201	BASIC CIVIL AND MECHANICAL ENGINEERING	L	T	P	C
		4	0	0	4

Course Objectives:

1.	The objective of the course is to impart knowledge on different fields of civil engineering and various materials used for construction

Unit I	CIVIL ENGINEERING MATERIALS AND SURVEYING	12	+	0

Mechanics : Mechanical properties of materials – Stress – Strain – Types of stresses and strains – Elasticity – Hooke's law – stress strain curve of ductile material.
Civil Engineering Materials : Bricks – Stones – Sand - Cement – Concrete – Steel Surveying : Objects – Principles – Classification – Measurement of Distances

Unit II	BUILDING COMPONENTS AND STRUCTURES	12	+	0

Foundations : Functions of foundation – Types Superstructure : Brick Masonry – Stone Masonry – Beams – Columns – Lintels – Roofing – Flooring – Plastering.Dams : Types of Dams – cross section details of gravity dam. Introduction to Green Building Concept .

UNIT III	BOILERS, TURBINES AND PUMPS	12	+	0

Boilers- Classification of boilers- Working Principle of various types of boilers – Horizontal boiler, Vertical boiler - Description of: Lancashire boiler, Locomotive boiler, Babcock andWilcox boiler, Cochran boiler, simple vertical boiler only)- Boiler Mountings and Accessories. Turbines- Classification- Working Principle of Impulse and Reaction turbines, Pumps-working principle of reciprocating (single and double acting) and centrifugal pumps.

UNIT IV	INTERNAL COMBUSTION ENGINES	12	+	0

Introduction, terminologies, classification and components – working principles of petrol and diesel engines – comparison of four stroke and two stroke cycle engines – applications of IC engines.

UNIT V	REFRIGERATION AND AIR CONDITIONING SYSTEM	12	+	0

Definition of refrigeration and air conditioning – terminology; refrigerants – definition, classification, working principle of vapour compression system and vapour absorption system – window and split type room air conditioner.

Total (60+0)=60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Students will acquire the basic knowledge in different fields of civil engineering.
CO2	:	Materials used in construction.
CO3	:	Understand the different parts of the buildings
CO4	:	Gain the knowledge about the working of IC engine, its components and its application.
CO5	:	Gain the knowledge about various types of boilers, turbines and pumps and also able to demonstrate the working of Refrigeration and Air conditioning.

Text Books:

1.	Shanmugam G and Palanichamy M S, "Basic Civil and Mechanical Engineering", TMH Publishing Co., New Delhi, (1996).
2.	Ramamrutham. S, "Basic Civil Engineering", Dhanpat Rai Publishing Co. (P) Ltd (1999).
3.	Shanmugam G and Palanisamy M S, "Basic Civil and Mechanical Engineering", TMH publishing Co, New Delhi, 1996.
4.	Ramamrutham.S,"Basic Civil Engineering", DhanpatRai publishing Co.(p) Ltd.1999.

Reference Books:

1	SeetharamanS."BasicCivilEngineering",AnuradhaAgencies,(2005).
2	Venugopal K and Prahu Raja V, "Basic Mechanical Engineering", Anuradha Publishers, Kumbakonam, (2000).
3	Shantha Kumar S R J., "Basic Mechanical Engineering", Hi-tech Publications, Mayiladuthurai, (2000).
4	Seetharaman S, , "Basic Civil Engineering",Anuradha Agencies,(2005).
5	Venugopal K and Prabu Raja V, "Basic Civil Engineering",Anuradha publishers, Kumbakonam,2000.
6	Shantha Kumar S R J, "Basic Civil Engineering",Hi-tech publications, Mayiladuthurai,2000.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2		2								
CO2			2	2								
CO3		2	2	2								
CO4												
CO5												

18PH103	PHYSICS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To handle different measuring instruments.
2.	To understand the basic concepts of interference, diffraction, heat conduction and to measure the important parameters

Experiments

1	Newton's rings – Determination of radius of curvature of a Plano convex lens.
2	Carey Foster's bridge – Determination of specific resistance of the material of the wire.
3	Poiseuille's flow – Determination of Coefficient of viscosity of a liquid.
4	Spectrometer – Grating – Normal incidence – Determination of Wavelength of Mercury lines.
5	Lee's disc – Determination of thermal conductivity of a Bad conductor.
6	Ultrasonic interferometer – Determination of velocity of Ultrasonic Waves in Liquid
7	Non-uniform bending – Determination of young's modulus of the material of the Bar.
8	Determination of Band gap of a given semi conductor
9	Determination of Wavelength of laser using grating and determination of particle size using Laser
10	Determination of Acceptance angle and Numerical Aperture of fiber.

Total (0+45)=45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Handle different measuring instruments and to measure different parameters.
CO2	:	Calculate the important parameters and to arrive at the final result based on the experimental measurements.

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		2	3	1	1		3	2	3	3
CO2	3	3		2	3	1	1		3	2	3	3

18CY102	CHEMISTRY LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To gain practical knowledge by applying theoretical principles and performing the followinexperiments

Experiments

1	Estimation of hardness of Water by EDTA
2	Estimation of Copper in brass by EDTA
3	Estimation of Alkalinity in water
4	Estimation of Chloride in water sample (Iodimetry)
5	Conductometric titration of Strong Acid and Strong Base
6	Conductometric titration of Mixture of acids and Strong base
7	Determination of strength of Iron by Potentiometric method
8	Estimation of Iron by Spectrophotometry
9	Determination of molecular weight and degree of Polymerisation by Viscometry

Total (0+45)=45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	To know the applicability of the practical skill gained in various fields.
CO2	:	To know the composition of brass quantitatively and the molecular weight of polymers.
CO3	:	To understand the principle and applications of conductometric titrations, spectrometer and potentiometric titrations

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1									
CO2	3	3	1									
CO3	3	3	1									

18EN103	PROFESSIONAL COMMUNICATION LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

1.	To improve their reading skills.
2	To address an audience and present a topic
3	To acquire speaking competency in English.
4	To strengthen their fluency in speaking.

List of experiments

1	**Methodology – Reading** 1) Reading a story aloud with exact pronunciation, with intonation, and with expressing sense. 2) Reading poems for improving verbal skills, memory, and critical thinking. 3) Reading newspaper articles for strengthening the vocabulary and writing skills. 4) Reading homophones with exact pronunciation for expressing different meaning
2	**Methodology – Speaking** 1) Power point presentation – on general topics - for organising and structuring presentation. 2) Oral presentation -on basic technical ideas related to engineering. 3) Speaking on a given topic – current affairs, expressing opinion on social issues. 4) Describing a process – booking Ticket online, survey for starting a new office, sending an e-mail, etc. 5) Organising official events –compering,presenting welcome address, proposing vote of thanks.

Total (0+30)=30 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Read short passages fluently, avoiding mispronunciation, substitution, omission and transposition of word-pairs.
CO2	:	Vocalize words without the aid of pictures.
CO3	:	Develop a well-paced, expressive style of reading.
CO4	:	Make effective oral presentations on technical and general contexts.
CO5	:	Describe a process with coherence and cohesion.

Text Books:

1.	Norman Whitby. Business Benchmark – Pre-Intermediate to Intermediate, Students book, Cambridge University Press, 2014.

Reference Books

1	Spoken English: A Self-Learning Guide. V.Sasikumar and P V Dhamija
2	English Conversation Practice: Grant Taylor Paperback 1976ly. Krishna Mohan, N P Singh
3	Discussions that Work. Penny Ur.CUP, 1981.
4	Speak Better Write Better English Paperback – November 2012 Norman Lewis, GoyalPublishers and Distributors.

E-Reference

1	http://www.onestopenglish.com/skills/speaking/speaking-matters/

CO/PO Maping

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

18CE201	BASIC CIVIL ENGINEERING LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

1.	To understand the fundamental concept on visual inspection and standard parameters about the materials used in the field of civil engineering
2.	To obtain basic knowledge in testing of the materials widely used for construction

EXPERIMENTS

1	Cement Tests a) Visual inspection b) Consistency c) Initial and final setting time
2	Bricks Test a) Visual examination b) Crushing strength test
3	Aggregate Test a) Specific gravity of fine aggregate b) Specific gravity of coarse aggregate
4	Concrete – Compression strength Test
5	Steel – Tension Test

Total (0+30)=30 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Testing the basic materials used in the field of civil engineering
CO2	:	n-depth knowledge about their standard specifications and applications

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2		2								
CO2		2		2								

18MA302	STATISTICS AND NUMERICAL METHODS	L	T	P	C
		3	1	0	4

Course objectives:

1	To understand the statistical averages and fitting of curves.
2	To gain the knowledge of significance test for large and small samples
3	To obtain the knowledge about numerical interpolation, differentiation and integration
4	To acquire knowledge of numerical solution to first order ordinary differential equations using single step and multi step methods.
5	To gain the knowledge of numerical solution to second order partial differential equations by using explicit and implicit methods

Unit I	BASIC STATISTICS	9	+	3

Measures of Central tendency: Moments, Skewness and Kurtosis, Curve fitting by the Method of Least Squares –Fitting of straight lines, second degree parabolas and curves reducible to linear forms.

Unit II	TEST OF HYPOTHESIS	9	+	3

Test of significance: Large Sample tests for Single proportion, difference of proportions, single mean and difference of means- Small Sample test for single mean, difference of means and correlation co-efficient, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Unit III	INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION	9	+	3

Solution of Algebraic and Transcendental equations by Newton-Raphson method- Solution of system of equations by Gauss Elimination and Gauss Seidal iterative methods - Interpolation using Newton's Forward and Backward formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange's formulae Numerical Differentiation and Integration: Trapezoidal rule and Simpson's 1/3 rule, Simpson's 3/8 rule.

Unit IV	NUMERICAL SOLUTION FOR ORDINARY DIFFERENTIAL EQUATIONS	9	+	3

Ordinary differential equations: Taylor series method- Euler and modified Euler's method- Runge-Kutta method of fourth order for solving first and second order differential equations- Milne's and Adam's predictor - corrector methods.

Unit V	NUMERICAL SOLUTION FOR PARTIAL DIFFERENTIAL EQUATION	9	+	3

Partial differential equations: Finite difference solution of two dimensional Laplace and Poisson equations- Implicit and Explicit methods for one dimensional heat equation (Bender Schmidt and Crank-Nicholson methods) - Finite difference explicit method for wave equation.

Total (45+15)=60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Learn about statistical averages and fitting the curves by Least Square Method
CO2	:	Acquire the techniques of interpolation.
CO3	:	Familiar with the numerical differentiation and integration
CO4	:	Solve the initial value problems for ordinary differential equations.
CO5	:	Find the numerical solution of partial differential equation by using Finite difference method.

Text Books:	
1.	Veerarajan T, “Probability and Random Process (With Queuing theory)”, 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2.	Kandasamy.P, Thilagavathy.K, Gunavathi.K, “Numerical Methods” S.Chand& Co., New Delhi, 2005.
3	Gupta, S.C. and Kapur, V.K., “Fundamentals of Mathematical Statistics”, S.Chand and Sons, New Delhi, 11th Edition 2014
Reference Books:	
1.	Fruend John, E. and Miller Irwin, “Probability and Statistics for Engineers”, 8thEdition, Prentice Hall India (P) Ltd, 2010.
2	Gerald, C. F. and Wheatley, P.O., “Applied Numerical Analysis” , Sixth Edition , Pearson Education Asia , New Delhi – 2002
3	M.K.Venkataraman, “Numerical Methods”, National Publishing Company,2000
4	Jain M.K.Iyengar, K & Jain R.K., “Numerical Methods for Scientific and Engineering Computation ”, New Age International (P) Ltd, Publishers 2003
5	Manish Goyal, “Numerical Methods and Statistical techniques Using “C” ”, 1st Edition, Laxmi Publications (P) Ltd, 2009.
E-Reference :	
1.	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EE301	ELECTRIC CIRCUIT ANALYSIS	L	T	P	C
		3	1	0	4

Course Objectives:

To expose basic circuit concepts, circuit modelling and methods of circuit analysis in time domain and frequency domain for solving simple and multi dimensional circuits including coupled circuits

Unit I	BASIC CIRCUITS ANALYSIS	9	+	3

Ohm's Law – Kirchoffs laws – DC and AC Circuits – Resistors in series and parallel circuits –Mesh current and node voltage method of analysis for DC and AC Circuits – Sinusoidal voltage and current – instantaneous, peak, average and effective values – form factor and peak factor (derivations for sine wave) – pure resistive, inductive and capacitive circuits – RL, RC, RLC series circuits – impedance – phase angle – phasor diagram – power and power factor – power triangle – apparent power, active and reactive power – parallel circuits (two branches only) – conductance, susceptance and admittance

Unit II	NETWORK REDUCTION AND NETWORK THEOREMS FOR DC AND AC CIRCUITS	9	+	3

Network reduction: voltage and current division, source transformation- star and delta transformation, Superposition Theorem - Thevenin's and Norton's Theorem –– Maximum power transfer theorem – Reciprocity Theorem - substitution theorem-Millman's theorem.

Unit III	RESONANCE AND COUPLED CIRCUITS	9	+	3

Series and parallel resonance – frequency response - Effects of varying inductance and capacitance – Selectivity – 'Q' factor – Resonance Frequency – Bandwidth – Half power frequencies. Self and mutual inductance – Coefficient of coupling – dot rule – analysis of coupled circuits – coupled circuits in series and parallel – Tuned circuits – analysis of Single and double tuned circuits.

Unit IV	TRANSIENT RESPONSE ANALYSIS	9	+	3

Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and AC sinusoidal input.

Unit V	THREE PHASE CIRCUITS	9	+	3

Significance of 3 phase circuits – Star, Delta connections – Phase sequence – Balanced load-Three phase balanced/ unbalanced voltage sources – analysis of three phase three wire and four wire circuits with star and delta connected with balanced and unbalanced loads – phasor diagrams of voltages and currents –power and power factor measurements in three phase circuits

Total (45+15) =60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Understand the basic concept of circuit elements, circuit laws and network reduction technique
CO2	:	Solve the electrical network using mesh, nodal analysis and applying network theorems.
CO3	:	Understand the resonance in series and parallel circuits.
CO4	:	Analyze the coupled circuits.
CO5	:	Analyze the transient response for DC input and AC sinusoidal input
CO6	:	Comprehend the concept of balanced and unbalanced three phase circuits

Text Books:	
1.	William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, “Engineering Circuit Analysis”, Seventh Edition, TMH publishers, New Delhi, 2013
2.	Sudhakar. A., and Shyammohan. S. Palli , 'Circuits & Networks Analysis and Synthesis', Fourth Edition , Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2015.
Reference Books:	
1.	A. Chakrabarti, 'Circuit Theory Analysis and Synthesis', Seventh Revised Edition, Dhanpat Rai & Co., New Delhi, 2018
2	Dr. M. Arumugam & N. Premkumar, ” Electric circuit theory”, Khanna Publishers, New Delhi,1991.
3	Charles K. Alexander, Mathew N.O. Sadiku, “Fundamentals of Electric Circuits”, Second Edition, McGraw Hill, 2013.
4	Mahmood Nahvi& Joseph Edminister, “Electric Circuits”, Schaum’s Outline Series, McGraw Hill Publications, Seventh Edition,2018
E-Reference :	
1.	NPTEL Courses on Basic Electrical Circuits, IIT Madras
2	NPTEL Courses on Circuit theory, IIT Delhi

CO/PO Mapping

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

18EE302	ELECTROMAGNETIC FIELDS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To introduce the basic mathematical concepts related to electromagnetic vector fields
2.	To impart knowledge on the concepts of Electrostatic fields, electrical potential, energy density and their applications.
3.	To impart knowledge on the concepts of Magneto static fields, magnetic flux density, vector potential and its applications.
4.	To impart knowledge on the concepts of Different methods of emf generation and Maxwell's equations.
5.	To impart knowledge on the concepts of Electromagnetic waves and characterizing parameters.

Unit I	ELECTROSTATICS – I	9	+	3

Sources and effects of electromagnetic fields – Coordinate Systems – Vector fields –Gradient, Divergence, Curl – theorems and applications - Coulomb's Law – Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications.

Unit II	ELECTROSTATICS – II	9	+	3

Electric potential – Electric field and equipotential plots, Uniform and Non-Uniform field, Utilization factor – Electric field in free space, conductors, dielectrics - Dielectric polarization- Dielectric strength - Electric field in multiple dielectrics – Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications.

Unit III	MAGNETOSTATICS	9	+	3

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media – Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications.

Unit IV	ELECTRODYNAMIC FIELDS	9	+	3

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications.

Unit V	ELECTROMAGNETIC WAVES	9	+	3

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.

Total (45+15) = 60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the basic mathematical concepts related to electromagnetic vector fields.
CO2	:	Understand the basic concepts about electrostatic fields, electrical potential, energy density and their applications.
CO3	:	Apply knowledge in magneto static fields, magnetic flux density, vector potential and its applications.
CO4	:	Understand the different methods of emf generation and Maxwell's equations
CO5	:	Apply knowledge in concepts of electromagnetic waves and characterizing parameters.
CO6	:	Understand and compute Electromagnetic fields and apply them for design and analysis of electrical equipment and systems.

Text Books:	
1.	Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2.	William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.
3.	Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.
Reference Books:	
1.	V.V.Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993.
2.	J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers.2013
3.	Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), McGraw Hill, 2013,4th edition.
4.	S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2012.
5.	K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Eighth Reprint : 2015.
E-Reference :	
1.	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EE303	DC MACHINES AND TRANSFORMERS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the concepts of electromechanical energy conversion and to gain the knowledge on single and multiply-excited magnetic systems.
2.	To gain the knowledge on construction and principles of operation of DC machines and transformers.
3.	To analyze the performance characteristics of different types of DC machines and transformers.
4.	To appreciate the applications of DC machines and transformers.
5.	To analyze the performance of DC machines and transformers by conducting various tests.

Unit I	ELECTROMECHANICAL ENERGY CONVERSION	9	+	0

Magnetic circuits – Magnetically induced EMF and force – AC operation of magnetic circuits – Energy in magnetic systems – Field energy & mechanical force – Single and Multiply-excited magnetic field systems.

Unit II	DC GENERATORS	9	+	0

Constructional features of DC machine – Principle of operation of DC generator – EMF equation – Types of excitation – No load and load characteristics of DC generators – Commutation - Armature reaction – Parallel operation of DC generators - Applications.

Unit III	DC MOTORS	9	+	0

Principle of operation of DC motors - Back EMF – Torque equation – Types of DC motors - Speed – Torque characteristics of DC motors – Starting of DC motors: 3- point starter, 4- point starter – Speed control: Field control, Armature voltage control – Applications.

Unit IV	TRANSFORMERS	9	+	0

Principle of operation – Constructional features of single phase transformers – EMF equation – Transformer on No- load and Load – Phasor diagrams -- Equivalent circuit – Regulation - Auto transformers - Three phase transformer connections.

Unit V	TESTING OF DC MACHINES AND TRANSFORMERS	9	+	0

Losses and efficiency – Condition for maximum efficiency – Testing of DC machines: Swinburne's test and Hopkinson's test - Testing of transformer: open circuit and short circuit tests, Sumpner's test – All day efficiency.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concepts of electromechanical energy conversion principles.
CO2	:	Understand the basic concepts of DC machines and transformers.
CO3	:	Evaluate the performance characteristics of DC machines and transformers.
CO4	:	Conduct various tests on DC machines.
CO5	:	Apply the concepts of transformers for testing.

Text Books:

1.	D.P. Kothari, I.J. Nagrath, "Electric Machines", 3rd edition, Tata McGraw-Hill Company Ltd., New Delhi, 2017,5th edition.
2.	Dr. P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, Delhi, 2021,2nd edition.

Reference Books:

1.	B.L. Theraja& A.K. Theraja, "Electrical Technology", Vol.II, S.Chand& Company Ltd., New Delhi, 2006.
2.	A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, 'Electric Machinery', Tata McGraw Hill Publishing Company Ltd, 2017.

3.	Dr. K. Murugesh Kumar, “DC Machines & Transformers”, Vikas Publishing House Pvt Ltd., 2nd edition, 2003.
E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

CO/PO Mapping

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

18EE304	ELECTRON DEVICES AND CIRCUITS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To understand the characteristics of diode. and transistors.
2.	To understand the characteristics of transistors.
3.	To design amplifier circuits
4.	To design the oscillator circuits.

Unit I	DIODES	9	+	3

Structure – Equilibrium conditions – Energy Band Concepts – Zero bias – Forward Bias – Reverse bias – Junction capacitances – one sided and Non- uniformly doped junctions – Ideal PN junction current, P-N junction diode, V-I characteristics of a diode, review of half-wave and full-wave rectifiers, Zener diodes, voltage regulator using zener diode, clamping and clipping circuits

Unit II	TRANSISTORS	9	+	3

Bipolar Junction Transistor-structure, V-I characteristics and Biasing, Input and output characteristics of CE, CB and CC configurations – Transistor hybrid model - Junction field effect transistor – structure, JFET V-I characteristics and Biasing - MOSFET structure and V-I characteristics- UJT- structure and characteristics

Unit III	AMPLIFIER CIRCUITS	9	+	3

BJT small signal model – Analysis of CE, CB, CC amplifiers- Gain and frequency response –MOSFET small signal model– Analysis of CS and Source follower – Gain and frequency response- High frequency analysis.

Unit IV	MULTISTAGE AMPLIFIERS AND DIFFERENTIAL AMPLIFIER	9	+	3

BIMOS cascade amplifier, Differential amplifier – Common mode and Difference mode analysis – FET input stages – Single tuned amplifiers – Gain and frequency response – Neutralization methods, power amplifiers – Types (Qualitative analysis).

Unit V	FEEDBACK AMPLIFIERS AND OSCILLATORS	9	+	3

Advantages of negative feedback – voltage / current, series, Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

Total (45+15)= 60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand overview of power semiconductor switches.
CO2	:	Analyse the fundamentals and characteristics of BJT and UJT.
CO3	:	Analyse the fundamentals and characteristics of FET andMOSFET.
CO4	:	Design and analyze the amplifiers
CO5	:	Design and analyze the differential amplifiers
CO6	:	Design and analyze the oscillator circuits

Text Books:

1.	Sedra and smith, “Microelectronic Circuits “ Oxford University Press, 2017,7th edition
2.	David A. Bell, “Electronic Devices and Circuits”, New Delhi: Oxford University Press, 5th Edition, 2008.
3.	Robert L.Boylestad, “Electronic Devices and Circuit theory”, 2014,10th edition.

Reference Books:

1.	Rashid, “Micro Electronic Circuits” Thomson publications, 1999.
2.	Donald L.Schilling and Charles Belove, 'Electronic Circuits', 3 Edition, Tata McGraw Hill, 2010.
3.	Jacob Millman, Christos C.Halkias, ‘Electronic Devices and circuits ’,Tata McGraw Hill, 2003

E –References	
1.	https://electronicsforum.com/resources/electronic-devices-and-circuit-theory
2.	https://nptel.ac.in/courses/117103063/

CO/PO Mapping

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

18EE305	DC MACHINES AND TRANSFORMERS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To understand the performance characteristics of DC machines and transformers
2.	To gain knowledge on experimental skill of testing different types of DC machines and transformers.
3.	Rig up circuits for testing a given machine.

Experiments:

1	Open circuit and load characteristics of separately excited DC generator.
2	Open circuit and load characteristics of DC shunt generator.
3	Load characteristics of DC long shunt and short shunt compound generator with cumulative and differential connections.
4	Load test on DC shunt motor.
5	Load test on DC series motor.
6	Swinburne's test on DC machines.
7	Speed control of DC shunt motor.
8	Hopkinson's test on two identical DC machines.
9	Load test on single-phase transformer.
10	Equivalent circuit of a single-phase transformer.
11	Sumpner's test on transformers.
12	Study of DC motor starters and 3-phase transformer connections.

Total (0+45)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Obtain the performance characteristics of DC generators.
CO2	:	Obtain the load characteristics of DC compound generator.
CO3	:	Acquire knowledge on performance characteristics of DC shunt and series motors.
CO4	:	Acquire knowledge on performance characteristics of DC machines using direct and indirect methods.
CO5	:	Acquire knowledge on performance characteristics of transformers using direct and indirect methods.

Reference Books:

1.	G.P. Chhalotra, 'Experiments in Electrical Engineering', 3rd Ed., Khanna Publishers, Delhi, 2004.
2.	C.S. Indulkar, 'Laboratory Experiments in Electrical Power', 3rd Ed., Khanna Publishers, Delhi, 2010.
3.	DC machines and transformers laboratory manual prepared by the department.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

CO/PO Mapping

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

18EE306	ELECTRON DEVICES AND CIRCUITS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To design analog electronic circuits using Diode, BJT and MOSFET
2.	To design amplifiers and oscillators.

Experiments:

1	Static characteristics of semiconductor diode, zener diode and study of simple voltage regulator circuits.
2	Single phase half wave and full wave rectifiers with inductive and capacitive filters.
3	Static Characteristics of BJT under CE, CB, CC and determination of hybrid parameters.
4	Static characteristics of JFET.
5	Static and Switching Characteristics of MOSFET
6	Static characteristics of UJT.
7	Frequency response of CB/CE/CC amplifiers.
8	Frequency response of CD/CS amplifiers.
9	Differential amplifiers using FET.
10	Design of RC Phase shift oscillators.
11	Design of Wien bridge oscillators.
12	Design of Hartley/Colpitts oscillators.

Total (0+45)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	To design analog electronic circuits using Diode
CO2	:	To design analog electronic circuits using BJT
CO3	:	To design analog electronic circuits using MOSFET
CO4	:	To design analog electronic circuits using FET
CO5	:	To design oscillator circuits
CO6	:	To design Wave generating circuits

Reference Books:

1	David A. Bell, “Electronic Devices and Circuits”, New Delhi: Oxford University Press, 5th Edition, 2008.
2	Jacob Millman, Christos C.Halkias, ‘Integrated Electronics - Analog and Digital circuits system’,Tata McGraw Hill, 2003.
3	Robert L.Boylestad, “Electronic Devices and Circuit theory”, 2002.

E –References

1	https://electronicsforu.com/resources/electronic-devices-and-circuit-theory
2	https://nptel.ac.in/courses/117103063/

CO/PO Mapping

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

18CYMC01	ENVIRONMENTAL SCIENCE	L	T	P	C
		0	0	1	0

Course objectives:

1	They are part of the environment
2	To have an ancient wisdom drawn from Vedas
3	Activities based knowledge to preserve environment, Conservation of water and its optimization.

Experiments

	Environmental Awareness **6 hours**
1	Group activity on water management
2	Group discussion on recycle of waste (4R's)
3	Slogan making contest.
4	Poster making event.
5	Expert lecture on environmental awareness.
6	Imparting knowledge on reduction of electricity usage
	Environmental activities **8 hours**
1	Identification and segregation of biodegradable and non biodegradable waste
2	Campus cleaning activity
3	Plantation of trees in the college campus and local waste lands.
4	Identification of varieties of plants and their usage
5	Shutting down the fans and ACs of the campus for an hour
6	Field work on growing of kitchen garden for mess.

Total (14+0)= 14 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Use and save water effectively
CO2	:	Reuse the waste effectively
CO3	:	Save electricity for future generation
CO4	:	Classify biodegradable and non biodegradable waste
CO5	:	Plant trees in the college campus and local waste lands.

Reference Books:

1	D K Asthana "A Text book on Environmental studies", S.Chand Publications, 5th Edition, 2010
2	Rajesh Gopinath," Environmental Science and Engineering", Cengage, 2011.

CO/PO Mapping

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

18EE401	SIGNALS AND SYSTEMS	L	T	P	C
		2	1	0	3

Course objectives:

1.	Understand the concepts of continuous time and discrete time systems.
2.	Analyze systems in complex frequency domain.
3.	Understand sampling theorem and its implications.

UNIT I	INTRODUCTION TO SIGNALS AND SYSTEMS	6	+	3

Signals and systems- Signal properties: periodicity, absolute integrability, deterministic and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals. System properties: linearity, additivity and homogeneity, shift-invariance, causality, stability, realizability, Examples.

UNIT II	CONTINUOUS AND DISCRETE-TIME LTI SYSTEMS	6	+	3

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

UNIT III	FOURIER AND LAPLACE TRANSFORMS	6	+	3

Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior.

UNIT IV	Z- TRANSFORMS	6	+	3

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z transform, application to discrete systems - Stability analysis, frequency response – Convolution.

UNIT V	SAMPLING AND RECONSTRUCTION	6	+	3

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

Total (30+15)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Determine if a given system is linear/causal/stable
CO2	:	Capable of determining the frequency components present in a deterministic signal
CO3	:	Capable of characterizing LTI systems in the time domain and frequency domain
CO4	:	Compute the output of an LTI system in the time and frequency domains
CO5	:	Capable of determining the frequency response of discrete system using Z transform
CO6	:	Understand the concepts and importance of sampling

Text Books:

1.	Allan V.Oppenheim, S.Wilsky and S.H.Nawab, ―Signals and Systemsǁ, Pearson, 2015.
2.	J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.

3.	B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2009.
4.	A. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall,2009.

Reference Books:

1.	H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
2.	S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.
3.	M. J. Robert “Fundamentals of Signals and Systems”, McGraw Hill Education, 2007.
4.	R.E.Zeimer, W.H.Tranter and R.D.Fannin, —Signals & Systems - Continuous and Discrete‖, Pearson, 2007.

E -References

1	https://nptel.ac.in/courses/117104074/

CO/PO Mapping

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

18EE402	SYNCHRONOUS AND INDUCTION MACHINES	L	T	P	C
		3	0	0	3

Course Objectives:

This course provides understanding of AC machinery fundamentals, machine parts and helps to develop the skills for operating AC machines, and equips students to analyze the equivalent circuits of Induction and Synchronous Machines.

Unit I	ALTERNATOR	9	+	0

Construction, types, practical rating of synchronous generators, winding factors, production of EMF, armature reaction, Synchronous reactance, phasor diagram, Methods of pre-determination of voltage regulation-Synchronous impedance, ampere turn, Potier triangle methods. Two reaction theory–Slip test, synchronization - Change of excitation and mechanical input

Unit II	SYNCHRONOUS MOTOR	9	+	0

Theory of operation–phasor diagrams, Torque equation – Operation on infinite bus bars, variation of current and power factor with excitation. Hunting and its suppression, V and inverted V curves, Synchronous condenser, method of starting.

Unit III	THREE PHASE INDUCTION MACHINES	9	+	0

Constructional details, types, production of rotating magnetic field-principle of operation and practical rating of induction motors. Need for starting – Types of starters – DOL, Rotor resistance and Auto transformer starters. Generator action: self-excitation, operation, and applications.

Unit IV	ANALYSIS AND TESTING OF THREE PHASE INDUCTION MOTORS	9	+	0

Phasor diagram, equivalent circuit, Torque equation-starting and maximum-torque, maximum-output, slip for maximum-output, Torque-slip characteristics, losses and efficiency. Testing-no load and blocked rotor tests-equivalent circuit parameters, circle diagram.

Unit V	SINGLE PHASE INDUCTION MOTOR	9	+	0

Constructional details of single-phase induction motor – Double field revolving theory and operation – Equivalent circuit – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Familiarize with construction, working principle, synchronizing techniques and performance of Synchronous Generator.
CO2	:	Understand the working principle, torque equation, and excitation control for Synchronous Motor.
CO3	:	Operate three phase Induction machine as motor and as a generator.
CO4	:	Analyze the performance of three phase induction motor with testing.
CO5	:	Know double field revolving theory and starting mechanisms for single-phase induction motors
CO6	:	Use synchronous and induction motors in practical domain with specified ratings.

Text Books:

1.	D.P. Kothari, I.J. Nagrath, “Electric Machines”, 5th edition, Tata McGraw-Hill Company Ltd., New Delhi, 2017.
2.	Dr.P.S.Bimbhra, “Electrical Machinery”, Khanna Publishers, Delhi, 2021,2nd edition.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, ‘Electric Machinery’, Tata McGraw Hill Publishing Company Ltd, 2017,5th edition.

Reference Books:

1.	B.L.Theraja& A.K. Theraja, “Electrical Technology”, Vol.II, S.Chand& Company Ltd., New Delhi, 2015.

2.	Alexander S. Langsdorf, Theory of Alternating-Current Machinery, Tata McGraw Hill Publications, 2009.
E-Reference	
1	www.nptel.ac.in

CO/PO Mapping

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

18EE403	MEASUREMENTS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To introduce the basic functional elements of instrumentation
2.	To introduce the fundamentals of electrical and electronic instruments
3.	To educate on the various magnetic measurement techniques
4.	To be familiarized with the various bridge circuits for measurement of R, L, C
5.	To introduce various transducers and the data acquisition systems.

Unit I	ANALOG INSTRUMENTS	9	+	0

Elements of a Generalized Measurement System- Measurement System performance – Static Characteristics – Dynamic Characteristics – Classification of Analog instruments – Principle of operation – operating forces – constructional details – types of control systems – types of damping systems. Operation – torque equation for deflection – errors – extension range of – PMMC – MI – Electrodynamometer – induction type instruments.

Unit II	MEASUREMENT OF POWER AND ENERGY	9	+	0

Measurement of power in DC circuits, power in AC circuit- single and three phase- electrodynamometer, induction type watt meters – Construction, operation – torque equation for deflection – errors- measurements of high power using instrument power transformer – measurement of energy for AC circuits- induction type watt-hour meters – construction theory and operation – torque equation – adjustment in energy meter

Unit III	MAGNETIC MEASUREMENTS	9	+	0

Measurement of flux density – magnetizing force – magnetic potentiometer- testing of ring specimens determination of B-H curve –determination of hermistor loop by step by step method and method of reversal – testing of bar specimens – Hopkinson permeameters – Illiovici permeameters – alternating current magnetic testing varying with form factor and frequency – wattmeter method of iron loss measurements method.

Unit IV	MEASUREMNT OF R, L, C AND POTENTIOMETERS	9	+	0

Balance equations – Wheatstone bridge – Kelvin double Bridge – Maxwell's inductance bridge – Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and Wien's bridge. DC potentiometer – lab type hermist's potentiometer, Duo range potentiometer – precision type potentiometer – AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type - Campbell – Larsen type.

Unit V	MEASUREMENT OF NON-ELECTRICAL QUANTITIES	9	+	0

Classification of transducers – factor influencing the choice of transducers. Resistive transducers, Inductive Transducers – potentiometers. Linear Variable Differential Transformer – RVDT – Capacitive transducers using change in Area of Plates. Photoelectric transducers, Piezoeletrci transducers – Measurement of angular velocity – Tachogenerator – Photoelectric tachometerMeasurement of temperature – hermistor – thermocouple – pyrometer – Measurement of flow – hot wire anemometers – turbine meters – electromagnetic flow meters.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Measure current and voltage in AC and DC circuits
CO2	:	Measure Power and energy AC and DC circuits and magnetic measurements.
CO3	:	Calculate R,L,C using various bridges
CO4	:	Measure non-electrical quantities
CO5	:	Share knowledge on electrical instruments and measurements.
CO6	:	Teach the Instrumentation techniques and its applications.

Text Books:	
1.	A.K. Sawhney, 'A Course in Electrical & Electronics Measurement & Instrumentation', Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, 'Measurements Systems- Application and Design', Tata McGraw Hill publishing company, 2015.
Reference Books:	
1.	D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, 2017,3rd edition.
3.	Martin Reissland, ' Electrical Measurements', New Age International(P) Ltd., Delhi, 2011.
4.	J.B. Gupta, 'A Course in Electronic and Electrical Measurements', S.K. Kataria& Sons, Delhi,2015
E References:	
1	https://nptel.ac.in/courses/108105064/
2	https://nptel.ac.in/courses/108106074/

CO/PO Mapping

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

18EE404	ANALOG AND DIGITAL INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study the characteristics and applications of Operation Amplifier.
2.	To gain knowledge about functional diagram and applications of linear Ics
3.	To simplify the switching functions.
4.	To design combinational logic circuits.
5.	To design of sequential logic circuits

Unit I	CHARACTERISTICS OF OP-AMP	9	+	0

Ideal OP-AMP: characteristics-Inverting and non-inverting amplifier- voltage follower – differential amplifier – DC characteristics – AC characteristics. Basic applications: summer- multiplier- divider- differentiator and integrator-instrumentation amplifier – V/I and I/V converters

Unit II	APPLICATIONS OP-AMP AND LINEAR Ics	9	+	0

Applications of OP-AMP: comparators – multivibrators – Peak detector- Sample and Hold circuit – first and second order low pass and high pass active filters.
Functional block diagram and Applications of Linear Ics: IC 555 Timer – IC 566 Voltage controlled oscillator – IC 565 Phase-locked loops – IC LM317 voltage regulators.

Unit III	COMBINATIONAL LOGIC CIRCUITS	9	+	0

Representation of logic functions: SOP and POS forms – Simplification of switching functions: K-map method and Quine McCluskey (Tabulation) method.
Design: Adder – Subtractor – 2 bit Magnitude Comparator – Multiplexer- Demultiplexer- Encoder – Priority Encoder – Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder.

Unit IV	SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	+	0

Flip-flops: SR, D, JK and T – Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models – Analysis and design of synchronous sequential circuits – Design of synchronous counters – Universal shift register.

Unit V	ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	+	0

fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches- primitive state / flow table – Reduction of state and flow table – state assignment – Design Procedure of asynchronous circuits with /without using of SR latches – Problems in asynchronous sequential circuits: cycles – Races – Hazards.

Total (L+T)=45/0 Periods

Course Outcomes:

At the end of the course the student will be able to

CO1	:	Explain the OP-AMP characteristics
CO2	:	Understand the applications of OP-AMP and other linear Ics.
CO3	:	Utilize K-map and Tabulation methods to simplify the switching functions
CO4	:	Design and implement of combinational logic circuits
CO5	:	Analysis and design of synchronous sequential logic circuits
CO6	:	Analysis and design of asynchronous sequential logic circuits

Text Books:

1.	D.Roy Chowdhury and Shail B. Jain , “Linear Integrated Circuits”, Fourth Edition, New Age International (P) Ltd Publishers, 2014.
2.	M. Morris Mano, “Digital Design” , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .

3.	S. Salivahanan and S. Arivazhagan, “Digital Circuits and Design”, Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 2011.
Reference Books:	
1.	Ramakant A Gayakward, “Op-Amps and Linear Integrated Circuits”, Fourth Edition, Pearson Education, 2003.
2	Jacob Millman, Christos C.Halkias, “Integrated Electronics- Analog and Digital circuits system”, Tata McGraw Hill 2003.
3	R.P.Jain, “Modern Digital Electronics”, Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
4.	Thomas L. Floyd, “Digital Fundamentals”, Pearson Education, Inc, New Delhi, 2015
5.	Donald P.Leach and Albert Paul Malvino, “Digital Principles and Applications”, Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.
E-Reference	
1	NPTEL courses on Analog Integrated Circuits, IIT Madras- web: http://nptel.ac.in/courses/108106068/
2	NPTEL courses on Analog Circuits, IIT Bombay https://nptel.ac.in/courses/108/101/108101094/
3	NPTEL courses on Digital Electronic Circuits, IIT Kharagpur. Web:https://nptel.ac.in/courses/108/105/108105132/
4	NPTEL courses on Digital Circuits, IIT Kharagpur. Web: https://nptel.ac.in/courses/108/105/108105113/

CO/PO Mapping

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

18ME408	ENGINEERING MECHANICS	L	T	P	C
		2	1	0	3

Course Objectives:

1.	To develop capacity to predict the effect of force and motion in the course of carrying out the design functions of engineering.
2.	To analyze the force systems, friction and to study the dynamics of particles, impulse and momentum.

UNIT I	STATICS OF PARTICLES	6	+	3

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility.

UNIT II	EQUILIBRIUM OF RIGID BODIES	6	+	3

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

UNIT III	PROPERTIES OF SURFACES AND SOLIDS	6	+	3

Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections.

UNIT IV	FRICTION	6	+	3

Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack.

UNIT V	KINETICS OF PARTICLES AND RIGID BODIES	6	+	3

Equations of motion- Rectilinear motion-curvilinear motion- Relative motion- D'Alembert's Principle-work-Energy equation-Conservative forces and principle of conservation of energy-Impulse- momentum- Impact- Direct central impact and oblique central impact. Plane motion- Absolute motion- Relative motion- work and energy- impulse and momentum.

Total (30+15) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Illustrate the vectorial and scalar representation of forces and moments
CO2	:	Analyze the rigid body in equilibrium
CO3	:	Evaluate the properties of surfaces and solids
CO4	:	Determine the friction and the effects by the laws of friction
CO5	:	Apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems

Text Books:

1.	A Textbook of Engineering Mechanics, R.K. Bansal, Laxmi Publications, 2015,5t edition.
2.	Engineering Mechanics, R.S. Khurmi, S.Chand Publishing, 2018.

Reference Books:

1.	Engineering Mechanics, D.S. Bedi, Khanna Book Publishing Co. (P) Ltd.
2.	Rajasekaran S and Sankarasubramanian G., "Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., 2017 ,3rd edition.
3.	Palanichamy M.S. and Nagam S., "Engineering Mechanics – Statics & Dynamics", Tata McGraw-Hill, 2001

4.	Engineering Mechanics, DP Sharma, Pearson,2010.
5.	F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I – Statics, Vol II, – Dynamics, 12^{th} Ed, Tata McGraw Hill, 2019.
E-Referencce	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1					2		
CO2	2	1	1	0	1					2		
CO3	2	1	1	0	0							
CO4	1	1	1	1	0							
CO5	2	2	1	1	0							

18EE405	SYNCHRONOUS AND INDUCTION MACHINES LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1	To expose the students to operate of synchronous machines and induction motors and strength their experimental skill.

Experiments:

1	Predetermination of Voltage Regulation of three-phase alternator by EMF and MMF methods.
2	Predetermination of Voltage Regulation of three-phase alternator by ZPF method.
3	Slip test on three-phase salient pole alternator.
4	V and inverted V curves of synchronous motors
5	Load test on three-phase induction motor.
6	Circle diagram for three phase induction motor with No load and blocked rotor test data.
7	Three Phase Induction Generator action with self-excitation.
8	Synchronization of three-phase alternator
9	Separation of losses in three phase induction motor.
10	Load test on single-phase induction motor.
11	Equivalent circuit and pre-determination of performance characteristics of single-phase induction motor.
12	Separation of losses in single phase transformer using alternator

Total(0+45)= 45Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Analyze the voltage regulation of a given alternator using different methodologies
CO2	:	Analyze the performance of a given synchronous motor under various excitation Conditions
CO3	:	Analyze the characteristics of a induction motor under various load conditions
CO4	:	Analyze the load sharing capability of given alternators
CO5	:	Develop the equivalent circuit and analyze the characteristics of single-phase induction motor
CO6	:	Do loss analysis in AC machines.

CO/PO Mapping

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

18EE406	MEASUREMENTS AND INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To study the use of Transducer.
2.	To measure the resistance, capacitance and inductance using bridges.
3.	To calibrate voltage and current using measuring equipment.
4.	To calibrate the efficiency of PV modules.

Experiments:

1	Measurement of displacement using transducers.
2	Measurement of pressure using transducers.
3	Measurement of inductance by Maxwell's bridge.
4	Measurement of inductance by Anderson's bridge
5	Measurement of resistance by Wheatstone bridge.
6	Measurement of capacitance, Inductance by schering bridge.
7	Study of Instrumentation amplifiers.
8	A/D converters.
9	D/A converters.
10	Study of transients.
11	Calibration of single phase and three phase energy meter.
12	Calibration of AC, DC voltmeter and Ammeter.
13	Calibration of current transformer and potential transformer.
14	Measurement of three phase power and power factor.
15	Calibration and Voltage – Current Measurement of solar light.
16	Study of PLC.
17	Calibration of series and parallel connection of PV modules.
18	Calculation of efficiency for PV system modules, Battery and Inverter.

2Total(0+45)= 45Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Explain analog instruments.
CO2	:	Measure power in AC and DC circuits
CO3	:	Calculate R,L,C using various bridges.
CO4	:	Know about basic of PLC.
CO5	:	Measure the efficiency of PV modules
CO6	:	Calibrate ammeter, voltmeter, energy meter and transformers.

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	1	2		2	1		2	1	1		1	1
CO2	1	2		2	2		2	1	1		2	1
CO3	1	2		2	1		2	2	1		1	1
CO4	1	2		2	1		2	1	1		1	1
CO5	1	2		2	1		2	1	2		1	1
CO6	1	3		3	1		3	1	1		1	1

18EE407	ANALOG AND DIGITAL INTEGRATED CIRCUITS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To Expose the characteristics and applications of Linear Ics.
2.	To study various digital electronics circuits used in simple system configuration

List of Experiments: (Any 10 Experiments)

1	Verification of IC 741 characteristics: inverting and non-inverting amplifier – voltage follower.
2	Verification of IC 741 Applications circuits: summer, differentiator and integrator.
3	Design of zero crossing detector and Schmitt trigger circuit using OP-AMP.
4	Design and testing of first order Low Pass and High Pass Active filters.
5	Design of Wien bridge oscillator and RC phase shift oscillator using OP-AMP.
6	Design of astable and monostable multivibrator circuits using NE/SE 555 timer.
7	Design of Voltage controlled oscillator using NE/SE 566.
8	Design of Voltage regulator using IC723.
9	Design of +5V, 1A regulated Power supply using IC 7805.
10	Design of variable power supply using IC LM317.
11	Design of dual power supply using LM 320 / LM340.
12	Realize the switching functions using minimum number of NAND/NOR gates.
13	Design of code converter circuits.
14	Study of different types of Flip-Flops.
15	Design of 3-bit synchronous counters.
16	Implementation of multipliexers and demultiplexers – encoders and decoders
17	Design of 4-Bit shift registers using flip-flop.
18	Testing of asynchronous counters using flip-flops.

Total (0+45)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Study the characteristics and mathematical applications of op-amp
CO2	:	Design and verify waveform generator circuits and filter circuits using op-amp.
CO3	:	Design voltage regulator and power supply circuits using Linear Ics.
CO4	:	Realize the switching function using universal gates.
CO5	:	Realize the various types of combinational logic circuits
CO6	:	Implement the various types of sequential logic circuits

Reference Books:

1.	Department Integrated Circuits Laboratory Manual
2.	Roy Choudhury. D and Shail. B. Jain, “Linear Integrated Circuits”, New Age International 4th Edition, 2011.
3	Gayakwad. R.A, “Op-amps & Linear Integrated Circuits”, Pearson education, 4th Edition, 2015

CO/PO Mapping

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

18MC301	INDIAN CONSTITUTION	L	T	P	C
		1	0	0	0

Course Objectives:

1.	Learn the salient features of the Indian Constitution
2.	List the fundamental rights and fundamental duties
3.	Present a systematic analysis of all dimensions of the Indian political Systems
4.	Understand the power functions of Parliament, the legislature and Judiciary.

Unit I		3	+	0

Union and its Territory – Citizenship – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties.

Unit II		3	+	0

The Union – The States – The Union Territories –The Panchayats – the Municipalities

Unit III		3	+	0

The Co-operative Societies – The Scheduled and Tribal Areas – Relations between the Union and the States – Finance, Property, Contracts and Suits – Trade and Commerce within the territory of India.

Unit IV		3	+	0

Service under the Union, the States – Tribunals –Elections –Special provisions –Relating to certain classes.

Unit V		2	+	0

Languages - Emergency provisions –Miscellaneous – Amendment of the Constitution.

Total (14+0)= 14 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the emergence and evolution of the Indian Constitution.
CO2	:	Explain the key concepts of Indian Political System
CO3	:	Describe the role of Constitution in a democratic society
CO4	:	Present the structure and functions of the central and state Governments, the legislature and Judiciary.

Reference Books:

1.	Subhash C. Kashyap , Our Constitution , national Book trust, 2017
2.	Durga Das basu, Introduction to the History of Modern India.Lexis Nexis, 2015.
3.	M.V.Pylee, Constitutional History of India, S.Chand Publishing, 2010.
4.	Granville Austin, The Indian Constitution, Cornerstone of a nation, Oxford university Press, 1999.

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									1	1		1
CO2									1	1		1
CO3									1	1		1
CO4									1	1		1

18EE501	POWER GENERATION, TRANSMISSION AND DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study the characteristics of load curve, power tariff methods and the various power generating systems.
2.	To become familiar with the different components used in Transmission and Distribution levels of power systems and modeling of these components

Unit I	POWER GENERATION SYSTEMS	9	+	0

Structure of electric power system: Various levels such as generation, transmission and distribution, Load curve-load duration curve - tariff- types of tariff- Power generating Station: layout- selection of site of Thermal power plant, Hydroelectric power plant and Nuclear power plants - major power stations in India.

Unit II	TRANSMISSION LINE PARAMETERS	9	+	0

Line resistance- Inductance and capacitance calculations of single phase and 3- phase transmission lines with single and double circuits – Inductance of composite conductors- Effect of bundling and earth on the capacitance – Skin and proximity effects-Inductive interference between power and communication lines.

Unit III	MODELING AND PERFORMANCE OF TRANSMISSION LINES	9	+	0

Representation of Lines-Performance of Short line, medium line and long line; equivalent circuits, phasor Diagrams, transmission efficiency and voltage regulation and ABCD constants-surge-impedance loading-power transmission capability-Ferranti effect and corona loss.

Unit IV	OVERHEAD LINE INS ULATORS AND CABLES	9	+	0

Insulators: Types, Potential distribution over a string of suspension insulators- improvement of string efficiency. Underground cables: Constructional features of LT and HT cables, capacitance of single core and 3- core cables, dielectric stress in a single core cable- grading of cables, thermal resistance of dielectric of a single core cable**.**

Unit V	SUBSTATION, GROUNDING SYSTEM AND DISTRIBUTION SYSTEM	9	+	0

Substation: Classification-bus-bar arrangements in sub stations- Neutral grounding: Effectively grounded system-Underground system –Resonant grounding- Methods of neutral grounding-Distribution system: Radial and ring-main distribution systems-Methods of solving AC distributed problems.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Design the layout of various types of power generating systems such as thermal, Hydro, nuclear, diesel and MHD.
CO2	:	Develop expression for computation of fundamental parameters off lines.
CO3	:	Categorize the lines into different classes and develop equivalent circuits.
CO4	:	Analyze the voltage distribution in insulator strings and cables and methods to improve the same.
CO5	:	Comprehend the substation components and grounding techniques.
CO6	:	Grasp the different distribution system

Text Books:

1.	M.L. Soni, P.V. Gupta, V.S. Bhatnagar, A. Chakrabarti, ‘A Text Book on Power System Engineering’, DhanpatRai& Co.,2013.
2.	C.L. Wadhwa, ‘Electrical Power Systems’, Newage International (P) Ltd., 2017.
3.	Singh,”Electric Power Generation,Transmission and Distribution”, IIndEdition,PHIPvt. Ltd., New Delhi, 2012.

Reference Books:	
1.	Ray, “Electrical Power systems: Concepts, Theory and Practice”, PHI Pvt.Ltd., New Delhi,2014,2nd edition.
2.	V.K. Mehta, Rohit Mehta, “Principles of Power System”, S.Chand& Company Ltd., New Delhi, 2012
3.	Dr. S.L.UPPAL, ‘ELECTRICAL POWER’, Khanna publishers, New Delhi, 1987.
E-Reference	
1	www.onlinecourses.nptel.ac.in/noc18_ee41
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EE502	CONTROL SYSTEMS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To understand the methods of representation of systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the three ways of designing compensators for a control system.

Unit I	SYSTEMS AND THEIR REPRESENTATION	9	+	3

Basic elements in control systems – Open and closed loop systems – Mathematical model and Electrical analogy of mechanical systems – Transfer function – Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

Unit II	TIME RESPONSE ANALYSIS	9	+	3

Standard test signals – Time response of first order and second order systems – Steady-state errors and error constants – Types of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

Unit III	FREQUENCY RESPONSE ANALYSIS	9	+	3

Correlation between time and frequency response: Second order systems – Polar plots – Bode plots – Computation of Gain Margin and Phase Margin – Frequency domain specifications – Constant M and N-circles – Nichols chart.

Unit IV	STABILITY OF CONTROL SYSTEM	9	+	3

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

Unit V	COMPENSATOR DESIGN	9	+	3

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators – Cascade compensation in frequency domain.

Total (45+15)= 60 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Derive the transfer function models of any electrical and mechanical systems.
CO2	:	Develop the time response and steady state error analysis of the control systems.
CO3	:	Analyze the frequency response of the systems.
CO4	:	Analyze the stability of closed loop control systems.
CO5	:	Construct the root locus plot and analyze system stability.
CO6	:	Design the compensators using conventional techniques.

Text Books:

1.	A. Anand Kumar, “Control Systems”, PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2015.
2.	I.J. Nagrath& M. Gopal, “Control Systems Engineering”, New Age International Publishers, Delhi, 5th Edition, 2015.

Reference Books:

1.	K. Ogata, “Modern Control Engineering”, Pearson Education, New Delhi, 2010.
2.	M. Gopal, “Control Systems: Principles and Design”, TMH, New Delhi, 4th Edition, 2012.

E-References:

1.	www.onlinecourses.nptel.ac.in/

CO/PO Mapping

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

18EE503	POWER ELECTRONICS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study an overview of power semiconductor devices, principles of controlled rectifiers, DC-DC converters, inverters, AC voltage controller circuits and their analysis.

Unit I	**POWER SEMICONDUCTOR DEVICES**	**9**	**+**	**0**

Concept of power electronics- Structure, Operation, Static and Switching characteristics of power semiconductor devices: Power Diode, SCR, MOSFET, IGBT, IGCT –- Thyristor ratings and protection, Gate drive circuits for MOSFET and IGBT, Switching and Conduction losses in a generic power semiconductor device.

Unit II	**PHASE CONTROLLED RECTIFIERS**	**9**	**+**	**0**

Single phase and three phase fully controlled rectifiers – Power circuit, Operation, Waveform analysis and performance parameters – Effect of source and load inductance –Single phase and Three phase dual converters-Introduction to PWM rectifiers

Unit III	**DC TO DC CONVERTER**	**9**	**+**	**0**

Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage– control strategy – Power Circuit and steady state analysis of Buck converter, Boost converter, Buck – boost converter and SEPIC converter- Design of inductor and capacitors for DC-DC converters.

Unit IV	**INVERTERS**	**9**	**+**	**0**

Power circuit of single-phase voltage source inverter, square wave operation of the inverter, bipolar and unipolar sinusoidal modulation, modulation index and output voltage, Power circuit of a three-phase voltage source inverter, operation, switch states, instantaneous output voltages, three-phase sinusoidal modulation -Space vector modulation

Unit V	**AC TO AC CONVERTERS**	**9**	**+**	**0**

Introduction and principle of operation of Single phase and Three phase AC voltage controllers – Multistage sequenc control –Applications of AC Voltage Controllers–Introduction to Matrix converters.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Select the Power Semiconductor Devices based on Characteristics.
CO2	:	Evaluate the performance of phase-controlled rectifier.
CO3	:	Design and analyze the DC/DC converter circuits
CO4	:	Analyze the inverter operation and its control techniques.
CO5	:	Know the operation and applications of AC voltage controller and matrix converters

Text Books:

1.	M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI 4th Edition New Delhi, 2014.
2.	P .S.Bimbra "Power Electronics" Khanna Publishers, New Delhi 2018.

Reference Books:

1.	Ned Mohan, Tore. M. Undel and, William. P. Robbins, 'Power Electronics: Converters, Applicationsan Design', John Wiley and sons, 2007.
2.	R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
3.	M.D. Singh and K.B. Khanchandani, "Power Electronics," McGraw Hill India, 2013.

E-Reference

1	www.onlinecourses.nptel.ac.in/
2	www.class-central.com

CO/PO Mapping

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

18EE504	MICROPROCESSOR AND MICROCONTROLLER	L	T	P	C
		3	0	0	3

Course Objectives:

1.	A thorough understanding in establishing a digital control system
2	Learn different digital communications and their applications
3	Get ideas to apply digital controls for different electrical applications

Unit I	8085 8 BIT MICROPROCESSOR	9	+	0

Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.

Unit II	8051 8 BIT MICROCONTROLLER	9	+	0

Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers

Unit III	INTERFACING WITH 8051 MICROCONTROLLER	9	+	0

Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.

Unit IV	EXTERNAL COMMUNICATION INTERFACE	9	+	0

Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Unit V	APPLICATIONS OF MICROCONTROLLERS	9	+	0

Stepper motor interfacing, DC Motor interfacing, Data Acquisition System, Measurement of Electric Power, Powe factor. Solid State Relays

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand any other types of modern microprocessor and microcontroller,
CO2	:	Select appropriate digital system based on applications
CO3	:	Design simple controls using software programs
CO4	:	Design and interface communications between digital systems
CO5	:	Apply the digital concepts to measure and control simple electrical systems

Text Books:

1.	R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applicat ions with the 8085”, Penram International Publishing, 2013, 6th edition.
2.	K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning,2004.
3.	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The8051Microcontroller and Embedded Systems: Using Assembly and C”,Pearson Education, 2007.

Reference Books:

1.	R. Kamal, “Embedded System”, McGraw Hill Education,2017
2.	D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 2005

E-Reference

1	www.onlinecourses.nptel.ac.in/
2	www.class-central.com

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1		1	1		1	1	1
CO2	1	1	1	1	1		1	1		1	1	1
CO3	1	1	1	1	1		1	1		1	1	1
CO4	1	1	1	1	1		1	1		1	1	1
CO5	1	1	1	1	1		1	1		1	1	1

18EE505	CONTROL SYSTEMS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To provide a platform for understanding the basic concepts of linear control theory and its application to practical systems.

Experiments:

1	Transfer function of separately excited DC generator.
2	Transfer function of self-excited DC generator.
3	Transfer function of armature-controlled DCmotor.
4	Transfer function of field-controlled DC motor.
5	Transfer function of AC servo-motor.
6	Frequency response of Lag, Lead and Lag-lead networks.
7	Study of Synchros.
8	Study of Stepper motor.
9	Ward Leonard method of speed control of DC motor.
10	Study of DC position control system.
11	Study of P, PI and PID controllers (First-order).

Total (0+45)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Design the transfer function of DC and AC machines.
CO2	:	Design compensators for control system.
CO3	:	Gain knowledge about Synchros.
CO4	:	Gain knowledge about Stepper motor.
CO5	:	Design controllers for control systems.

Reference Books:

1.	A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2015.
2.	I.J. Nagrath& M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 5th Edition, 2015.
3.	K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 2010.

E-References:

1.	www.onlinecourses.nptel.ac.in/
2.	www.class-central.com

CO/PO Mapping

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

18EE506	POWER ELECTRONICS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1	To simulate and analyze the performance of different power electronic converter circuits.

Experiments:

1	V-I Characteristics of power diode and SCR
2	Static and Switching Characteristics of Power MOSFET and IGBT
3	Single phase AC to DC fully controlled converter
4	Single phase PWM rectifiers
5	Buck and Boost Converters
6	MOSFET based single-phase PWM inverter
7	IGBT based three-phase PWM inverter
8	Single phase AC voltage controller
9	Simulation for Single phase and three phase dual converters
10	Simulation of Buck – boost converter and SEPIC converter
11	Simulation of three phase voltage source inverters with sinusoidal modulation
12	Simulation of Matrix converter

Total(0+45) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Analyze the characteristics of MOSFET, SCR and IGBT.
CO2	:	Evaluate the performance of DC-DC Converters and inviters.
CO3	:	Design and control of inverters with different modulations.
CO4	:	Analyze the performance of power converters with simulation studies
CO5	:	Demonstrate the operation of power converters

Text Books:

1.	M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2009.
2.	P.S.Bimbra "Power Electronics" Khanna Publishers, New Delhi 2016.

Reference Books:

1.	Ned Mohan, Tore. M. Undel and, William. P. Robbins, 'Power Electronics: Converters, Application and Design', John Wiley and sons, 2007.
2.	R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
3.	M.D. Singh and K.B. Khanchandani, "Power Electronics," McGraw Hill India, 2013.

E-References:

1.	www.onlinecourses.nptel.ac.in/
2.	www.class-central.com

CO/PO Mapping

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

18EE507	MICROPROCESSOR AND MICROCONTROLLER LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	Able to write own programs for different applications
2.	Interface and program for interconnected digital systems

Experiments:

1 Simple arithmetic operations: addition / subtraction / multiplication / division.

2 Programming with control instructions:
   a. Ascending / Descending order, Maximum / Minimum of numbers
   b. Programs using Rotate instructions
   c. Hex / ASCII / BCD code conversions.

3 Interface Experiments: with 8085
   a. A/D Interfacing. & D/A Interfacing.

4 Traffic light controller.

5 I/O Port / Serial communication

6 Programming Practices with Simulators/Emulators/open source

7 Keyboard interfacing

8 LCD interfacing 4bit/8bit mode

9 Demonstration of basic instructions with 8051 Micro controller execution, including:
   a. Conditional jumps, looping
   b. Calling subroutines.

10 Programming I/O Port 8051
   a. Interface with external A/D & D/A
   b. Interface with stepper motor

11 Interrupt programming with external sensors/ devices

12 Programming for communication using Zigbee protocol.

Total (0+45)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Write coding to implement different types of algorithms
CO2	:	Design and implement simple controllers
CO3	:	Use simulators and emulators for debugging and verifying codes
CO4	:	Write efficient codes using interrupts for time critical applications
CO5	:	Interface any application module to microprocessor/microcontroller.

Text Books:

1.	R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applicat ions with the 8085”, Penram International Publishing, 1996
2.	K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning,2004.
3.	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The8051Microcontroller and Embedded Systems: Using Assembly and C”,Pearson Education, 2007.

Reference Books:

1.	R. Kamal, “Embedded System”, McGraw Hill Education,2009
2.	D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991

E-References:

1.	www.onlinecourses.nptel.ac.in/
2.	www.class-central.com

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	0	1	1	1	1	0	1
CO2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	0	1	1	1	1	0	1
CO4	1	1	1	1	1	0	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1

18EE601	POWER SYSTEM ANALYSIS AND STABILITY	L	T	P	C
		3	0	0	3

Course Objectives:

1	To model the power system under steady state operating condition
2	To apply efficient numerical methods to solve the power flow problem
3.	To model and analyze the power systems under abnormal (or) fault conditions
4.	To model and analyse the transient behaviour of power system when it is subjected to a fault.

Unit I	POWER SYSTEM OVERVIEW AND MODELLING	9	+	0

Basic components of modern power system - Per-phase analysis: Generator model - Synchronous motor model- - Three-phase transformer model - Three-winding transformer model - Line model- per unit quantities - Changing the base of per-unit quantities - representation of load impedance - Single line diagram -Impedance and reactance diagrams.

Unit II	POWER FLOW ANALYSIS	9	+	0

Bus classification – Bus admittance matrix Formulation: Direct inspection method and Singular transformation method -Development of power flow model - solution of load flow equations: Gauss Seidel method - Newton Raphson method- Fast decoupled method – flowcharts – Comparison of the three power flow solution methods.

Unit III	FAULT ANALYSIS - BALANCED FAULT	9	+	0

Introduction – Balanced three phase fault – Short circuit capacity - Algorithm for formation of the Bus Impedance matrix- Systematic fault analysis using Bus Impedance matrix -Selection of circuit breakers.

Unit IV	FAULT ANALYSIS - UNBALANCED FAULT	9	+	0

Fundamentals of symmetrical components – Sequence impedances – Construction of sequence networks – Unsymmetrical faults on power system: Single line-ground fault, line-line fault – Double line-ground fault- Unbalanced Fault analysis using bus impedance matrix.

Unit V	STABILITY STUDIES	9	+	0

Importance of stability studies – Classification of power system stability – Stability limits – Power angle equation- Inertia constant- Swing equation of single-machine connected to infinite bus – Solution of Swing equation by step-by-step method-II – Modified Euler’s method – Runge-Kutta method – Equal area criterion – Critical clearing angle and time -Factors affecting transient stability – Techniques for transient stability improvement.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Develop the single line diagram for the power system.
CO2	:	Perform and analyze load flow computations using bus admittance matrix
CO3	:	Perform and analyze balanced fault using bus impedance matrix
CO4	:	Develop computational models for unsymmetrical fault analysis in power systems
CO5	:	Understand the transient stability studies.

Text Books:

1.	Hadi Saadat, “Power System Analysis”, Tata McGraw Hill Publishers, New Delhi, 21st reprint 2010
2.	D.P.Kothari, and I.J.Nagrath, “Modern Power System Analysis", Tata McGraw Hill Education Private limited, New Delhi, Fourth Edition, 2011.

Reference Books:

1.	John J. Grainger and W.D. Stevenson Jr., “Power System Analysis”, McGraw Hill Inc., New Delhi, 2017.
2.	B.R. Gupta, “Power System Analysis and Design”, S.Chand& Co. Ltd., New Delhi, 2012
3.	C. L. Wadhwa, “Electrical Power Systems”, New Age International Publishers, New Delhi, 2010.

E-References	
1.	https://onlinecourses.nptel.ac.in/, for power system analysis course, IIT Kharagpur
2.	NPTEL courses on Power System Generation, Transmission and Distribution, IIT Delhi.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	2	1	3	1	3		1					
CO2	2	2	3	2	3		1					
CO3	2	2	3	2	3		1					
CO4	2	2	3	2	3		1					
CO5	2	2	3	2	3		1					

18EE602	ELECTRICAL DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know about the Analyze the operation of the chopper fed dc drive, both qualitatively and quantitatively.
2.	To understand the Operation and performance of AC motor drives.

UNIT I	DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES	9	+	0

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, exampleload torque-speed characteristics, operating point, armature voltage control for varying motorspeed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper

UNIT II	MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE	9	+	0

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	INDUCTION MOTOR CHARACTERISTICS	9	+	0

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

UNIT IV	SCALAR CONTROL OR CONSTANT V/F CONTROL OF INDUCTION MOTOR	9	+	0

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

UNIT V	CONTROL OF SLIP RING INDUCTION MOTOR	9	+	0

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

Total (45+0)= 45 Periods

Course outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the characteristics of dc motors and induction motors.
CO2	:	Understand the principles of speed-control of dc motors and induction motors.
CO3	:	Understand the power electronic converters used for dc motor and induction motor speed control.
CO4	:	Gain knowledge on the Scalar control or constant V/f control of induction motor
CO5	:	Gain knowledge on chopper fed DC drives.

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2015

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2010.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-referencess

1	https://www.iith.ac.in/~ketan/drives.htmL

CO/PO Mapping

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

18EE603	PROFESSIONAL ETHICS AND HUMAN VALUES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To create awareness on Engineering Ethics and providing basic knowledge about engineering Ethics, Variety of moral issues and Professional Ideals.
2.	To provide basic familiarity about Engineers as responsible Experimenters, Codes of Ethics, Industrial Standards.
3.	To inculcate knowledge and exposure on Safety and Risk, Risk Benefit Analysis.

UNIT I	HUMAN VALUES	9	+	0

Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for Others – Living Peacefully – caring – Sharing – Honesty – Courage – Valuing Time – Co-operation – Commitment – Empathy – Self-Confidence – Character – Spirituality.

UNIT II	ENGINEERING ETHICS	9	+	0

Senses of 'Engineering Ethics' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy – Models of Professional Roles - theories about right action – Self-interest- customs and religion - uses of ethical theories.

UNIT III	ENGINEERING AS SOCIAL EXPERIMENTATION	9	+	0

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law – the challenger case study.

UNIT IV	SAFETY, RESPONSIBILITIES AND RIGHTS	9	+	0

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - the three mile island and Chernobyl case studies. Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest – occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination.

UNIT V	GLOBAL ISSUES	9	+	0

Multinational corporations - Environmental ethics - computer ethics - weapons development - engineers as managers consulting engineers-engineers as expert witnesses and advisors -moral leadership-sample code of Ethics like ASME,ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of electronics and telecommunication engineers (IETE),India.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the importance of ethics and values in life and society.
CO2	:	Understood the core values that shape the ethical behavior of an engineer.
CO3	:	Expose awareness on professional ethics and human values.
CO4	:	Analyse a person based on human value concepts
CO5	:	Analyse our responsibility and rights to social problems

Text Books:

1.	Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 2005.
2.	Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

Reference Books:

1.	Tripathi A N, "Human values" , New Age international Pvt. Ltd., New Delhi, 2002.
2.	Charles D. Fleddermann, "Engineering Ethics", Pearson Education / Prentice Hall, New Jersey, 2004.
3.	Charles E Harris, Michael S. Protchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Wadsworth Thompson Learning, United States, 2000.
4.	John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, 2003.

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1			2			3		3	2			3
CO2			2			3		3	1			2
CO3			2			2		3				2
CO4			2			3		3	1	1		2
CO5			2			2		2		1		2

18EN501	COMMUNICATION SKILLS LABORATORY	L	T	P	C
		0	0	2	1

Course Objectives:

1.	Communicate effectively with interviewers
2.	Express opinions, illustrate with examples, elucidate and conclude in group discussions
3	Write error free letters and prepare reports
4	Speak fluently and avoid pitfalls in pronunciation and grammatical errors

WRITING SKILLS **(15 hours)**

- Letter seeking permission to go on industrial visit
- Letter of invitation
- Resume and Cover Letter
- Report Writing – Progress in project work

SPEAKING SKILLS **(15 hours)**

- Welcome Address and Vote of Thanks
- Analysing and presenting business articles
- Power Point Presentation
- Group Discussion

SOFT SKILLS **(15 hours)**

- Psychometric profile
- Self-Introduction
- Interview skills
- Conducting a board meeting

VERBAL ABILITIES **(15 hours)**

- Error Spotting
- Listening Comprehension
- Rearranging Jumbled sentences
- Vocabulary

Lab Record

1. Group Discussion - Literature survey
2. Group Discussion - Transcripts
3. Group Discussion - Assessment forms
4. Interview Skills – Psychometric profile
5. Interview Skills - Self-introduction
6. Interview Skills – Resume and Cover Letter
7. Interview Skills - Transcription of interview
8. Interview Skills - Assessment sheet signed by interview panel
9. Power Point Presentation
10. Error spotting worksheet
11. Jumbled sentences worksheet
12. Welcome Address
13. Vote of Thanks
14. Letter seeking permission to go on industrial visit
15. Report Writing – Progress in project work
16. Presentation of business articles - Transcription

Total (0+30)= 30 Periods

Course Outcomes:		
Upon completion of this course, the students will be able to:		
CO1	:	Write error free letters and prepare reports
CO2	:	Deliver welcome address and vote of thanks
CO3	:	Speak coherently with proper pronunciation and accent
CO4	:	Avoid common Indianisms and grammatical errors
CO5	:	Improve repertoire of passive vocabulary
CO6	:	Answer questions posed by interviewers confidently
CO7	:	Participate in group discussion effectively
CO8	:	Undertake online psychometric and IQ test to understand their strengths and weaknesses

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1				2		1	3	3	1	2
CO2	1	3		1				1	1	3	1	3
CO3		1		3		1		2	1	3	1	2
CO4		1		1		2			1	3		3
CO5				2				1		3	2	3
CO6		1		1		1		1	1	3	1	2
CO7				1		1		2	2	3	1	2
CO8	1	2		2		1				3		2

18EE701	POWER SYSTEM PROTECTION AND SWITCHGEAR	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know about the power system protection and switchgear components.
2.	To understand the concepts of various protection schemes.
3.	To know about numerical protection schemes.

Unit I	PROTECTIVE RELAYS	9	+	0

Functional characteristics of a protective relay – Operating principles of relays - Over current relays – Instantaneous and time over current relays - Definite time and inverse time characteristics - Direct over current relay – Directional overcurrent relay - Universal torque equation - Performance characteristics of distance relays - Differential relays - Under frequency and over frequency relays - Translay scheme - HRC fuses for relays.

Unit II	CIRCUIT BREAKERS	9	+	0

Arc in oil - Arc interruption – Current chopping - Bulk oil and minimum oil circuit breaker – Air circuit breakers - Air blast circuit breakers - Vacuum circuit breakers- SF6 circuit breakers -Rating of circuit breakers - Testing of circuit breakers – Autoreclosure. HVDC circuit breakers - Energy consideration in breaking. HVDC system - Commutating principle - Control of di/dt and dv/dt - Surge suppression - Main circuit breakers for HVDC switching.

Unit III	EQUIPMENT PROTECTION SCHEMES	9	+	0

Feeder protection - Distance protection – Alternator protection - Short circuit protection of stator windings by percentage differential relays - Protection against turn to turn faults in stator winding - Field ground fault protection - Protection of stator windings by overvoltage relays - Protection against stator open circuits, loss of synchronism, loss of excitation, rotor overheating - Protection of transformers - Typical schemes.

Unit IV	STATIC RELAYS	9	+	0

Introduction - Advantages of static relays - Basic construction - Phase and amplitude comparators - Static directional relay - Directional overcurrent relay – Static differential relays and differential protective schemes.

Unit V	NUMERICAL PROTECTION	9	+	0

Introduction – Block diagram – Sampling theorem – Fourier analysis of analogue signals – Least error squared technique – Digital filtering – Over current protection – Differential protection – Distance protection.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concepts and applications of protective relays.
CO2	:	Acquire knowledge about different types of circuit breakers
CO3	:	Understand the protection schemes of various power components.
CO4	:	Understand numerical protection schemes.
CO5	:	Design protection scheme for any electrical system

Text Books:

1.	Badri Ram and Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill, 2017,2nd edition.
2.	Arun Ingole, “Switchgear and Protection”, Pearson India, 2018.

Reference Books:

1.	Rao, T. S. M, “Power System Protection Static Relays with Microprocessor Applications”, Tata McGraw-Hill, 2017,2nd edition.
2.	Paithankar, Y. G and Bhide, S. R, “Fundamentals of Power System Protection”, Prentice Hall, 2013.

3.	Uppal, S.L, “Electrical Power", Khanna Publishers, New Delhi, 2019.
4.	Ravindranath. B and Chander, N, “Power System Protection and Switchgear”, New Age International, 2018 ,2nd edition.

E-References:

1.	NPTEL Course: Power System Protection - Prof. S.A. Soman, IIT-B.
2.	NPTEL Course: Power System Protection – organized by IIT-B.
3.	www.cdeep.iitb.ac.in. (Electrical Engineering)

CO/PO Mapping

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

18EE702	INDUSTRIAL MANAGEMENT AND ECONOMICS	L	T	P	C
		3	0	0	3

Course Objectives:

1	To understand the concept of management , economics and Indian financial system

Unit I	MODERN CONCEPT OF MANAGEMENT	9	+	0

Scientific management-Functions of management-Planning-Organising- Staffing-Directing- Motivating-Communicating- Co-ordinating- Controlling-Organisational structures- Line, Line and staff and Functional relationships- Span of control- Delegation- Management by Objectives.

Unit II	PERSONNEL MANAGEMENT	9	+	0

Objectives and functions of personnel management- Recruitment-Selection and training of workers- Labour Welfare- Industrial Fatigue- Industrial disputes-Trade Unions- Quality circles. Formation of companies: Proprietory-Partnership-Joint stock companies- Public sector- Joint sector and Co-operative sector.

Unit III	MARKETING MANAGEMENT	9	+	0

Pricing- Promotion- Channels of distribution- Market research-Advertising. Production Management: Batch and mass production- Inventory control- EOQ-Project planning by PERT/CPM- Construction of Network (Basic ideas only).

Unit IV	BASICS OF ECONOMICS	9	+	0

Theory of demand and supply- Price mechanism- Factors of production- Land, labour, capital and organization- National income- Difficulties in estimation- Taxation- Direct and indirect taxes- Progressive and regressive- Black money- Inflation-Causes and consequences.

Unit V	INDIAN FINANCIAL SYSTEM	9	+	0

Reserve bank of India: Functions- Commercial banking system-Development financial institutions- IDBI- ICICI- SIDBI- IRBI- NABARD- Investment institutions-UTI- Insurance companies- Indian capital market- Stock market- Functions- Role of the public sector- Privatisation- Multinational corporations and their impact on the Indian economy

Total 45+0)=45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Understand the conceptsof managment
CO2	:	Understand various types of managment.
CO3	:	Understand the Indian economics
CO4	:	Manage an organization efficiently for its upliftment
CO5		Apply marketing concept to any organization to earn more profit.

Text Books:

1.	O P Khanna , “Industrial Management” , Dhanpat Rai Publications,4th edition, 1980.
2.	Philip Kotler, Kevin Lane Keller, SweeHoon Ang, Chin Tiong Tan, Siew Meng Leong, “Marketing Management: An Asian Perspective” Pearson Education Limited, 7th Edition, 2017
3	A. N. Agrawal, “Indian Economy”,Vikas Publishing House PVT, 4th edition, 1978.

Reference Books:

1	K. K. Ahuja, “Industrial management” Khanna Publishers, 1978.
2	K.K Dewett, Shyam Lal , “Modern economic theory” S Chand and Company Limited, 2008

CO/PO Mapping

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

18EE703	POWER SYSTEMS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	Hands - on and computational experiments related to various power system problems.
2.	Programming of numerical methods for solution of various power system operation and control problems.

Experiments

1. Formation of bus admittance matrix.
2. Bus impedance matrix formulation.
3. Load flow analysis using Gauss Seidel method.
4. Power flow analysis using Newton Raphson method.
5. Transient stability analysis: Single machine infinite bus system.
6. Transient stability analysis of multi machine power systems.
7. Load frequency control of single area and two area power systems.
8. Economic dispatch by lambda iteration method.
9. Solution to combined economic emission dispatch problems.
10. Thermal unit commitment using priority list method.

Total (0+45) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Formulate power system network matrices.
CO2	:	Get knowledge about power flow analyses.
CO3	:	Analyse power system stability problems.
CO4	:	Formulate and solve power system operational problems.
CO5	:	Allocate system load to various generators in the system economically

Reference Books:

1. Hadi Saadat, “Power System Analysis”, Tata McGraw Hill, 2010.
2. Kothari D.P and Dhillon J.S, “Power System Optimization”, Prentice Hall of India, New Delhi, 2004.

E-References:

1. NPTEL Course: Power Systems Engineering – Prof. Debapriya Das, IIT-K.
2. NPTEL Course: Computer Aided Power System Analysis – Prof. Biswarup Das, IIT-R.
3. www.cdeep.iitb.ac.in. (Electrical Engineering)

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	1	2	2	1	1	1	2	1	1	1	2	2
CO2	1	2	1	1	1	1	1	1	1	1	2	2
CO3	1	2	2	2	1	1	1	1	2	2	1	2
CO4	1	2	2	2	1	1	2	1	1	2	2	2
CO5	1	2	2	2	1	1	2	1	1	2	2	2

18EE704	ELECTRICAL DRIVES AND CONTROL LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To impart knowledge on Performance of the fundamental control practices associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using power electronics
2.	To impart industry oriented learning
3.	To evaluate the use of computer-based analysis tools to review the major classes of machines and their physical basis for operation

Experiments:

1	Study of thysistor controlled DC Drive using PSPICE / MATLAB / PSIM Software
2	Study of Chopper fed DC Drive using PSPICE / MATLAB / PSIM Software
3	Study of AC Single phase motor-speed control using TRIAC.
4	PWM Inverter fed 3 phase Induction Motor control using PSPICE / MATLAB / PSIM Software
5	VSI / CSI fed Induction motor Drive analysis using MATLAB/DSPICE/PSIM Software
6	Study of V/f control operation of 3F induction motor drive using PSPICE / MATLAB / PSIM Software
7	Study of permanent magnet synchronous motor drive fed by PWM Inverter using Software
8	Regenerative / Dynamic braking operation for DC Motor - Study using software
9	Regenerative / Dynamic braking operation of AC motor - Study using software

Total (0+45) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Set up control strategies to synthesize the voltages in dc and ac motor drives
CO2	:	Develop testing and experimental procedures applying basic knowledge in electronics, electrical circuit analysis, electrical machines, microprocessors, and programmable logic controllers
CO3	:	Use standard methods to determine accurate modeling/simulation parameters for various general-purpose electrical machines and power electronics devices required for designing a system and solve drives related problems
CO4	:	Combine the use of computer-based simulation tools relevant to electrical Drives with practical laboratory experimentation.
CO5	:	Design VSI/CSI for induction motor using any simulation software.

Text Books:

1.	Seung-Ki Sul, "Control of Electric Machine Drive Systems" , John Wiley & Sons, Ltd., 2011.
2.	ShaahinFilizadeh ,"Electric Machines and Drives,", CRC Press,2013.
3	Haitham Abu-Rub, Atif Iqbal, JaroslawGuzinski,"High Performance Control of AC Drives with Matlab/Simulink Models"John Wiley & Sons, Ltd., 2012.

Reference Books:

1	Werner Leonhard ,"Control of Electrical Drives",Springer, 2006.

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	2	1	1				1	1
CO2	1	2	2	2	2	1	1				1	1
CO3	1	2	2	2	2	1	1				1	1
CO4		1	2	2	2	1	1				1	1
CO5		1	2	2	2	1	1				1	1

PROGRAMME ELECTIVES

18EEP01	ELECTRICAL MACHINE DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To Study mmf calculation and thermal rating of various types of electrical machines
2.	To Design armature and field systems for D.C. machines.
3.	To Design core, yoke, windings and cooling systems of transformers.
4.	To Design stator and rotor of induction machines.
5.	To Design stator and rotor of synchronous machines and study their thermal behaviour

UNIT I	INTRODUCTION	9	+	0

Major considerations – Limitations – Electrical Engineering Materials – Space factor – temperature gradient – Heat flow in two dimensions – thermal resistivity of winding – Temperature gradient in conductors placed in slots – Rating of machines – Eddy current losses in conductors – Standard specification

UNIT II	DC MACHINES	9	+	0

Magnetic circuit calculations – Net length of Iron –Real & Apparent flux densities – Design of rotating machines – D.C machines output equations – Main dimensions-Selection of number of poles – Armature design – Design of commutator and brushes-Design of slot, air gap, field coils.

UNIT III	TRANSFORMERS	9	+	0

KVA output for single and three phase transformers – Window space factor – Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise of Transformers– Design of Tank with & without cooling tubes – Thermal rating – Methods of cooling of Transformers – Design of chokes – Design of welding Transformers – Design of CTs &PTs.

UNIT IV	INDUCTION MOTORS	9	+	0

Output equation of Induction motor – Main dimensions –Length of air gap- Rules for selecting rotor slots of squirrel cage machines– Design of rotor bars & slots – Design of end rings – Design of wound rotor-Operating characteristics –Short circuit current –Dispersion co efficient – relation between D & L for best power factor.

UNIT V	SYNCHRONOUS MACHINES	9	+	0

Runaway speed – construction – output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length– Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Introduction to computer aided design – Program to design main dimensions of Alternators.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Know the philosophy of design and thermal rating of Electrical machines.
CO2	:	Remember for the component of magnetic and electrical loading of AC and DC Machines.
CO3	:	Design Armature and Field Systems for DC Machines.
CO4	:	Design core, windings and cooling system of transformers.
CO5	:	Design Stator and rotor of Induction Machines.
CO6	:	Design Rotor of synchronous machines and understand their thermal behaviour.

Text Books:

1.	Sawhney, A.K., 'A Course in Electrical Machine Design', Dhanpat Rai & Sons, New Delhi, 2010,6th edition.

2.	Sen.,S.K., 'PrinciplesofElectricalMachineDesignswithComputerProgrammes', OxfordandIBHPublishingCo.Pvt.Ltd.NewDelhi,2014,3rd edition.
Reference Books:	
1.	R.K.Agarwal, Principles of Electrical Machine design, S.K. Kataria and Sons, Delhi 2014 5th edition.
2.	V.N. Mittle, ' Design of Electrical Machines', Standard Publications and Distributors, Delhi, 2002.
E- References	
1	http://cusp.umn.edu/machine_design.php

CO/PO Mapping

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

18EEP02	BIOLOGY FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

The purpose of this course is to provide a basic and easy understanding of modern biology to engineers as it is a multi – disciplinary field. It emphasis on the basic engineering principles of bimedicalequipments. In addition, the course is expected to encourage the engineering students to think about solving biological problems with engineering tools. These will be gained by the following:

1.	An understanding of biological mechanisms of living organisms from the perspective of engineers.
2.	To Understand the principles of Biomedical Equipments.
3.	An understanding of the function and regulation of human system and acquire knowledge about biological problems that requires engineering expertise to solve them.
4.	An Understanding of the basics of molecular biology and genetics.
5.	To know about the radiation safety instruments and X Ray examinations.
6.	To evaluate the kinetics and thermodynamics of enzymatic process.

Unit I	BIOMOLECULES AND METABOLISM	9	+	0

Carbohydrates- classification - Glycolysis- definition- flow chart- steps involved in glycolysis- preparatory phase and pay off phase- kinds of reactions in glycolysis. Photosynthesis- definition- significance photosynthetic-pigments types- structure of pigments factors affecting photosynthesis- external and internal factors.

Unit II	BASICS OF ENZYMES, MACROMOLECULES AND NUCLEIC ACIDS	9	+	0

Introduction - Enzymes – Proteases and amylases. Proteins- classification- structure of proteins- primary, secondary, tertiary and quaternary structure- properties of proteins- physical and chemical properties: protein synthesis. Types-Structural components of nucleic acids- acid, pentose sugar and nitrogenous base- nucleoside – nucleotide and its functions - single and double helical structure of DNA-comparison between DNA and RNA-types of RNA -mRNA, tRNA and rRNA and their function.

Unit III	X RAY EXAMINATIONS	9	+	0

Blood cell counter – Electron microscope – radiation detectors – photo meters and colorimeters – digital thermometer – audio meters – X-ray tube – X-ray machine – Radiography and fluoroscopy – image intensifiers – angiography – applications of X-ray examination.

Unit IV	HUMAN PHYSIOLOGY	9	+	0

Cells and their structure – Transport of ions through the cell membrane – resting and action potential – bio-electric potential. Physiology of Human body- Brain, heart, lungs - Cardiovascular system - Respiratory system - nervous system. Design of medical instruments components of biomedical instrument systems – electrodes – micro, needle, surface electrode - transducers.

Unit V	BIOMEDICAL EQUIPMENTS AND RADIATION SAFETY INSTRUMENTS	9	+	0

Pacemakers – Pacemaker batteries – Defibrillators – heart lung machine. Surgical diathermy – short wave diathermy – microwave diathermy – ultrasonic diathermy – therapeutic effect of heat – range and area of irritation of different diathermy techniques – Ventilators – oxymeters.

Radiation safety instrumentation – physiological effects due to 50 Hz current passage – Micro shock and macro shock – electrical accidents in hospitals – Devices to protect against electrical hazards. Nuclear imaging techniques – computer tomography – thermography – ultrasonic imaging system – Magnetic resonance imaging – Positron emission tomography – digital subs traction angiography.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Be aware that all types of life have the identical structural units.
CO2	:	Explain, analyze, diagnose, and develop new therapies to treat disease and heal damaged tissues and organ systems.
CO3	:	To teach the working principles of biomedical equipments.

CO4	:	Explain human physiological systems.
CO5	:	Share knowledge in genetics and molecular biology.
CO6	:	Know about the applications and implementation of medical equipments as it is a challenging interdisciplinary process

Text Books:

1.	FJ.L.Jain, Sanjay jain and Nitin jain- "Fundamentals of Biochemistry" - Sixth edition, S.Chand and company Ltd., Ram nagar, 2005.
2.	Dr.A.V.S.S.Rama Rao-" Text book of Biochemistry"- Text book of Biochemistry- First edition- UBS Publishers' Distributors Pvt. Ltd., 2019
3.	U. Satyanarayana –" Biochemistry"-5th edition – Sri Padmavathi Publications Ltd.,2017.
4.	N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, "Biology: A global approach", Pearson Education Ltd, 2014.
5.	Dr.M.Arumugam, 'Bio-Medical Instrumentation', Anuradha Agencies, 2012.
6.	Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, 'Bio-Medical Instrumentation andMeasurements', II edition, Pearson Education, 2011 / PHI.

Reference Books:

1.	Stent, G. S.; and Calender-" Molecular Genetics"- Second edition - R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
2.	By Nelson, D. L.; and Cox- "Principles of Biochemistry"- V Edition- M. M.W.H. Freeman and Company
3.	Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H-" Outlines of Biochemistry"- John Wiley and Sons
4.	Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, 'Biological Science', Pearson Education India, 2016.
5.	Reinhard Renneberg, Viola Berkling and Vanya Loroch, 'Biotechnology for Beginner's', Academic Press, 2017.
6.	S Balaji, S Lakshminarayanan, "Conceptual comparison of metabolic pathways with electronic circuits", Journal of Bionics Engineering, Vol 1, Issue 3, pg 175-182, 2004
7.	R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd.,2012.
8.	L.A. Geddes and L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', John Wiley &Sons, 2011.
9.	C.Rajarao, 'Medical Instrumentation', John Wiley & Sons,2013.
10.	C.Rajarao and S.K. Guha, 'Principles of Medical Electronics and Bio-medical Instrumentation',Universities press (India) Ltd, Orient Longman ltd, 2012.

E-Reference:

1	www.onlinecourses.nptel.ac.in/

CO/PO Mapping

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

18EEP03	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To classify signals and systems & their mathematical representation.
2.	To analyze the discrete time systems.
3.	To study various transformation techniques & their computation.
4	To study about filters and their design for digital implementation.
5	To study about a programmable digital signal processor & quantization effects.

UNIT I	INTRODUCTION TO SIGNALS AND SYSTEMS	9	+	0

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.

UNIT II	DISCRETE TIME SYSTEM ANALYSIS	9	+	0

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z transform, application t discrete systems - Stability analysis, frequency response –Convolution – Discrete TimeFouriertransform magnitude and phase representation.

Unit III	DISCRETE FOURIER TRANSFORM & COMPUTATION	9	+	0

Discrete Fourier Transform- properties, magnitude and phase representation - Computation of DFT using FF algorithm – DIT &DIF using radix 2 FFT – Butterfly structure.

Unit IV	DESIGN OF DIGITAL FILTERS	9	+	0

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice o windows – Linear phase characteristics. Analog filter design – Butterworth and Chebyshev approximations; II Filters, digital design using impulse invariant and bilinear transformation - mWarping, pre warping.

Unit V	DIGITAL SIGNAL PROCESSORS	9	+	0

Introduction – Architecture – Features – Addressing Formats – Functional modes - Introduction to Commercial DSP Processors.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the types of systems and signals.
CO2	:	Solve problems in digital system using Z transform.
CO3	:	Apply Fourier transforms for processing of digital signals.
CO4	:	Analyze digital systems using Fast Fourier transform.
CO5	:	Design digital filters algorithms in digital signal processor platforms
CO6	:	Gain knowledge about DSP processors.

Text Books:

1.	J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, 2007.
2.	S.K. Mitra, 'Digital Signal Processing – A Computer Based Approach', McGraw Hill Edu, 2013.
3.	Robert Schilling & Sandra L.Harris, "Introduction to Digital Signal Processing using Matlab", Cengage Learning, 2014.

Reference Books:

1.	Poorna Chandra S, Sasikala. B ,Digital Signal Processing, Vijay Nicole/TMH,2013.
2.	B.P.Lathi, 'Principles of Signal Processing and Linear Systems', Oxford University Press, 2010.
3.	Taan S. ElAli, 'Discrete Systems and Digital Signal Processing with Mat Lab', CRC Press, 2012.
4.	Sen M.kuo, woonseng…s.gan, "Digital Signal Processors, Architecture, Implementations & Applications, Pearson,2013.

E -References	
1	https://nptel.ac.in/courses/108105055/34
2	https://books.google.co.in/books/isbn=8131710009

CO/PO Mapping

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

18EEP04	DISCRETE CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the digital signal processing.
2.	To study the design of sampled data control systems in state space.
3.	To impart knowledge on digital control algorithms and stability study.

Unit I	INTRODUCTION	9	+	0

Review of frequency and time response analysis and specifications of continuous time systems - need for controllers - continuous time compensations - continues time PI, PD, PID controllers, Realization of basic compensators: Lag, Lead and Lag-Lead compensation schemes - problems.

Unit II	SIGNAL PROCESSING IN DIGITAL CONTROL	9	+	0

Need for digital control – Configuration of basic digital control scheme – Principles of signal conversion – Basi discrete-time signals – Time domain and frequency domain models for discrete-time systems - Aliasing Reconstruction of analog signals – Practical aspects of the choice of sampling rate – Discretization based o bilinear transformation.

Unit III	MODELING AND ANALYSIS OF SAMPLED DATA CONTROL SYSTEM	9	+	0

Differential equation description – Z-transform method of description– Z-transform analysis of sampled data control systems –Jury's stability test – Routh stability criterion on the r-plane – State variable concepts: First companion – Second companion – Jordan canonical models – Discrete state variable models – Elementary principles.

Unit IV	DESIGN OF DIGITAL CONTROL ALGORITHMS	9	+	0

Introduction – z-plane specifications of control system design –Digital lead , lag and lag-lead compensator desig using frequency response plots - Digital lead lag compensator design using Root locus plots – z-plane synthesi – Digital controllers for deadbeat performance - Examples.

Unit V	PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS	9	+	0

Development and implementation of digital PID control algorithms – Tunable PID controllers - Digital temperature control system: Control algorithm – Digital position control system: Digital measurement of shaft position/speed, control algorithm – Stepping motors and their controls: Torque-speed curves, Interfacing of stepper motors to microprocessors

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Get knowledge about digital control scheme.
CO2	:	Get knowledge about sampling techniques.
CO3	:	Design the various digital control algorithms.
CO4	:	Design the various types of digital controllers.
CO5	:	Design the various types of digital compensators.
CO6	:	Get knowledge about applications of digital control.

Text Books:

1.	M.Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 2003,2nd edition.
2.	I.J.Nagrath&M.Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 2009,5th edition.

Reference Books:

1.	B.C.Kuo, Digital Control Systems,Oxford University Press,2nd Edition,2007.
2.	K. Ogata, Modern Control Engineering, Pearson Education, 2010 5th edition.

3.	Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.
E -References	
1	https://nptel.ac.in/courses/108103008/
2	https://www.sciencedirect.com/topics/engineering/digital-control-system

CO/PO Mapping

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

18EEP05	HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To expose the various types of over voltage transients and their effect on power system.
2.	To introduce the concept of insulation co-ordination technique.
3.	To provide an overview of solid, liquid and gaseous dielectrics breakdown mechanism
4.	To show how to generate over voltages in the HV testing laboratory
5.	To show how to measure of high voltage and current quantity in HV testing laboratory
6.	To introduce testing procedure of HV power apparatus.

Unit I	OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS AND INSULATION CO-ORDINATION	9	+	0

Causes of over voltages and its effect on power system – Lightning, switching surges and temporary over voltages – Bewley lattice diagram-protection against over voltages; Principle of Insulation Coordination on High voltage and Extra high voltage power systems.

Unit II	ELECTRICAL BREAKDOWN IN GASES, LIQUIDS AND SOLIDS DIELECTRICS	9	+	0

Properties of Dielectric materials- Gaseous breakdown in uniform and non-uniform fields – corona discharges – Vacuum breakdown - conduction and breakdown in pure and commercial liquids dielectrics – breakdown mechanisms in solid and composite dielectrics- Application of insulating materials in electrical equipments.

Unit III	GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS	9	+	0

Generation of High DC voltages: Rectifiers, voltage multipliers and Vande Graff generator- Generation of High AC voltages: cascaded transformer, resonant transformer and tesla coil- Generation of High impulse voltages: single and multistage Marx circuits - Generation of switching voltages - Generation of impulse currents. Tripping and control of impulse generators.

Unit IV	MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS	9	+	0

Measurement of high DC, AC, impulse voltages – Measurement of high currents: Direct, Alternating and Impulse – digital techniques in impulse voltage and current measurements.

Unit V	HIGH VOLTAGE TESTING OF ELECTRICAL POWER APPARATUS	9	+	0

Overviews of International and Indian standards- laboratory test procedure: multi-level method, Up and Down method - HV Testing of Insulators and Bushings, Isolators and Circuit Breakers, Power transformers, Surge Arresters, Power capacitors and Cables.

Total (45+0)=45Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Understand various types of over voltages and its effect on power system.
CO2	:	Know generation of various over voltages in HV testing laboratories.
CO3	:	Know measurement of high voltage DC, AC and impulse quantities.
CO4	:	Know measurement of high current DC, AC and impulse quantities.
CO5	:	Understand high voltage breakdown phenomena in insulating materials.
CO6	:	Comprehend the test procedures as per the Indian standards.

Text Books:

1.	M.S. Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill Publishing Company Ltd, New Delhi ,Fifth Edition, 2013.

Reference Books:

1.	E. Kuffel W.S. Zaengl, and J.Kuffel , 'High Voltage Engineering Fundamentals', Newnes Publishers, second Edition, Elsevier, New Delhi,2005.

2.	C.L. Wadhwa, 'High Voltage Engineering', New Age International (P) Ltd Publishers, Third Edition, 2012
3.	Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International (P) Ltd Publishers, 4th Edition, 2011.
E-references	
1	www.onlinecourses.nptel.ac.in/noc18_ee41
2	NPTEL courses on High Voltage Engineering, IIT Kanpur.

CO/PO Mapping

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

18EEP06	HVDC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the concept, planning of DC power transmission and comparison with AC power transmission.
2.	To analyze HVDC converters.
3.	To study about the HVDC system control.
4.	To analyze harmonics and design of filters.
5.	To model and analysis the DC system under steady state.

Unit I	INTRODUCTION	9	+	0

DC Power transmission technology – Comparison of AC and DC transmission–Application of DC transmission – Description of DC transmission system– Planning for HVDC transmission–Modern trends in HVDC technology – DC breakers – Operating problems– HVDC transmission based on VSC –Types and applications of MTDC systems.

Unit II	ANALYSIS OF HVDC CONVERTERS	9	+	0

Line commutated converter-Analysis of Graetz circuit with and without overlap-Pulse number–Choice of converter configuration–Converter bridge characteristics–Analysis of 12 pulse converters –Analysis of VSC topologies and firing schemes

Unit III	CONVERTER AND HVDC SYSTEM CONTROL	9	+	0

Principles of DC link control–Converter control characteristics–System control hierarchy– Firing angle control– Current and extinction angle control–Starting and stopping of DC link–Power control –Higher level controllers – Control of VSC based HVDC link

Unit IV	REACTIVE POWER AND HARMONICS CONTROL	9	+	0

Reactive power requirements in steady state–Sources of reactive power–SVC and STATCOM–Generation of harmonics –Design of AC and DC filters –Active filters

Unit V	POWER FLOW ANALYSIS IN AC/DC SYSTEMS	9	+	0

Per unit system for DC quantities–DC system model –Inclusion of constraints –Power flow analysis–Case study.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Basic principles and types of HVDC system are studied.
CO2	:	Analyze the converters used in HVDC system are studied.
CO3	:	Familiarize with the HVDC control.
CO4	:	Gain knowledge about the reactive power management.
CO5	:	Design the filters to overcome harmonics.
CO6	:	Familiarize with the power flow analysis of HVDC system.

Text Books:

1.	Padiyar,K.R.,"HVDCpower transmission system",NewAg eInternational(P) Ltd., New Delhi, Second Edition, 2015
2.	Edward Wilson Kimbark,"DirectCurrent Transmission",Vol.I, Wiley Interscience, New York, London, Sydney,1971

Reference Books:

1.	Colin Adamson and HingoraniNG, "High Voltage Direct Current Power Transmission", Garraway Ltd, London,1977.
2.	Arrillaga,J.,"HighVoltage Direct Current Transmission",PeterPregrinus, London,1998,2nd edition

E- Reference:	
1	www.onlinecourses.nptel.ac.in/noc18_ee41

CO/PO Mapping

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

18EEP07	EHVAC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the concept and planning of HVAC power transmission.
2.	Evaluate EHVAC transmission system with all parameters
3.	Understand electrostatic effects in EHVAC transmission
4.	Understand effects of Corona in EHVAC transmission
5.	Select a suitable voltage controller for an EHVAC transmission system

Unit I	INTRODUCTION	9	+	0

Necessity of EHV AC transmission, advantages and problems, power handling capacity and line losses, mechanical considerations, resistance of conductors, temperature rise of conductors and current-carrying capacity, properties of bundled conductors – problems.

Unit II	LINE AND GROUND REACTIVE PARAMETERS	9	+	0

Inductance of EHV line configurations, line capacitance calculation, sequence inductances and capacitances, line parameters for modes of propagation, resistance and inductance of ground return.

Unit III	VOLTAGE GRADIENTS OF CONDUCTORS	9	+	0

Electrostatics, field of sphere gap, field of line changes and properties, charge – potential relations for multi-conductors lines, surface voltage gradient on conductors, distribution of voltage gradient on sub-conductors of bundle, effect of high electro static field on Humans, animals and plants.

Unit IV	CORONA EFFECTS	9	+	0

Power loss and corona loss, corona-loss formulae, charge-voltage (q–V) diagram and corona loss, attenuation of travelling waves due to corona loss, audible noise: generation and characteristics, limits for audible, audible noise measurement and meters, formulae for audible noise and its use in design, relation between single-phase and three-phase AN levels example.

Unit V	POWER FREQUENCY VOLTAGE CONTROL	9	+	0

Power circle diagram and its use - voltage control using synchronous condensers - cascade connection of shunt and series compensation - sub synchronous resonance in series capacitor - compensated lines - static VAR compensating system.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Learn about the trends in EHV AC Transmission and calculate Line inductance and capacitances of bundled conductors.
CO2	:	Calculate voltage gradient of bundled conductors
CO3	:	Understand the effects of corona like Audible noise
CO4	:	Understand the effect of Radio Interference and analyze travelling waves
CO5	:	Calculate electrostatic field of EHV AC lines
CO6	:	Analyze compensated devices for voltage control.

Text Books:

1.	R. D. Begamudre, “EHVAC Transmission Engineering” New Age International(P)Ltd., Third Edition,2014.
2.	S. Rao,“HVAC and DC Transmission 7 practice”,Khanna Publishers, Delhi, Third Edition, 1993.

Reference Books:

1.	Shobhit Gupta and Deepak Gupta,“ EHV AC/DC Transmission”,Engineering Books Publishers, 2014.

E- References:	
1	www.onlinecourses.nptel.ac.in
2	www.electrical-engineering-portal.com

CO/PO Mapping

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

18EEP08	FACTS CONTROLLERS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To Introduce the Reactive Power Control Techniques.
2.	To Educate on Static VAR Compensators and Their Applications
3.	To Provide Knowledge on Thyristor Controlled Series Capacitors
4.	To Educate on STATCOM Devices
5.	To Provide Knowledge on FACTS Controllers

Unit I	**INTRODUCTION**	**9**	**+**	**0**

Reactive Power Control in Electrical Power Transmission Lines -Uncompensated Transmission Line – Series Compensation – Basic Concepts of Static Var Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC).

Unit II	**STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS**	**9**	**+**	**0**

Voltage Control by SVC – Advantages of Slope in Dynamic Characteristics – Influence of SVC on System Voltage – Design of SVC Voltage Regulator –Modelling of SVC for Power Flow and Fast Transient Stability – Applications: Enhancement of Transient Stability – Steady State Power Transfer – Enhancement of Power System Damping.

Unit III	**THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS**	**9**	**+**	**0**

Operation of The TCSC – Different Modes of Operation – Modelling of TCSC – Variable Reactance Model – Modelling for Power Flow and Stability Studies. Applications: Improvement of the System Stability Limit – Enhancement of System Damping

Unit IV	**VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**	**9**	**+**	**0**

Static Synchronous Compensator (STATCOM) – Principle of Operation – V-I Characteristics. Applications: Steady State Power Transfer-Enhancement of Transient Stability – Prevention of Voltage Instability. SSSC-Operation of SSSC and the Control of Power Flow –Modelling of SSSC In Load Flow and Transient Stability Studies.

Unit V	**CO-ORDINATION OF FACTS CONTROLLERS**	**9**	**+**	**0**

Controller Interactions – SVC – SVC Interaction – Co-Ordination of Multiple Controllers Using Linear Control Techniques – Control Coordination Using Genetic Algorithms.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Analyze Power System Operation, Stability, Control and Protection.
CO2	:	Analyze and develop analytical model of FACTS controller for power system application.
CO3	:	Apply knowledge in load compensation techniques.
CO4	:	Analyze the performance of steady state and transients of facts controllers.
CO5	:	Apply knowledge in advanced FACTS controllers.

Text Books:

1.	R.Mohan Mathur, Rajiv K.Varma, “Thyristor – Based Facts Controllers For Electrical Transmission Systems”, IEEE Press And John Wiley & Sons, Inc, 2011.
2.	Narain G. Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi- 110 006, 2011.
3.	K.R.Padiyar,” FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Limited, Publishers, New Delhi, 2014.

Reference Books:	
1.	A.T.John, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 2019.
2.	V.K.Sood,”HVDC And FACTS Controllers – Applications of Static Converters in Power System”, APRIL 2004 , Kluwer Academic Publishers, 2004.
3.	Xiao – Ping Zang, Christian Rehtanz And Bikash Pal, “Flexible AC Transmission System: Modelling and Control” Springer, 2012.
E-Reference:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EEP09	POWER QUALITY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Introduce the power quality terms and definitions
2.	Understand the sources and issues of various power quality problems.
3.	Gain in-depth knowledge of the mitigation/ suppression techniques of voltages sags, interruptions and harmonics.
4.	Introduce the computer tools for transient's analysis.
5.	Expose the various methods of power quality monitoring.

Unit I — INTRODUCTION TO POWER QUALITY — 9 + 0

Terms and definitions of Power quality, General classes of power quality problems: transients- long duration voltage variations- short duration voltage variations, voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations-International standard of power quality-CBEMA and ITI curves.

Unit II — VOLTAGE SAGS AND LONG DURATION VOLTAGE VARIATIONS — 9 + 0

Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of voltage sag Protection –voltage sag mitigation solution at the End-User level- Evaluating the economics of different ride-through alternatives –Motor Starting sags.

Long Duration voltage variations: Principles of regulating the voltage – devices for voltage regulation-utility voltage regulator application- capacitor for voltage regulation- End user capacitor application-–**Flicker**: sources and mitigation techniques.

Unit III — TRANSIENT OVERVOLTAGE — 9 + 0

Sources of transientover voltage- Principles of overvoltage Protection- Devices for mitigation of over voltages – Utility capacitor-switching transients – Utility system lightning protection - Managing Ferro resonance- switching transients problems with loads - computer tools for transients analysis: PSCAD and EMTP.

Unit IV — HARMONICS — 9 + 0

Fundamentals of Harmonics: Harmonic Distortion, voltage versus current distortion, Harmonics versus transients- harmonics phase sequences- triplen harmonics -harmonic indices, harmonic sources from commercial and industrial loads. Locating harmonic sources - power system response characteristics – Effects of Harmonics Distortion –Interharmonics - harmonic distortion evaluations, Principles and devices for controlling harmonic distortion, IEEE and IEC standards on harmonics.

Unit V — POWER QUALITY MONITORING AND DISTRIBUTED GENERATION — 9 + 0

Monitoring considerations - power quality measurement equipment: disturbance analyser, spectrum and harmonics analysers, flicker meters, applications of Intelligent system for power quality monitoring Distributed Generation: perspectives - DG technologies - power quality issues by DG - operating conflicts

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the definitions and characterization of various power quality issues.
CO2	:	Comprehend the sources of sag & long duration voltage variations and its control methods
CO3	:	Comprehend the sources of transient overvoltage and principle of control methods
CO4	:	Analyse harmonics problem and apply filters to suppress harmonics in distribution system
CO5	:	Understand the operation and application of power quality measuring equipment.
CO6	:	Know PQ issues by Distributed Generation integration with grid.

Text Books:

1.	Roger. C. Dugan, Mark. F. McGranaghan, Surya Santoso, H.WayneBeaty, “Electrical Power Systems Quality”, Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2012.

Reference Books:	
1.	C. Sankaran ,"Power quality", CRC Press, First Indian Edition, 2019.
2.	G.T.Heydt, "Electric power quality", Stars in a Circle publishers, Second Edition, 1994.
3.	Arindam Ghosh **and** Gerald **Led wich**, "Power Quality Enhancement Using Custom Power Devices", Springer-Verlag Publishers, New York Inc., Second Edition.2009.
E-Reference:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EEP10	UTILIZATION OF ELECTRICAL ENERGY	L	T	P	C
		3	0	0	3

Course Objectives

1.	To understand the generation of electrical power by conventional and non-conventional methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

Unit I	INTRODUCTION	9	+	0

Generation of electrical power by conventional & non-conventional methods – a brief review of tidal power, wind power, geothermal power, solar energy, hydro station, steam and nuclearpower plants.
Economics of generation – definitions – load duration curve – number and size ofgenerator units – Cost of electrical energy – tariff – need for electrical energy conservation –methods.

Unit II	ILLUMINATION	9	+	0

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lightingand sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energyefficiency lamps – types of lighting schemes – requirements of good lighting

Unit III	HEATING AND WELDING	9	+	0

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arcwelding-electrical properties of arc-applications of electric arc welding.

Unit IV	ELECTRIC TRACTION	9	+	0

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speedcontrol of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

Unit V	DRIVES AND THEIR INDUSTRIAL APPLICATIONS	9	+	0

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concept of generation of electrical power from conventional and non-conventional energy resources.
CO2	:	Understand the economic aspects connected with power system.
CO3	:	Understand the concept behind illumination and design a suitable illumination system for a specific application.
CO4	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.
CO5	:	Understand the concepts and recent trends of traction system.
CO6	:	Understand the concepts of electric drives and their characteristics.

Text Books:

1.	C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt.Ltd, 2015.

2.	Eric Openshaw Taylor, “Utilisation of Electric Energy”, English Universities Press Limited, 2009
3.	J.B. Gupta, “Utilization of Electric Power and Electric Traction”, S.K.Kataria and Sons, 2013.
Reference Books:	
1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, “A Course in Utilization of Electrical Energy”, Khanna Publishers, Delhi, 2003.
2.	H. Partab, “Art and Science of Utilization of Electrical Energy”, Dhanpat Rai and Co, New Delhi, 2004.
E-Reference	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

18EEP11	ELECTRICAL ENERGY CONSERVATION AND AUDITING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario on India.
2.	To understand the energy conservation concepts.
3.	To know about energy auditing.

Unit I	ENERGY SCENARIO	9	+	0

Commercial and Non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms -Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Unit II	ENERGY SOURCES	9	+	0

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Unit III	ENERGY MANAGEMENT AND AUDIT	9	+	0

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

Unit IV	ENERGY EFFICIENCY	9	+	0

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

Unit V	ENERGY EFFICIENT TECHNOLOGIES	9	+	0

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors -Softstarters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the present energy scenario.
CO2	:	Get fundamental knowledge about energy and its various forms.
CO3	:	Understand the process of energy management and energy auditing.
CO4	:	Understand the methods improving energy efficiency and energy efficient devices.
CO5	:	Conduct Energy Audit in industry.

Text Books:

1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2017.
2.	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.

Reference Books:	
1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2.	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.
E-References:	
1.	www.bee-india.nic.in
2.	NPTEL Course: Non-Conventional Energy Resources – Prof. PrathapHaridoss, IIT-M.
3.	NPTEL Course: Energy Management Systems and SCADA, 2015 organised by IIT-M.

CO/PO Mapping

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

18EEP12	POWER SYSTEM OPERATION AND CONTROL		L	T	P	C
			3	0	0	3

Course Objectives:

1	To get an overview of system operation and control.
2	To understand and model power-frequency dynamics and to design power-frequency controller.
3	To understand and model reactive power-voltage interaction and different methods of control for maintaining voltage profile against varying system load.
4	To study the economic operation of power system
5	To teach about SCADA and its application for real time operation and control of power systems

Unit I	OVERVIEW OF POWER SYSTEM OPERATION AND CONTROL	9	+	0

System load variation: System load characteristics, load curves -daily, weekly and annual, load-duration curve, load factor, diversity factor - Reserve requirements: Installed, spinning , cold and hot reserves. Overview of system operation: Load forecasting, unit commitment, load dispatching. Overview of system control: Governor control, LFC, EDC, AVR, system voltage control, security control.

Unit II	REAL POWER - FREQUENCY CONTROL	9	+	0

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases; Multi-area systems: Two-area system modeling: static analysis, uncontrolled case, tie-line with frequency bias control; state variable model- integration of economic dispatch control with LFC.

Unit III	REACTIVE POWER–VOLTAGE CONTROL	9	+	0

Typical excitation system, modeling, static and dynamic analysis, stability compensation; generation and absorption of reactive power: Relation between voltage, power and reactive power at a node; method of voltage control: Injection of reactive power, Tap-changing transformer, numerical problems - System level control using generator voltage magnitude setting, tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

Unit IV	ECONOMIC DISPATCH AND UNIT COMMITMENT	9	+	0

Incremental cost curve, co-ordination equations with and without loss, solution by direct method and Lambda - iteration method (No derivation of loss coefficients.)- Base point and participation factors- Economic dispatch controller added to LFC control.

Statement of Unit Commitment problem- Constraints in Unit Commitment: spinning reserve- thermal unit constraints- hydro constraints- fuel constraints and other constraints; Unit Commitment solution methods: Priority-list methods, forward dynamic programming approach, numerical problems only in priority-list method using full-load average production cost.

Unit V	COMPUTER CONTROL OF POWER SYSTEMSIN	9	+	0

EMS functions - Energy control centre functions: Monitoring, data acquisition and control, energy control centre levels - SCADA: system hardware configuration –master station-remote terminal units- and functions; Network topology determination- state estimation, security analysis and control - Various operating states: normal, alert, emergency, extremis and restorative; State transition diagram showing various state transitions and control strategies.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the overview of power system operation and control.
CO2	:	Design power-frequency controller for single and two area system

CO3	:	Understand reactive power control methods for maintaining voltage profile against varying system load.
CO4	:	Formulate the optimal scheduling problems in power system.
CO5	:	Get the knowledge about the computer control of power systems.

Text Books:

1.	Allen J. Wood and Bruce F.Wollenberg, “Power Generation, Operation and Control”, Wiley India Ltd, New Delhi, Second Edition, Reprint 2016.
2.	Olle. I. Elgerd, 'Electric Energy Systems Theory – An Introduction', Tata McGraw Hill Publishing Company Ltd, New Delhi, 34th reprint 2010.
3.	P. Kundur, 'Power System Stability & Control', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint 2011.

Reference Books:

1.	D.P. Kothari and I.J. Nagrath, 'Modern Power System Analysis', Fourth, Tata McGraw Hill Education Pvt., Limited, New Delhi, 2011.
2.	L.L. Grigsby, 'The Electric Power Engineering, Hand Book', CRC Press & IEEE Press, 2012

E-Reference

1	NPTEL courses on Power System Operation and Control, IIT, Bombay.
2.	NPTEL courses on Power System Generation, Transmission And Distribution, IIT Delhi.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1	1				1	1
CO2	2	2	2	2	2	2	2				2	2
CO3	1	1	1	1	1	1	1				1	1
CO4	2	2	2	2	2	2	2				2	2
CO5	2	2	2	2	2						1	1

18EEP13	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the concept of microgrid
2.	To impart knowledge about distributed generation technologies, their interconnection in grid
3.	To understand relevance of power electronics in DG,

Unit I	INTRODUCTION	9	+	0

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources

Unit II	DISTRIBUTED GENERATIONS (DG	9	+	0

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

Unit III	IMPACT OF GRID INTEGRATION	9	+	0

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

Unit IV	BASICS OF A MICROGRID	9	+	0

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids

Unit V	CONTROL AND OPERATION OF MICROGRID	9	+	0

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

Total (45+0)=45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Explain various distributed generation systems
CO2	:	Understand various developments happening in the field of Grid integration.
CO3	:	Understand the microgrids and their control schemes.
CO4	:	Implement distributed generation in a hilly or remote place
CO5	:	Configure a microgrid for a group of energy sources

Text Books:

1.	H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2018, 1st edition.
2.	M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.2007
3	Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.

Reference Books:	
1	John Twidell and Tony Weir, “Renewable Energy Resources” Tyalor and Francis Publications, 2015, 3rd edition
2	DorinNeacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006.
3	AmirnaserYezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2009
4	F. Katiraei, M.R. Iravani, ‘Transients of a Micro-Grid System with Multiple Distributed Energy Resources’, International Conference on Power Systems Transients (IPST’05) in Montreal, Canada on June 19-23, 2005.
5	Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson, ‘Facility Microgrids’, General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005
E-Reference	
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2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	1	2	1				2
CO2	1	2	2	2	2	1	2	1				2
CO3	1	2	2	2	2	1	2	1				2
CO4	1	2	2	2	2	1	2	1				2
CO5	1	2	2	2	2	1	2	1				2

18EEP14	WIND AND SOLAR ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Understand the concepts of power generation through Wind and Solar Power
2.	Learn optimal extraction of renewable power and their integration to grid

Unit I	PHYSICS OF WIND POWER	9	+	0

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions

Unit II	WIND GENERATOR TOPOLOGIES	9	+	0

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

Unit III	THE SOLAR RESOURCE	9	+	0

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Unit IV	SOLAR PHOTOVOLTAIC	9	+	0

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms.Converter Control.

Unit V	GRID INTEGRATION ISSUES	9	+	0

Overview of grid code technical requirements. Fault ride-through for wind farms – real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the physics behind the wind and solar power generation
CO2	:	Implementation of optimal extraction techniques in renewable power generation
CO3	:	Apply power electronics to renewable power optimization
CO4	:	Understand integration techniques used, power quality issues and their mitigation
CO5	:	Device methods to create an approximate energy conversion systems.

Text Books:

1.	Mohan, Net al. "Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 2008.
2.	Bimbhra, P.S, "Power Electronics ", Khanna Publishers, New Delhi, 4thEdition, 2018.

Reference Books:

1.	T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2012, 2nd edition.
2.	G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2013
3.	S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill, 2008.
4.	H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006
5.	G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.
6.	J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, 2013, 4th edition
7.	Rashid M.H., "Power Electronics: Circuits, Devices and Applications ", Pearson, 3rd Edition, 2013.

E-Reference	
1	www.onlinecourses.nptel.ac.in
	www.class-central.com

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1	1	1	0	1	1	1
CO2	1	1	1	1	1	1	1	1	0	1	1	1
CO3	1	1	1	1	1	1	1	1	0	1	1	1
CO4	1	1	1	1	1	1	1	1	0	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1

18EEP15	ELECTRICAL AND HYBRID VEHICLES		L	T	P	C
			3	0	0	3
Course Objectives:						
To understand the operation and need of electrical vehicles, hybrid vehicles with its energy storage technologies						
Unit I	**ELECTRIC VEHICLES**			**9**	**+**	**0**
Configurations of Electric Vehicles (EV), Performance of Electric Vehicles: Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Energy Consumption						
Unit II	**HYBRID ELECTRIC VEHICLES**			**9**	**+**	**0**
Concept of Hybrid Electric Vehicle (HEV) Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains and Parallel Hybrid Electric Drive Trains, Torque-Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains						
Unit III	**ELECTRIC PROPULSION SYSTEMS**			**9**	**+**	**0**
Functional block diagram of a typical electric propulsion system, Classification of electric motor drives for EV and HEV applications, Multiquadrant Control of Chopper-Fed DC Motor Drives, Performance Analysis and Control of BLDC Machines, Switched Reluctance Motor Drives, SRM Drive Converter, Generating Mode of Operation, Vibration and Acoustic Noise in SRM						
Unit IV	**ENERGY STORAGES**			**9**	**+**	**0**
Battery Technologies: Lead-Acid Batteries, Nickel-based Batteries, Lithium-Based Batteries – Ultracapacitors, Features, Basic Principles and its Performance, Ultracapacitor Technologies- Ultrahigh-Speed Flywheels, Operation and Power Capacity						
Unit V	**FUEL CELL VEHICLES**			**9**	**+**	**0**
Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell Electric Vehicle – configuration and control strategy						
Total (45+0)= 45 Periods						

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the operation of Electrical Vehicles and its energy storage technologies.
CO2	:	Know Fuel cell, types and characteristics.
CO3	:	Operate the vehicle with BLDC and SRM motor drives
CO4	:	Design the EV’s and HEV’s.
CO5	:	Choose the energy storage technology for electric vehicle

Text Books:

1.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, ‘Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design’, CRC PRESS, New York, third edition, 2016

Reference Books:

1.	Iqbal Hussain ,“Electric and Hybrid Vehicles: Design Fundamentals” , CRC Press, Taylor & Francis Group, 3rd Edition (2021).
2.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,“Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010

E-Reference	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

CO/PO Mapping

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

18EEP16	SOFT COMPUTING AND MACHINE LEARNING	L	T	P	C
		3	0	0	3

Course Objectives:

1	To provide adequate knowledge about neural network and fuzzy systems
2	To provide adequate knowledge of genetic algorithms and its application to economic dispatch and unit commitment problems
3	To expose the students to the concepts of machine learning

Unit I	BASIC CIRCUITS ANALYSIS	9	+	0

Introduction – Biological neuron – Artificial neuron – Neuron model – Supervised and unsupervised learning-Single layer – Multi layer feed forward network – Learning algorithm- Back propagation network- Feedback networks

Unit II	NETWORK REDUCTION AND NETWORK THEOREMS FOR DC AND AC CIRCUITS	9	+	0

Classical sets – Fuzzy sets – Fuzzy relations – Fuzzification – Defuzzification – Fuzzy rules – Membership function – Knowledge base – Decision-making logic – Introduction to neuro fuzzy system- Adaptive fuzzy system- Fuzzy logic control: Home heating system – fuzzy PID control, Fuzzy based motor control.

Unit III	GENETIC ALGORITHMS	9	+	0

Introduction-Gradient Search – Non-gradient search – Genetic Algorithms: binary and real representation schemes, selection methods, crossover and mutation operators for binary and real coding – constraint handling methods – applications to economic dispatch and unit commitment problems.

Unit IV	MACHINE LEARNING MODELS	9	+	0

Generative models: Definition and characteristics, probabilistic graphical models, density estimation in learning

Unit V	MACHINE LEARNING CLASSFIERS	9	+	0

Combining classifiers: Advantages, boosting, hierarchical classifiers, and issues; Selected special topics such as manifold learning and case studies.

Total (45+0)=45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	:	Ability to understand and apply basic science, circuit theory, Electro-magnetic field theory control theory and apply them to electrical engineering problems.
CO2	:	To understand and apply computing platform and software for engineering problems.
CO3	:	To understand machine learning concepts and apply for engineering problems.
CO4	:	Solve economic dispatch and unit commitment problem using genetic algorithm
CO5	:	Design a fuzzy controller based home heating system

Text Books:

1.	LauranceFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks',Pearson Education, 2010
2.	S.N.Sivanandam and S.N.Deepa,' Principles of Soft computing, Wiley India Edition, 2nd Edition, 2013
3	Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997.
4	S. Marsland, 'Machine Learning: An Algorithmic Perspective', Chapman & Hall/CRC, 2009.

Reference Books:

1	Simon Haykin, 'Neural Networks', Pearson Education, 2009 ,3rd edition.
2	Hagan, Demuth, Beale, " Neural Network Design", Cengage Learning, 2012.
3	N.P.Padhy, " Artificial Intelligence and Intelligent Systems", Oxford, 2013.
4	I. H. Witten, Data Mining: Practical Machine Learning Tools And Techniques, 2nd Edn., Elsevier India, 2011.
5	C. . Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2008.

E-References:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

CO/PO Mapping

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

18EEP17	ADVANCED ELECTRIC DRIVES	L	T	P	C
		3	0	0	3

Course objectives:

1.	To know about the overview of Electrical drives.
2.	To know about the Vector control strategies for AC motor drives.
3.	To understand the concepts of various DSP based control.

UNIT I	POWER CONVERTERS FOR AC DRIVES	9	+	0

PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.

UNIT II	INDUCTION MOTOR DRIVES	9	+	0

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).

UNIT III	SYNCHRONOUS MOTOR DRIVES	9	+	0

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

UNIT IV	PERMANENT MAGNET MOTOR AND SWITCHED RELUCTANCE MOTOR DRIVES	9	+	0

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives. Various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

UNIT V	DSP BASED MOTION CONTROL	9	+	0

Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Explain DSP based motion control.
CO2	:	Understand the basics of Permanent magnet motor and Switched reluctance motor drives.
CO3	:	Learn the concepts of Synchronous motor drives.
CO4	:	Gain knowledge of Induction motor drives.
CO5	:	Apply Power converters for AC drives.

Text Books:

1.	B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2.	P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.

Reference Books:

1.	H. A. Taliyat and S. G. Campbell, “ DSP based Electromechanical Motion Control” , CRC press, 2013.
2.	R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2010,1st edition.

E-References

1	https://nptel.ac.in/courses/

CO/PO Mapping

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

18EEP18	COMPUTATIONAL ELECTROMAGNETICS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study the fundamental concepts and analytical methods.
2.	To give basic knowledge on finite difference methods.
3.	To understand the concept of variable methods.
4.	To provide adequate knowledge on moment methods.
5.	To gain knowledge on finite element method.

Unit I	FUNDAMENTAL CONCEPTS AND ANALYTICAL METHODS	9	+	0

Review of EM theory – Classification of EM problems – Superposition principle – Uniqueness theorem - Separation of variables in three coordinate systems – Series expansion – Practical applications: Scattering by dielectric sphere, scattering cross sections.

Unit II	FINITE DIFFERENCE METHODS	9	+	0

Finite difference schemes – Finite differencing of Parabolic, Hyperbolic and Elliptic PDEs – Accuracy and stability of FD solutions – Practical applications: Transmission lines, Yee's finite difference algorithm – Finite differencing for non-rectangular systems – Numerical integration: Euler's rule, Trapezoidal rule, Simpson's rule.

Unit III	VARIABLE METHODS	9	+	0

Operators in linear spaces – Calculus of variations – Construction of functional from PDEs – Rayleigh-Ritz method – Weighted Residual method – Collocation method: Subdomain method, Galerkin method, Least Squares method – Eigen value problems.

Unit IV	MOMENT METHODS	9	+	0

Differential equations – Integral equations – Green's functions – Applications: Quasi-static problems, Scattering by conducting cylinder, Hallen's IE, Pocklington's IE, Expansion and weighting functions, EM absorption in the human body.

Unit V	FINITE ELEMENT METHOD	9	+	0

Solution of Laplace's equation – Solution of Poisson's equation – Solution of the wave equation – Automatic mesh generation: Rectangular domains, Arbitrary domains – Bandwidth reduction – Higher order elements – Three-dimensional elements – Infinite element method – Finite-element time-domain method.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the fundamental concepts of field theory and analytical methods.
CO2	:	Understand the finite difference methods and applications.
CO3	:	Analyze the Variable methods of electromagnetics.
CO4	:	Analyze the concepts of Moment methods.
CO5	:	Gain knowledge on the concept of finite element method.

Text Books:

1.	Matthew N.O. Sadiku, "Computational Electromagnetics with MATLAB", CRC Press, 4th Edition, 2018.
2.	Matthew N.O. Sadiku, "Elements of Electromagnetics", CRC Press, 7th Edition, 2021.

Reference Books:

1.	Thomas Rylander, Par Ingelstorm, "Computational Electromagnetics", Springer Publications, 2017.

E-Reference:

1.	www.onlinecourses.nptel.ac.in

CO/PO Mapping

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

18EEP19	SPECIAL ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

Course Objectives:

1	Learn the fundamental concepts of special electric machines
2	Learn proper selection of special machines based on applications

Unit I	SYNCHRONOUS RELUCTANCE MOTORS	9	+	0

Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor

Unit II	PERMANENT MAGNET BRUSHLESS D.C. MOTORS	9	+	0

Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control.

Unit III	PERMANENT MAGNET SYNCHRONOUS MOTORS	9	+	0

Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

Unit IV	SWITCHED RELUCTANCE MOTORS	9	+	0

Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control.

Unit V	STEPPING MOTORS	9	+	0

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the principles behind the principle of operation of different special machines
CO2	:	Apply the electromagnetic concepts in development of EMF and Torque in machines
CO3	:	Select the control structure in terms of hardware to control the special machines
CO4	:	Select appropriate control techniques for efficient control of special machines
CO5		Develop strategy and methods to implement suitable application-based projects

Text Books:

1	T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989. 2nd edition
2.	P.P. Acarnley, "Stepping Motors – A Guide to Motor Theory and Practice", Peter Perengrinus, London, 1982.
3	R. Krishnan, "Switched reluctance motor drives", CRC Press, 2017.
4	R. Krishnan , "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, 2010

E-References:

1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	0	1	1	0	1	1	1
CO2	1	1	1	1	1	0	1	1	0	1	1	1
CO3	1	1	1	1	1	1	1	1	0	1	1	1
CO4	1	1	1	1	1	1	1	1	0	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1

18EEP20	ELECTRICAL WIRING, ESTIMATION AND COSTING	L	T	P	C
		3	0	0	3

Course Objectives

1.	Knowledge of I.E rules for different types of electrical installations.
2.	Planning and preparation of different installation projects
3.	Knowledge on the costing and estimates of different installations.
4.	Knowledge on repairs and maintenance of electrical equipment.

Unit I	ELECTRICAL WIRING AND INDIAN ELECTRICITY RULES	9	+	0

Electrical symbols, need of electrical symbols, examples of wiring and schematic diagram, Electrical tools, precautions in handling the tools, wiring system, sizes of wires, stranded wires, types of wires, wire splicing and termination, difference between neutral and earth wire, domestic and industrial panel wiring. Testing tools. Indian Electricity rules for wiring, Installation of earth electrode as per I.E rule. Indian Electricity Act-2003.

Unit II	ESTIMATION AND COSTING OF DOMESTIC AND INDUSTRIAL WIRING	9	+	0

General principles of estimation - Electrical Schedule of rates, catalogues, Survey and source selection, Recording estimates Quantity and cost of material required. Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills.
Domestic & Industrial wiring : layout, load calculation, cable selection, earthing, selection of switchgear, overall estimating and costing.

Unit III	ESTIMATION OF OVERHEAD TRANSMISSION LINES	9	+	0

Main components of overhead lines, Line supports, Factors governing height of pole, Conductor materials, size of conductor for overhead transmission line, cross arms, pole brackets and clamps, guys and stays, conductors configuration spacing and clearances, span lengths, overhead line insulators, insulator materials lightning arrestors, erection of supports, setting of stays, earthing of lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between conductors, I.E rules pertaining to LV transmission lines.

Unit IV	ESTIMATION OF OVERHEAD AND UNDERGROUND DISTRIBUTIONSYSTEM AND SUBSTATION INSTALLATIONS	9	+	0

Overhead distribution system and underground distribution system : materials and accessories required for the overhead distribution system, estimate for 440V/3-phase/ 4 wires or 3 wires overhead distribution system, types of service connections, method of installation of service connection(1-phase and 3-phase), I.E. rules pertaining to overhead lines and service connection.
Classification of substation, selection and location of site for substation, main electrical connections, graphical symbols for various types of apparatus and circuit elements on substation, main connection diagram, key diagram of typical sub stations, equipment for substation and switchgear installations, substation auxiliaries supply, substation earthing.

Unit V	ESTIMATING AND COSTING OF REPAIRS AND MAINTENANCE OF ELECTRICAL DEVICES AND EQUIPMENT	9	+	0

D.O.L. starter, small motor, automatic electric iron, table/ceiling fan, ICDP/ICTP Switch, preparation of detailed drawing work of the product, preparation of material quantity sheet for the product, materials and cost required for maintenance work, estimation of repairing cost and overall cost, tools used for repairs &maintenance work Preparation of cost schedule for repair and maintenance of
electric fan, automatic electric iron, single phase transformer, mixer grinder, D.O.L. Starter.

Total (45+0)= 45 Periods

Course Outcome:

Upon completion of this course, the students will be able to:

CO1	:	To understand various types of materials required for wiring.
CO2	:	To comprehend the estimation of a domestic and industrial installation.
CO3	:	To know different systems of earthing.

CO4	:	To prepare detail estimate and costing of overhead transmission line, overhead and underground distribution projects following IE rules.
CO5	:	To comprehend the estimation of substations.
CO6	:	To prepare estimates for repairs and maintenance of electrical devices and equipment

Text Books:

1.	Raina K. B. and Bhattacharya S.K. " Electrical Design, estimating & Costing", New Age International (p) Limited, New Delhi,2017 2nd edition.
2.	Gupta J.B. , "Electrical Installation Estimating & Costing", S. K. Kataria& Sons, New Delhi,2015.
3.	Uppal S.L. "Electrical Estimating & Costing", New Age International (p) Limited, New Delhi ,2018

Reference Books:

1.	SurjithSingh,"Electrical Estimating and Costing", Danpat Rai &Co2016.
2.	CEA Regulations 2019
3.	I.E rules for wiring and supply act manuals.

E-Reference:

1	www.onlinecourses.nptel.ac.in

CO/PO Mapping

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

18EEP21	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the statistical approach for quality control.
2.	To Learn about the TQM principle.
3.	To introduce the concept of statistical process control
4.	To provide awareness on TQM standards
5.	To create an awareness about the ISO and QS certification process and its need for the industries

Unit I	INTRODUCTION	9	+	0

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

Unit II	TQM PRINCIPLES	9	+	0

Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

Unit III	STATISTICAL PROCESS CONTROL (SPC)	9	+	0

The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.

Unit IV	TQM TOOLS	9	+	0

FBenchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

Unit V	QUALITY SYSTEMS	9	+	0

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the importance of quality, leadership and motivation in TQM
CO2	:	Understand the problem of customers and continuous process improvement in supplier partnership, selection and rating
CO3	:	Recall the seven traditional tools, management tools and sigma concepts in TQM
CO4	:	Identify the TQM tools and know the performance measures, quality control in TQM
CO5	:	Understand the need for various quality control systems and quality auditing
CO6	:	Perform the case study on ISO 9000 and 14000.

Text Books:

1.	Dale H.Besterfiled, et al., “Total Quality Management”, Pearson Education, Inc. 2018. . ISBN 81-297-0260-6.2018

Reference Books:	
1.	James R.Evans& William M.Lidsay, "The Management and Control of Quality", (5th Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
2.	Feigenbaum.A.V. "Total Quality Management, McGraw Hill, 2004.
3.	Oakland.J.S. "Total Quality Management Butterworth " Hcinemann Ltd., Oxford. 1989.
4.	Narayana V. and Sreenivasan, N.S. "Quality Management – Concepts and Tasks", New Age International 1996.
5.	Zeiri. "Total Quality Management for Engineers", Wood Head Publishers, 1991.
E-References:	
1	http://textofvideo.nptel.ac.in/video.php?courseId=110104080
2	https://nptel.ac.in/courses/110104085/

CO/PO Mapping

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

18EEP22	RESTRUCTURED POWER SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1	Know about the implementation of power Systems based on applications
2	Learn various safety equipment and their installations
3	Get a clear awareness about automation in power Systems

Unit I	POWER SYSTEM RESTRUCTURING	9	+	0

Introduction –Deregulation - Need for deregulation – Power system restructure models - Electricity Market Participants – GENCOS- DISCOS- TO- ISO- PX- SC - trading arrangements - Operational Planning Activities (OPA) of Electricity Market Participants - Causes of restructuring- types and effects of restructuring – restructure models

Unit II	ELECTRICAL UTILITY	9	+	0

Electrical utility restructuring Power System Operation in competitive environment –Electricity Market Models (PoolCo- bilateral- hybrid)- Components of restructured system - Power Sector restructuring and influence on environment - Functions and responsibilities of PX- ISO- RTO and ITP - Electric Utility Market – Market Models - wholesale electricity market characteristic – Electricity Market types (energy- ancillary services- transmission- forward- real time) – Market power evaluation and mitigation

Unit III	EVALUATION OF TRANSMISSION SYSTEM	9	+	0

Electricity pricing and Transmission pricing in a restructured market - Congestion management in a deregulated market – Available Transfer Capabilities (ATC) of transmission system – Application of Monte Carlo Simulation in ATC calculation – ATC calculation with sensitivity analysis method - Tagging Electricity Transaction – Tagging process – Implementation- Curtailment and cancellation of transaction - Availability Based Tariff

Unit IV	OPTIMUM POWER FLOW (OPF) ANALYSIS IN MARKET ENVIRONMENT	9	+	0

Introduction – Approaches to OPF – Application of OPF analysis in Electricity and Power Markets with Electricity Market Participants – Power Flow Tracing – current decomposition axioms- Mathematical model of loss allocation- usage sharing problem on transmission facilities - Methodology of graph theory - Economic issues- Mechanism and transmission issues in the new market environment.

Unit V	AGC IN RESTRUCTURED POWER SYSTEM	9	+	0

Introduction – Traditional Vs Restructured Scenario –AGC in New market environment - Block diagram and State Space representation of a two-area interconnected power system in deregulated environment – Load-Frequency Control (LFC) dynamics and Bilateral Contacts – Modelling- DISCO Participation Matrix (DPM)- Generation Participation Matrix (GPM).

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Select appropriate electrical utility based on applications
CO2	:	Design power system according to requirements
CO3	:	Design an electrical market model
CO4	:	Understand proper selection of automation in power systems
CO5	:	Design load frequency control scheme for two area interconnected systems.

Text Books:

1.	Loi Lei Lai, "Power System Restructuring and deregulation"- John Wiley & Sons,2001
2	Md.Shahidehpour, MuwaffagAlmoush, "Restructured Electric Power System – Operation- Trading and Volatility", Marcel Dekker Inc, New York, 2001.
3.	Arthur.R.Bergen, Vijay Vittal, "Power System Analysis," Prentice Hall, New Jersey, 2000

Reference Books:	
1	Xi Fan,Wang, Yonghua Song, Malcolm Irving, “Modern Power System Analysis”, Springer, 2008
2	Das D, “Electrical Power Systems”, New Age International (P) Ltd, New Delh,- 2008.
3	Iiic M, Galiana F, Fink L, “Power Systems Restructuring” Norwell MA Kluwer 1998
4	Philipson. L, Willis H.Le, “Understanding Electric Utilities and de-regulation”, Marcel Dekker Inc Publishers, New York, 2006
E-Reference	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

CO/PO Mapping

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

18EEP23	INDUSTRIAL ELECTRICAL SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1	Know about the implementation of Electrical Systems based on applications
2	Learn various safety equipment and their installations
3	Get a clear awareness about automation in Electrical Systems

Unit I	**ELECTRICAL SYSTEM COMPONENTS**	**9**	**+**	**0**

LT system wiring components, select ion of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, RCCB inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

Unit II	**RESIDENTIAL AND COMMERCIAL ELECTRICAL SYSTEMS**	**9**	**+**	**0**

Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

Unit III	**ILLUMINATION SYSTEMS**	**9**	**+**	**0**

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

Unit IV	**INDUSTRIAL ELECTRICAL SYSTEM**	**9**	**+**	**0**

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

Unit V	**INDUSTRIAL ELECTRICAL SYSTEM AUTOMATION**	**9**	**+**	**0**

Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Select appropriate switchgears based on applications
CO2	:	Design electrical wiring system according to requirements
CO3	:	Design an illumination system for different types of constructions
CO4	:	Understand proper selection of automation in electrical systems
CO5	:	Develop need based projects.

Text Books:

1.	S.L. Uppal and G.C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008. K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
2.	S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 2010,2nd edition.
3.	Web site for IS Standards. 2021
4.	H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

E-References:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	0	1	1	1	1	0	0	0	1
CO2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1

18EEP24	SMART GRID	L	T	P	C
		3	0	0	3

Course Objectives:

1	To introduce communication technologies, advanced Metering infrastructure and high-performance computing for Smart Grid.

Unit I	INTRODUCTION TO SMART GRID	9	+	0

Definitions and Need for Smart Grid, Today's Electric Grid versus Smart Grid, key aspects of Smart Grid development, Smart Grid architecture, Functions of Smart Grid Components, challenges and benefits.

Unit II	COMMUNICATION TECHNOLOGIES	9	+	0

Communication infrastructure for the Smart Grid, IEEE 802 architecture and, communication technologies specified under IEEE 802, Wireless LANs, ZigBee and 6LoWPAN, ZigBee communication network for smart metering, Power line communication, Standards for smart metering, Modbus, DNP3, IEC 61850 data structure and usage.

Unit III	CONTROL AND AUTOMATION TECHNOLOGIES	9	+	0

Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Demand-side integration (DSI): Definitions and services provided by DSI, Substation automation equipment: architecture, components and functions, Intelligent electronic devices (IED), Relay IED, Bay controller.

Unit IV	TRANSMISSION AND DISTRIBUTION MANAGEMENT SYTSEMS	9	+	0

Structure of Energy management systems**-** Phasor measurement units- Wide-Area Measurement for transmission Systems- Structure and main components of Distribution Management System- Supervisory Control and Data Acquisition- Customer information system

Unit V	ENERGY STORAGE SYSTEM	9	+	0

Need of Energy Storage for the smart grid- Energy storage technologies - Flow battery - Fuel cell and hydrogen electrolyser - Superconducting magnetic energy storage systems - Supercapacitors

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concepts of Smart Grid and its present developments.
CO2	:	Get acquainted with the smart resources and devices
CO3	:	Acquire knowledge of automation and control infrastructure.
CO4	:	Select an energy storage system and its integration with Smart Grids
CO5	:	Identify suitable communication networks for smart grid applications

Text Books:

1.	James Momoh "SMART GRID Fundamentals of Design and Analysis", Wiley, 2012.
2.	Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "SmartGrid: Technology and Applications", Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015

CO/PO Mapping

PO / CO	PO1	PO2	PO3	PO	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1				3		2	1		1			1
CO2		2	3	1				1			1	
CO3			2		2					2		
CO4	2				3	1	3				2	
CO5		3		2				1	2			2

OPEN ELECTIVES

18EEOE1	RENEWABLE ENERGY SOURCES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To impart knowledge on the Awareness about renewable Energy Sources and technologies.
2.	To impart knowledge on the Recognize current and possible future role of renewable energy sources.

Unit I	**INTRODUCTION**	**9**	**+**	**0**

World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy Utilisation – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials – Achievements / Applications – Economics of Renewable Energy Systems.

Unit II	**SOLAR ENERGY**	**9**	**+**	**0**

Solar Radiation – Measurements of Solar Radiation – Flat Plate and Concentrating Collectors – Solar Direct Thermal Applications – Solar Thermal Power Generation – Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications.

Unit III	**WIND ENERGY**	**9**	**+**	**0**

Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects.

Unit IV	**BIO – ENERGY**	**9**	**+**	**0**

Biomass Direct Combustion – Biomass Gasifiers – Biogas Plants – Digesters – Ethanol Production – Bio Diesel – Cogeneration – Biomass Applications.

Unit V	**OTHER RENEWABLE ENERGY SOURCES**	**9**	**+**	**0**

Tidal Energy – Wave Energy – Open and Closed Ocean Thermal Energy Conversion(OTEC) Cycles – Small Hydro-Geothermal Energy – Hydrogen and Storage – Fuel Cell Systems – Hybrid Systems.

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Create awareness about renewable Energy Sources and technologies.
CO2	:	Apply knowledge in solar energy.
CO3	:	Understand basics about biomass energy.
CO4	:	Apply adequate inputs on a variety of issues in harnessing renewable Energy.
CO5	:	Apply knowledge to recognize current and possible future role of renewable energy sources.
CO6	:	Apply knowledge in various renewable energy resources and technologies and their applications.

Text Books:

1.	Rai. G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2011.
2.	Twidell, J.W. & Weir, A., “Renewable Energy Sources”, EFN Spon Ltd., UK, 2009.

Reference Books:

1.	Sukhatme. S.P., “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2009,3rd edition.
2.	Godfrey Boyle, “Renewable Energy, Power for A Sustainable Future”, Oxford University Press, U.K., 2012. 3rd edition.
3.	Tiwari. G.N., Solar Energy – “Fundamentals Design, Modelling & Applications”, Narosa Publishing House, New Delhi, 2002.
4.	Freris. L.L., “Wind Energy Conversion Systems”, Prentice Hall, UK, 1990.
5.	Johnson Gary, L. “Wind Energy Systems”, Prentice Hall, New York, 1985

6.	David M. Mousdale – “Introduction to Biofuels”, CRC Press, Taylor & Francis Group, USA 2010
7.	Chetan Singh Solanki, Solar Photovoltaics, “Fundamentals, Technologies and Applications”, PHI Learning Private Limited, New Delhi, 2009.

E-References:

1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

CO/PO Mapping

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

18EEOE2	SMART GRID TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To introduce communication technologies, infrastructure and high performance computing for Smart Grid.

Unit I	INTRODUCTION TO SMART GRID	9	+	0

Definitions and Need for Smart Grid, key aspects of Smart Grid development, Smart Grid architecture, Functions of Smart Grid Components, challenges and benefits.

Unit II	COMMUNICATION TECHNOLOGIES	9	+	0

Communication infrastructure for the Smart Grid, IEEE 802 architecture and, communication technologies specified under IEEE 802, Wireless LANs, ZigBee and 6LoWPAN, ZigBee communication network for smart metering.

Unit III	AUTOMATION TECHNOLOGIES	9	+	0

Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Intelligent electronic devices (IED), Relay IED, Bay controller.

Unit IV	ENERGY MANAGEMENT SYTSEMS	9	+	0

Structure of Energy management systems- Phasor measurement units - Supervisory Control And Data Acquisition- Customer information system

Unit V	ENERGY STORAGE SYSTEMS	9	+	0

Need of Energy Storage for the smart grid- Energy storage technologies - Flow battery - Fuel cell - Superconducting magnetic energy storage systems - Supercapacitors

Total (45+0) = 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concepts of Smart Grid and its present developments.
CO2	:	Get acquainted with the smart resources and devices
CO3	:	Acquire knowledge of automation and control infrastructure.
CO4	:	Select an energy storage system and its integration with Smart Grids
CO5	:	Identify suitable communication networks for smart grid applications

Text Books:

1.	James Momoh "SMART GRID Fundamentals of Design and Analysis", Wiley, 2015.
2.	Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "SmartGrid: Technology and Applications", Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015

CO/PO Mapping

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

18EEOE3	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario on India.
2.	To understand the energy conservation concepts.
3.	To know about electrical energy management.

Unit I	ENERGY SCENARIO	9	+	0

Energy scenario of India – Present non-renewable energy scenario – Gross domestic product- Energy intensity – Current energy production and pricing – Energy security - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Unit II	BASICS OF ENERGY	9	+	0

Introduction – Work, power and energy – Electricity basics – Thermal energy basics – Energy units and conversions – Energy performance – Matching energy usage to requirement.

Unit III	ENERGY CONSERVATION APPROACHES	9	+	0

Energy saving opportunities in electric motors, Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc., Energy conservation by industrial drives, Methods and techniques of energy conservation in ventilation and air conditioners, compressors pumps, fans and blowers. Energy conservation in electric furnaces, ovens and boilers., lighting techniques – Natural , CFL, LED lighting sources and fittings.

Unit IV	ENERGY MANAGEMENT	9	+	0

Demand side management (DSM)– DSM planning – DSM Techniques – Load management as a DSM satergy – energy conservation – tarrif options for DSM - Energy audit – instruments for energy audit – Energy audit for generation, distribution and utilization systems – economic analysis.

Unit V	ENERGY EFFICIENT TECHNOLOGIES	9	+	0

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors -Softstarters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the present energy scenario.
CO2	:	Get fundamental knowledge about energy and its various forms.
CO3	:	Understand the process of energy management and energy auditing.
CO4	:	Understand the methods improving energy efficiency and energy efficient devices.
CO5	:	Familiarize the role of energy efficient devices in energy conservation

Text Books:

1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2.	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.

Reference Books:

1.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-1, General Aspects (available online).
2.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-3, Electrical Utilities (available online)
3.	Murphy. W.R and McKay G “Energy Management” Butterworths Publications, London, 1982.
4.	Wayne C Tuner, “Energy Management Hand Book” John Wiley and Sons, 2011,7th edition..

E-References:	
1.	www.bee-india.nic.in
2.	NPTEL Course: Non-Conventional Energy Resources – Prof. PrathapHaridoss, IIT-M.
3.	NPTEL Course: Energy Management Systems and SCADA, 2015 organised by IIT-M.

CO/PO Mapping

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

18EEOE4	ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives

1.	To understand the components of Electric Vehicle and its global and Indian scenario.
2.	To understand the types of Electric Vehicle and its architectural design.
3.	To analyze the performance of different types of motor and its electrical and mechanical connections.
4.	To analyse the energy storage performance and battery management systems.
5.	To understand the types of charging stations and its components.

Unit I	**INTRODUCTION TO ELECTRIC VEHICLES**	**9**	**+**	**0**

Components of Electric Vehicle, Comparison with Internal combustion Engine : Technology, Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels, EV Terminology, Global and Indian Scenario: Technology Scenario, Market scenario, Policies and Regulations,

Unit II	**ELECTRIC VEHICLE ARCHITECTURE DESIGN**	**9**	**+**	**0**

Types of Electric Vehicle and components, Electrical protection and system requirement, Photovoltaic solar based EV design, Battery Electric vehicle (BEV), Hybrid electric vehicle (HEV) , Plug-in hybrid vehicle (PHEV), Fuel cell electric vehicle (FCEV), Electrification Level of EV, Comparison of fuel Vs electric and solar power, Solar Power operated Electric vehicles.

Unit III	**ELECTRIC DRIVE AND CONTROLLER**	**9**	**+**	**0**

Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers, Component sizing.
Physical locations, Mechanical connection of motor, Electrical connection of motor.

Unit IV	**ENERGY STORAGE SOLUTIONS AND BATTERY MANAGEMENT SYSTEM**	**9**	**+**	**0**

Cell Types (Lead Acid/Li/NiMH),Battery charging and discharging calculation, Cell Selection and sizing, Battery lay outing design, Battery Pack Configuration, Battery Pack Construction, Battery selection criteria. Need of BMS, Rule based control and optimization based control, Software-based high level supervisory control, Mode of power, Behavior of motor, Advance Features.

Unit V	**ELECTRIC VEHICLES CHARGING STATION**	**9**	**+**	**0**

Type of Charging station, Selection and Sizing of charging station, Components of charging station, Single line diagram of charging station.

Total (45+0)= 45 Periods

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the concept of Electric Vehicle technology
CO2	:	Understand the types of EV and analyse their characteristics.
CO3	:	Analyse the selection and sizing of drive and controller.
CO4	:	Analyse and interpret the battery calculations and configurations.
CO5	:	Understand the control of battery management system
CO6	:	Understand and analyse the sizing of charging station

Text Books:

1.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi,Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design, CRC PRESS, New York, third edition, 2016

2.	Iqbal Hussain "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Taylor &Francis Group, Second Edition (2011).
Reference Books:	
1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010
2.	Standards. IEC IEC 60068-2 (1,2,14,30),IEC 61683,IEC 60227,IEC 60502 IEC 60947 part I,II, III ,IEC 61215
E-References:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

CO/PO Mapping

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

PROTOSEM COURSES SYLLABUS

18MEPS11	APPLIED DESIGN THINKING			Semester			VI
PREREQUISITES			Category	PE	Credit		3
			Hours/Week	L	T	P	TH
				3	0	0	3
Course Learning Objectives							
1	The course enables product innovators and early-stage startup founders to learn the customer development process						
2	To familiarize with the tools & techniques & validate the inherent risks by linking their progress to customer-motivation, customer-commitment & customer-acceptance.						
3	To learn the system thinking concepts by reverse engineering technique.						
Unit I	DESIGN THINKING PRINCIPLES			9	0	0	9
Exploring Human – Centered Design – Understanding the innovation process, discovering areas of opportunity, interviewing &empathy –building techniques, Mitigate validate risk with FIR(Forge Innovation Rubric) – Case Studies.							
Unit II	CUSTOMER-CENTRIC INNOVATION			9	0	0	9
Importance of customer-centric innovation – Problem Validation and Customer Discovery – Understanding problem significance and problem incidence- Customer Validation. Target user, User persona & user stories. Activity : Customer development process – Customer interviews and field visit.							
Unit III	APPLIED DESIGN THINKING TOOLS			9	0	0	9
Concept of Minimum Usable Prototype(MUP) – MUP challenge brief – Designing & Crafting the value proposition – Designing and Testing Value Proposition: Design a compelling value proposition: Process, tools and techniques of Value Proposition Design.							
Unit IV	CONCEPT GENERATION			9	0	0	9
Solution Exploration, Concepts Generation and MUP design – Conceptualize the solution concept: explore, iterate and learn; build the right prototype: Assess capability, usability and feasibility. Systematic concept generation; evaluation technology alternatives and the solution concepts.							
Unit V	SYSTEM THINKING & REVERSE ENGINEERING			9	0	0	9
System Thinking, Understanding Systems, Examples and Understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components – Re-Engineering a complex system.							
							Total = 45 Periods

Text Books:	
1	Steve Blank, (2013), The four steps to epiphany: Successful strategies for products that win, Wiley.
2	Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, Trish Papadakos, (2014), Value
3	Proposition Design: How to Create Products and Services Customers Want, Wiley
4	Donella H. Meadows, (2015), “Thinking in Systems -A Primer”, Sustainability Institute.
5	Tim Brown,(2012) “Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation”, Harper Business.

Reference Books:	
1	https://www.ideou.com/pages/design-thinking#process
2	https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations-49f253c a8624
3	https://blog.forgeforward.in/product-innovation-rubric-adf5ebdfd356
4	https://blog.forgeforward.in/evaluating-product-innovations-e8178e58b86e
5 6	https://blog.forgeforward.in/user-guide-for-product-innovation-rubric-857181b253dd 6 https://blog.forgeforward.in/startup-failure-is-like-true-lie-7812cdfe9b85

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Define & treat various hypotheses to mitigate the inherent risks in product innovations	L1: Remembering
CO2	Design the solution concept based on the proposed value by exploring various alternate solutions to achieve value-price fit.	L6: Creating
CO3	Develop skills in empathizing, critical thinking, analyzing, storytelling & pitching.	L3: Applying
CO4	Apply system thinking to reverse engineer a product/prototype and understand its internal correlations.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1	1	1	1	1	1	1	2	2	3
CO2	2	2	3	2	2	1	1	1	1	1	1	1	3	3	2
CO3	1	2	2	1	1	3	1	1	3	3	1	1	1	1	1
CO4	2	3	3	3	3	2	2	1	2	2	1	1	3	3	3
AVG	**1.75**	**2.5**	**2.5**	**2.25**	**2**	**1.75**	**1.25**	**1**	**1.75**	**1.75**	**1**	**1**	**2.25**	**2.25**	**2.25**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS12	STARTUP FUNDAMENTALS				Semester		VI
PREREQUISITES			**Category**		**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	Learn the science of to transforming an innovative idea into high-growth enterprises.
2	To understand the basic concepts of IPR, and develop a patent draft for a potential IP

Unit	Title	L	T	P	TH
Unit I	**ENTREPRENEURIAL MINDSET & METHOD**	**9**	**0**	**0**	**9**
Introduction to Innovation-led, tech-powered entrepreneurship - Understand from research the attributes of an expert entrepreneur - Effectuation principles - Dealing with the unknowns - Case studies of startup failures.					
Unit II	**IDEA TO ENTERPRISE**	**9**	**0**	**0**	**9**
Design and Planning of Product Concept - Business Model - Business Planning - Building Proof of Product and Value Testing - Target Market and Revenue Planning					
Unit III	**MINIMUM VIABLE BUSINESS**	**9**	**0**	**0**	**9**
Framework for Minimum Viable Business - Disruptive Innovation - Theory of Disruption - Competitive advantage - Building proof of viable business model - Demystifying Scalability - Funding Opportunities					
Unit IV	**INTELLECTUAL PROPERTY**	**9**	**0**	**0**	**9**
Introduction and the need for Intellectual Property Rights - IPR Genesis and Development - Copyright - Trademark - Trade Secret - Geographical Indicators - Industrial Designs - Types of Patent – Sample Patent Application - IPR in INDIA; Global trends - Patent fees					
Unit V	**PRIOR ART SEARCH AND PATENT DRAFTING**	**9**	**0**	**0**	**9**
Prior Art Search - IP Licensing – IP Commercialization - IP Infringement- Case Study on Apple vs Samsung, Case study on basmati rice. The invention as a concept - Keywords formation - Structure of patent - Key attributes in patent drafting - Drafting provisional specifications - Drafting complete specifications - Draft claims - Case studies on patent drafting					
					Total = 45 Periods

Text Books:

1	Steven Blank and Bob Dorf, (2012), The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch
2	Dr Saras Sarasvathy, (2008), Effectuation: Elements of Entrepreneurial Expertise, New Horizons in Entrepreneurship series.
3	Elizabeth Verkey, (2005), Law of Patents, Eastern Book Company
4	Prabuddha Ganguli, (2017), Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education; 1st edition

Reference Books:	
1	WIPO Intellectual Property Handbook https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
2	https://assets.entrepreneur.com/static/20220301113822-Marketing.pdf
3	https://www.deluxe.com/blog/startup-fundamentals-guide/
4	https://www.forbes.com/sites/allbusiness/2018/07/15/35-step-guide-entrepreneurs-starting-a-business/?sh=69a6031e184b

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop an entrepreneurial mindset to identify, assess, shape & act on opportunities.	L3: Applying
CO2	Demonstrate the potential of an innovative idea to create economic value, as a startup	L2: Understanding
CO3	Understand the scientific process to explore a viable business model	L2: Understanding
CO4	Demonstrate knowledge on the fundamental concepts of Intellectual Property	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	2	1	2	2	2	3	3	1	1	2
CO2	2	2	3	1	1	1	1	2	2	1	3	2	2	2	2
CO3	1	2	2	2	1	1	1	1	1	1	3	2	1	1	1
CO4	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1
AVG	**1.25**	**1.75**	**2**	**1.25**	**1**	**1.25**	**1**	**2**	**1.5**	**1.25**	**2.5**	**2**	**1.25**	**1.25**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS13	COMPUTATIONAL HARDWARE			Semester			VI
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To learn basic concepts of Embedded Systems by familiarizing the functionalities of embedded platforms with development boards.
2	To understand the core concepts of GPIO Pins, Functionality of peripherals, Selection of I/O devices , Usage of Internal functions, and Communication protocols.
3	To familiarize the current technologies and protocols used in the Internet of Things (IoT) and to learn the Cloud services.

Unit I	**BASICS OF EMBEDDED SYSTEM**	**9**	**0**	**0**	**9**

Embedded Platform: Architecture and working - Factors for Microcontroller/Microprocessor selection. Arduino - Boards and schematics – Tool chain - Setup and Configuration - Input/Output Configurations and Access - Libraries - Digital I/O - ADC - Analog I/O - Timers, Interrupts - Pulse Width Modulation - Display: 7-segment , LCD , OLED.

Unit II	**BASICS OF RASPBERRY PI**	**9**	**0**	**0**	**9**

Raspberry Pi: Raspberry pi Board - Processor - Setup and Configuration - Installing Python IDLE using Command Terminal - General Purpose I/O Pins - Protocol Pins - GPIO Access - Pulse Width Modulation - Network Libraries - Web services - Twitter APIs - Twitter Bot - Interfacing pi with camera modules.

Unit III	**SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**

Interfacing of Sensors and Actuators - Sensors: Introduction, Characteristics: Analog - Potentiometer, Temperature Sensor, Soil Moisture Sensor, LDR - Digital - PIR Sensor, Smoke Sensor, Infrared - Sensor, Ultra- Sonic Sensor. Actuators - Introduction, Characteristics and working with relay, DC motors, Servo motor, Stepper motor and its drivers.

Unit IV	**COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Protocols - Wired: RS232 Standard - UART, SPI, I2C - Comparative study of wired protocols - Implementation of wired Serial Communication protocols Wireless: Standards - Bluetooth, RF - Comparative study of wireless protocols - Implementation of wireless Serial Communication protocols.

Unit V	**INTERNET OF THINGS**	**9**	**0**	**0**	**9**

Definition and Architecture of IoT, Building blocks of IoT, Programming with IoT protocols - MQTT, CoAP - Connecting embedded target board to Web, Basics networking in IoT: creating a web page - Creating a server on target board - Controlling I/O peripherals from the webpage, Embedded Application Development, Creating communication between different nodes - Cloud platforms for IoT, Cloud data logging and monitoring, Interfacing with web services.

Total = 45 Periods

Text Books:

1	Raj Kamal, “ Embedded Systems - SoC, IoT, AI and Real-Time Systems”, 4th Edition, McGraw Hill, 2020.
2	Mohit Arora, “Embedded System Design”, 1st Edition, Learning Bytes Publishing, 2016.
3	Elecia White, “Making Embedded Systems”, 1st Edition, Shroff/ O’ Reilly, 2012.
4	Jack Ganssle, “ The Firmware Handbook”, 1st Edition, Newnes, 2004.

Reference Books:	
1	https://juniorfall.files.wordpress.com/2011/11/arduino-cookbook.pdf
2	https://drive.google.com/file/d/13s0m3lHPEFP2f2aCuVNRWeBZNKXWKTW5/view?ts=6231cab 3
3	https://ptolemy.berkeley.edu/books/leeseshia/releases/LeeSeshia_DigitalV2_2.pdf 4.
4	https://www.riverpublishers.com/pdf/ebook/RP9788793519046.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand and implement the functions & Capabilities of embedded platforms for easy prototyping.	L2: Understanding
CO2	Identify the type of sensors and actuators for required applications.	L3: Applying
CO3	Develop communication between devices using different protocols.	L3: Applying
CO4	Develop IoT based systems with wireless network connections and accessing devices over cloud.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	2	2	2	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
AVG	**3**	**2.25**	**2.75**	**2**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS14	CODING FOR INNOVATORS			Semester		VI
PREREQUISITES		Category			Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To learn and express creativity using coding skills.
2	To gain knowledge of Python programming with hands-on experience.
3	To demonstrate a problem solving using OOPs concepts.
4	To learn basics of Linux by familiarizing the concepts of management and file structure.
5	To practise full stack development using cloud platform.

Unit I	PROGRAMMING PARADIGMS	9	0	0	9

Need for programming - Outside box thinking to solve problems - Need for algorithms and data structures - Flowcharts & Algorithms - Memory Allocation - Conditions and loops - Creating effective functions - Case studies - Visual Programming - Types of programming languages & paradigms - Getting started with development - Build & test an algorithm - best practices

Unit II	BASIC OF PROGRAMMING	9	0	0	9

Introduction to Python: statements, variables, functions, operators, modules, conditional statements, loop statements, Lists: list operations, traversing a list, slicing a list - Text Handling: Strings, string functions, conversion functions, Dictionaries - File Operations: File open, close, read, copy, word frequency, creating word histograms from text file.

Unit III	OOPS 5	9	0	0	9

OOPS- Why OOPS- verticals- implementation in python - Classes and Objects, Methods, Constructors and Destructors, Inheritance, Polymorphism, Abstraction, Encapsulation.

Unit IV	SOFTWARE DEVELOPMENT TO DELIVERY	9	0	0	9

Software Engineering - Life Cycle (Tools), Agile Methodologies - Framework - Why Frameworks - Software Testing(Tool Based) - Data Structures - Database Management System - A case study to experiment from Development to Deployment(D2D) - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs AWS- Anaconda

Unit V	OPERATING SYSTEMS	9	0	0	9

Introduction to Linux - Process Management - Process Scheduling - Memory Management - Storage Management - System calls - File System Structure - Multithreading - Multicore Programming - Deadlock Handling - Disk Structure - Disk Management - Dockers - Kubernetes

Total = 45 Periods

Text Books:

1	Zed A. Shaw, “Learn Python 3 the Hard Way”, 3rd edition, Addison-Wesley Professional, 2013.
2	Silberschatz Abraham, “Operating System Concepts”, 9th edition, John Wiley & Sons Inc (Sea) Pte Ltd, 2016.
3	Paul Barry, "Head-First Python", 2nd edition, O'Reilly Media, Inc, 2016.
4	Anton Spraul, “Think Like a Programmer”, 1st edition, No Starch Press, 2012.

E-References :	
1	https://www.geeksforgeeks.org/python-programming-language/
2	https://www.guru99.com/python-tutorials.html
3	https://www.tutorialspoint.com/python/python_tutorial.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the aspects of programming protocols	L2: Understanding
CO2	Develop optimized code for real-world problems	L3: Applying
CO3	Build full-stack development to deployment	L3: Applying
CO4	Demonstrate problem solving and continuous development	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	0	0	0	0	0	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	1	3	0	0	0	0	0	0	0	3	2	2
CO4	2	3	2	1	2	0	0	0	0	0	0	3	2	1	1
AVG	**2.5**	**2.5**	**2.5**	**1.25**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**1.5**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS15	INDUSTRIAL DESIGN AND RAPID PROTOTYPING TECHNIQUES		Semester			VI
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	Learn to design a UI/UX design and develop an android application.
2	Provide working CAD model for prototype development.
3	Knowledge in hardware, 3D Printers and Laser cutters.
4	Acquire basic knowledge in designing electrical circuits and fabrication of electronic devices.

Unit I	UI / UX	9	0	0	9

Fundamental concepts in UI & UX - Tools - Fundamentals of design principles - Psychology and Human Factors for User Interface Design - Layout and composition for Web, Mobile and Devices - Typography - Information architecture - Colour theory - Design process flow, wireframes, best practices in the industry -User engagement ethics - Design alternatives

Unit II	APP DEVELOPMENT	9	0	0	9

SDLC - Introduction to App Development - Types of Apps - web Development - understanding Stack - Frontend - backend - Working with Databases - Introduction to API - Introduction to Cloud services - Cloud environment Setup- Reading and writing data to cloud - Embedding ML models to Apps - Deploying application.

Unit III	INDUSTRIAL DESIGN	9	0	0	9

Introduction to Industrial Design - Points, lines, and planes - Sketching and concept generation - Sketch to CAD - Introduction to CAD tools - Types of 3D modeling - Basic 3D Modeling Tools - Part creation - Assembly - Product design and rendering basics - Dimensioning & Tolerancing

Unit IV	MECHANICAL RAPID PROTOTYPING	9	0	0	9

Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - **Mechanical Prototyping:** 3DPrinting and classification - Laser Cutting and engraving - RD Works - Additive manufacturing

Unit V	ELECTRICAL RAPID PROTOTYPING	9	0	0	9

Electronic Prototyping: Basics of electronic circuit design - lumped circuits - Electronic Prototyping - Working with simulation tool - simple PCB design with EDA

Total = 45 Periods

Text Books:

1	Peter Fiell, Charlotte Fiell, Industrial Design A-Z, TASCHEN America Llc(2003)
2	Samar Malik, Autodesk Fusion 360 - The Master Guide.
3	Steve Krug, Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability, Pearson,3rd edition (2014)

E - References:	
1	https://www.adobe.com/products/xd/learn/get-started.html
2	https://developer.android.com/guide
3	https://help.autodesk.com/view/fusion360/ENU/courses/
4	https://help.prusa3d.com/en/category/prusaslicer_204

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Create quick UI/UX prototypes for customer needs	L6: Creating
CO2	Develop web application to test product traction / product feature	L3: Applying
CO3	Develop 3D models for prototyping various product ideas	L3: Applying
CO4	Built prototypes using Tools and Techniques in a quick iterative methodology	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	0	0	0	1	1	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	1	1	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
CO4	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
AVG	**2.75**	**2.25**	**3**	**2**	**3**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2.75**	**1.75**	**1.75**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS16	INDUSTRIAL AUTOMATION DATA LIFE CYCLE MANAGEMENT				Semester		VI
PREREQUISITES		**Category**	**OE**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	Acquire conceptual knowledge in Industrial Controllers by scaling of on-board devices and embedded board interfacing with various I/O peripherals.
2	Learn PLC by working on internal features and also interfacing with Sensors and actuators along HMI concept using SCADA and standard communication protocols.
3	To work with FPGA boards and RT controllers for reprogrammable embedded applications using LabVIEW
4	Understand the concepts and design electronics circuits

Unit	Title	L	T	P	TH
Unit I	**INDUSTRIAL CONTROLLERS - I**	**9**	**0**	**0**	**9**

Industrial Controllers - Introduction to RIO Controllers - Platform - Connection and Configuring controllers - Accessing onboard devices - Module SOM - Interfacing with Input and Output devices - Interfacing protocol based Analog and Digital sensors - Acquiring and Data Logging from sensors - Interfacing Actuators: Relay, DC Motor, Servo Motor - Creating standalone applications.

Unit	Title	L	T	P	TH
Unit II	**INDUSTRIAL CONTROLLERS - II**	**9**	**0**	**0**	**9**

Industrial Controllers - II - PLC - Introduction - Mode of Operation - IEC 61131 Programming languages for PLC - Programming & sequence control - Instruction set - Scan Time - Timers - Counters - Interfacing with Input/Output devices - Interfacing with Sensors - Interfacing with Actuators - Interfacing with Human Machine Interface - Commissioning and operational safety of PLC – SCADA.

Unit	Title	L	T	P	TH
Unit III	**INDUSTRIAL COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Serial Communication Protocols - I2C, SPI - Serial Field bus protocols CAN, PROFIBUS - Ethernet, HTTP, TCP/UDI, WiF, Cloud data logging. Multi-sensor communication, Data parsing between Embedded platforms. Comparative study of Industrial communication protocols - Implementation of Industrial Communication protocols.

Unit	Title	L	T	P	TH
Unit IV	**FPGA AND RT CONTROLLER PROGRAMMING**	**9**	**0**	**0**	**9**

Introduction to FPGA - Architecture - Operations in FPGA programming - FPGA Programming in LabVIEW and implementation in myRIO - Introduction to RT controllers - Architecture - Programming RT Controllers - Creating standalone applications.

Unit	Title	L	T	P	TH
Unit V	**INDUSTRIAL CIRCUIT BOARD DESIGN**	**9**	**0**	**0**	**9**

Designing basics circuits and to simulate in environment setup - Component selection - Creating libraries - Schematic design - Design rules, supply & communication track rules - Component and footprint editor - Understanding component package types - Test point creation for measurement - PCB Layout, placement rules - Footprint, 3D models, BoMs - Generating GERBER and output documentation.

Total = 45 Periods

Text Books:	
1	Ed Doering, NI myRIO Project Essential Guide, National Instruments, 2016.
2	Willian Bolton, Programmable Logic Controllers, 6th edition, Newnes Publications, 2015
3	Richard Zurawski, Industrial Communication Technology Handbook, Second edition, CRC Press, 2014
4	Simon Monk, Make Your Own PCBs with EAGLE, McGraw Hill Education, 2014.
References Books:	
1	Jeffrey Travis, Jim Kring, LabVIEW for Everyone: Graphical Programming Made Easy and Fun, 3rd edition, Prentice Hall
2	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, Fourth edition, Pearson Education, 2016
3	Michael J. Hamill, Industrial Communications and Control Protocols, PDH centre, 2016
4	Ema Design Automation, The Hitchhiker's Guide to PCB Design, First edition, Blurb Publishers, December 2021

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the usage of controllers in an industrial environment	L2: Understanding
CO2	Build Real-Time systems for Industrial embedded monitoring and controlling deterministic applications	L3: Applying
CO3	Communicate between devices at different levels using industrial protocols	L3: Applying
CO4	Understand the process involved in PCB design using EDA tools and fabricate it	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	3	2.25	2.75	1.75	3	0	0	0	0	0	0	0	3	2.75	2.5

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS17	ROBOTICS/ML&MLOps				Semester		VI
PREREQUISITES		**Category**	**EE**		**Credit**		**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives	
1	Learn the fundamentals of ROS
2	Understand the requirements and choose the right sensors and actuators for the application development
3	Create Bot in the virtual environment and simulate it to know the functionalities of the system developed
4	Learn the basics of Robotics Vision System
5	Integrate ROS and Computer Vision to build systems for various use cases

Unit I	**INTRODUCTION TO ROBOT KINEMATICS**	**9**	**0**	**0**	**9**
Introduction to Robotics - Transformations - Forward Kinematics - Kinematics equations - Link transformations - Inverse Kinematics - Kinematic analysis - Numerical Inverse Kinematic Solutions - Analytical Inverse Kinematic Solutions					
Unit II	**SELECTION OF SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**
Introduction - Sensors & Actuators - Types - Selection criteria - Design considerations: Motor sizing - Selection of motors based on torque and speed characteristics - Hardware Interface & Assembly					
Unit III	**INTRODUCTION TO ROBOT OPERATING SYSTEM**	**9**	**0**	**0**	**9**
Introduction to ROS framework and prerequisites - Understanding communications in ROS - ROS Ecosystem - Introduction to ROS programming - ROS nodes, topics, messages - ROS services - ROS Tools and Utilities - URDF , Rviz - Simulation - Gazebo - ROS Motion					
Unit IV	**INTRODUCTION TO ROBOTICS VISION SYSTEM**	**9**	**0**	**0**	**9**
Image basics - Image Processing - Histograms - Gray scale, Color, Equalization - Smoothing and blurring/filtering - Averaging, Gaussian, Median, Bilateral - Thresholding - Simple, Adaptive, Otsu - Gradients and Edge detection - Laplacian, Sobel, Canny - Contours - Camera calibration					
Unit V	**INTEGRATION OF ROS AND COMPUTER VISION**	**9**	**0**	**0**	**9**
Introduction - Installation - CV Bridge - Image publisher node - Image subscriber node - Nodes building and launching - Building real world applications					
					Total = 45 Periods

Text Books:	
1	Introduction to Robotics: Mechanics and Control by John J Craig, Pearson Publishers.
2	Robot Operating System (ROS) for Absolute Beginners by Lentin Joseph, A press; Publishers (2018).
3	Learning OpenCV by Gary Bradski, Adrian Kaehler, O'Reilly Media, Inc.

Reference Books:	
1	https://www.intechopen.com/chapters/379
2	https://www.plantengineering.com/articles/eight-selection-criteria-for-actuation-components/
3	https://www.controleng.com/articles/tips-on-sensor-selection/
4	https://www.toptal.com/robotics/introduction-to-robot-operating-system
5	https://www.thomasnet.com/articles/automation-electronics/machine-vision-systems/
6	https://automaticaddison.com/working-with-ros-and-opencv-in-ros-noetic/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand kinematics considerations of robot	L2: Understanding
CO2	Selection of sensors and actuators according to application	L3: Applying
CO3	Utilize the ROS environment to simulate and communicate between robot	L3: Applying
CO4	Develop algorithms to extract features and data from image	L3: Applying
CO5	Utilize the open CV for robotic applications	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	0	0	0	0	0	0	0	3	3	2
CO2	3	3	2	1	2	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	3	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	**3**	**2.5**	**2.75**	**1.5**	**2.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

PROGRAMME ELECTIVE COURSEVERTICALS FOR HONOURS / MINOR DEGREE

VERTICAL I : POWER ENGINEERING

18EEHO101	SUBSTATION ENGINEERING AND AUTOMATION		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
Power system protection, Electrical Measurements, Power system		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the importance of the substation design
2.	To outline the different factor for effecting substation design
3.	To classify the bus configurations
4.	To know the design criteria for substation grounding
5.	To understand the importance of substation automation

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Background, Need Determination, Budgeting, Financing, Traditional and innovative Substation Design, Site Selection and Acquisition, Design, Construction and Commissioning Process

UNIT II	**HIGH VOLTAGE SWITCHING EQUIPMENT**	**9**	**0**	**0**	**9**

Ambient conditions, Disconnect switches, Load Break switches, high speed grounding switches, power fuses, circuit switches, circuit breakers.

UNIT III	**TYPES OF SUBSTATIONS & BUS/SWITCHING CONFIGURATIONS**	**9**	**0**	**0**	**9**

Transmission substation, distribution substation, collector substation, switching substations, gas insulated substations, air insulated substations, bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, Comparison of configurations.

UNIT IV	**DESIGN OF SUBSTATION GROUNDING AND PROTECTION**	**9**	**0**	**0**	**9**

Reasons for substation grounding system, accidental ground circuit, Design criteria-Actual Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design equations, selection of conductors, grounding fence, other design considerations. Lightning stroke protection-lightning parameters, empirical design methods. Substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion.

UNIT V	**SUBSTATION AUTOMATION AND COMMUNICATIONS**	**9**	**0**	**0**	**9**

Introduction , components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment.

Total (45L+0T)= 45 Periods

Text Books:

1.	John D. McDonald , Electrical Power Substation Engineering , CRC Press, 3 rd Edition, 2017

Reference Books:

1.	R. S. Dahiya, VinayAttri," Sub-Station Engineering Design & Computer Applications " S K Kataria and son Publications, 1 st Edition, 2013.
2.	P. S. Satnam, P. V. Gupta, " Substation Design and Equipment " Dhanapat Rai Publications, 1 st Edition, 2013.
3.	Turan Gonen, " Electric Power Distribution Engineering " CRC press, third edition, 2014.

E-Reference

1	https://www.transgrid.com.au/what-we-do/our-network/connections
2	https://new.abb.com/substations

3	https://ieeexplore.ieee.org/document/178016
4	https://www.sciencedirect.com/topics/engineering/substations

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the commissioning of substation	L2: Understanding
CO2	:	Know working principles of substation switching equipment	L2: Understanding
CO3	:	Identify the different types of bus configurations	L1: Remembering
CO4	:	Design substation grounding and protection	L6: Creating
CO5	:	Analyse the substation communication (SCADA)	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	3	1	1		1	1			1		2	2	1
CO2	1	2	1	1	1								1	1	2
CO3	1	3	2	2	2		1	1				1	1	2	1
CO4	2	2	3	2	3	2						1	2	2	1
CO5	1	2	1	1	3	1	1	1			1	1	2	2	1
Avg	1.4	2.2	2	1.4	2	1.5	1	1	0	0	1	1	1.6	1.8	1.2

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO102	EMS AND SCADA		SEMESTER			
PREREQUISITES		**CATEGORY**	**PEC**	**Credit**		**3**
Power System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on energy management system.
2.	To understand network analysis function of EMS.
3.	To study the function and control of SCADA.
4.	To analyze the concept of SCADA hardware and software.
5.	To study the concept of power system automation using SCADA.

UNIT I	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Introduction to EMS, Objectives, Evolution of EMS, Evolution of SCADA, Function and Benefits of EMS, EMS Architecture, Practical EMS, Working of EMS, Power System Security: Introduction, Static Security Assessment, Operating states of Power System. Real Time or Online Application : Control Function, Protection Function, Operating States of Power System

UNIT II	**NETWORK ANALYSIS FUNCTION OF EMS**	**9**	**0**	**0**	**9**

Real Time Function, Extended Real Time Function, State Estimation: Introduction, Conventional State Estimation, Linear state estimation. Economic Dispatch and Optimal Power Flow: Introduction, Economic Dispatch, Generation Model, Economic Dispatch Problem, Optimal Power Flow problem Formulation.

UNIT III	**SCADA**	**9**	**0**	**0**	**9**

Introduction to SCADA, Evolution of SCADA, Benefits of SCADA, Function of SCADA, SCADA in Process control, SCADA Application, Usage of SCADA, Real-Time Monitoring and Control using SCADA, Data Acquisition, Data Communication, Data Presentation, and Control.

UNIT IV	**SCADA HARDWARE AND SOFTWARE**	**9**	**0**	**0**	**9**

Introduction, SCADA hardware Functions, Remote Terminal Units, SCADA RTU, Basic Functions, RTU Standards, Difference Between RTU and PLC, Features of SCADA. SCADA Software and Protocols: Introduction to ISO Model, DNP3 Model, Important Features of DNP3, IEC60870 PROTOCOL, HDLC, Modbus Protocol.

UNIT V	**POWER SYSTEM AUTOMATION**	**9**	**0**	**0**	**9**

Power System Automation – Benefits - Architecture for Power System Automation, Classification of Power system Automation, Implementation of Power System Automation and Protection using SCADA, SCADA based Model for Automation and Digital Protection.

Total (45L+0T)= 45 Periods

Text Books:

1.	Wayne C. Turner, Steve Doty, Energy Management Hand book, The Fairmont Press, 6th Edition, 2007.
2.	Handschin, E. “Energy Management Systems”, Springer Verlag, 1990.
3.	Mini S. Thomas, John D McDonald, “Power System SCADA and Smart Grids”, CRC Press, 2015.

Reference Books:

1.	John D Mc Donald, “Electric Power Substation Engineering”, , CRC press, 2001
2.	Handschin, E, “Real Time Control of Electric Power Systems”, Elsevier, 1972.

E-References:

1.	NPTEL Online Courses, Energy Management Systems and SCADA, IIT Madras. Link : “https://nptel.ac.in/courses/108106022/12“

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explore the objectives of EMS.	L2: Understanding
CO2	:	Understand the real time function of EMS.	L1: Remembering
CO3	:	Explain the real time monitoring and control of SCADA.	L4: Analyzing
CO4	:	Analyze the hardware and software functions of SCADA.	L4: Analyzing
CO5	:	Outline the power system automation and protection using SCADA.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1						1					2		3
CO2	3		2			2							2		3
CO3	3		2										2		3
CO4	3		2										2		3
CO5	3		2										2		3
Avg	3	1	2	0	0	2	0	1	0	0	0	0	2	0	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO103	POWER SYSTEM STATE ESTIMATION AND SECURITY CONTROL		SEMESTER			
PREREQUISITES		**CATEGORY**	**PEC**	**Credit**		**3**
Power Generation, Transmission and Distribution System; Power System Analysis and Stability		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To acquire fundamental knowledge on power system state estimation.
2.	To familiarise on network observability analysis.
3.	To get conceptual aspects in power system state estimation and strategies to enhance the secure power system operations.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

State estimation- Energy management system- SCADA system- Energy control centers- Security monitoring and control-Concepts of reliability, security and stability - State transitions and control strategies- Data acquisition systems - Modulation techniques, MODEMS, Power line carrier communication.

UNIT II	**POWER SYSTEM STATE ESTIMATION**	**9**	**0**	**0**	**9**

Static state estimation: Active and reactive power bus measurements – Line flow measurements - Line current measurements – Bus voltage measurements - Measurement model and assumptions - Weighted least square state estimation algorithm-Maximum likelihood estimation - Decoupled formulation of WLS state estimation- Fast decoupled state estimation.

UNIT III	**NETWORK OBSERVABILITY ANALYSIS**	**9**	**0**	**0**	**9**

Tracking state estimation: Algorithm - Computational aspects – Measurement redundancy - Accuracy and variance of measurements - Variance of measurement residuals- Detection, identification and suppression of bad measurements - Pseudo measurements- Virtual measurements- External system equivalencing- Network observability - Observability analysis using phasor measurement units.

UNIT IV	**DISTRIBUTION SYSTEM STATE ESTIMATION**	**9**	**0**	**0**	**9**

Distribution system state estimation- State of the art methods – Comparison of different DSSE algorithms- Developments in measurement system and DSSE design- Pseudo measurements- System architecture.

UNIT V	**SECURITY ASSESSMENT AND ENHANCEMENT**	**9**	**0**	**0**	**9**

Contingency analysis: Linearized AC and DC models of power systems for security assessment - Line outage distribution factors and generation shift factors for DC and linearized AC models - Single contingency analysis using these factors. Contingency ranking and security indices-Correcting the generator dispatch for security enhancement using linearized DC models – Methods using sensitivity
factors - Compensated factors. Emergency and restorative control procedures.

Total (45 L + 0 T)= 45 Periods

Text Books:

1.	Ali Abur, “Power System State Estimation Theory and Implementation”, Marcel Dekker, 2004.
2.	Wood, A.J., Wollenberg, B.F., and Sheble, G.B., “Power Generation, Operation and Control”, John Wiley and Sons, 3rd Edition, 2013.
3.	Mahalanabis, Kothari and Ahson, “Computer Aided Power System Analysis and Control”, Tata McGraw Hill Publishers, 1991.

Reference Books:

1.	Abhijit Chakrabarti and Sunita Halder, “Power System Analysis Operation and Control”, PHI Learning, 2010.
2.	G.L. Kusic, “Computer Aided Power System Analysis”, Prentice Hall of India, 1989.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the conceptual aspects in power system state estimation.	L2: Understanding
CO2	:	Demonstrate various state estimation methods.	L3: Applying
CO3	:	Acquire proficiency to perform observability analysis.	L4: Analysing
CO4	:	Demonstrate the distribution state estimation.	L3: Applying
CO5	:	Realize the security assessment and enhancement strategies.	L3: Applying

COURSE ARTICULATION MATRIX

COs\ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	1	3	3	1	1		1				1	2	1	3	1
CO 2	1	2	3	2	2		2				1	2	1	3	1
CO 3	1	2	3	2	2		2				1	2	1	2	1
CO 4	1	2	2	1	1		1				1	2	1	2	1
CO 5	1	2	3	2	2		2				1	2	1	1	1
Avg	1	2.2	2.8	1.6	1.6	0	1.6	0	0	0	1	2	1	2.2	1

3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)

<table>
<tr><td>18EEHO104</td><td colspan="2">POWER SYSTEM AUTOMATION</td><td colspan="4">SEMESTER</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PEC</td><td colspan="2">Credit</td><td>C</td></tr>
<tr><td colspan="2" rowspan="2">Power Generation, Transmission and Distribution System; Power System Analysis and Stability</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1.	To acquire fundamental knowledge on power system instrumentation.
2.	To familiarise on automations in electric power distribution systems.
3.	To get conceptual aspects in modern tools for power system automation.

UNIT I	**MEASUREMENTS AND SIGNAL TRANSMISSION TECHNIQUES**	**9**	**0**	**0**	**9**

Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment, RTU, IED - computer control of power system - Man Machine Interface.

UNIT II	**COMMUNICATION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Communication requirements; Two way capability – outages and faults; Public switched telephone network, Power line carrier communication – ripple control, cyclocontrol, carrier frequency (PLC, DLC, BPL), Radio communication (UHF point to point, UHF multi address system radio, VHF, PSN, Cellular radio), Fibre optics, Satellite communication. Standards: IEE802, IEC61850

UNIT III	**DISTRIBUTION SYSTEM INSTRUMENTATION**	**9**	**0**	**0**	**9**

Definitions – automation switching control – management information systems (MIS) – remote terminal units – communication method for data transfer – consumer information service (CIS) – graphical information systems (GIS) - automatic meter reading (AMR) – Remote control load management.

UNIT IV	**DISTRIBUTION AUTOMATION**	**9**	**0**	**0**	**9**

Introduction to distribution automation: Customer automation- Feeder automation – Substation automation, Subsystems in distribution control centre – Distribution management systems-Outage management systems, Distribution management system framework-Advanced real time DMS applications- Advanced analytical DMS applications – DMS coordination with other systems.

UNIT V	**CONCEPTS FOR SMART SYSTEMS**	**9**	**0**	**0**	**9**

Smart system solutions – Asset optimization, Demand optimization, distribution optimization, smart meter and communications, transmission optimization; Demand side management and demand response – DSM Planning-DSM techniques; Advanced metering infrastructure integration with distribution automation, distribution management system, and outage management system; Smart homes with home energy management systems.

Total (45 L + 0 T)= 45 Periods

Text Books:

1.	Pabla. A.S, “Electric Power Distribution”, Tata McGraw Hill, New Delhi, 2004.
2.	Mini S Thomas, and John D McDonald, “Power System SCADA and Smart Grids”, Taylor and Francis, 2015.
3.	Mahalanabis, Kothari and Ahson, “Computer Aided Power System Analysis and Control”, Tata McGraw Hill Publishers, 1991.

Reference Books:

1.	Momoh A. Momoh, and James A. Momoh., “Electric Power Distribution, Automation, Protection, and Control”, CRC Press, 2007.
2.	Gonen., “Electric Power Distribution System Engineering”, BSP Books, Pvt. Ltd, 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the conceptual aspects in power system measurements and signal transmission techniques.	L2: Understanding
CO2	:	Demonstrate various communication technologies for data transmission.	L3: Applying
CO3	:	Acquire proficiency to distribution system instrumentation.	L3: Applying
CO4	:	Demonstrate the automation in power distribution system.	L3: Applying
CO5	:	Conceptualize the smart tools for automation.	L3: Applying

COURSE ARTICULATION MATRIX

CO\/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	1	3	3	1	1		1				1	2	1	3	1
CO 2	1	2	3	2	2		2				1	2	1	3	1
CO 3	1	2	3	2	2		2				1	2	1	2	1
CO 4	1	2	2	1	1		1				1	2	1	2	1
CO 5	1	2	3	2	2		2				1	2	1	1	1
Avg	1	2.2	2.8	1.6	1.6	0	1.6	0	0	0	1	2	1	2.2	1

3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)

18EEHO105	POWER PLANT ENGINEERING				SEMESTER			
PREREQUISTIES			**CATEGORY**		**PEC**	**Credit**		**3**
Power Systems			**Hours/Week**		**L**	**T**	**P**	**TH**
					3	**0**	**0**	**3**

Course Objectives:

The objective of this course is to familiarize with operation of various power plants

UNIT I	**THERMAL POWER PLANT**	**9**	**0**	**0**	**9**

Thermal Stations- layout- main components- boiler- economizer- air preheater- super heater- reheater- condenser- feed heater- cooling powers- FD and ID fans- Coal handling plant-water treatment plant- Ash handling plant- Types of boilers and theirs characteristics- Steam turbines- and their characteristics- governing system for thermal stations

UNIT II	**HYDRO POWER PLANT**	**9**	**0**	**0**	**9**

Hydro Electric Stations- Selection of site- layout- classification of hydro plants- general arrangement and operation of a hydro-plant- governing system for hydel plant- types of turbines-pumped storage plants.

UNIT III	**NUCLEAR POWER PLANT**	**9**	**0**	**0**	**9**

Nuclear power plants - Principles of nuclear energy -Working of Nuclear Reactors : Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors - location - advantages and disadvantages of nuclear power plants - Reactor control

UNIT IV	**POWER FROM RENEWABLE ENERGY**	**9**	**0**	**0**	**9**

Principle, Construction and working of Solar Thermal, Solar Photo Voltaic (SPV), Wind, Tidal, Geo Thermal, Biogas and Fuel Cell power systems.

UNIT V	**POWER PLANT ECONOMICS AND ENVIRONMENTAL HAZARDS**	**9**	**0**	**0**	**9**

Economics of power generation -Capital & Operating Cost of different power plants. Environmental aspect of power generation- Comparison of site selection criteria, relative merits & demerits of different plants - Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants- safety measures for Nuclear Power plants.

Total (45L) = 45 Periods

Text Books:

1. Nag. P.K., Power Plant Engineering, 2nd ed., Tata McGraw-Hill, 2002
2. Domkundwar, S., Power Plant Engineering, Dhanpat Rai & Sons, 1988
3. El-Wakil, M.M., “Power plant Technology”, McGraw-Hill Book Co, 2002

Reference Books:

1. Deshpande.M.V, “Elements of Electrical Power station Design”, Pitman, New Delhi,Tata McGraw Hill, 2008.
2. Soni Gupta, Bhatnagar and Chakrabarti, “A text book on Power Systems Engineering”, Dhanpat Rai and Sons, New Delhi, 1997.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the construction and principle of working for different power plants.	L1: Remembering

CO2	:	Identify the site requirements and component requirements.	L2: Understanding
CO3	:	Analyze the concept governors and their control of power plant.	L4: Analysing
CO4	:	Assess the power plant and its suitability for the environment.	L3: Applying
CO5	:	Interpret the economics involved in design of power plant.	L2: Understanding

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2	1	1	1	1	1	1	1	3	1	1
CO2	1	2	2	2	2	1	1					1	2	1	1
CO3	1	3	2	2	2	1	1					1	2	1	1
CO4	1	1	3	3	2	2	1		1	1		1	2	2	1
CO5	1	1	3	2	2	2	1	1	1	1	1	1	2	2	1
Avg	1.4	2	2.4	2.2	2	1.4	1	1	1	1	1	1	2	1.4	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO106	COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS			SEMESTER			
PREREQUISTIES			**CATEGORY**	**PEC**	**Credit**		**3**
Power System Protection			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

To understand different techniques of digital relaying - their constructions, working principles, applications and limitations along with introduction to Wide Area Measurement System and network protection.

		L	T	P	TH
UNIT I	**INTRODUCTION TO COMPUTER RELAYING**	**9**	**0**	**0**	**9**

Computer relay architecture - analog-to-digital converters - anti-aliasing filters - expected benefits of computer relaying

		L	T	P	TH
UNIT II	**RELAYING PRACTICES**	**9**	**0**	**0**	**9**

Introduction to protection systems, function of protection system, protection of transmission lines, overcurrent relays, directional relays, distance relays, pilot relaying, transformer protection, reactor protection, generator protection and bus protection

		L	T	P	TH
UNIT III	**MATHEMATICAL BASIS FOR PROTECTIVE RELAYING ALGORITHMS**	**9**	**0**	**0**	**9**

Fourier series, Walsh functions, Fourier transforms, probability and random process, Kalman filtering

		L	T	P	TH
UNIT IV	**SYSTEM RELAYING AND CONTROL**	**9**	**0**	**0**	**9**

Phasor Measurement Unit - Measurement of frequency and phase – sampling clock synchronization – Application of phasor measurement to state estimation – Monitoring- Control applications

		L	T	P	TH
UNIT V	**WIDE AREA MEASUREMENT SYSTEMS**	**9**	**0**	**0**	**9**

Wide Area Measurement Systems (WAMS) architecture – WAMS based protection concepts : Adaptive dependability and security – Monitoring approach of apparaent impedances towards relay characteristics – WAMS based out-of step relaying – Supervision of backup zones – Intelligent load shedding – Intelligent islanding – System wide integration of SIPS – Load shedding and restoration

Total (45L) = 45 Periods

Text Books:

1.	Arun G. Phadke, James S. Thorp, Computer Relaying for Power Systems, Wiley, Second Edition,2009.
2.	Allan Thomas Johns, S.K. Salman, Digital Protection for Power Systems, The Institution of Engineering and Technology, Second Edition, 1995.

Reference Books:

1.	A.G. Phadke, J.S. Thorp, Synchronized Phasor Measurements and Their Applications, Springer
2.	Walter A. Elmore, 'Protective Relaying: Theory and Applications, CRC Press

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand on protection system schemes, its co-ordination and settings for any general power network.	L2: Understanding
CO2	:	Identify the digital relaying, its fundamentals, attributes and implementation.	L2: Understanding
CO3	:	Analyze the concept synchro-phasor based power system relaying	L4: Analysing
CO4	:	Assess the algorithms and its importance	L3: Applying
CO5	:	Recall the power system monitoring using wide area measurement system	L1: Remembering

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2	1	1					1	3	1	1
CO2	1	3	2	2	2	1	1					1	2	1	1
CO3	1	3	3	3	3	1	1					1	3	2	1
CO4	3	3	3	3	3	2	1					1	3	2	1
CO5	1	1	3	2	2	2	1					1	2	2	1
Avg	1.8	2.6	2.6	2.4	2.4	1.4	1	0	0	0	0	1	2.4	1.6	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO107	POWER SYSTEM PLANNING AND RELIABILITY		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
Power Systems		**Horus/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understand the concepts of power system planning
2.	Analyze power system reliability
3.	Understand generation, transmission and distribution planning and reliability

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

UNIT II	**RELIABILITY**	**9**	**0**	**0**	**9**

Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

UNIT III	**GENERATION PLANNING AND RELIABILITY**	**9**	**0**	**0**	**9**

Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches),Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods, Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

UNIT IV	**TRANSMISSION PLANNING AND RELIABILITY**	**9**	**0**	**0**	**9**

Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

UNIT V	**DISTRIBUTION PLANNING AND RELIABILITY**	**9**	**0**	**0**	**9**

Radial Networks, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices, Parallel & Meshed Networks, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Breaker Failure.

Total (45L+0T)= 45 Periods

Text Books:

1.	R.L. Sullivan “Power System Planning”, Tata McGraw Hill Publishing Company Ltd.
2.	Roy Billinton & Ronald N. Allan “Reliability Evaluation of Power System”, Springer Publication
3.	T. W. Berrie “Electricity Economics & Planning”, Peter Peregrinus Ltd., London.

Reference Books:

1.	Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press, 2009.
2.	Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer, 1996.

E-Reference

1	https://archive.nptel.ac.in/courses/117/103/117103149/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	To understand the power system planning	L2: Understanding
CO2	:	To determine the reliability of power system	L1: Applying

CO3	:	to understand the generation planning and reliability of power system	L1: Remembering
CO4	:	to understand the transmission planning and reliability of power system	L2: Understanding
CO5	:	to understand the distribution planning and reliability of power system	L1: Remembering

COURSE ARTICULATION MATRIX															
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	1	1	1	1	1	1			1		1	1	1
CO2	1	3	3	3	2	1	2	1	1		1		1	1	1
CO3	1	2	2	3	2	1	2	1	1		1		1	1	1
CO4	1	3	2	3	2	1	2	1	1		1		1	1	1
CO5	1	2	3	3	2	1	2	1	1		1		1	1	1
Avg	1	2.2	2.2	2.6	1.8	1	1.8	1	1	0	1	0	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO108	ADVANCED POWER SYSTEM PROTECTION		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
Power systems protection		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. Understand the concepts of advances in power system protection
2. Analyze digital protection of power system equipments
3. Design of protection relays

UNIT I	**NUMERICAL PROTECTION**	**9**	**0**	**0**	**9**

Introduction - Block diagram of numerical relay - Sampling theorem - Correlation with a reference wave - Least Error Squared (LES) technique - Digital filtering and numerical over- Current protection.

UNIT II	**DIGITAL PROTECTION OF TRANSMISSION LINE**	**9**	**0**	**0**	**9**

Introduction - Protection scheme of transmission line – Distance relays - Traveling wave relays - Digital protection scheme based upon fundamental signal - Hardware design - Software design - Digital protection of EHV/UHV transmission line based upon traveling wave phenomenon - New relaying scheme using amplitude comparison.

UNIT III	**DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR & TRANSFORMER**	**9**	**0**	**0**	**9**

Introduction - Faults in synchronous generator - Protection schemes for Synchronous Generator - Digital protection of Synchronous Generator - Faults in a Transformer - Schemes used for Transformer Protection - Digital Protection of Transformer.

UNIT IV	**DISTANCE AND OVERCURRENT RELAY SETTING AND CO-ORDINATION**	**9**	**0**	**0**	**9**

Directional instantaneous IDMT over current relay - Directional multi-Zone distance relay - Distance relay setting - Co-ordination of distance relays - Co-ordination of over current relays - Computer graphics display - Man-machine interface subsystem - Integrated operation of national power system - Application of computer graphics.

UNIT V	**PC APPLICATIONS FOR DESIGNING PROTECTIVE RELAYING SCHEME**	**9**	**0**	**0**	**9**

Types of faults – Assumptions - Development of algorithm for SC studies - PC based integrated software for SC studies - Transformation to component quantities - SC studies of multiphase systems - Ultra high speed protective relays for high voltage long transmission line.

Total (45L+0T)= 45 Periods

Text Books:

1. L. P. Singh, "Digital Protection - Protective Relaying from Electromechanical to Microprocessor", New Age International Ltd., New Delhi, Second Edition, 2006
2. S. R. Bhide, “Digital Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, 2014
3. Paithankar and Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, second edition, 2010.

Reference Books:

1. Paithankar, “Transmission Network Protection”, Marcel & Dekker, New York, 1998
2. Stanley Horowitz, “Protective Relaying for Power System II”, John Wiley & Sons, 2008.

E-Reference

1 https://nptel.ac.in/courses/108101039

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To understand the numeric protection	L2: Understanding
CO2	:	To design the digital protection of transmission line	L1: Applying
CO3	:	To design the digital protection of synchronous generator	L4: Analysing
CO4	:	To design the digital protection relays	L5: Evaluating
CO5	:	To study the pc based digital protection relays	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	1	1	1	1	1	1			1		1	1	1
CO2	1	3	3	2	2	1	2	1	1		1		1	1	1
CO3	1	2	2	2	2	1	2	1	1		1		1	1	1
CO4	1	3	2	2	2	1	2	1	1		1		1	1	1
CO5	1	2	3	2	2	1	2	1	1		1		1	1	1
Avg	1	2.2	2.2	1.8	1.8	1	1.8	1	1	0	1	0	1	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO109	HIGH VOLTAGE INSULATION SYSTEMS		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**C**
High voltage Engineering, Measurements and Instrumentation		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To expose the various types of insulating materials used for power system equipment
2.	To introduce the concept of insulation design.
3.	To provide an overview of insulation defects in power system equipment
4.	To understand insulation condition monitoring techniques.

UNIT I	**INSULATING MATERIALS**	**9**	**0**	**0**	**9**

Review of electrical insulating materials, characterization of insulation condition, models of deterioration and failure of practical insulating materials, electrical breakdown and operating stresses, development of insulation applications

UNIT II	**ELECTRICAL INSULATION DESIGN CONCEPTS**	**9**	**0**	**0**	**9**

Overview of insulation design requirements – electrical stress distribution in simple insulation system – electric stress control: Principles of stress control, Stress distribution in multiple dielectrics, Stress calculation.

UNIT III	**INSULATION DEFECTS IN HV POWER SYSTEM EQUIPMENTS**	**9**	**0**	**0**	**9**

HV Insulators - HV bushings - HV power capacitors - HV surge arresters – HV circuit breakers, HV Cables - Gas Insulated system – HV Transformers - HV instrument transformers.

UNIT IV	**BASIC METHODS FOR INSULATION ASSESSMENT**	**9**	**0**	**0**	**9**

Generation and measurement of test high voltages - Non-destructive electrical measurements: Insulation Resistance, dielectric dissipation factor, partial discharges, dielectric response – Physical and chemical diagnostic methods.

UNIT V	**ONLINE INSULATION CONDITION MONITORING TECHNIQUES**	**9**	**0**	**0**	**9**

Main problem with Offline condition monitoring - Noise-mitigation techniques - Non-electrical online condition monitoring - Online acoustic/electric PD location methods for transformers - Electrical online condition monitoring.

Total (45L+0T)= 45 Periods

Text Books:

1.	R. E. James and Q. Su, “Condition Assessment of High Voltage Insulation in Power System Equipment”, IET power and Energy Series Publisher, London, United Kingdom, 2008.

Reference Books:

1.	Dieter Kind and Hermann Kärner (1985). High-Voltage Insulation Technology. Springer.
2.	Ravindra Arora & Wolfgang Mosch, “High Voltage and Electrical Insulation Engineering”, John Wiley& Sons Publishers, 2011.
3.	E. Kuffel W.S. Zaengl, and J.Kuffel, ‘High Voltage Engineering Fundamentals', Newness Publishers, Second Edition, Elsevier, New Delhi, 2005.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Know the various insulating materials.	L2: Understanding
CO2	:	Understand the concepts of insulation design for power system equipment.	L2: Understanding
CO3	:	Analyze insulation defects in high voltage power system equipment	L4: Analyzing
CO4	:	Recite the basic methods for insulation assessment	L1: Remembering
CO5	:	Apply online insulation condition monitoring techniques	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2			1			1						1	1	
CO2	2	1	3	1	1		1						3	2	
CO3	2			3	2	1	1						1	3	
CO4	2	1	1	3		1						1	2	3	1
CO5	2	1	1	3	2		1					1	2	3	1
Avg	2	1	1.6	2.2	1.6	1	1	0	0	0	0	1	1.8	2.4	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO110	TRACTION ENGINEERING			SEMESTER			
PREREQUISITES			**CATEGORY**	**PEC**	**Credit**		**3**
Power Electronics, Electrical Machines			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To learn the fundamentals of electric traction, power substation, distribution system and overhead contact system design, construction and operation
2.	To learn the traction mechanics, power supply systems and role of battery banks and maintenance
3.	To learn the traction motor drives and control
4.	To learn about traction power supply and protection
5.	To learn about railway signalling

UNIT I	INTRODUCTION TO ELECTRIC TRACTION	9	0	0	9

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

UNIT II	TRACTION MECHANICS	9	0	0	9

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

UNIT III	TRACTION MOTOR AND DRIVES	9	0	0	9

Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, speed control methods, Braking methods, special Emphasis and techniques of regenerative braking, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor/IGBT based Converter Controlled Drives, DC Traction using Chopper Controlled Drives, AC Traction employing Poly-phase motors, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & amp; Auxiliary circuit equipment (Other than traction motors), Linear Induction motors, introduction to Maglev Technology.

UNIT IV	POWER SUPPLY AND PROTECTION	9	0	0	9

Traction substation, spacing and location of Traction substations, Major equipment at traction substation, selection and sizing of major equipment like transformer and Switchgear, Types of protection provided for Transformer and overhead lines, surge protection, maximum demand and load sharing between substations, sectionalizing paralleling post and feeder posts, Booster transformers, Return Conductor, 2X25KV AC system, controlling/monitoring, Railway SCADA systems, Train lighting and Air-conditioning.

Design requirement of catenary wire, contact wire, Dropper, Height, span length, Automatic weight tensioning, section insulator, overlap, Different techniques of current collection (overhead and underground systems), neutral section, overhead crossing of power lines, Protection

UNIT V	RAILWAY SIGNALING	9	0	0	9

Block Section Concept, AC/DC Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing. Permissible limit of EMI and EMC, Permissible capacitively-coupled current, Coupling between circuits, conductive coupling, Electrostatic induction.

Total (45L+0T) = 45 Periods

Reference Books:

1. E. A. Binney, "Electric Traction Engineering: An Introduction", Cleaver-Hume Press, 1955, 1 Oct 2007

2.	Douglas W. Hinde, M. Hinde, “Electric Traction Systems and Equipment”, Elsevier Science & Technology, 1968
3.	Samuel Sheldon, Erich Hausmann, “Electric Traction and Transmission Engineering”, Van Nostrand, 1911
4.	Frederick William Carter, “Railway Electric Traction”, E. Arnold & Company, 1922
5.	Edward Parris Burch, “Electric traction for railway trains; a book for students, electrical and mechanical engineers, superintendents of motive power and others”, New York, McGraw-Hill Book Company
6.	Edward Trevert, “Electric Railway Engineering”, Lynn, Mass. : Bubier Pub. Co.
7.	Burch Edward Parris, “Electric Traction for Railway Trains; a Book for Students, Electrical and Mechanical Engineers, Superintendents of Motive Power and Others”, Arkose Press, ISBN: 9781345582376, 9781345582376

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	To understand the basics of traction and supply systems.	L2: Understanding
CO2	:	To understand the traction mechanics and ideal choice of supply systems.	L4: Analyzing
CO3	:	To describe the concepts of traction motors and applying the solid state drive control.	L3: Applying
CO4	:	To design the protection system for the traction power supply system	L5: Evaluating
CO5	:	To understand the concepts of railway signaling	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	3	2	2	3	2	1				1	3	2	3
CO2	3	2	3	2	2	3	2	1				1	3	2	3
CO3	3	2	3	2	2	3	2	1				1	3	2	3
CO4	3	2	3	2	2	3	2	2	1	1	2	1	3	2	3
CO5	3	2	3	2	2	3	2	3	1	1	2	1	3	3	3
Avg	3	2	3	2	2	3	2	1.6	1	1	2	1	3	2.2	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

PROGRAMME ELECTIVE COURSE VERTICALS FOR HONOURS / MINOR DEGREE

VERTICAL II : POWER CONVERTERS AND DRIVES

18EEHO201	**ANALYSIS OF ELECTRICAL MACHINES**		**SEMESTER**			
PREREQUISITES		**CATEGORY**	**PEC**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
DC Machines , Synchronous and Induction Machines			**2**	**0**	**2**	**4**

Course Objectives:

1. To model & simulate all types of DC machines
2. To develop reference frame equations for various elements like R, L and C
3. To model an induction (three phase and 'n' phase) and synchronous machine
4. To drive reference frame equations for induction and synchronous machine
5. To study the need and working of multiphase induction and synchronous machine

UNIT I	**MODELING OF BRUSHED-DC ELECTRIC MACHINERY**	**6**	**0**	**6**	**12**

Fundamentals of Operation – Introduction – Governing equations and modeling of Brushed DC-Motor – Shunt, Series and Compound – State model derivation – Construction of Model of a DC Machine using state equations- Shunt, Series and Compound.

UNIT II	**REFERENCE FRAME THEORY**	**6**	**0**	**6**	**12**

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame .

UNIT III	**INDUCTION MACHINES**	**6**	**0**	**6**	**12**

Three phase induction machine - equivalent circuit– free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – Simulation under no load and load conditions- Machine variable form, arbitrary reference variable form.

UNIT IV	**SYNCHRONOUS MACHINES**	**6**	**0**	**6**	**12**

Three phase synchronous machine - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations).

UNIT V	**MULTIPHASE (MORE THAN THREE-PHASE) MACHINES CONCEPTS**	**6**	**0**	**6**	**12**

Preliminary Remarks - Necessity of Multiphase Machines - Evolution of Multiphase Machines- Advantages of Multiphase Machines - Working Principle - Multiphase Induction Machine, Multiphase Synchronous Machine -Modeling of 'n' phase machine. Applications of Multiphase Machines

LAB COMPONENT

1	Modeling of DC machines.
2	Simulation under no-load and loaded conditions for a PMDC motor
3	Simulation of smooth starting for DC motor.
4	Simulation under no-load and load conditions of a three phase induction machine in machine variable form and arbitrary reference variable form
5	Simulation under no-load and load conditions of a three phase synchronous machine in machine variable form and arbitrary reference variable form.

Total (30L+0T+30P)= 60 Periods

Test Books:

1.	Stephen D. Umans, “Fitzgerald & Kingsley’s Electric Machinery”, Tata McGraw Hill, 7th Edition, 2020.
2.	Bogdan M. Wilamowski, J. David Irwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011, 1st Edition.
3.	Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, “Analysis of Electric Machinery and Drive Systems”, 3rd Edition, Wiley-IEEE Press, 2013..
4.	Chee Mun Ong, Dynamic Simulation of Electric Machinery using MATLAB, Prentice Hall, 1997, 1st Edition
5.	Atif Iqbal,Shaikh Moinoddin, Bhimireddy Prathap Reddy, Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Wiley,2021,1st Edition
Reference Books	
1.	R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015, 1st Edition.
2.	R.Ramanujam, Modeling and Analysis of Electrical Machines, I.k.International Publishing House Pvt.Ltd,2018.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Find the modeling for a brushed DC-Motor (Shunt, Series, Compound and separately excised motor) and to simulate DC motors using state models	L1: Remembering
CO2	:	Apply reference frame theory for, resistive and reactive elements (three phase)	L2: Understanding
CO3	:	Compute the equivalent circuit and torque of three phase induction motor and synchronous motor in machine variable arbitrary reference frame variable	L5: Evaluating
CO4	:	Demonstrate the working of multiphase induction and synchronous machine.	L3: Applying
CO5	:	Compute the model of three phase and multiphase induction and synchronous machine.	L6: Creating

COURSE ATTRICULATION MATRIX

COs/ Pos	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	3		2	1		3		3	3	3
CO2	3	3	3	3	3		2	1		3		3	3	3
CO3	3	3	3	3	3		2	1		3		3	3	3
CO4	3				3		2	1		3		3	3	3
CO5	3				3		2	1		3		3	3	3
Avg	3	3	3	3	3	0	2	1	0	3	0	3	3	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO202	MULTILEVEL POWER CONVERTERS		SEMESTER			
PREREQUISTIES		CATEGORY	PEC	Credit		3
Power electronics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To introduce the fundamentals of multilevel voltage source inverters and multilevel current source inverters with its modulation control

UNIT I	DIODE-CLAMPED MULTILEVEL INVERTERS	9	0	0	9

Three-Level Inverter - Converter Configuration and Switching State, Space Vector Modulation - Stationary Space Vectors, Dwell Time Calculation and Switching Sequence Design, Neutral-Point Voltage Control 164
Discontinuous Space Vector Modulation, SVM Based on Two-Level Algorithm, High-Level Diode-Clamped Inverters - Four- and Five-Level Diode-Clamped Inverters

UNIT II	MULTILEVEL VOLTAGE SOURCE INVERTERS	9	0	0	9

Introduction, NPC/H-Bridge Inverter, Inverter Topology and Modulation Scheme, Waveforms and Harmonic Content, Multilevel Flying-Capacitor Inverters, Inverter Configuration, Modulation Schemes

UNIT III	CASCADED MULTILEVEL INVERTERS	9	0	0	9

H-Bridge Inverter, Bipolar Pulse-Width Modulation and Unipolar Pulse-Width Modulation, CHB Inverter with Equal DC Voltages, H-Bridges with Unequal DC Voltages, Carrier Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes

UNIT IV	MODULAR MULTILEVEL INVERTER	9	0	0	9

Five level Modular Multilevel Inverter- Power circuit , operation and applications, DC Voltage balance control, Carrier Based PWM for Modular Multilevel Inverter

UNIT V	PWM TECHNIQUES	9	0	0	9

Trapezoidal Modulation, Selective Harmonic Elimination, Space Vector Modulation-Switching States, Space Vectors, Dwell Time Calculation, Switching Sequence, Harmonic Content

Total (45L+0T)= 45 Periods

Text Books:

1.	Bin Wu, Mehdi Narimani, 'High-Power Converters and AC Drives, 2nd Edition, Wiley-IEEE Press, 2017

Reference Books:

1.	N. Mohan, T. M. Undeland, et al., Power Electronics—Converters, Applications and Design, 3rd edition, John Wiley & Sons, New York, 2003

E-Reference

1	https://archive.nptel.ac.in/courses/108/102/108102157/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the configurations for multilevel voltage source inverters.	L1: Remembering
CO2	:	Describe the working principle of multilevel current source inverters	L2: Understanding
CO3	:	Draw the topology structure of different types of multilevel inverters	L3: Applying
CO4	:	Understand the principle of space vector modulation for multilevel inverters	L1: Remembering
CO5	:	Select an appropriate modulation scheme for multilevel inverters	L4: Analyzing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	2				1	2	2		2	2	2	2
CO2	1	3			2				2	2		1	1	3	
CO3	1	1		1	1	1	2						1	1	
CO4	1	1		1	1		2	2	1		2	2	1	1	
CO5	2	2	3	1	2	2	1			1	3		2	2	3
Avg	1.4	1.8	2.5	1.25	1.5	1.5	1.67	1.5	1.67	1.67	2.5	1.67	1.4	1.8	2.5
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO203	SMPS AND UPS		SEMESTER			
PREREQUISITES		CATEGORY	PEC	Credit		3
Power Electronics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To impart knowledge about modern power electronic converters and their applications in power utility.
2.	To impart knowledge about Resonant converters and UPS.

UNIT I	DC-DC CONVERTERS	9	0	0	9

Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.

UNIT II	SWITCHED MODE POWER CONVERTERS	9	0	0	9

Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.

UNIT III	RESONANT CONVERTERS	9	0	0	9

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.

UNIT IV	DC-AC CONVERTERS	9	0	0	9

Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.

UNIT V	POWER CONDITIONERS, UPS, AND FILTERS	9	0	0	9

Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for power electronic applications – Selection of capacitors.

Total (45L+0T)= 45 Periods

Text Books:

1.	Simon Ang, Alejandro Oliva,” Power-Switching Converters”, Third Edition, CRC Press, 2010.
2.	M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1.	Ned Mohan, Tore.M.Undeland, William.P.Robbins, “Power Electronics Converters, Applications and Design”, 3rd Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, “Power Electronics circuits, devices and applications”, 3rd Edition, PHI, New Delhi, 2007.

E-References:

1.	NPTEL Course: Power Electronics, IIT-B.
2.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding

CO5	:	Identify the filters and UPS.	L2: Understanding

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	2	2			3	2		2		2	2	2	1
CO2	1	1	3	2			3	2		2		2	3	3	2
CO3	2	2	2	3			3	3		2		1	2	2	1
CO4	2	1	1	2			3	2		2		2	2	3	2
CO5	1	1	2	1			3	3		3		1	2	2	1
Avg	1.6	1.2	2	2	0	0	3	2.4	0	2.2	0	1.6	2.2	2.4	1.4
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO204	MODELING AND CONTROL OF POWER CONVERTERS		SEMESTER			
PREREQUISITES		**CATEGORY**	**PEC**	**Credit**		**3**
Power Electronics and Control Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To learn the basics of control system simulation.
2.	To do symbolic calculation and study the principles of sliding mode control and the way of apply smc for buck converter.
3.	To learn the concept of power factor correction.
4.	To design simulate smc for buck converter and power factor correction circuit with controller.

		L	T	P	TH
UNIT I	**SIMULATION BASICS IN CONTROL SYSTEMS**	**9**	**0**	**0**	**9**

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space model.

UNIT II	**SYMBOLIC CALCULATIONS**	**9**	**0**	**0**	**9**

Symbolic Variables - Symbolic Vector Variables, Commands for Handling Polynomial Expressions - Extracting Parts of a Polynomial -. Factorization and Roots of Polynomials, Symbolic Matrix Algebra - Operations with Symbolic Matrices - Other Symbolic Matrix Operations.

UNIT III	**SLIDING MODE CONTROL BASICS**	**9**	**0**	**0**	**9**

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory- Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

UNIT IV	**POWER FACTOR CORRECTION CIRCUITS**	**9**	**0**	**0**	**9**

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

UNIT V	**CONTROLLER DESIGN FOR PFC CIRCUITS**	**9**	**0**	**0**	**9**

Power factor correction circuit using other SMPS topologies: Cuk and SEPIC converter - PFC circuits employing bridgeless topologies.

Total (45L+0T) = 45 Periods

Text Books:

1.	Feedback Control problems using MATLAB and the Control system tool box By Dean Frederick and Joe Chow, 2000, 1st Edition, Cengage Learning.
2.	Ned Mohan,"Power Electronics: A First Course", Johnwiley, 2013, 1st Edition.
3.	Marian K. Kazimierczuk and AgasthyaAyachit,"Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters", Wiley 2016, 1st Edition.
4.	Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002, 1st Edition.

Reference Books:

1.	Sliding mode control for Switching Power Converters:, Techniques and Implementation, Slew-Chong Tan, Yuk Ming Lai Chi-Kong Tse, 1st Edition, CRC Press.
2.	Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters", Springer 1991.
3.	MATLAB Symbolic Algebra and Calculus Tools, Lopez Cesar, Apress, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To calculate transfer function for constant, differential, integral, First order and Second order factors.	L2: Understanding
CO2	:	To illustrate the effect of poles and zero's in the 's' plane.	L1: Remembering
CO3	:	To select Symbolic equations for solving problems related with Matrices, Polynomial and vectors.	L5: Evaluating
CO4	:	To compute the control expression for DC – DC buck converter using sliding mode control theory	L3: Applying
CO5	:	To determine the controller expression for power factor correction circuits and to simulate sliding mode control of buck converter and power factor correction circuit.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	3	3	3			1		2		3	3	3	3
CO2	3	3	3	3	3			1		2		3	3	3	3
CO3	3	3	3	3	3			1		2		3	3	3	3
CO4	3	3	3	3	3			1		2		3	3	3	3
CO5	3	3	3	3	3			1		2		3	3	3	3
Avg	3	3	3	3	3	0	0	1	0	2	0	3	3	3	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO205	DIGITAL CONTROLLER IN POWER ELECTRONICS APPLICATION		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
Control systems, Power Electronics		**Hours\Week**	**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concepts of discrete time systems.
2.	To analyze systems in z domain.
3.	To design the digital controllers

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

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

UNIT II	**Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS**	**9**	**0**	**0**	**9**

Impulse sampling and data hold -Pulse transfer function - Realization of digital controllers- Mapping between s-plane and zplane - Stability analysis of closed loop systems in z-plane–Transient and steady state analyses.

UNIT III	**STATE SPACE APPROACH TO DISCRETE-TIME CONTROL SYSTEMS**	**9**	**0**	**0**	**9**

State space representation of continuous and digital control systems - Solution of continuous and discrete time state space equations -Pulse transfer function matrix - Discretization of continuous time state space equations.

UNIT IV	**DIGITAL CONTROLLER DESIGN METHODS**	**9**	**0**	**0**	**9**

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.

UNIT V	**DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS**	**9**	**0**	**0**	**9**

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

Total (45L+0T)= 45 Periods

Text Books:

1.	M. Gopal, "Digital Control and State Variable Methods", McGraw Hill Education, 4th Edition, 2014.
2.	K.Ogata "Discrete- Time control systems", Pearson Education, India, 2nd Edition, 2015.
3.	B.C.Kuo, "Digital Control System", Oxford University Press; 2ndEdition, 2012.
4.	Karl J. Astrom & Tore Hagglun. "PID Controllers: Theory, Design and Tuning" International Society for Measurement and Control, 1995.

Reference Books:

1.	G.F.Franklin, J.David Powell and M.Workman, Digital Control of Dynamic Systems, 3rd ed., Addison Wesley, 2000.
2.	Constantine H. Houpis and Gary B. Lamont, Digital control systems: Theory, hardware, software, Mcgraw-Hill Book Company, 1985.
3.	M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.

E-Reference	
1	https://nptel.ac.in/courses/108103008

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To understand the digital control system	L2: Understanding
CO2	:	Capable of determining the stability in z domain	L1: Applying
CO3	:	To understand the state space analysis	L1: Remembering
CO4	:	To design the various types of digital controllers	L3: Analysing
CO5	:	To check the digital controllers in power electronics design	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1	1	1			1		1	1	1
CO2	1	3	3	3	2	1	2	1	1		1		1	1	1
CO3	1	2	2	3	2	1	2	1	1		1		1	1	1
CO4	1	3	2	3	2	1	2	1	1		1		1	1	1
CO5	1	2	3	3	2	1	2	1	1		1		1	1	1
Avg	1	2.2	2.2	2.6	1.8	1	1.8	1	1	0	1	0	1	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO206	PWM CONVERTERS AND APPLICATIONS		SEMESTER			
PREREQUISITES		**CATEGORY**	**PEC**	**Credit**		**3**
Power Electronics.		**PEC**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide a strong foundation of fundamental concepts in basic operation of PWM converters like solid state drives and power quality.
2.	To enable the student to apply these techniques in applications including basic circuit operation and design
3.	To enable understand the steady-state and dynamic analysis of PWM converters applications

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Power conversion Overview of applications of voltage source converters and current source converters. DC to AC Converters: Classification of inverters, operation of each type, design of commutating circuits, Analysis of voltage and current waveforms, voltage and frequency control, current source inverter and pulse width modulated inverter .

UNIT II	**PWM TECHNIQUES**	**9**	**0**	**0**	**9**

Pulse width modulation techniques for bridge converters Bus clamping PWM. Space vector based PWM. Advanced PWM techniques. DC to DC Converters: Classification of choppers, operating principle and control circuits for each type. Analysis of voltage and current waveforms.

UNIT III	**PERFORMANCE ANALYSIS OF LINE CURRENT RIPPLE**	**9**	**0**	**0**	**9**

Analysis of line current ripple: Synchronously revolving reference frame; error between reference voltage and applied voltage; integral of voltage error; evaluation of line current ripple; hybrid PWM for reduced line current ripple. **Analysis of dc link current**: Relation between line-side currents and dc link current; dc link current and inverter state; rms dc current ripple over a carrier cycle; rms current rating of dc capacitors.

UNIT IV	**PERFORMANCE ANALYSIS OF TORQUE RIPPLE AND LOSS**	**9**	**0**	**0**	**9**

Analysis of torque ripple: Evaluation of harmonic torques and rms torque ripple, hybrid PWM for reduced torque ripple **Analysis for inverter's loss**: Simplifying assumptions in evaluation of inverter loss, dependence of inverter loss on line power factor, influence of PWM techniques on switching loss, design of PWM for low inverter loss.

UNIT V	**PWM FOR MULTILEVEL INVERTER AND APPLICATIONS**	**9**	**0**	**0**	**9**

PWM for multilevel inverter -Extensions of sine-triangle PWM to multilevel inverters, voltage space vectors, space vector based PWM, analysis of line current ripple and torque ripple . Applications Active power filtering, Reactive power compensation, Constant Volt Per hertz drives, PWM Rectifier etc.

Total (45L+0T)= 45 Periods

Test Books:

1.	D. G. Holmes, T. A. Lipo, 'Pulse Width Modulation For Power Converters: Principles and Practice', John Wiley and Sons., 2003.
2.	Bin Wu, "High Power Converters and AC Drives", John Willey & sons, Inc., 2006.
3.	Ned Mohan, Undeland and Robbins, "Power Electronics: Converters, Applications and Design", John's Wiley and Sons.

Reference Books

1.	Euzeli Cipriano dos Santos Jr. and Edison Roberto Cabral Da Silva "Advanced Power Electronics Converters - PWM Converters Processing AC Voltages", Willey – IEEE Press, 2014.
2.	M.H.Rashid, "Power Electronics", Prentice Hall of India

E -References

1.	NPTEL Lecture series by Prof. G. Narayanan, Department of Electrical Engineering, IISC Bangalore on the web-course . http://www.digimat.in/nptel/courses/video/108108035/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the need of PWM	L1: Remembering
CO2	:	Compare the PWM techniques on different aspects	L2: Understanding
CO3	:	Analyze parameter current ripple for different PWM approaches.	L5: Analyzing
CO4	:	Analyze parameters like losses, torque ripple for different PWM approaches.	L4: Analyzing
CO5	:	Develop suitable Pulse Width Modulation method for power converter used for different applications	L3: Applying

COURSE ARTICULATION MATRIX

COs/ Pos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	2	2	2	1	1			1	1	2	1	2	1	2
CO2	3	1	1	2	2			1	2	2	1	1	1	1
CO3	1	1	1	2	1			2	2	2	2	2	1	2
CO4	1	2	2	3	3			2	1	1	1	1	1	1
CO5	1	1	1	1	1			1	2	1	1	2	1	2
Avg	1.6	1.4	1.4	1.8	1.6	0	0	1.4	1.6	1.6	1.2	1.6	1	1.6

18EEHO207	GRID CONVERTERS FOR RENEWABLE ENERGY APPLICATIONS			SEMESTER			
PREREQUISTIES			**CATEGORY**	**PEC**	**Credit**		**3**
Power electronics			**Hours\Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the inverter structures and grid integration methods for solar and wind energy systems.

UNIT I	**PHOTOVOLTAIC INVERTER STRUCTURES**	**9**	**0**	**0**	**9**

Power circuit, operation modes and Solar PV integration with H5 Inverter, HERIC Inverter, REFU Inverter, Neutral Point Clamped (NPC) Half-Bridge Inverter, Conergy NPC Inverter, Three-Phase PV Inverter, Control Structures

UNIT II	**GRID SYNCHRONIZATION IN SINGLE-PHASE POWER CONVERTERS**	**9**	**0**	**0**	**9**

Grid Synchronization Techniques for Single-Phase Systems, Grid Synchronization Using the Fourier Analysis, Grid Synchronization Using a Phase-Locked Loop, PLLs Based on In-Quadrature Signal Generation, PLL Based on the Hilbert Transform , PLL Based on the Inverse Park Transform, PLLs Based on Adaptive Filtering

UNIT III	**GRID CONVERTER STRUCTURES FOR WIND TURBINE SYSTEMS**	**9**	**0**	**0**	**9**

Wind Turbine System Power Configurations, Grid Power Converter Topologies: Single-Cell (Voltage Source Converter or Current Source Converter), Multicell (Interleaved or Cascaded), Wind Turbine System Control: Generator-Side Control, Wind Turbine System Control Grid Control

UNIT IV	**GRID SYNCHRONIZATION IN THREE-PHASE POWER CONVERTERS**	**9**	**0**	**0**	**9**

Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, Decoupled Double Synchronous Reference Frame PLL (DDSRF-PLL): Double Synchronous Reference Frame, Decoupling Network and Analysis of the DDSRF, Double Second-Order Generalized Integrator FLL (DSOGI-FLL), Structure of the DSOGI, Relationship between the DSOGI and the DDSRF

UNIT V	**GRID CONVERTER CONTROL FOR WIND TURBINE SYSTEMS**	**9**	**0**	**0**	**9**

Voltage Oriented Control and Direct Power Control: Synchronous Frame VOC: PQ Open-Loop Control, Synchronous Frame VOC: PQ Closed-Loop Control, Stationary Frame VOC: PQ Open-Loop Control, Stationary Frame VOC: PQ Closed-Loop Control, Virtual-Flux-Based Control, Direct Power Control, Stand-alone, Micro-grid, Droop Control and Grid Supporting: Grid-Connected/Stand-Alone Operation without Load Sharing, Micro-Grid Operation with Controlled Storage, Droop Control

Total (45L+0T)= 45 Periods

Text Books:

1.	Remus Teodorescu, Marco Liserre, Pedro Rodríguez, ‘Grid Converters for Photovoltaic and Wind Power Systems, Wiley-IEEE Press, 2017

Reference Books:

1.	Chetan Singh Solanki, " Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011.

E-Reference

1	https://onlinecourses.nptel.ac.in/noc22_ee71

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the configurations for inverter structures for solar photovoltaic system	L1: Remembering
CO2	:	Use grid synchronization technique for single phase converters	L3: Applying
CO3	:	Draw the topology structure of three phase converter for wind energy conversion system	L3: Applying
CO4	:	Understand the principle of grid converter control for wind energy conversion system	L1-Remembering
CO5	:	Select an grid synchronization scheme for three phase converters	L4-Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	3	2	2			1		2		2	2	1	3
CO2	1	3		2	2					2		1	1	2	
CO3	1	1	2			1	2		1				1	1	2
CO4	1	1	1				2	2	1		2	2	1	1	1
CO5	1	2	1	1	1	2	1			1	3		2	2	1
Avg	1.2	1.8	1.75	1.67	1.67	1.5	1.67	1.5	1	1.67	2.5	1.67	1.4	1.4	1.75
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO208	CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES			SEMESTER			
PREREQUISITES			**CATEGORY**	**PEC**	**Credit**		**3**
Nil			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand electric power Generation, Transmission and Distribution
2.	To study Power System Operation and Control

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

UNIT II	**DYNAMIC ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies

UNIT III	**STATIC ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

UNIT IV	**CONTROL ISSUES AND CHALLENGES**	**9**	**0**	**0**	**9**

Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.

UNIT V	**INTEGRATION OF ENERGY CONVERSION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations

Total (45L+0T) = 45 Periods

Text Books:

1.	Renewable and Efficient Electric Power Systems, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013,2nd Edition
2.	Microgrids and Active Distribution Networks, S.Chowdhury, S. P. Chowdhury, P.Crossley, IET Power Electronics Series, 2012.
3.	Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali, Min Dai, John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1.	Solar Photovoltaic: Fundamentals, technologies & Applications, Chetan Singh Solanki, PHI Publishers, 2019, 3rd Edition.
2.	Solar PV Power: Design, Manufacturing and Applications from Sand to Systems, Rabindra Kumar Satpathy, Venkateswarlu Parmuru, Academic Press, 2020.
3.	Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013,1st Edition.

4.	Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, NavidZargari, IEEE- John Wiley and Sons Ltd. Publishers,2011,1st Edition.
5.	Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity Authority, GoI, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand different renewable energy sources and storage devices.	L2: Understanding
CO2	:	Model and simulate renewable energy sources.	L5: Evaluating
CO3	:	Apply various MPPT techniques for wind and solar energy generation	L3: Applying
CO4	:	Analyze and simulate control strategies for grid connected and off-grid systems	L4: Analyzing
CO5	:	Develop converters to comply with grid standards to obtain grid integration	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	2	3	3	1	1	2	1	2	3	3	3	3
CO2	3	2	3	3	3	3	1	1	2	1	2	1	3	3	3
CO3	3	2	3	3	3	3	1	1	1	2	1	1	3	3	3
CO4	3	2	3	3	3	3	1	2	2	2	1	1	3	3	3
CO5	3	2	3	3	3	3	1	2	2	2	2	1	3	3	3
Avg	2.8	2	2.8	2.8	3	3	1	1.4	1.8	1.6	1.6	1.4	3	3	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO209	MODERN ELECTRICAL DRIVES			SEMESTER			
PREREQUISITES			**CATEGORY**	**PEC**	**Credit**		**3**
Electrical Drives and control.			**Hours\Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To know about the overview of Electrical drives.
2.	To know about the Vector control strategies for DC motor drives.
3.	To understand the concepts of various DSP based control.

UNIT I	DC MOTOR DRIVES:	9	0	0	9
Modeling of DC motors, State space modeling, block diagram & Transfer function, Single phase, three phases fully controlled and half controlled DC drives. Dual converter control of DC drives Closed loop control of separately excited dc motor drive. Supply harmonics and ripple in motor current chopper controlled DC motor drives.					
UNIT II	**INDUCTION MOTOR DRIVES**	**9**	**0**	**0**	**9**
Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control (DTC)					
UNIT III	**SYNCHRONOUS MOTOR DRIVES**	**9**	**0**	**0**	**9**
Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.					
UNIT IV	**PERMANENT MAGNET MOTOR AND SWITCHED RELUCTANCE MOTOR DRIVES**	**9**	**0**	**0**	**9**
Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives. Various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.					
UNIT V	**DSP BASED MOTION CONTROL**	**9**	**0**	**0**	**9**
Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.					

Total (45L+0T)= 45 Periods

Text Books:

1.	B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2.	P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.

Reference Books:

1.	H. A. Taliyat and S. G. Campbell, “ DSP based Electromechanical Motion Control” , CRC press, 2003
2.	R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.
3.	https://nptel.ac.in/courses/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Apply Power converters for DC drives.	L1: Remembering
CO2	:	Understand the basics of Permanent magnet motor and Switched reluctance motor drives.	L2: Understanding
CO3	:	Learn the concepts of Synchronous motor drives.	L5: Evaluating

CO4	:	Gain knowledge of Induction motor drives.	L4: Analyzing
CO5	:	Explain DSP based motion control.	L3: Applying

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	1	1	3	2	2	1	1	1			1	1	1	1	1
CO2	3	3	3	3	3	1	1	1			1	1	3	3	3
CO3	1	3	3	3	3	1	1	1					1	3	1
CO4	1	3	3	3	3	1	1	1				1	1	3	1
CO5	3	3	3	3	3	1	1	1			1	1	3	3	3
Avg	1.8	2.6	3	2.8	2.8	1	1	1	0	0	1	1	1.8	2.6	1.8

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

PROGRAMME ELECTIVE COURSE VERTICALS FOR HONOURS / MINOR DEGREE

VERTICAL III: ELECTRIC VEHICLE TECHNOLOGY

18EEHO301	ELECTRIC VEHICLE ARCHITECTURE		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
Electric Drives, Energy management, Electric Vehicles			**3**	**0**	**0**	**3**

Course Objectives:

1.	To provide knowledge about electric vehicle architecture and power train components.
2.	To know the concepts of dynamics of electrical vehicles
3.	To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs)
4.	To understand the concept of energy storage systems
5.	To provide knowledge about different energy sources and energy management in HEVs.

UNIT I	**HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS**	**9**	**0**	**0**	**9**

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT II	**MECHANICS OF HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

UNIT III	**CONTROL OF DC AND AC MOTOR DRIVES**	**9**	**0**	**0**	**9**

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

UNIT IV	**ENERGY STORAGE SYSTEMS**	**9**	**0**	**0**	**9**

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. Alternate sources: Fuel cells, Ultra capacitors, Fly wheels.

UNIT V	**HEV CONTROL STRATEGY AND ENERGY MANAGEMENT**	**9**	**0**	**0**	**9**

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode series parallel mode - energy management of HEV's.

Total (45L+0T)= 45 Periods

Text Books:

1.	Iqbal Husain, ‘Electric and Hybrid Electric Vehicles’, CRC Press, 2011.
2.	Wei Liu, ‘Hybrid Electric Vehicle System Modeling and Control’, Second Edition, WILEY, 2017.

Reference Books:

1.	James Larminie and John Lowry, ‘Electric Vehicle Technology Explained’, Second Edition, 2012.
2.	Goodarzi, Gordon A., Hayes, John G, Electric power train: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles, Wiley 2018
3.	De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, Advanced Electrical Drives, First Edition, CRC Press, Taylor and Francis Group, 2011.

4.	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.
	RiK De Doncker, Advanced Electric Drives – Analysis , Modeling ,Control, Springer publications
E-Reference	
1	https://nptel.ac.in/courses/108/106/108106170/
2	https://nptel.ac.in/courses/108/102/108102121/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Learn the electric vehicle architecture and power train components.	L1: Remembering
CO2	:	Acquired the concepts of dynamics of electrical vehicles	L2: Understanding
CO3	:	Apply the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs).	L3: Applying
CO4	:	Ability to design and select energy storage systems.	L6: Creating
CO5	:	Evaluate different energy sources and energy management in HEVs.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1
CO2	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1
CO3	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1
CO4	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1
CO5	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1
Avg	2	2	2	2	2	2	2	2	1	1	1	1	2	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO302	DESIGN OF MOTORS AND POWER CONVERTERS FOR ELECTRIC VEHICLE		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PEC**	**Credit**		**3**
Power Electronics, Special Electrical Machines		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To study the characteristics of motors used Electric Vehicle
2. To understand the design of dc drives used in Electric Vehicle
3. To analyse the ac drives used in Electric Vehicle
4. To understand the role of converters used in Electric Vehicle

UNIT	TITLE	L	T	P	TH
UNIT I	**EV MOTORS CHARACTERISTICS**	**9**	**0**	**0**	**9**

Requirement of EV motors, Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving, Comparison of EV motors,
Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation

UNIT	TITLE	L	T	P	TH
UNIT II	**DESIGN OF DC DRIVES**	**9**	**0**	**0**	**9**

Single quadrant variable speed chopper fed DC drives, Four quadrant variable speed chopper fed DC Drives, Single phase/ three phase converter, Dual converter fed DC Drive, current loop control, Armature current reversal, Field current control, Different controllers and firing circuits.

UNIT	TITLE	L	T	P	TH
UNIT III	**INVERTER FED AC DRIVES**	**9**	**0**	**0**	**9**

Analysis of different AC motor with single phase and three phase inverters Operations in different modes and configurations., Problems and strategies.

UNIT	TITLE	L	T	P	TH
UNIT IV	**PERMANENT MAGNET AC MOTORS AND CONTROL**	**9**	**0**	**0**	**9**

BLDC dynamic modelling, torque equations, BLDC control methods, machine sizing, current, voltage and speed limits, extending constant power speed range, current control methods- Application of hall current sensor in PM AC motors.

UNIT	TITLE	L	T	P	TH
UNIT V	**PWM AND INVERTER**	**9**	**0**	**0**	**9**

Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation Encoders, Resolvers, R/D Converters.

Total (45L+0T)= 45 Periods

Text Books:

1. B.K. Bose, "Power Electronics and Motor Drives", Elsevier 2015.

Reference Books:

1. H. Buyse and I.J. Robert, "Electrical machines and converters: Modeling and simulation", North Holland, digitized 2007.
2. R. Krishnan, " Electric Motor Drives Modeling Analysis and Control", Prentice -Hall of India2001.
3. P.S. Bhimra," Generalized Theory of Electrical Machines", Khanna Publisher.

E-Reference

1 https://nptel.ac.in/courses/108104140

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the characteristics of the motors use in EV.	L1: Remembering
CO2	:	Analyze dynamics of DC motor and different controllers used in their control	L4: Analysing
CO3	:	Explain the speed control and PWM techniques used in the control of ac motor	L2: Understanding
CO4	:	Analyze the operation and control of permanent magnet ac motors.	L4: Analyzing
CO5	:	Analyze sensors used for control of 3-phase ac motors.	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	1	1		1	1			1		2	2	1
CO2	2	2	1	1	1								1	1	2
CO3	1	2	3	2	2		1	1				1	1	2	1
CO4	2	2	3	2	3	2						1	3	2	1
CO5	1	3	2	1	3	1	1	1			1	1	3	2	1
Avg	1.6	2.2	2.4	1.4	2	1.5	1	1	0	0	1	1	2	1.8	1.2

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO303	ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL		SEMESTER			
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
Power Electronics and Electrical Machines		**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To learn the basics of EV and vehicle mechanics
2.	To know the EV architecture and to study the energy storage system concepts
3.	To derive model for batteries and to know the different types of batteries and its charging methods
4.	To learn the control preliminaries for DC-DC converters.

UNIT I	**INTERNAL COMBUSTION ENGINES**	**9**	**0**	**0**	**9**

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions, Comparison of Internal Combustion Engine and Electric Vehicle, Review of light-, medium-, and heavy-duty all-electric vehicles.

UNIT II	**ELECTRIC VEHICLES AND VEHICLE MECHANICS**	**9**	**0**	**0**	**9**

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT III	**BATTERY MODELING, TYPES AND CHARGING**	**9**	**0**	**0**	**9**

Batteries in Electric and Hybrid Vehicles - Battery Basics -Battery Parameters. Types- Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (Ni MH) Battery - Li-Ion Battery - Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride, Research and Development for Advanced Batteries. Battery Modelling, Electric Circuit Models. Battery Pack Management, Battery Charging.

UNIT IV	**CONTROL PRELIMINARIES**	**9**	**0**	**0**	**9**

Control Design Preliminaries - Introduction - Transfer Functions – Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter - Gain margin and Phase margin study-open loop mode.

UNIT V	**CONTROL OF AC MACHINES**	**9**	**0**	**0**	**9**

Introduction- Reference frame theory, basics-modeling of induction and synchronous machine in various frames-Vector control- Direct torque control.

Total (45L+0T) = 45 Periods

Reference Books:

1.	Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2.	Power Electronic Converters,: Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley - VCH.
3.	Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
4.	C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001, 1st Edition.
5.	Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
6.	Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition.
7.	Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To describe the concepts related with EV, HEV and to compare the same with internal combustion engine vehicles	L2: Understanding
CO2	:	To find gain margin & phase margin for various types of transfer functions of boost converter	L5: Evaluating
CO3	:	To demonstrate the Control of A.C Machines	L3: Applying
CO4	:	To explain the concepts related with batteries and parameters of battery	L4: Analyzing
CO5	:	To module the battery and to study the research and development for batteries	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3								1	2		2	3		3
CO2	3								1	2		2	3		3
CO3	3						3		1	2		2	3		3
CO4	3						3		1	2		2	3		3
CO5	3						3		1	2		2	3	2	3
Avg	3	0	0	0	0	0	3	0	1	2	0	2	3	2	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO304	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	SEMESTER			
PREREQUISTIES	**CATEGORY**	**L**	**T**	**P**	**C**
Electric vehicle	**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1. To introduce the fundamentals of charging architectures, converter topologies and control schemes for electric vehicle charging system

UNIT I	CHARGING ARCHITECTURES FOR ELECTRIC VEHICLES	9	0	0	9

Classification of EV charging architectures, Onboard Chargers, Level 1: Dedicated Converter (Slow Charging), Level 2: Integrated Converter (Semi-fast Charging), Off-Board Chargers, Level 3: Dedicated Off-Board DC Chargers (Fast Charging), Common AC Bus Architecture, Common DC Bus Architecture

UNIT II	CONVERTER TOPOLOGIES FOR CHARGING STATION	9	0	0	9

Vienna Rectifier, Multipulse Rectifier with DC Active Power Filter, Non-isolated Multichannel Interleaved Buck Converter, Phase-Shifted ZVS Full-Bridge Converter, Grid-connected cascaded H-bridge converter, Grid-connected Modular Multilevel Converter based integrated charger for split integrated battery pack, Neutral-Point Clamped Converter

UNIT III	CONTROL SCHEMES AND CHARGING STANDARDS	9	0	0	9

Control Schemes for Charging Converters, Single-Phase AC–DC Converter Control, Three-Phase AC–DC Converter Control, voltage-oriented control (VOC) and direct power control (DPC), Electric Vehicle / Plug in Hybrid Electric Vehicle charging Standards

UNIT IV	BATTERY TECHNOLOGIES FOR TRANSPORTATION APPLICATIONS	9	0	0	9

Nickel-Cadmium (Ni-Cd) Battery, Nickel-Metal Hydride (Ni-MH), Lithium-Ion (Li-Ion), Flow Batteries, Battery Charging Methods, Battery management system

UNIT V	LATEST DEVELOPMENTS IN EV CHARGING	9	0	0	9

Inductive Charging, Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H), EV charging safety configuration and considerations, Grid-Tied Residential charging Systems, Grid-Tied Public charging Systems, EV cable communication protocols, Charging cable standards

Total (45L+0T)= 45 Periods

Text Books:

1. Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, Smart Charging Solutions for Hybrid and Electric Vehicles, Wiley-Scrivener Publishing LLC, 2022

Reference Books:

1. Mary Murphy " Electric and Hybrid Vehicles: Principles, Design and Technology ", Larsen and Keller Education, 2019

E-Reference

1 https://archive.nptel.ac.in/courses/108/103/108103009/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the configurations for chargers for electric vehicle	L1: Remembering

CO2	:	Select a converter topology for electric vehicle charging station	L3: Applying
CO3	:	Use an appropriate control scheme for charging converter	L3: Applying
CO4	:	Understand the principle of batteries used for EV charging station	L1: Remembering
CO5	:	Explain the latest developments in Electric vehicle charging technologies	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1	1	2	2		2		1		2		2	2	2	2
CO2	2	1			1					2		1	1	3	
CO3	2	1	1	2	1	1	2		1				1	1	1
CO4	1	1		1		2	2	2	1		2	2	1	1	
CO5	2	2	3	1		3	1			1	3		2	2	3
Avg	1.6	1.2	2	1.5	1	2	1.67	1.5	1	1.67	2.5	1.67	1.4	1.8	2

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO305	TESTING OF ELECTRIC VEHICLES		SEMESTER			
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
Electrical Machines and Power Electronics		**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To know various standardization procedures
2.	To learn the testing procedures for EV & HEV components
3.	To know the functional safety and EMC
4.	To realize the effect of EMC in EVs
5.	To study the effect of EMI in motor drives and in DC-DC converter system

UNIT I	**EV STANDARDIZATION**	**9**	**0**	**0**	**9**

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.

UNIT II	**TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

UNIT III	**FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC**	**9**	**0**	**0**	**9**

Functional safety life cycle - Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.

UNIT IV	**EMC IN ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements.

UNIT V	**EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM**	**9**	**0**	**0**	**9**

Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path

Total (45L+0T) = 45 Periods

Reference Books:

1.	Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition.
2.	Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition.
3.	EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET 2018, 1st Edition.
4.	EMI/EMC Computational Modeling Handbook, Druce Archam beault, colin branch, Omar M.Ramachi ,Springer 2012, 2nd Edition.
5.	Automotive EMC, Mark Steffika, Springer 2013, 1st Edition.
6.	Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition.

Course Outcomes: Upon completion of this course, the students will be able to:	**Bloom's Taxonomy Mapped**

CO1	:	To describe the status and other details of standardization of EVs	L1: Remembering
CO2	:	To illustrate the testing protocols for EVs and HEV components	L2: Understanding
CO3	:	To analyze the safety cycle and need for functions safety for EV	L4: Analyzing
CO4	:	To analyze the problems related with EMC for EV components.	L4: Analyzing
CO5	:	To evaluate the EMI in motor drive and DC-DC converter system.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3
CO1	3	1	1				2						3		2
CO2	3	1	1				1						3		2
CO3	3	1	1				2						3		2
CO4	3	1	1				1						3		2
CO5	3	1	1				2						3		3
Avg	3	1	1	0	0	0	1.6	0	0	0	0	0	3	0	2.2

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO306	INTELLIGENT CONTROL OF ELECTRIC VEHICLES		SEMESTER			
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
Power Electronics and Electric Vehicle		**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To design and drive the mathematical model of a BLDC motor and its characteristics
2.	To learn the different control schemes for BLDC motor
3.	To study the basics of fuzzy logic
4.	To study the FPGA & VHDL basics
5.	To implement fuzzy logic control of BLDC motor in real time

UNIT I	**MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR**	**9**	**0**	**0**	**9**

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristics Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

UNIT II	**SPEED CONTROL FOR ELECTRIC DRIVES**	**9**	**0**	**0**	**9**

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor

UNIT III	**FUZZY LOGIC**	**9**	**0**	**0**	**9**

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems, overview of fuzzy expert system-fuzzy decision making

UNIT IV	**FPGA AND VHDL BASICS**	**9**	**0**	**0**	**9**

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection

UNIT V	**REAL TIME IMPLEMENTATION**	**9**	**0**	**0**	**9**

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

Total (45L+0T) = 45 Periods

Reference Books:

1.	Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, Wiley 1st Edition 2018.
2.	VHDL Primer, A (3rd Edition), Jayaram Bhasker, Prentice Hall, 1st Edition 2015.
3.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Third Edition” CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4.	Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition.
5.	M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6.	Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley 2017, 2nd Edition
7.	Electric and Plug-in Hybrid Vehicle Networks Optimization and Control, Emanuele Crisostomi • Robert Shorten, Sonja Stüdli • Fabian Wirth, CRC Press, 1st Edition. 2018.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To design the mathematical model of a BLDC motor and to discuss about its characteristics	L2: Understanding
CO2	:	To demonstrate the PID control, anti-windup controller, Intelligent Controller and Vector Control. Control applied to BLDC motor.	L5: Evaluating
CO3	:	To illustrate the basics of fuzzy logic system	L1: Remembering
CO4	:	To describe the basics of VHDL & FPGA applied to control of EVs.	L2: Understanding
CO5	:	To design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3								1	2		2	3		3
CO2	3								1	2		2	3		3
CO3	3						3		1	2		2	3		3
CO4	3						3		1	2		2	3		3
CO5	3						3		1	2		2	3	2	3
Avg	3	0	0	0	0	0	3	0	1	2	0	2	3	2	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO307	HYBRID ELECTRIC VEHICLES					SEMESTER IV
PREREQUISTIES		**CATEGORY**	**L**	**T**	**P**	**C**
Electric Drives, Electric Vehicles		**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1. This course introduces the fundamental concepts, principles and analysis of hybrid and electric vehicles.

UNIT I	**HISTORY OF HYBRID ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance, Capabilities, Automation system computer facilities.

UNIT II	**HYBRID ELECTRIC VEHICLES - INTRODUCTION**	**9**	**0**	**0**	**9**

Micro hybrid vehicles, mild hybrid vehicles, full hybrid vehicles, Parallel Hybrid vehicles, series Hybrid Vehicles, Series-Parallel Hybrid vehicles, plug-in hybrid vehicles, power flow diagrams for various operating modes. Plug-in Hybrid Vehicles: Operating principle, architectures: series-parallel-series-parallel, challenges related to grid connection. Range-extended Electric Vehicles: Classification and configurations, Fuel Cell Electric Vehicles, Solar electric Vehicles, Electric Bi-cycles and their propulsion systems, Vehicle-to- grid, vehicle- to-home concepts, Concept of Hybrid Electric Vehicles.

UNIT III	**ELECTRIC PROPULSION UNIT**	**9**	**0**	**0**	**9**

Electric components used in electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, Drive system efficiency.

UNIT IV	**ELECTRIC DRIVE-TRAINS**	**9**	**0**	**0**	**9**

Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis

UNIT V	**EV MODELLING AND SIMULATION**	**9**	**0**	**0**	**9**

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

Total (45L+0T)= 45 Periods

Text Books:

1.	Goodarzi, Gordon A., Hayes, John G, Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles, Wiley 2018
2.	Wei Liu, Introduction of Hybrid Vehicle system Modelling and Control, Wiley student edition 2013.
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.	James Larminie John Lowry, Electric Vehicle Technology Explained, Second Edition, Wiley, 2012.
5.	Ali Emadi, Mehrdad Ehsani, John M. Miller, 'Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles', CRC Press, 2003.
6.	Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2003, 2ndEdition.

Reference Books:

1.	RiK De Doncker, Advanced Electric Drives – Analysis , Modeling ,Control, Springer publications
2.	De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, Advanced Electrical Drives, First Edition, CRC Press, Taylor and Francis Group, 2011.
3.	Ned Mohan, Power Electronics Convertor, Applications, and Design, Third Edition, Wiley, 2002.

4.	Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, Second Edition, CRC Press, Taylor and Francis Group, 2011.
5.	Sandeep Dhameja, 'Electric Vehicle Battery Systems', Newnes, 2002.
6.	Chris Mi, M. Abul Masrur, David Wenzhong Gao, 'Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives', Wiley, 2011.
E-Reference	
1	https://nptel.ac.in/courses/108/106/108106170/
2	https://nptel.ac.in/courses/108/102/108102121/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Plan the selection of electrical machines for hybrid and electric vehicles.	L3: Applying
CO2	:	Analyze the drive-train topologies and advanced propulsion techniques	L4: Analyzing
CO3	:	Understand the concepts of electric vehicles, hybrid electric vehicles and their impact on environment	L2: Understanding
CO4	:	Evaluate modelling and simulation of EV	L5: Evaluating
CO5	:	Demonstrate the power system of various vehicular system.	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
CO2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
CO3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
CO4	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
CO5	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Avg	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEHO308	BATTERY MANAGEMENT SYSTEMS		SEMESTER			
PREREQUISTIES		**CATEGORY**	**L**	**T**	**P**	**C**
Basics of Electrical Engineering, Electric Circuit theory, Chemistry and Physics		**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

To understand different techniques of digital relaying - their constructions, working principles, applications and limitations along with introduction to Wide Area Measurement System and network protection.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction to Battery Management System(BMS), Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

UNIT II	**BATTERY-MANAGEMENT-SYSTEM REQUIREMENTS.**	**9**	**0**	**0**	**9**

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation.

UNIT III	**BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION**	**9**	**0**	**0**	**9**

Preliminary definitions. - Battery state of charge estimation (SOC)- voltage-based methods to estimate SOC , Model-based state estimation - Battery State of Health Estimation (SOH) - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode

UNIT IV	**MODELLING AND SIMULATION.**	**9**	**0**	**0**	**9**

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, Simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs.

UNIT V	**DESIGN OF BMS**	**9**	**0**	**0**	**9**

Design of battery BMS: Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

Total (45L) = 45 Periods

Text Books:

1.	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2.	Plett, G., Battery Management Systems: Volume II, Equivalent-Circuit Methods, Artech House, 2015
3	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L “Battery Management Systems -Design by Modelling” Philips Research Book Series 2002.

Reference Books:

1.	Davide Andrea,” Battery Management Systems for Large Lithium-ion Battery Packs” Artech House, 2010
2.	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the role of battery management system	L1: Remembering

CO2	:	Identify the requirements of Battery Management System w.r.t application	L2: Understanding
CO3	:	Analyze the concept associated with battery charging / discharging process	L4: Analysing
CO4	:	Assess the various parameters of battery and battery pack	L3: Applying
CO5	:	Design the battery pack model.	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	2	2	2	2	1					1	2	2	1
CO2	1	2	2	2	2	2	1					1	2	2	1
CO3	2	3	3	3	3	2	1					1	3	2	1
CO4	3	3	3	3	3	2	1					1	3	2	1
CO5	2	2	3	3	3	3	1					1	3	2	1
Avg	2	2.4	2.6	2.6	2.6	2.2	1	0	0	0	0	1	2.4	1.9	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO309	ADVANCED ELECTRICAL DRIVES FOR ELECTRIC VEHICLE	SEMESTER			
PREREQUISTIES	**CATEGORY**	**L**	**T**	**P**	**C**
Solid state drives	**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1. To introduce the electrical machines with control module for electric vehicle propulsion.

UNIT I	PERMANENT MAGNET BRUSHLESS MOTOR DRIVES	9	0	0	9

PM Brushless Machines : Structure and Principle of PM Brushless Machines, Inverters for PM Brushless, Switching Schemes for Brushless AC Operation, PM Brushless Motor Control, Application of PM Brushless Motor Drives in Electric vehicle

UNIT II	SWITCHED RELUCTANCE MOTOR DRIVES	9	0	0	9

System Configurations, Switched Reluctance Machine: Structure and Principle of operation, Switched Reluctance Motor Converter Topologies, Soft-Switching Switched Reluctance Motor Converter Topologies, Switched Reluctance Motor Control, Torque-Ripple Minimization Control, Switched Reluctance Motor Drives for Electric Vehicle, Application Examples of Switched Reluctance Motor Drives in Electric Vehicles

UNIT III	MAGNETLESS MOTOR DRIVES	9	0	0	9

Synchronous Reluctance Motor Drives, Doubly-Salient DC Motor Drives, Flux-Switching DC Motor Drive, Axial-Flux Magnetless Motor Drives, Design Criteria of Advanced Magnetless Motor Drives for EVs, Design Examples of Advanced Magnetless Motor Drives for EVs, Potential Applications of Advanced Magnetless Motor Drives in EVs

UNIT IV	VERNIER PERMANENT MAGNET MOTOR DRIVES	9	0	0	9

System Configurations and Vernier Permanent Magnet Machines, Structure and Principle of Vernier Permanent Magnet Machines, Inverters for Vernier Permanent Magnet Motors, Vernier Permanent Magnet Motor Control, Design Examples of Vernier PM Motor Drives for EVs, Outer-Rotor Vernier PM Motor Drive, Outer-Rotor Flux-Controllable Vernier PM Motor Drive, Potential Applications of Vernier PM Motor Drives in EVs

UNIT V	DOUBLE-ROTOR ELECTRIC VARIABLE TRANSMISSION SYSTEMS	9	0	0	9

Double-Rotor Machines, Double-Rotor Electric Variable Transmission System (DR EVT) Structure and operation, Advance Double-Rotor EVT Systems, PM DR EVT System, SR DR EVT System, Axial-Flux DR EVT System, Potential Application of DR EVT Systems in HEVs

Total (45L+0T)= 45 Periods

Text Books:

1. K. T. Chau, 'Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley-IEEE Press, 2015

Reference Books:

1. Mary Murphy " Electric and Hybrid Vehicles: Principles, Design and Technology ", Larsen and Keller Education, 2019

E-Reference

1 https://archive.nptel.ac.in/courses/108/103/108103009/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the use for Permanent magnet Brushless motor drive for electric vehicle	L1: Remembering

CO2	:	Select converter topology for Switched Reluctance Motor used for electric vehicle	L3: Applying
CO3	:	Describe the operation of Magnetless Motor Drives in Electric Vehicles	L2: Understanding
CO4	:	Understand the principle of Vernier Permanent Magnet Machines	L1: Remembering
CO5	:	Select a suitable electric drive for electric vehicle	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	2	3		3		1		2		2	2	1	2
CO2		3			1					2		1	1	2	
CO3	2	1		2	1		1		1				1	1	1
CO4	1	1		1		2	1	2	1		2	2	1	1	1
CO5	1	2	3	1		3				1	3	1	2	2	1
Avg	1.75	1.8	2.5	1.75	1	2.67	1	1.5	1	1.67	2.5	1.5	1.4	1.4	1.25

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEHO310	ENERGY STORAGE SYSTEMS AND APPLICATIONS	SEMESTER			
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
Electrical Engineering	**PEC**	**3**	**0**	**0**	**3**

Course Objectives:

1.	To understand the various types of energy storage technologies.
2.	To analyze thermal storage system.
3.	To analyze different battery storage technologies.
4.	To model the Lithium-ion batteries.
5.	To study the various applications of energy storage systems.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Necessity of energy storage – Types of energy storage – Comparison of energy storage technologies – Demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

UNIT II	**THERMAL STORAGE SYSTEM**	**9**	**0**	**0**	**9**

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modeling of phase change storage system – Simple units, packed bed storage units – Modeling using porous medium approach – Use of TRNSYS.

UNIT III	**ELECTRICAL ENERGY STORAGE**	**9**	**0**	**0**	**9**

Fundamental concept of batteries – Measuring battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries – Mathematical modeling of Lead Acid batteries – Flow batteries.

UNIT IV	**LITHIUM-ION BATTERY MODELING**	**9**	**0**	**0**	**9**

Analysis on charge and discharge temperature characteristics of Lithium-ion batteries – Electrothermal coupling Modeling - Modeling and Optimization of Air Cooling Heat Dissipation of Lithium-ion Battery Packs.

UNIT V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**9**	**0**	**0**	**9**

Flywheel, Supercapacitors, Principles and methods – Applications, Compressed air energy storage, Concept of Hybrid storage – Applications, Pumped hydro storage – Applications.

Total (45L+0T)= 45 Periods

Text Books:

1.	Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', John Wiley & Sons, 3rd Edition, 2021.
2.	Ru-shi Liu, Lei Zhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2nd Volume set, 2012.
3.	Junqiu Li, "Modeling and simulation of Lithium-ion power battery thermal management", Springer, 2020.

Reference Books:

1.	Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1st Edition
2.	Schmidt. F.W. and Willmott. A.J., 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition

E-References:

1.	Prof. Subhasish Basu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102
2.	Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course, https://nptel.ac.in/courses/112105221.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand different types of storage technologies.	L2: Understanding
CO2	:	Model a thermal battery energy storage system	L1: Remembering
CO3	:	Analyze the modeling of Lithium-ion batteries.	L4: Analyzing
CO4	:	Analyze the appropriate storage technologies for different applications.	L3: Applying
CO5	:	Explore the alternate energy storage technologies.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1											2		3
CO2	3		2										2		3
CO3	3		2										2		3
CO4	3		2										2		3
CO5		3				2		1					2		3
Avg	3	2	2	0	0	2	0	1	0	0	0	0	2	0	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

GOVERNMENT COLLEGE OF ENGINEERING, SALEM

REGULATION 2018 A - VERTICALS FOR MINOR DEGREE

VERTICAL - I	VERTICAL - II	VERTICAL - III	VERTICAL - IV	VERTICAL - V	VERTICAL - VI
Civil Engineering	**Computer Science and Engineering**	**Electronics and Communication Engineering**	**Electrical and Electronics Engineering**	**Mechanical Engineering**	**Metallurgical Engineering**
18CEM01 Construction Materials	18CSM01 Programming in C++	18ECM01 Electron Devices	18EEM01 – Network Analysis and Synthesis	18MEM01 Engineering Thermodynamics	18MTM01 Advanced Physical Metallurgy
18CEM02 Building Construction & Equipment	18CSM02 Advanced Data Structures and Algorithms	18ECM02 Digital Electronics	18EEM02 – Signals and Systems	18MEM02 Fluid Mechanics and Machinery	18MTM02 Metallurgical Thermodynamics and kinetics
18CEM03 Concrete Technology	18CSM03 Computer Organization and Design	18ECM03 Electronic Circuits (EC-I & EC-II, LIC)	18EEM03 – Linear and Digital Electronics Circuits	18MEM03 Manufacturing Processes	18MTM03 Mechanical Behaviour of Materials
18CEM04 Environmental Engineering	18CSM04 Advanced Operating Systems	18ECM04 Signal Processing	18EEM04 – Microprocessor and Microcontrollers	18MEM04 Materials Engineering	18MTM04 Rate Processing in Metallurgy
18CEM05 Basics of Transportation Engineering	18CSM05 Data Communication and Computer Networks	18ECM05 Microprocessors and Microcontrollers	18EEM05 – Control Systems	18MEM05 Kinematics of Machinery	18MTM05 Corrosion and Surface Engineering
18CEM06 Repair and Rehabilitation Structures	18CSM06 Programming Essentials in Python	18ECM06 Analog and Digital Communication	18EEM06 – Measurement and Instrumentation	18MEM06 Hydraulics and Pneumatics	18MTM06 Characterization of Materials
18CEM07 Green Building Technology	18CSM07 Advanced Database System Concepts	18ECM07 Communication Networks (CN)	18EEM07 – Electrical Machines	18MEM07 Design of Machine Elements	18MTM07 Automotive, Aerospace and Defense Materials
-----	18CSM08 Virtualization and Cloud Computing	18ECM08 Fundamentals of IoT	18EEM08 – Electric Drives and Control	18MEM08 Heat and Mass Transfer	-----
-----	-----	18ECM09 Wireless Sensors and Networking (WSN)	18EEM09 – Electric Vehicle and Control	18MEM09 Metrology and Quality Control	-----
-----	-----	18ECM10 Basics of Embedded Systems	18EEM10 –Electric Energy Conservation and Auditing	18MEM10 Dynamics of Machinery	-----

LIST OF MINOR DEGREE - VERTICALS

S.No.	Course Code	Course	Cat	Hours/Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
CIVIL ENGINEERING										
1	18CEM01	Construction Materials	OE	3	0	0	3	40	60	100
2	18CEM02	Building Construction & Equipment's	OE	3	0	0	3	40	60	100
3	18CEM03	Concrete Technology	OE	3	0	0	3	40	60	100
4	18CEM04	Environmental Engineering	OE	3	0	0	3	40	60	100
5	18CEM05	Basics of Transportation Engineering	OE	3	0	0	3	40	60	100
6	18CEM06	Repair and Rehabilitation of Structures	OE	3	0	0	3	40	60	100
7	18CEM07	Green Building Technology	OE	3	0	0	3	40	60	100
COMPUTER SCIENCE AND ENGINEERING										
1	18CSM01	Programming in C++	OE	3	0	0	3	40	60	100
2	18CSM02	Advanced Data Structures and Algorithms	OE	3	0	0	3	40	60	100
3	18CSM03	Computer Organization and Design	OE	3	0	0	3	40	60	100
4	18CSM04	Advanced Operating Systems	OE	3	0	0	3	40	60	100
5	18CSM05	Data Communication and Computer Networks	OE	3	0	0	3	40	60	100
6	18CSM06	Programming Essentials in Python	OE	3	0	0	3	40	60	100
7	18CSM07	Advanced Database System Concepts	OE	3	0	0	3	40	60	100
8	18CSM08	Virtualization and Cloud Computing	OE	3	0	0	3	40	60	100
ELECTRONICS AND COMMUNICATION ENGINEERING										
1	18ECM01	Electron Devices	OE	3	0	0	3	40	60	100
2	18ECM02	Digital Electronics	OE	3	0	0	3	40	60	100
3	18ECM03	Electronic Circuits	OE	3	0	0	3	40	60	100
4	18ECM04	Signal Processing	OE	3	0	0	3	40	60	100
5	18ECM05	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100

6	18ECM06	Analog and Digital Communication	OE	3	0	0	3	40	60	100
7	18ECM07	Communication Networks	OE	3	0	0	3	40	60	100
8	18ECM08	Fundamentals of IoT	OE	3	0	0	3	40	60	100
9	18ECM09	Wireless sensors and networking	OE	3	0	0	3	40	60	100
10	18ECM10	Basics of Embedded systems	OE	3	0	0	3	40	60	100
ELECTRICAL AND ELECTRONICS ENGINEERING										
1	18EEM01	Linear and Digital Electronics Circuits	OE	3	0	0	3	40	60	100
2	18EEM02	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100
3	18EEM03	Control Systems	OE	3	0	0	3	40	60	100
4	18EEM04	Measurements and Instrumentation	OE	3	0	0	3	40	60	100
5	18EEM05	Electrical Machines	OE	3	0	0	3	40	60	100
6	18EEM06	Electric Drives and Control	OE	3	0	0	3	40	60	100
7	18EEM07	Electric Vehicles and Control	OE	3	0	0	3	40	60	100
8	18EEM08	Electrical Energy Conservation and Auditing	OE	3	0	0	3	40	60	100
9	18EEM09	SMPS and UPS	OE	3	0	0	3	40	60	100
10	18EEM10	Utilization of Electrical Energy	OE	3	0	0	3	40	60	100
MECHANICAL ENGINEERING										
1	18MEM01	Engineering Thermodynamics	OE	3	0	0	3	40	60	100
2	18MEM02	Fluid Mechanics and Machinery	OE	3	0	0	3	40	60	100
3	18MEM03	Manufacturing Processes	OE	3	0	0	3	40	60	100
4	18MEM04	Materials Engineering	OE	3	0	0	3	40	60	100
5	18MEM05	Kinematics of Machinery	OE	3	0	0	3	40	60	100
6	18MEM06	Hydraulics and Pneumatics	OE	3	0	0	3	40	60	100
7	18MEM07	Design of Machine Elements	OE	3	0	0	3	40	60	100
8	18MEM08	Heat and Mass Transfer	OE	3	0	0	3	40	60	100
9	18MEM09	Metrology and Quality Control	OE	3	0	0	3	40	60	100

10.	18MEM10	Dynamics of Machinery	OE	3	0	0	3	40	60	100
METALLURGICAL ENGINEEING										
1	18MTM101	Advanced Physical Metallurgy	OE	3	0	0	3	40	60	100
2	18MTM102	Thermodynamics and Kinetics in Metallurgy	OE	3	0	0	3	40	60	100
3	18MTM103	Mechanical Behaviour of Materials	OE	3	0	0	3	40	60	100
4	18MTM104	Rate Processes in Metallurgy	OE	3	0	0	3	40	60	100
5	18MTM105	Corrosion and Surface Engineering	OE	3	0	0	3	40	60	100
6	18MTM106	Materials Characterization	OE	3	0	0	3	40	60	100
7	18MTM107	Automotive, Aerospace and Defence Materials	OE	3	0	0	3	40	60	100

B.E. – CIVIL ENGINEERING - MINOR DEGREE

18CEM01	CONSTRUCTION MATERIALS			Semester			
PREREQUISITES		Category	OE	Credit			3
NIL		Hours/Week	L	T	P		TH
			3	0	0		3

Course Learning Objectives

1	To study the characteristics and Properties of Stones and Brick
2	To impart knowledge on Cement, Aggregate and Mortar
3	To understand the behaviour of concrete and seasoning timber
4	To study the Parts and types of flooring and roofing
5	To study carpentry, arches, lintels and finishing works.

Unit I	STONES, BRICKS	9	0	0	9

Building Stone –classification of rocks-characteristics of good building stone – deterioration and preservation of stone work – tests on stones - Bricks- manufacture of clay bricks -classification - tests on bricks- bricks for special use- refractory bricks.

Unit II	CEMENT, AGGREGATES, MORTAR	9	0	0	9

Cement- composition- manufacturing process-wet and dry processes. Aggregates –coarse and fine aggregates-characteristics and function. Mortar- properties- uses- types of mortars- selection of mortars for various Civil Engineering construction.

Unit III	CONCRETE, TIMBER AND OTHER MATERIALS	9	0	0	9

Concrete- ingredients - principles of hardened concrete- Special concrete- types.
Timber- characteristics- seasoning-preservation- Panels of laminates. Glass- properties- uses. Steel- Uses - market forms.

Aluminum and other metallic materials for construction.

Paints, Varnishes and Distempers-types-properties.

Unit IV	FLOORING AND ROOFING	9	0	0	9

Components of floor- selection of flooring materials- suitability of floors for various applications. damp proof course, causes of dampness- effect of dampness - requirements of good stairs - classification of stairs -Roofs - types of roofs- requirements - pitched roof - lean to roof-gable roof-hip roof-flat roof-RCC roof.

Unit V	CARPENTARY, ARCHES, LINTELS AND FINISHING WORKS	9	0	0	9

Location of doors and windows - size of doors - types of doors - fixture and fastenings for doors and windows - arches - classification - stability of an arch - lintels - classification of lintels - steel lintel. scaffolding - component parts - shoring - methods of plastering - defects in plastering - pointing - objectives- methods of pointing

Total= 45 Periods

Text Books:	
1	B.C. Punmia, Building Construction, Laxmi Publications; Eleventh edition -2021
2	S.C.Rangwala, Building Construction,CharotarPublishing House Pvt. Ltd, 34th Edition - 2022
3	P. Purushothama Raj., Building Construction Materials and Techniques, Pearson Education India, First Edition - 2017
Reference Books:	
1	Shetty M.S., Concrete Technology (Theory and Practice), S.Chand& Company Ltd.,2021.
2	Rangwala S.C., Engineering Materials (Material Science) revised and enlarged by Rangwala K.S. and Rangwala P.S., Charotar Publishing House, 2010.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and characterize and properties of Stone and brick	Remember
CO2	Understand the manufacturing process of cement and functions of mortar	Understand
CO3	Identify the age of timber and preservation methods of timber	Remember
CO4	Differentiate the types of roofing and flooring	Understand
CO5	Understand the miscellaneous works such as carpentry, lintels, Arch, etc.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
CO2	-	2	-	-	-	2	3	-	-	-	-	-	-	-	-
CO3	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO4	1	-	2	-	2	3	2	-	-	-	-	-	-	-	-
CO5	1	-	-	-	3	-	2	-	-	-	-	-	-	-	-
Avg	1	2	2	-	2	3	2	-	-	-	-	-	-	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td>18CEM02</td><td colspan="4">BUILDING CONSTRUCTION & EQUIPMENT</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td colspan="2">Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">NIL</td><td colspan="2" rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="9">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="8">Able to gain basic knowledge in construction methods.</td></tr>
<tr><td>2</td><td colspan="8">Able to gain basic knowledge in equipment.</td></tr>
<tr><td>3</td><td colspan="8">Able to gain basic knowledge in machineries.</td></tr>
<tr><td>4</td><td colspan="8">Able to gain basic knowledge in fire safety principles.</td></tr>
<tr><td>5</td><td colspan="8">Able to gain basic knowledge in green technology.</td></tr>
<tr><td colspan="2">Unit I</td><td colspan="3">CLASSIFICATION OF BUILDINGS, FOUNDATIONS AND TYPES OF MASONRY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Component parts of a building -Their functions. Classification of buildings according to National building code.
Site investigation for foundation as per N.B.C, Types of foundation and prevention of dampness at basement level,Classification of stone masonry</td></tr>
<tr><td colspan="2">Unit II</td><td colspan="3">DOORS, WINDOWS, LINTELS, SCAFFOLDING AND STAIRCASES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Doors and windows – parts of door and window – Types of Door and windows–Ventilators – fixed, swinging type and louvered. Lintels – Functions, Scaffolding – Purpose and types –Location of stairs.Types of stairs</td></tr>
<tr><td colspan="2">Unit III</td><td colspan="3">ROOFS, FLOORINGS, PROTECTIVE AND DECORATIVE FINISHES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Roof Beams and Roof Slabs – Types of Roofing Systems – Methods of Termite Proofing – Methods of Damp proofing.
Types of floors- Plastering (Interior and Exterior) – Pointing for Walls and Floors using Grouts – White Washing, Color Washing with different Color Shades available in the Markets – Painting – Types of Painting for Interior and Exterior application.</td></tr>
<tr><td colspan="2">Unit IV</td><td colspan="3">CONSTRUCTION EQUIPMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Selection of equipment for earthwork excavation, drilling, blasting, tunnelling, erection and dewatering and pumping, concreting, material handling and erection of structures</td></tr>
<tr><td colspan="2">Unit V</td><td colspan="3">GREEN BUILDING TECHNOLOGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="9">Introduction to green technology – types and importance; zero waste and r concept, green materials – green concrete (purpose and limitations), green buildings, green engineering.</td></tr>
<tr><td colspan="9" align="right">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Building Construction by S.C.Rangawala
2	Construction Technology by Sarkar Oxford University Press
3	Building Material & Construction by S.P. Arora& S. P. Bindra
Reference Books:	
1	Hopkinson And Kay J.D., The Lighting of Building, Faber and Faber, London.
2	Koerner, R.M, Construction & Geotechnical Methods in Foundations Engineering, McGraw Hill, 1984
3	Varna M., Construction Equipment and Its Planning & Applications, Metropolitan Books Co, 1979

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Organize the construction technique to be followed in brick and stone masonry, concreting, flooring, roofing and plastering etc.	Create
CO2	Select safe practices in building construction activities	Evaluate
CO3	Clarify the different types of roofs, floor and productive materials of buildings	understand
CO4	Select the relevant equipment for building construction	Evaluate
CO5	Apply the Principles of green building technology.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	3	2	2	2	1	1	-	-	-	-	1
CO2	-	-	-	-	3	2	2	2	2	2	-	-	-	-	1
CO3	-	-	-	-	2	3	2	2	2	1	-	-	-	-	1
CO4	-	-	-	-	2	2	3	1	1	2	-	-	-	-	1
CO5	-	-	-	-	2	3	2	2	2	2	-	-	-	-	1
Avg	-	-	-	-	2.4	2.4	2.2	1.8	1.6	1.6	-	-	-	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM03	CONCRETE TECHNOLOGY				Semester		
PREREQUISITES		**Category**	**OE**	**Credit**			**3**
NIL		**Hours/Week**	**L**	**T**		**P**	**TH**
			3	**0**		**0**	**3**

Course Learning Objectives

1	To understand the properties of ingredients of concrete.
2	To study the behavior of concrete at its fresh and hardened state.
3	To study about the concrete design mix.
4	To know about the procedures in concrete at different stage.
5	To understand special concrete and their uses.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Concrete materials, Cement: Field and laboratory tests on cement, Types of cement and their uses, different tests for aggregates. Methods for manufacturing of cement- Wet and dry process. Hydration of cement, Bogue's compound.					
Unit II	**ADMIXTURES**	**9**	**0**	**0**	**9**
Accelerating admixtures, Retarding admixtures, water reducing admixtures, Air entraining admixtures, coloring agent, Plasticizers. Batching, Mixing, Transportation, placing of concrete, curing of Concrete					
Unit III	**MIX DESIGN**	**9**	**0**	**0**	**9**
Factors influencing mix proportion, Mix design by ACI method and I.S. code method, Design of high strength concrete.					
Unit IV	**BEHAVIOUR OF CONCRETE**	**9**	**0**	**0**	**9**
Strength of concrete, Shrinkage and temperature effects, creep of concrete, permeability of concrete, durability of concrete, Corrosion, Causes and effects, remedial measures, Thermal properties of concrete, Micro cracking of concrete.					
Unit V	**SPECIAL CONCRETE**	**9**	**0**	**0**	**9**
Light-weight concrete, Fibre reinforced concrete, Polymer modified concrete, Ferro cement, Mass concrete, Ready-mix concrete, Self-compacting concrete, Quality control, Sampling and testing, Acceptance criteria.					
					Total= 45 Periods

Text Books:

1	Neville A.M Properties of Concrete, Pearson publication, 2012.
2	Shetty M.S Concrete technology, S.Chand and Company Ltd, New Delhi 2022.
3	Santha Kumar A.R Concrete Technology, Oxford university Press, NewDelhi, 2022.
4	Mehta K.P Concrete Technology, Chand & Co, NewDelhi, 2006.
5	Robert RatayForensic Structural Engineering Handbook, McGraw Hill LLC, 2009

Reference Books:	
1	Indian Standard Recommended Guide lines for Concrete Mix Design, IS:10262 – 2019, Bureau of Indian Standards, NewDelhi.
2	Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete IS:383-1970 R2011, Bureau of Indian Standards, NewDelhi.
3	Gambhir.M.L,Concrete Technology, Volume I & II, Tata McGraw-HillBookCompany,Third print, 2003
4	Krishna Raju N. Design of Concrete Mixes, CBS publishers. NewDelhi, 2002.
5	Stephen E. Petty,Forensic Engineering: Damage Assessments for Residential and Commercial Structures,CRCpress,Taylor& Francis,2013.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To identify suitable materials to be used in the cement concrete by conducting various tests as per BIS code.	Evaluate
CO2	To know about the specific applications and uses of admixtures.	Understand
CO3	Design the concrete mix using ACI and BIS code methods.	Create
CO4	Determine the properties of fresh and hardened of concrete.	Evaluate
CO5	Design special concretes and to Ensure quality control while testing/ sampling and acceptance criteria for pre and post construction work.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	3	-	1	1	1	2	1	1	1	-	1
CO2	-	-	-	-	3	-	3	-	1	1	-	-	2	-	1
CO3	-	-	-	-	3	-	3	-	-	1	-	-	1	-	1
CO4	-	-	-	-	3	2	1	-	-	-	-	-	-	-	1
CO5	-	-	-	-	3	3	3	1	1	3	1		3	-	1
Avg	-	-	-	-	3	2.5	2.2	1	1	1.75	1	1	1.75	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM04	ENVIRONMENTAL ENGINEERING			Semester		
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To evaluate the sources of water and analyse its characteristics and processes in water treatment, express the analysis of distribution network
2	To design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and its disposal
3	To predict the sources, effects, dispersion of air pollutants air quality management and its control measures
4	To identify the characteristics and sources of municipal solid wastes, its collection methods, off-site processing of municipal solid wastes and its recovery, disposal methods
5	To assess the sources, effects and control measures of noise pollution

Unit I	WATER TREATMENT	9	0	0	9

Water Quality and its Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.

Unit II	WASTEWATER TREATMENT	9	0	0	9

Sewerage system design, quantity and quality of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

Unit III	AIR POLLUTION	9	0	0	9

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.

Unit IV	SOLID WASTE MANAGEMENT	9	0	0	9

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Unit V	NOISE POLLUTION	9	0	0	9

Noise pollution: Sources; Health effects; Standards; Measurement and control methods

Total= 45 Periods

Text Books:

1	Garg, S.K. Water supply Engineering, Khanna Publishers, New Delhi, 2010.
2	Garg, S.K. Sewage water disposal and Air pollution, Khanna Publishers, New Delhi, 2010.
3	George Tchobanoglous et.al., Integrated Solid Waste Management, McGraw-Hill, Publishers, 1993.
4	Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.

Reference Books:	
1	Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2	Peavy S.W., Rowe D.R. and Tchobanoglous G. Environmental Engineering, McGraw Hill, NewDelhi, 1985.
3	Metcalf and Eddy,M.C., Wastewater Engineering – Treatment &Reuse,TataMcGraw-Hill Publications, New Delhi,2003.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the sources of water supply, analyze the characteristics of water with its standards and various unit operations and processes in water treatment, express the analysis of distribution network	Remember
CO2	Expertise design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and disposal and justify the methods for disposal of sewage	Analyze
CO3	Predict the sources, effects, dispersion of air pollutants air quality management and its control measures	Apply
CO4	Aware about the characteristics, types and sources of municipal solid wastes, Learn the collection methods, Know about off-site processing of municipal solid wastes and its recovery, disposal methods	Remember
CO5	Understand the sources, effects and control methods of noise pollution	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	1	3	2	1	1	2	1	1	3	-	2
CO2	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO3	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO4	2	1	3	1	1	3	1	-	-	2	2	1	3	-	2
CO5	2	-	3	-	-	3	-	-	-	2	1	1	3	-	2
Avg	2	1	3	1.3	1	3	1.3	1	1	2	1.6	1	3	-	2
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM05	BASICS OF TRANSPORTATION ENGINEERING			Semester			
PREREQUISITES		**Category**	**OE**	**Credit**			**3**
NIL		**Hours/Week**	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	The objective of the course is to educate the students on various components of highway engineering.
2	To educate the geometric design concepts of highway engineering
3	To develop skills on construction and maintenance of highway.
4	Ability to plan various civil engineering aspects of railways and educate various components of railways
5	The course enables the students to develop skill on evaluation and maintenance of railway track.

Unit I	**CROSS SECTIONAL ELEMENTS OF HIGHWAYS**	**9**	**0**	**0**	**9**

Classification of Highways - Classification and Cross Section of Urban and Rural Roads (IRC), Highway Cross Sectional Elements- Right of Way, Carriage Way, Camber, Kerbs, Shoulders and Footpaths (IRC Standards), Sight Distances - Stopping Sight Distance (SSD), Overtaking Sight Distance (OSD), Sight Distance at Intersections, Intermediate Sight Distance and Illumination Sight Distance - Cross Sections of Different Class of Roads -

Unit II	**GEOMETRIC DESIGN OF HIGHWAYS**	**9**	**0**	**0**	**9**

Horizontal Alignments – Superelevation, Widening of Pavements on Horizontal Curves, Vertical Alignments - Rolling. Limiting, Exceptional and Minimum Gradients, Summit and Valley Curves -Geometric Design of Hill Roads (IRC Standards Only)

Unit III	**CONSTRUCTION AND MAINTENANCE OF HIGHWAY**	**9**	**0**	**0**	**9**

Construction of Flexible and Rigid Pavements – Defects in Flexible and Rigid Pavements -Highway Drainage – Evaluation and Maintenance of Pavements.

Unit IV	**RAILWAY PLANNING AND DESIGN**	**9**	**0**	**0**	**9**

Permanent Way, its Components and Functions of Each Component: Rails - Types of Rails, Rail Fastenings, Concept of Gauges, Coning of Wheels, Creeps Sleepers - Functions, Materials, Density. Ballasts - Functions, Materials, Ballast less Tracks Geometric Design of Railway Tracks Gradients and Grade Compensation, Super-Elevation, Widening of Gauges in Curves, Transition Curves, Horizontal and Vertical Curves.

Unit V	**RAILWAY TRACK CONSTRUCTION MAINTENANCE AND OPERATION**	**9**	**0**	**0**	**9**

Points and Crossings – Turnouts, Track circuiting, Signaling, Interlocking, Lay Outs of Railway Stations and Yards, Rolling Stock, Tractive Power, Track Resistance, Level Crossings.

Total= 45 Periods

Text Books:

1	Khanna K., Justo C.E.G., Highway Engineering Revised 10th Edition Khanna Publishers, Roorkee, 2014
2	Kadiyalil. R, Engineering Traffic and Transport Planning, Khanna Publishers, New Delhi, 2019.
3	Chandola S.P. Transportation Engineering-2019

Reference Books:	
1	Sharma S.K., Principles Practice and Design of Highway Engineering, S. Chand & Co Ltd. New Delhi, 2006
2	Guidelines Of Ministry of Road Transport and Highways, Government of India.
3	Agarwal M.M., Indian Railway Track, 14th Edition, Prabha and Co., New Delhi, 2002.
4	Saxena S.C. Highway & Traffic Engineering, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Classify roads as per Indian Road Congress and describe the principles of highway alignment	Understand
CO2	Determine the highway geometric elements	Analyse
CO3	Differentiate between types of pavements, their construction and design principles	Analyse
CO4	Explain the functions of components of Railways	Understand
CO5	Carry out the various methods for track alignment & procedure for construction of railway & maintenance of track	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
CO2	2	3	2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	2	2	3	1	3	-	-	-	1	-	-
CO4	-	-	-	-	2	2	3	1	2	-	-	-	-	-	-
CO5	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
Avg	2	3	2	2	2	2	3	1	2.25	-	-	-	1	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td>18CEM06</td><td colspan="3">REPAIR AND REHABILITATION OF STRUCTURES</td><td colspan="2">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">Study the various types and properties of repair materials</td></tr>
<tr><td>2</td><td colspan="6">Learn various distress and damages to concrete structures</td></tr>
<tr><td>3</td><td colspan="6">Understand the importance of maintenance of structures</td></tr>
<tr><td>4</td><td colspan="6">Assess the damage to structures using various tests</td></tr>
<tr><td>5</td><td colspan="6">Learn various repair techniques of damaged structures, corroded structures</td></tr>
<tr><td>Unit I</td><td colspan="2">MAINTENANCE AND REPAIR STRATEGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Maintenance, repair and rehabilitation, Facts of Maintenance, importance of Maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.</td></tr>
<tr><td>Unit II</td><td colspan="2">SERVICEABILITY AND DURABILITY OF CONCRETE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Quality assurance for concrete construction, concrete properties- strength, permeability, thermal properties and cracking-effects due to climate, temperature, chemical, corrosion- Design and construction errors-effects of cover thickness and cracking.</td></tr>
<tr><td>Unit III</td><td colspan="2">MATERIALS AND TECHNIQUES FOR REPAIR</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Special concretes and mortar, concrete chemical, special elements for accelerated strength gain, expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, fibre reinforced concrete, rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings and cathodic protection.</td></tr>
<tr><td>Unit IV</td><td colspan="2">REPAIRS, REHABILITATION AND RETROFITTING OF STRUCTURES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Strengthening of Structural elements, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.</td></tr>
<tr><td>Unit V</td><td colspan="2">DEMOLITION TECHNIQUES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Demolition methods by machines, explosives, Advanced techniques-Demolition sequences, dismantling techniques, safety precautions in dismantling and demolition, Engineered demolition techniques for dilapidated structures- case studies</td></tr>
<tr><td colspan="7" align="right">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Shetty, M.S, Concrete Technology- Theory and Practice, S. Chand and company, New Delhi,2019
2	Repair and protection of concrete structures by Noel P. Mailvaganam, CRC Press,1991.
3	CPWD: Handbook on Repair & Rehabilitation of R.C.C. Buildings, CPWD, Govt. of India, 2002, updated reprint 2011

Reference Books:	
1	Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low-cost housing, "RHDC.NBO" Anna University, July 1992.
2	Raikar R.N.,Learning from failures- deficiencies in design, construction and services – R&D Centre (SDCPL), Raikar bhavan, Bombay,1987
3	Palaniyappan, N., Estate management, Anna Institute of Management, Chennai,1992.
4	Lakshmipathy, M. etal., Lecture notes of workshop on Repairs and Rehabilitation of structures, 29-30th October 1999.
5	https://nptel.ac.in/courses/114106035/38

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate the condition of structures	Understand
CO2	Inspect and evaluate the damaged structure	Analyze
CO3	Implement the repairing techniques of a structure	Analyze
CO4	Identify and Use different materials for repairing works	Apply
CO5	Demonstrate the dismantling and demolishing structures	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-
CO2	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-
CO3	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-
CO4	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-
CO5	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-
Avg	1	-	2	2	2	2	3	2	-	-	-	1	2	-	-

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM07	**GREEN BUILDING TECHNOLOGY**			**Semester**			
PREREQUISITES		**Category**		**OE**	**Credit**		**3**
NIL		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To Know various aspects of green buildings
2	To Learn the principles of planning and orientation of buildings.
3	To Relate the construction of green building with prevailing energy conservation policy and regulations.
4	To Know and identify different green building construction materials.
5	To Learn different rating systems and their criteria

Unit I	**INTRODUCTION TO GREEN BUILDING**	**9**	**0**	**0**	**9**

Introduction, Necessity, Definition & concept of Green Building, Issues and strategies of Green Building, Principles and Benefits of Green Building, Components/ features of Green Building, Energy Efficiency, Water efficiency, Material Efficiency, Indoor Air Quality.

Unit II	**SITE SELECTION AND PLANNING**	**9**	**0**	**0**	**9**

Site selection, Site selection strategies, Landscaping, building form, orientation, building envelope and fenestration, material and construction techniques, roofs, walls, fenestration and shaded finishes, Environmental design (ED) strategies for building construction, Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, recycle and reuse systems, Waste Management.

Unit III	**ENERGY AND ENERGY CONSERVATION**	**9**	**0**	**0**	**9**

Introduction, Environmental impact of building constructions, present scenario, Need of energy conservation, Concepts of embodied energy,

operational energy and life cycle energy, Methods to reduce operational energy, Energy efficient building, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.

Unit IV	**BUILDING MATERIALS**	**9**	**0**	**0**	**9**

Green building materials and products- Bamboo, Rice husk ash concrete, plastic bricks, Bagasse particle board, Insulated concrete forms. use of materials with recycled content such as blended cements, pozzolana cements, flyash bricks, vitrified tiles, materials from agro and industrial waste, reuse of waste material-Plastic, rubber, Newspaper wood, Nontoxic paint, green roofing.

Unit V	**RATING SYSTEM**	**9**	**0**	**0**	**9**

Introduction to Leadership in Energy and Environmental Design (LEED) criteria, Indian Green Building council (IGBC) Green rating, Green Rating for Integrated Habitat Assessment. (GRIHA) criteria, National Productivity council (NPC) Ministry of New and Renewable Energy (MNRE) Bureau of Energy efficiency (BEE) -BER (Building Energy Rating) – Certificates.

Total= 45 Periods

Text Books:

1	Kibert, C.J., Sustainable construction: Green Building design and Delivery, John Wiley Hobouken, NewJersey, 3rd Edition, 2012.
2	Chauhan, D S Sreevasthava, S K., Non-conventional Energy Resources, New Age International Publishers, NewDelhi, 4th Edition, 2021

Reference Books:	
1	O.P. Gupta, Energy Technology, Khanna Publishing House, NewDelhi
2	Jagadeesh, K S, Reddy Venkatta Rama &Nanjunda Rao, K S., Alternative Building Materials and Technologies, New Age International Publishers,Delhi.
3	Sam Kubba., Handbook of Green Building Design and Construction, Butterworth- Heinemann.
4	Means R S, Green Building - Project Planning and Cost Estimating, John Wiley &Sons
5	Sharma K V, Venkataseshaiah P., Energy Management and Conservation, IK International.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concepts of Green Building	Understand
CO2	Discuss the Planning of Green Building.	Understand
CO3	Explain the concept of Energy and Energy Conservation.	Understand
CO4	Select appropriate green building material and technique.	Understand
CO5	Summarize the Green Building Functions in various organizations.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	1	-	2	3	-	-	-	2	1	2	-	-
CO2	1	1	1	2	1	-	-	-	-	-	-	-	2	-	-
CO3	-	1	3	-	2	-	-	-	-	-	-	-	2	-	-
CO4	-	1	2	-	3	-	-	-	-	-	2	-	2	-	-
CO5	1	1	2	3	2	-	-	-	-	-	2	-	2	-	-
Avg	1	1	2	2	2	2	3	-	-	-	2	1	2	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

B.E. – COMPUTER SCIENCE ENGINEERING - MINOR DEGREE

18CSM01	**PROGRAMMING IN C++**					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand and develop the object oriented programming concepts.
2	To familiarize and design the template functions and classes
3	To disseminate and apply exception handling mechanisms.
4	To learn and exploit stream classes.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Procedure oriented programming paradigm - Object oriented programming paradigm - Basic concepts of object oriented programming, benefits of OOP, application of OOP - C++ fundamentals –structure of C++ program, tokens, data types - Operators and expressions - Control structures - Functions.

Unit II	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.

Unit III	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Inheritance – defining derived classes, types, virtual base classes, abstract classes, constructor in derived classes - Pointers- pointers to objects, this pointer, pointer to derived classes - Virtual functions.

Unit IV	**TEMPLATES AND EXCEPTION HANDLING**	**9**	**0**	**0**	**9**

Generic Classes – class template, class templates with multiple parameters - Generic Functions - function templates, function templates with multiple parameters, member function templates - Exception handling – basics, exception handling mechanism, rethrowing an exception – Exception handling options – understanding terminate() and unexpected() – the uncaught_exception() function – bad_exception().

Unit V	**CONSOLE I/O AND FILE HANDLING**	**9**	**0**	**0**	**9**

C++ Stream Classes – unformatted I/O operations, formatted console I/O operations, manipulators - Files-classes for file operation, opening and closing a file, detecting end of file, files modes, sequential file operations, random file operations.

Total (45 L) =45 Periods

Text Books:

1	E. Balagurusamy “Object –Oriented Programming with C++” Sixth Edition Tata McGraw-Hill

Reference Books:

1	Herbert Schildt, "The Complete Reference C++", Fifth Edition, Tata McGraw Hill
2	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley
3	K.R.Venugopal, Rajkumar Buyya, T.Ravishankar , Mastering in C++, Second Edition, Tata McGraw Hill

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Build the object oriented programming concepts.	Apply
CO2	Familiarize and build the template functions and classes	Understand
CO3	Disseminate and apply exception handling mechanisms.	Apply
CO4	Depict and exploit steam classes.	Understand

18CSM02	ADVANCED DATA STRUCTURES AND ALGORITHMS					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the concepts of ADTs
2	To Learn linear data structures – lists, stacks, and queues
3	To have knowledge about non-linear data structures like trees and graphs
4	To understand concepts about searching and sorting and hashing techniques

Unit I	**LINEAR DATA STRUCTURES – LIST**	**9**	**0**	**0**	**9**

Abstract Data Types (ADTs) – List ADT - Array based Implementation - Linked List Implementation – Singly Linked Lists - Circularly Linked Lists - Doubly-Linked Lists - Applications of Lists – Polynomial Manipulation – All operations (Insertion, Deletion, Merge, Traversal).

Unit II	**LINEAR DATA STRUCTURES –STACKS AND QUEUES**	**9**	**0**	**0**	**9**

Stack ADT - Operations - Applications of Stacks - Evaluating Arithmetic Expression - Conversion of infix to postfix Expression - Queue ADT - Operations - Circular Queue - DeQueue - Applications of Queue

Unit III	**NON LINEAR DATA STRUCTURES – TREES**	**9**	**0**	**0**	**9**

Tree ADT – Tree traversals – Binary Tree ADT – Expression Trees – Applications of Trees – Binary Search Tree ADT – Threaded Binary Trees- AVL Trees – B-Tree – Heaps - Operations of Heaps - Priority Queues - Binary Heap - Max Heap - Min Heap - Applications of Heap.

Unit IV	**NON LINEAR DATA STRUCTURES – GRAPHS**	**9**	**0**	**0**	**9**

Definition – Representation of Graphs –Types of Graphs - Graph Traversals - Breadth First Search - Depth First Search - Application of Graph Structures: Shortest Path Problem: Dijkstra's Algorithm - Minimum Spanning Trees: Prim's Algorithm - Kruskal's Algorithms

Unit V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**	**0**	**0**	**9**

Searching: Linear Search - Binary Search - Sorting Algorithms - Insertion Sort - Selection Sort - Shell Sort - Bubble Sort - Quick Sort - Merge Sort - Radix Sort - Hashing: Hash Functions – Separate Chaining – Open Addressing – Rehashing – Extendible Hashing.

Total (45 L) =45 Periods

Text Books:

1	Mark Allen Weiss, " Data Structures and Algorithm Analysis in C ", 4/E Pearson Education, 2013.

Reference Books:

1	Seymour Lipschutz, "Data Structures With C ",(Schaum`s Outline Series) Published by Tata McGraw-Hill Education Pvt. Ltd., 2015
2	Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, "Fundamentals of Data Structures In C", Second Edition, Silicon Press, 2008.
3	Richard F.Gilberg & Behrouz A.Forouzan, "Data Structures: A Pseudo code Approach With C", Second Edition, Cengage Learning Publishers,2005.
4	Classic Data Structures", Second Edition by Debasis Samanta, PHI Learning, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Implement various abstract data types to solve real time problems by using Linear Data Structures	Apply
CO2	Apply the different Non-Linear Data Structures to solve problems	Apply
CO3	Analyze and implement graph data structures to solve various computing problems.	Analyze
CO4	Critically analyze the various sorting and searching algorithms	Analyze

18CSM03	COMPUTER ORGANIZATION AND DESIGN					
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the basic structure and operations of digital computer
2	To learn the working of different arithmetic operations
3	To understand the different types of control and the concept of pipelining
4	To study the hierarchical memory system including cache memory and virtual memory
5	To understand the different ways of communication with I/O devices and standard I/O interfaces

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Functional units ,Basic Operational Concepts, Bus Structure ,Memory Locations and Addresses, MemoryOperations, Instruction and Instruction Sequencing, Addressing modes.

UNIT II	**ARITHMETIC UNIT**	**9**	**0**	**0**	**9**

Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, BoothAlgorithm, Fast Multiplication, Integer Division, Floating point number operations.

UNIT III	**PROCESSOR UNIT AND PIPELINING**	**9**	**0**	**0**	**9**

Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards ,Data path & Control Considerations.

UNIT IV	**MEMORY SYSTEMS**	**9**	**0**	**0**	**9**

Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory,Memory Management requirements, Secondary Storage Device.

UNIT V	**INPUT AND OUTPUT ORGANIZATION**	**9**	**0**	**0**	**9**

Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/O Interfaces (PCI, SCSI, USB).

Total (45 L) =45 Periods

Text Books:

1	Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill,5th Edition, 200

Reference Books:

1	Patterson and Hennessey, "Computer Organization and Design ". The Hardware/Software interface,Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2	Hayes, "Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006
3	Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley,2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the working principles of computer componets	Understand
CO2	Design the arithmetic and processing units	Create
CO3	Analyze the various computer components	Analyze

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18CSM04	ADVANCED OPERATING SYSTEMS		Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the structure and functions of Operating systems
2	To understand the process concepts and scheduling algorithms
3	To understand the concept of process synchronization and deadlocks
4	To learn various memory management schemes
5	To illustrate various file systems and disk management strategies

UNIT I	**INTRODUCTION AND OPERATING SYSTEM STRUCTURES**	**9**	**0**	**0**	**9**

Main frame Systems, Desktop Systems, Multiprocessor Systems, Distributed Systems, Clustered Systems, Real Time systems, Hand held Systems; Operating Systems Structures - System Components, Operating System Services, System calls, System Programs, System Design and Implementation.

UNIT II	**PROCESS MANAGEMENT**	**9**	**0**	**0**	**9**

Processes-Process Concepts, Process Scheduling, Operation on Processes, Co-Operating Processes, InterProcess Communication; Threads- Multithreading Models, Threading Issues; CPU Scheduling-Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

UNIT III	**PROCESS SYNCHRONIZATION AND DEADLOCKS**	**9**	**0**	**0**	**9**

Process Synchronization- The Critical Section Problem, Synchronization Hardware, Semaphores, Classical Problem of Synchronization, Monitors; Deadlocks- Deadlock Characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance ,Deadlock Detection, Recovery from Deadlock.

UNIT IV	**MEMORY MANAGEMENT AND VIRTUAL MEMORY**	**9**	**0**	**0**	**9**

Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.

UNIT V	**FILE SYSTEM AND MASS-STORAGE STRUCTURE**	**9**	**0**	**0**	**9**

File System Interface - File Concepts, Access methods, Directory Structure, File Sharing, File Protection; File System Implementation- File System Structure and Implementation, Directory Implementation, Allocation Methods, Free Space Management; Mass-Storage Structure - Disk Structure, Disk scheduling, Disk Management, RAID Structure; Case study: Linux system.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, P.B.Galvin, G.Gagne —Operating System Concepts 6th edition, John Wiley & Sons, 2003.

Reference Books:

1	Andrew S. Tanenbaum, —Modern Operating Systems, PHI , 2nd edition, 2001
2	D.M.Dhamdhere, “Systems Programming and Operating Systems ", 2nd edition, Tata McGraw Hill Company, 1999.
3	Maurice J. Bach, —The Design of the Unix Operating System, 1st edition, PHI, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify the components and their functionalities in the operating system	Apply
CO2	Apply various CPU scheduling algorithms to solve problems	Apply
CO3	Analyze the needs and applications of process synchronization and deadlocks	Analyze
CO4	Apply the concepts of memory management including virtual memory and page replacement to the issues that occur in real time applications	Apply
CO5	Solve issues related to file system implementation and disk management	Apply

18CSM05	DATA COMMUNICATION AND COMPUTER NETWORKS			Semester			
PREREQUISITES			Category	OE	Credit		3
			Hours/Week	L	T	P	TH
				3	0	0	3

Course Learning Objectives

1	To study the concepts of data communications and functions of different ISO/OSI reference architecture
2	To understand the error detection and correction methods and also the types of LAN
3	To study the concepts of subnetting and routing mechanisms
4	To understand the different types of protocols and congestion control
5	To study the application protocols and network security

UNIT I	DATA COMMUNICATIONS AND PHYSICAL LAYER	9	0	0	9
Data Communication; Networks- Physical Structures (Types of Connections, Physical Topology),Categories of Networks, Interconnection of Networks: Internetwork; Protocols and Standards; Network Models-The OSI Model, Layers in the OSI Model, Addressing; Transmission media-Guided Media, Unguided Media.					
UNIT II	DATA LINK LAYER	9	0	0	9
Introduction-Types of errors, Redundancy, Detection versus Correction, Modular Arithmetic; Block Coding-Error Detection and Correction (VRC,LRC,CRC, Checksum, Hamming Code);Data link Control- Flow Control (Stop- and-Wait, Sliding Window),Error Control (Automatic Repeat Request, Stop-and-wait ARQ, Sliding Window ARQ), HDLC; Local Area Networks-Ethernet, Token Bus, Token Ring, FDDI.					
UNIT III	NETWORK LAYER	9	0	0	9
Network Layer services-Packet Switching-Network Layer Performance-IPv4 addresses-IPv6 addressing- Subnetting-Bridges-Gateways- Routers-Routing Algorithm-Distance Vector Routing, Link State Routing.					
UNIT IV	TRANSPORT LAYER	9	0	0	9
Duties of the Transport layer-User Datagram Protocol-Transmission Control Protocol- Congestion Control and Quality of Service-Congestion, Congestion Control, Quality of Service, Techniques to improve QoS, Integrated Services.					
UNIT V	PRESENTATION LAYER AND APPLICATION LAYER	9	0	0	9
Domain Name System - Domain Name Space, DNS in the Internet; Electronic Mail-FTP- HTTP- World Wide Web.					
					Total (45 L) =45 Periods

Text Books:

1	Behrouz A.Ferouzan, “Data Communications and Networking”, 4th Edition, Tata McGraw-Hill, 2007.

Reference Books:

1	Andrew S. Tanenbaum, “Computer networks “PHI, 4th edition 2008
2	William Stallings,” Data and computer communications”, 10th edition,PHI, 2012
3	Douglas E. comer,” Internetworking with TCP/IP-Volume-I”, 6th edition,PHI, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Classify the fundamentals of data communications and functions of layered architecture	Understand
CO2	Apply the error detection and correction methods and also identify the different network technologies	Apply
CO3	Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and routing technologies	Analyze
CO4	Illustrate the transport layer principles and reliable data transfer using protocols	Apply
CO5	Analyze the application layer protocols and also the use of network security	Analyze

18CSM06	PROGRAMMING ESSENTIALS IN PYTHON		Semester			
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives	
1	To learn Python data structures, conditional and control structures and files
2	To study Python Modules, packages, Functions and Exceptions.
3	To describe Object oriented programming features and Regular Expressions.
4	To learn about Web programming, GUI Programming and Database programming

UNIT I	INTRODUCTION	9	0	0	9
Python: Features - The Basics-Python Objects-Numbers-Sequences-Mapping and set types- Conditionals and loops-if statement-else statement-elif-Conditional Expressions-while statement-for statement-break-continue.					
UNIT II	**FUNCTIONS, MODULES AND PACKAGES**	**9**	**0**	**0**	**9**
Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments-variable scope-Recursion, Modules-Packages.					
UNIT III	**FILES AND EXCEPTIONS**	**9**	**0**	**0**	**9**
Files and Input/ Output –Errors and Exceptions-Introduction-Detecting and handling Exceptions-Context Management-Raising Exceptions-Assertions-Standard Exceptions.					
UNIT IV	**OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSIONS**	**9**	**0**	**0**	**9**
Object Oriented Programming Introduction-Classes-class Attributes-Instances-Instances attributes-Building and Method Invocation-Static methods and class Methods-Inheritance-Operator overloading - Regular Expressions-Network Programming – Multithreaded Programming					
UNIT V	**ADVANCED TOPICS**	**9**	**0**	**0**	**9**
GUI Programming- Web Programming-Database Programming					
					Total (45 L) =45 Periods

Text Books:	
1	Wesley J.Chun-“Core Python Programming” –Prentice Hall, Second Edition, 2006.
Reference Books:	
1	Swaroop C N, “ A Byte of Python “, ebshelf Inc., 1st Edition, 2013
2	“A Practical Introduction to python programming”, Brian Heinold,Mount St.Mary’s University,2012
3	Learning to Program with Python,” Richard L. Halterman”., Southern Adventist University

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Develop programs using control structures and files.	Create
CO2	Create own Python Modules, packages, functions and Exceptions.	Create
CO3	Illustrate Object oriented Programming features and Regular Expressions.	Apply
CO4	Create own Web programs, GUI and database programs.	Create

22CSM07	ADVANCED DATABASE SYSTEM CONCEPTS				Semester	
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the fundamentals of data models ,SQL queries and relational databases
2	To make a study of database design using ER Diagram and normalize
3	To impart knowledge in transaction processing.
4	To make the students to understand the file operations and indexing
5	To familiarize the students with advanced databases

UNIT I	**RELATIONAL DATABASES**	**9**	**0**	**0**	**9**

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL.

UNIT II	**DATABASE DESIGN**	**9**	**0**	**0**	**9**

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form.

UNIT III	**TRANSACTION**	**9**	**0**	**0**	**9**

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery – Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

UNIT IV	**IMPLEMENTATION TECHNIQUES**	**9**	**0**	**0**	**9**

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

UNIT V	**ADVANCED TOPICS**	**9**	**0**	**0**	**9**

Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL – XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Data Warehousing and Data Mining - information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, Henry F.Korth and S.Sundarshan “Database System Concepts”, Sixth Edition,Tata McGraw Hi 2011.

Reference Books:

1	Ramez Elamassri and Shankant B-Navathe, “Fundamentals of Database Systems”, Sixth Edition,Pearson Education, 2011.
2	C.J. Date, “An Introduction to Database Systems”, Eighth Edition, Pearson Education Delhi, 2008.
3	Raghu Ramakrishnan, ―Database Management Systems, Fourth Edition, McGraw-Hill CollegePublications, 2015.
4	G.K.Gupta,”Database Management Systems”, Tata McGraw Hill, 2011.

E-References:

1.	Lecture Series on Database Management System by Dr.S.Srinath, IIIT Bangalore, nptl

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Understand the basic concepts of the database and data models.	Understand
CO2	Design a database using ER diagrams and map ER into Relations and normalize the relations.	Create
CO3	Develop a simple database for applications	Create

18CSM08	**VIRTUALIZATION AND CLOUD COMPUTING**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To introduce the broad perceptive of Parallel Computing, Distributed Computing and Cloud Computing.
2	To understand the concept of Virtualization
3	To identify the approaches of SLA and programming model in Cloud
4	To understand the Cloud Platforms in Industry and Software Environments.
5	To learn to design the trusted Cloud Computing system

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Principles of Parallel and Distributed Computing – Elements of Parallel and Distributed Computing, Technologies for Distributed Computing; Vision of Cloud, Defining a Cloud, characteristics and benefits; Cloud Computing Architecture- Cloud Reference Model, Types of Clouds, Open Challenges.

UNIT II	**VIRTUALIZATION**	**9**	**0**	**0**	**9**

Introduction, Characteristics of Virtualized environments, Virtualization techniques-Machine Reference Model, Hardware-Level Virtualization, Programming Language-Level Virtualization, Application-Level Virtualization ,Other types of Virtualization, Virtualization and Cloud computing, Pros and cons of Virtualization, Technology examples-Xen: Para virtualization, VMware: Full Virtualization.

UNIT III	**SLA MANAGEMENT IN CLOUD COMPUTING AND PROGRAMMING MODEL**	**9**	**0**	**0**	**9**

Traditional Approaches to SLA Management, Types of SLA, Life Cycle of SLA, SLA Management in Cloud; Data Intensive Computing - Technologies for Data Intensive Computing, MapReduce Programming Model.

UNIT IV	**CLOUD INDUSTRIAL PLATFORMS AND SOFTWARE ENVIRONMENTS**	**9**	**0**	**0**	**9**

Cloud Platforms in Industry - Amazon Web Service, Google App Engine; Cloud Software Environments –Eucalyptus, OpenNebula; Aneka Cloud Application Platform-Aneka Framework Overview, Anatomy of Aneka Container.

UNIT V	**CLOUD SECURITY AND APPLICATIONS**	**9**	**0**	**0**	**9**

An Introduction to the Idea of Data Security, The Current State of Data Security in the Cloud, Cloud Computing and Data Security Risk, Cloud Computing and Identity; The Cloud, Digital Identity, and Data Security, Content Level Security, Pros and Cons; Cloud Scientific Applications.

Total (45L) = 45 Periods

Text Books:

1	Rajkumar Buyya, Christian Vecchiola, S.Tamarai Selvi, ‘Mastering Cloud Computing-Foundations and Applications Programming”, TMGH,2013.(Unit- I,II & IV)
2	RajKumar Buyya, James Broberg, Andrezei M.Goscinski, “Cloud Computing: Principles and paradigms”,2011(Unit-III & V)

Reference Books:

1	Kai Hwang.GeoffreyC.Fox.JackJ.Dongarra, “ Distributed and Cloud Computing ,From Parallel Processing to The Internet of Things”, 2012 Elsevier
2	Barrie Sosinsky, “Cloud Computing Bible”, Wiley Publisher, 2011

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain the main concepts and architecture of Parallel computing, Distributed Computing and Cloud Computing.	Understand
CO2	Analyze the concept of Virtualization	Analyze
CO3	Identify the approaches of SLA and programming model in Cloud	Apply
CO4	Analyze the Cloud Platforms in Industry and Software Environments.	Analyze
CO5	Identify the security issues in scientific and real time applications.	Apply

B.E. – ELECTRONICS AND COMMUNICATION ENGINEERING - MINOR DEGREE

18ECM01	ELECTRON DEVICES					
PREREQUISITES		CATEGORY	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:	
1.	To introduce components such as diodes, BJTs and FETs, their characteristics and applications
2.	To understand, analyse and design of simple diode and transistor circuits.
3.	To know the switching characteristics of components and the concept of rectifiers and power supplies

Unit I	EXTRINSIC SEMICONDUCTOR AND PN JUCTIONS	9	0	0	9

N and P type semiconductor and their energy band structures- Law of electrical neutrality-calculation of location of Fermi level and free electron and hole densities in extrinsic semiconductors-Mobility, drift current and conductivity-diffusion current-continuity equation- Hall effect and its applications. Band structure of PN junction – current component in a PN junction- derivation of diode equation-temperature dependence of diode characteristics and equivalent models.

Unit II	SWITCHING CHARACTERISTICS OF PN JUNTION AND SPECIAL DIODES	9	0	0	9

Calculation of transition and diffusion capacitance- varactor diode-charge control description of diode-switching characteristics of diode- mechanism of avalanche and Zener breakdown-temperature dependence of breakdown voltages-backward diode-tunneling effect in thin barriers - tunnel diode-photo diode-light emitting diodes.

Unit III	BIPOLAR JUNCTION TRANSISTORS	9	0	0	9

Construction of PNP and NPN transistors- BJT current components-emitter to collector and base to collector current gains-base width modulation CB, CE and CC characteristics- breakdown characteristics- Ebers-Moll model - transistor switching times- Photo translator.

Unit IV	FIELD EFFECT TRANSISTORS	9	0	0	9

Construction and characteristics of JFET-relation between pinch off voltage and drain current derivation. MOSFETS - enhancement and depletion types. CMOS circuits. MOS capacitance, BICMOS, SOI CMOS.

Unit V	RECTIFIERS AND POWER SUPPLIES	9	0	0	9

Half-wave, full-wave and bridge rectifiers with resistive load. Analysis for Vdc and ripple voltage with C, CL, L-C and C-L-C filters. Voltage multipliers Zener diode regulator. Electronically regulated d.c power supplies. Line regulation, output resistance and temperature coefficient.

Total (45L)= 45 Periods

Text Books:	
1.	JaconMillman& Christos C. Halkias, " Electronic Devices and Circuits" Tata McGraw-Hill, 1991.

2.	Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory 8th edition.", PHI, 2002
Reference Books:	
1.	Donald A. Neaman. " Semiconductor Physics and Devices" 3rd Ed., Tata McGraw-Hill 2002
2.	S. Salivahanan, N. Suresh kumar and A. Vallavaraj, Electronic Devices and Circuits, TMH, 1998.
3.	Ben, G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education 2000
4.	Floyd, "Electronic Devices", Sixth edition, Pearson Education, 2003.
E-References:	
1.	https://archive.nptel.ac.in/courses/108/108/108108122/
2.	https://www.youtube.com/watch?v=qqQ8wO-lNmI
3.	https://slideplayer.com/slide/12438044/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Interpret various applications of diode.	Applying
CO2	Classify various configurations and biasing technique of BJT	Applying
CO3	Apply the knowledge of using special devices for various applications	Understanding
CO4	Discuss operation, biasing and applications of JFET.	Analysing
CO5	Design power supplies and rectifiers	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	2	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO3	2	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO4	2	2	1	-	-	-	-	-	-	-	-	-	2	2	1
CO5	2	2	1	-	-	-	-	-	-	-	-	-	3	2	2
Avg	2	2	1	-	-	-	-	-	-	-	-	-	2.2	2	1.5

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM02	DIGITAL ELECTRONICS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1	To introduce basic postulates of boolean algebra and show the correlation between expressions
2	To Introduce the methods for Simplifying Boolean expressions
3	To Outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
4	To introduce the Concept of Memories and programmable logic devices
5	To illustrate the concept of synchronous and Asynchronous sequential circuits

Unit I	**NUMBER SYSTEMS AND LOGIC GATES**	**9**	**0**	**0**	**9**

Number Systems - signed Binary numbers - Binary Arithmetic - Binary codes -conversion from one code to another - Boolean Algebra and Minimization Techniques - Canonical forms – Conversion between canonical forms – Simplifications of Boolean expressions using Karnaugh map - LOGIC GATES - Implementations of Logic Functions using gates.

Unit II	**COMBINATIONAL CIRCUITS**	**9**	**0**	**0**	**9**

Design procedure – Adders/Subtractor – Serial adder/ Subtractor - Parallel adder/ Subtractor- BCD adder- Multiplexer/ Demultiplexer - encoder / decoder – code converters.

Unit III	**SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**

Design Procedure - Flip flops: SR, JK, T, D and JKMS – Triggering of Flip-flop - Realization of flip flops – Moore and Mealy – Counters: Asynchronous / Ripple counters – Synchronous counters – Modulo n counter. Register: shift registers- Universal shift register.

Unit IV	**ASYNCHRONOUS SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**

Design of fundamental mode circuits – primitive state / flow table – Minimization of primitive state table –state assignment. Problems in Asynchronous Circuits: Cycles – Races – Hazards. Design of Hazard Free Circuits: Static, Dynamic Hazards elimination

Unit V	**PLD AND MEMORY DEVICES**	**9**	**0**	**0**	**9**

Classification of memories –RAM organization –ROM organization. Programmable Logic Devices: Programmable Logic Array (PLA) - Programmable Array Logic (PAL). Implementation of combinational logic using MUX, ROM, PAL and PLA.

Total (45 L) = 45 Periods

Text Books:

1	M. Morris Mano, Digital Design, 4.ed.,Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2008
2	R.P.Jain, Modern Digital Electronics, 4th edition, TMH, 2010.

Reference Books:

1	S. Salivahanan and S. Arivazhagan, Digital Circuits and Design, 2nd ed., Vikas Publishing House Pvt. Ltd, New Delhi, 2004
2	Charles H.Roth. “Fundamentals of Logic Design”, Thomson Publication Company, 2003.
3	Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, 5 ed., Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
4	John F.Wakerly, Digital Design: Principles and practices, PHI, 2006

E-Reference:

1	http://nptel.ac.in/noc/individual_course.php?id=noc15-ec01

2	https://nptel.ac.in/courses/117105080/6
3	https://nptel.ac.in/courses/117105080/12

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Minimize Boolean expressions and implement using logic gates	Applying
CO2	Design and analyse combinational logic circuits.	Analysing
CO3	Design and analyse synchronous and asynchronous sequential logic circuits	Analysing
CO4	Understand the concepts of memories and PLDs	Understanding
CO5	Implement circuits using memory and PLDs.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	3	2	3	2	-	-	-	-	2	1	-
CO2	3	3	2	2	3	3	2	1	1	-	-	-	3	2	-
CO3	2	2	3	3	2	1	2	1	1	-	-	-	2	2	-
CO4	2	1	2	1	2	2	3	1	-	-	-	-	2	1	-
CO5	2	1	2	1	3	2	1	2	-	-	-	-	3	2	-
Avg	2.4	1.8	2.2	1.8	2.6	2	2.2	1.4	1	-	-	-	2.4	1.6	-
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM03	ELECTRONIC CIRCUITS					
PREREQUISITES		CATEGORY	OE	Credit		3
Electron Devices		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives

1	To perform analysis on Small signal amplifiers and large signal amplifiers.
2	To give a comprehensive exposure to all types of discrete amplifiers and oscillators.
3	To understand the various linear and non-linear applications of op-amp

Unit I	MIDBAND ANALYSIS OF SMALL SIGNAL AMPLIFIERS	9	0	0	9

BJT – Need for biasing - Fixed bias circuit - Load line and quiescent point. Different types of biasing circuits. Use of Self bias circuit as a constant current circuit. CE, CB and CC amplifiers. Method of drawing small-signal equivalent circuit. Mid-band analysis of various types of single stage amplifiers to obtain gain - input impedance and output impedance. Miller's theorem. Darlington connection using similar and Complementary transistors. Methods of increasing input impedance using Darlington connection and bootstrapping. CS, CG and CD (FET) amplifiers. Multistage amplifiers-Basic emitter coupled differential amplifier circuit. Differential gain - CMRR. Use of constant current circuit to improve CMRR.

Unit II	LARGE SIGNAL AMPLIFIERS	9	0	0	9

Low frequency & High frequency analysis of amplifiers -Hybrid – pi equivalent circuit of BJTs.-High frequency equivalent circuit of FETs. Gain-bandwidth product of FETs. General expression for frequency response of multistage amplifiers. Calculation of overall upper and lower cut off frequencies of multistage amplifiers. Amplifier rise time and sag time and their relation to cut off frequencies. Classification of amplifiers (Class A, B, AB, C&D), Efficiency of class A, RC coupled and transformer-coupled power amplifiers. Class B complementary-symmetry, push-pull power amplifiers. Calculation of power output, efficiency and power dissipation. Crossover distortion and methods of eliminating it. Calculation of actual power handling capacity of transistors with and without heat sink. Heat sink design.

Unit III	OSCILLATORS	9	0	0	9

Feedback Amplifier: Block diagram - Gain with feedback - Barkhausen Criterion - Mechanism for start of oscillation and stabilization of amplitude - Analysis of Oscillator using Cascade connection of RC and LC filters - RC phase shift Oscillator - Wien bridge Oscillator and Twin-T Oscillators - Analysis of LC Oscillators: Colpitts – Hartley – Clapp - Miller and Pierce oscillators - Frequency range of RC Oscillators - Electrical equivalent circuit of Crystal.

Unit IV	TUNED AMPLIFIERS AND MULTIVIBRATORS	9	0	0	9

Analysis of single tuned and synchronously tuned amplifiers - Class C tuned amplifiers and their applications - Efficiency of Class C tuned Amplifier- Collector coupled and Emitter coupled Astable Multi vibrator – Mono stable Multi vibrator – Bistable Multi vibrator - Triggering methods – Mono stable and Astable Blocking Oscillators using Emitter and base timing.

Unit V	OPERATIONAL AMPLIFIERS AND ITS APPLICATIONS	9	0	0	9

Basic structure and principle of operation - Calculation of differential gain - Common Mode gain, CMRR - OP-AMP design - DC and AC characteristics of OP-AMP. Applications: Inverting and non-inverting amplifiers - Integrator and Differentiator - Summing amplifier - Precision rectifier - Schmitt trigger and its applications - Active filters: Low pass, high pass, band pass and band stop filters - Sine wave oscillators – Comparator – Multi vibrator.

Total (45 L) = 45 Periods

Text Books:	
1	B.Visvesvara Rao, K.Raja Rajeswari, P.Chalam Raju Pantulu, K.Bhaskara Rama Murthy, "Electronic Circuits-II", Pearson Education,2012
2	D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2011.
Reference Books:	
1	Millman J. and Taub H., "Pulse Digital and Switching waveform", 3rd Edition, McGraw-Hill International , 2011.

2	Sedera& Smith, “Micro Electronic Circuits”, 4 th Edition, Oxford University Press, Chennai.
3	Michael Jacob, ‘Applications and Design with Analog Integrated Circuits’, Prentice Hall of India, 1996.
4	K.R.Botkar, ‘Integrated Circuits’, 10th edition, Khanna Publishers, 2010.
e-Reference:	
1	http://nptel.ac.in/courses/117105080/40
2	http://nptel.ac.in/courses/117108038/1
3	https://freevideolectures.com/course/2915/linear-integrated-circuits

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	To analyze small signal amplifiers and Large signal Amplifiers.	Applying
CO2	Analyze the frequency response characteristics of amplifiers	Applying
CO3	Develop insight of on oscillator design.	Applying
CO4	Construct and analyse tuned amplifiers and multivibrators.	Applying
CO5	Develop competence in linear and nonlinear Op amp circuit analysis.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO4	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO5	1	2	1	2	-	-	-	-	-	-	-	-	1	2	1
Avg	2.4	2	1	2	-	-	-	-	-	-	-	-	1	2	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM04	SIGNAL PROCESSING					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand and perform Fourier and Laplace analysis on signals and systems respectively.
2.	To analyse the Discrete Fourier Transform, Fast Fourier Transform algorithms.
3.	To design and realize IIR, FIR filters.

Unit I	**INTRODUCTION TO SIGNALS AND SYSTEMS**	**9**	**0**	**0**	**9**

Classification of Signals: Even and Odd Signal - Energy and power signals - Continuous time (CT) and Discrete time (DT) signals - Continuous and Discrete amplitude signal -. System properties and representation: linearity - Tme-invariance – Causality – Stability - Realizability. - Linear Time-Invariant (LTI) systems: Impulse response and step response – Convolution – Correlation - System representation through differential equations and difference equations.

Unit II	**ANALYSIS OF SIGNAL AND SYSTEMS**	**9**	**0**	**0**	**9**

Introduction to Fourier Transform, Fourier Series, Relating the Laplace Transform to Fourier Transform, Frequency response of continuous time systems. Introduction to z- Transform.

Unit III	**DISCRETE FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Introduction to DFT – Properties of DFT - Circular convolution - FFT algorithms – Radix-2 FFT algorithms – Decimation in Time and Decimation in Frequency algorithms.

Unit IV	**INFINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Characteristics of Analog Butterworth filter - Chebyshev filter - Low pass filter, High pass filter, Band pass filter and Band stop filter - Transformation of analog filters in to equivalent digital filters using bilinear transformation method - Realization structure for IIR filters-Direct form - Cascade form - Parallel form.

Unit V	**FINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Linear phase response of FIR filter - FIR design using window method: Rectangular, Hamming, Hanning and Blackmann Windows - Park-McClellan's method - Realization structures for FIR filters - Linear phase structures and Direct form structure - Comparison of FIR and IIR filters.

Total (45L)= 45 Periods

Text Books:

1.	A.Anand Kumar, “Signals and Systems” , 3rd Edition, PHI, 2013.
2.	John G Proakis and Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, 4th Edition, Pearson Education, 2009.

Reference Books:	
1.	Alan V Oppenheim, Alan S Willsky and S Hamid Nawab, “Signals and Systems”, 2nd edition, PHI Learning Private Limited, New Delhi, 2010.
2.	B.P. Lathi, "Principles of Signal Processing and Linear Systems", Oxford University Press, 2009.
3.	Emmanuel C. Ifeacher, Barry W. Jervis, “Digital Signal Processing: A Practical Approach”, 2nd Edition, Pearson Education, 2004.
4.	S.K. Mitra, “Digital Signal Processing, A Computer Based approach”, 4th Edition, McGraw-Hill, 2010.
E-References:	
1.	http://nptel.ac.in/courses/117104074/
2.	https://www.coursera.org/learn/dsp
3.	https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Analyse and understands different types of signals.	Analysing
CO2	Represent continuous signals and systems in time and frequency domain using different transforms.	Analysing
CO3	Analyse the need for Discrete Fourier Transform, Fast Fourier Transform algorithms in digital signals & systems.	Analysing
CO4	Design and realize IIR filters.	Applying
CO5	Design and realize FIR filters.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO2	3	2	2	3	3	2	-	-	-	-	-	-	2	2	2
CO3	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO4	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO5	1	1	1	1	1	-	-	-	-	-	-	-	2	2	1
Avg	2.6	1.8	2	2.2	1.8	2	1						1.6	1.6	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM05	MICROPROCESSORS AND MICROCONTROLLERS						
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1.	To familiarise with 8086 and 8051 architectures.
2.	To interface 8086 microprocessor and 8051 microcontrollers with peripherals by programming.
3.	To gain basic knowledge of PIC microcontrollers.

Unit I	**8086 MICROPROCESSOR ARCHITECTURE**	9	0	9
Overview of Microcomputer systems-8086 Architecture – Pin Assignments – Internal Architecture – Addressing modes-Instruction Formats- Directives and Operators-Assembly process.				
Unit II	**PROGRAMMING AND INTERFACING OF 8086**	9	0	9
Fundamental I/O considerations- Programmed I/O- Interrupt I/O- Basic 8086 Configurations- Minimum Mode-Maximum Mode-System Bus timing- I/O Interfaces-Peripheral Interfacing using 8255 PPI - 8279 Keyboard/Display controller - 8251 USART.				
Unit III	**8051 ARCHITECTURE**	9	0	9
8051 architecture - Registers in 8051 - Pin description - 8051 parallel I/O ports - memory organization - Instruction set — Addressing modes				
Unit IV	**PROGRAMMING AND INTERFACING OF 8051**	9	0	9
Assembly language programming.8051Timers - Serial Port Programming - Interrupts Programming - LCD and Keyboard Interfacing - ADC, DAC and Sensor Interfacing - Motor Control.				
Unit V	**PIC MICROCONTROLLERS**	9	0	9
Main characteristics of PIC microcontrollers – PIC microcontroller families-Memory-Program Memory – RAM Data Memory - Instruction set and timers in PIC				
				Total (L+T) = 45 periods

Text Books:	
1.	Yu-Cheng Liu, Glenn A. Gibson,” Microcomputer Systems, The 8086/8088 Family”, Pearson, 2e, 2019.
2.	Muhammad Ali Mazidi, Janice GillispieMazidi, RolinD.McKinlay, “The 8051 Microcontroller and Embedded Systems using Assembly and C”, 2e, 2022.
Reference Books:	
1.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, 2nd Edition, Pearson education, 2011.
2.	Martin Bates,”PIC Microcontrollers-An Introduction to Microelectronics”, 3e, Elsevier, 2011.
3.	Mathur Sunil,”Microprocessor 8086: Architecture, Programming and Interfacing” PHI Learning Pvt. Ltd. 2011.
4.	Salvador PinillosGimenez,” 8051 Microcontrollers Fundamental Concepts, Hardware, Software and Applications in Electronics”, Springer 2019.
E-References:	
1.	Ashraf Almadhoun,”A Detailed Look Into PIC Microcontroller and Its Architecture”, Amazon 2020.
2.	https://nptel.ac.in/courses/108105102
3.	http://www.satishkashyap.com/2012/02/video-lectures-on-microprocessors-and.html

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Describe and analyse the architecture of 8086 microprocessor and 8051 architectures.	Remembering
CO2	Develop assembly language programs and Interface peripherals with 8086.	Applying
CO3	Develop assembly language programs and Interface peripherals with 8051.	Applying
CO4	Determine application specific circuit for real-time applications.	Understanding
CO5	Associate appropriate PIC microcontroller for a given application.	Understanding

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	2	-	1	-	-
CO2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2
CO5	2	2	-	2	-	-	-	-	-	-	-	-	2	2	-
Avg	2	2	2	2	-	-	-	-	-	-	2	-	1.8	2	2

18ECM06	ANALOG AND DIGITAL COMMUNICATION					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understand analog and digital communication techniques.
2.	Learn data and pulse communication techniques.
3.	Be familiarized with source and Error control coding.

Unit	Title	L	T	P	TH
Unit I	**INFORMATION THEORY**	**9**	**0**	**0**	**9**
Uncertainty, information and entropy – Source coding theorem – Shannon Fano coding – Huffman coding – Discrete memoryless channels – Mutual information – Channel capacity – Channel coding theorem.					
Unit II	**ANALOG COMMUNICATION**	**9**	**0**	**0**	**9**
Noise: Source of Noise – External Noise- Internal Noise- Noise Calculation. Introduction to Communication Systems: Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of various Analog Communication System (AM – FM – PM).					
Unit III	**DIGITAL COMMUNICATION**	**9**	**0**	**0**	**9**
Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM).					
Unit IV	**PULSE COMMUNICATION AND MULTIPLE ACCESS TECHNIQUES**	**9**	**0**	**0**	**9**
Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System (PAM – PTM – PCM). Multiple access techniques: FDMA, CDMA, TDMA, SDMA.					
Unit V	**ERROR CONTROL CODING**	**9**	**0**	**0**	**9**
Linear block codes - Cyclic codes - Convolution codes – Maximum likelihood decoding of convolutional codes – Sequential decoding of convolutional codes – Trellis codes – Applications.					
	Total (45L)= 45 Periods				

Text Books:	
1.	Simon Haykin, “Communication Systems”, 4th Edition, John Wiley & Sons, 2014.
2.	J.G.Proakis, M.Salehi, ―Fundamentals of Communication Systems‖, Pearson Education 2014.
Reference Books:	
1.	B.P.Lathi, ―Modern Digital and Analog Communication Systems‖, 4th Edition, Oxford University Press, 2013.
2.	D.Roody, J.Coolen, ―Electronic Communications, 4th edition PHI 2015.
3.	B.Sklar, ―Digital Communications Fundamentals and Applications‖, 5th Edition Pearson Education 2017
4.	H P Hsu, Schaum Outline Series - ―Analog and Digital Communications‖ TMH, 5th edition 2006
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc21_ee74/preview
2.	https://nptel.ac.in/courses/117101051
3.	https://www.digimat.in/nptel/courses/video/117105143/L51.html

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO	:	Apply the concepts of Random Process to the design of Communication	Applying
CO	:	Apply analog and digital communication techniques.	Applying
CO	:	Understand the use of data and pulse communication techniques.	Understanding
CO	:	Analyze Source and Error control coding.	Analysing
CO	:	Design AM communication systems and Angle modulated communication	Applying

COURSE ARTICULATION MATRIX															
COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2	3	2	1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	3	2	1
CO3	2	2	2	3	1	-	-	-	-	-	-	-	3	2	-
CO4	1	1	2	1	2	-	-	-	-	-	-	-	2	3	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-	2	3	1
Avg	1.8	1.8	2	1.6	1.4	-	-	-	-	-	-	-	2.6	2.5	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM07	COMMUNICATION NETWORKS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understand the division of network functionalities into layers.
2.	Be familiar with the components required to build different types of networks
3.	Be exposed to the required functionality at each layer
4.	Learn the flow control and congestion control algorithms

Unit I	**FUNDAMENTALS & LINK LAYER**	9	0	0	9

Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction

Unit II	**MEDIA ACCESS & INTERNETWORKING**	9	0	0	9

Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)

Unit III	**ROUTING**	9	0	0	9

Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6

Unit IV	**TRANSPORT LAYER**	9	0	0	9

Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmiision Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements

Unit V	**APPLICATION LAYER**	9	0	0	9

Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS- Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need forCryptography and Network Security – Firewalls.

Total (45L)= 45 Periods

Text Books:	
1.	Behrouz A Forouzan, Data Communications and Networking, 4th Edition, 2020

2.	James F. Kurose, Keith W. Ross, Computer Networking - A Top-Down Approach Featuring the Internet, Seventh Edition, Pearson Education, 2016.
Reference Books:	
1.	Nader. F. Mir,“ Computer and Communication Networks”, Pearson Prentice Hall Publishers, 2nd Edition, 2014.
2.	Alberto Leon-Garcia, IndraWidjajaCommunication Networks 2nd Edition McGraw-Hill Education, 2003
3.	Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, “Computer Networks: An Open Source Approach”, McGraw Hill Publisher, 2011.
4.	Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth Edition, Morgan Kaufmann Publishers, 2011.
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc22_ee61/preview
2.	https://www.ee.iitb.ac.in/~sarva/courses/EE706/2012/EE706LecNotes.pdf
3.	http://www.cs.kent.edu/~farrell/net01/lectures/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Explain the basic concept in modern data communication and different level of layers in the protocol	Understanding
CO2	Analyse the functions and services of data link layer	Analysing
CO3	Categorize the functions and services of network layer	Understanding
CO4	Examine the basic functions of transport layer and congestion in networks	Understanding
CO5	Analyse the concepts of various network applications and data security	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	-	-	-	-	-	-	-	2	-	1
CO2	2	1	2	-	1	-	-	-	-	-	-	-	2	1	1
CO3	2	1	1	-	-	-	-	-	-	-	-	-	3	1	2
CO4	3	2	1	-	2	-	-	-	-	-	-	-	2	-	2
CO5	2	1	1	-	1	-	-	-	-	-	-	-	1	1	1
Avg	2.2	1.2	1.2	-	1.25	-	-	-	-	-	-	-	2	1	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM08	INTERNET OF THINGS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1	To understand Smart Objects and IoT Architectures
2	To learn about various IOT-related protocols
3	To build simple IoT Systems using Arduino and Raspberry Pi
4	To understand data analytics and cloud in the context of IoT
5	To develop IoT infrastructure for popular applications

Unit I	**FUNDAMENTALS OF IOT**	**9**	**0**	**0**	**9**
Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects					
Unit II	**IoT PROTOCOLS**	**9**	**0**	**0**	**9**
IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT					
Unit III	**DESIGN AND DEVELOPMENT**	**9**	**0**	**0**	**9**
Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.					
Unit IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**9**	**0**	**0**	**9**
Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG					
Unit V	**CASE STUDIES/INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**
Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model - Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control					
Total (45 L) = 45 Periods					

Text Books:

1	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
2	ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015

Reference Books:

1	Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).

2	Jan Ho¨ ller, VlasiosTsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
3	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
4	Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.
E-References:	
1	https://online.stanford.edu/courses/xee100-introduction-internet-things
2	https://www.udemy.com/topic/internet-of-things/
3	https://www.netacad.com/courses/iot

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of IoT.	Understanding
CO2	Analyze various protocols for IoT.	Applying
CO3	Design a PoC of an IoT system using Rasperry Pi/Arduino	Applying
CO4	Apply data analytics and use cloud offerings related to IoT.	Applying
CO5	Analyze applications of IoT in real time scenario	Analysing

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO2	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO3	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
CO4	2	2	2	1	1	-	-	-	-	-	1	-	2	2	2
CO5	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
Avg	2	1.6	2.4	1.4	1	-	-	-	-	-	1.4	-	2	2	2

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM09	WIRELESS SENSORS AND NETWORKING					
PREREQUISITE:		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Learn fundamental of Ad hoc network and architecture
2.	Understand the MAC and routing protocols.
3.	Have an in-depth knowledge on QoS, security and sensor network platforms

Unit I	**ROUTING PROTOCOLS**	9	0	0	9

Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).

Unit II	**ARCHITECTURES OF WSN**	9	0	0	9

WSN application examples, Types of applications, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Single-Node Architecture: Hardware Components, Energy Consumption of Sensor Nodes, Operating systems and execution environments

Network Architecture: Sensor Network Scenarios, Optimization goals and figures of merit, Design principles of WSN, Service interfaces of WSNs, gateway concepts.

Unit III	**MAC PROTOCOLS AND ROUTING PROTOCOLS**	9	0	0	9

Image compression: Predictive techniques – PCM – DPCM - DM - Transform coding - Introduction to JPEG - JPEG-2000 - JBIG standards - Study of EZW. Video compression: Video signal representation – ITU-T Recommendation H.261 – Model based coding – The MPEG-1 Video Standard - The MPEG-2 Video Standard: H.262 - ITU-T Recommendation H.263.

Unit IV	**QUALITY OF SERVICE AND ADVANCED APPLICATION SUPPORT**	9	0	0	9

Quality of Service: Coverage and deployment, Reliable data transport, Single packet delivery, Block delivery, Congestion control and rate control - Advanced application support: Advanced in-network processing, Security and Application-specific support.

Unit V	**SENSOR NETWORK PLATFORMS AND TOOLS**	9	0	0	9

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.

Total (45L) = 45 Periods

Text Books:	
1.	C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education – 2008
2.	Holger Karl and Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2007.
Reference Books:	
1.	Feng Zhao and LeonidesGuibas, "Wireless sensor networks ", Elsevier publication - 2004.
2.	Charles E. Perkins, ―Ad Hoc Networking‖, Addison Wesley, 2000.
3.	William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004
4.	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", Computer Networks, Elsevier, 2002, 394 - 422.
E-References:	
1.	https://nptel.ac.in/courses/106105183
2.	https://nptel.ac.in/courses/106105183
3.	https://archive.nptel.ac.in/courses/106/105/106105160/

Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Know the basics of Ad hoc networks and Wireless Sensor Networks	Understanding
CO2	Have a knowledge on architecture of Wireless Sensor Networks	Applying
CO3	Apply the knowledge to identify MAC and routing protocols	Applying
CO4	Understand the transport layer and security issues possible in Ad hoc and sensor networks	Understanding
CO5	Be familiar with the OS used in Wireless Sensor Networks and build basic modules	Remembering

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	3	3	2	-	-	-	3	3	3	-	2
CO2	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
CO3	3	3	3	3	3	3	2	-	-	-	3	3	3	-	2
CO4	3	3	2	3	3	3	2	-	-	-	2	3	3	-	2
CO5	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
Avg	3	3	2	3	3	3	2	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM10	BASICS OF EMBEDDED SYSTEMS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Microprocessors and Mmicrocontrollers		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1	To impart knowledge on embedded system architecture and embedded development Strategies
2	To understand the bus Communication in processors and peripheral interfacing
3	To understand basics of Real Time Operating System

UNIT I	**BASICS OF EMBEDDED SYSTEMS**	9	0	0	9
Introduction - Fundamental Components of Embedded Systems - Challenges for Embedded Systems - Examples - Programming Languages - Recent Trends in Embedded Systems - Architecture of Embedded Systems - Embedded Design Life Cycle - Selection Process - Hardware Software Partitioning - Development Environment.					
UNIT II	**MEMORY MANAGEMENT AND INTERRUPTS**	9	0	0	9
Memory Access Procedure - Types of Memory - Memory Management Methods - DMA – Memory Interfacing - Polling Vs Interrupts - Types of Interrupts - Interrupt Latency - Interrupt Priority – Programmable Interrupt Controllers - Interrupt Service Routines					
UNIT III	**COMMUNICATION INTERFACES**	9	0	0	9
Interfacing Buses - Serial Interfaces - RS232/UART - RS422/RS485 - I2C Interface - SPI Interface - USB – CAN - IRDA - Ethernet - IEEE 802.11 – Bluetooth					
UNIT IV	**REAL TIME OPERATING SYSTEMS**	9	0	0	9
Real-Time Concepts - Task Management - Task Scheduling - Classification of Scheduling Algorithms - Clock Driven Scheduling - Event Driven Scheduling - Resource Sharing - Priority Inheritance Protocol - Priority Ceiling Protocol - Inter Task Communication - Mutex - Semaphores - Message Queues - Timers - Commercial RTOS.					
UNIT V	**VALIDATION AND DEBUGGING**	9	0	0	9
Host and Target Machines - Validation Types and Methods - Host Testing - Host-Based Testing Setup - Target Testing - Remote Debuggers and Debug Kernels - ROM Emulator - Logical Analyzer – Background Debug Mode - InCircuit Emulator CASE STUDY: RFID Systems - GPS Navigation System – Development of Protocol Converter.					
Total (45 L) = 45 Periods					

Text Books:

1	Sriram V Iyer and Pankaj Gupta, ―Embedded Real-time Systems Programming‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2	Arnold S Berger, ―Embedded Systems Design - An Introduction to Processes, Tools and Techniques, Elsevier, New Delhi, 2011.

Reference Books:

1	Prasad K V K K, ―Embedded/Real-Time Systems: Concepts, Design and Programming – The Ultimate Reference, Himal Impressions, New Delhi, 2003
2	Heath, "Embedded Systems Design‖", Newnes an Imprint of Elsevier, Massachusetts, 2003.
3	Tammy Noergaard, "Embedded Systems Architecture‖, Newnes an Imprint of Elsevier, Massachusetts, 2006.
4	Raj Kamal, 'Embedded System-Architecture, Programming, Design', McGraw Hill, 2013

E-References:

1	https://lecturenotes.in/subject/225/embedded-system-es
2	https://nptel.ac.in/courses/108102045/19

3	https://www.coursera.org/learn/introduction-embedded-systems.

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Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Outline the concepts of embedded systems	Understanding
CO2	Understand the concept of memory management system and interrupts.	Understanding
CO3	Know the importance of interfaces.	Understanding
CO4	Understand real time operating system concepts.	Understanding
CO5	To realize the applications of validation and debugging.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	-	-	-	-	-	-	3	3	3	-	2
CO2	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
CO3	3	3	3	3	-	-	-	-	-	-	3	3	3	-	2
CO4	3	3	2	3	-	-	-	-	-	-	2	3	3	-	2
CO5	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
Avg	3	3	2	3	-	-	-	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

B.E. - ELECTRICAL AND ELECTRONICS ENGINEERING - MINOR DEGREE

18EEM01	**LINEAR AND DIGITAL ELECTRONICS CIRCUITS**		**SEMESTER**			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electron Devices and Circuits		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on the characteristics& applications of Operation Amplifier, functional diagram and applications of linear ICs.
2.	To simplify the switching functions
3.	To design the combinational logic circuits and sequential logic circuits

Unit I	**OPERATIONAL AMPLIFIERS**	**9**	**0**	**0**	**9**

Operational amplifiers - Equivalent circuit, voltage transfer curve - Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs.
Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.

Unit II	**APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS**	**9**	**0**	**0**	**9**

DC & AC amplifiers- Summing, Scaling and Averaging amplifiers-Instrumentation amplifier- Voltage to Current converter for floating and grounded loads - Current to voltage converter - Integrator, Differentiator. Voltage comparators - Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters.
Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.

Unit III	**COMBINATIONAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and QuineMcCluskey (Tabulation) method.
Design:Adders -Subtractors– 2 bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder.

Unit IV	**SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.

Unit V	**ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**9**	**0**	**0**	**9**

Fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.

Total (45L+0T) = 45 Periods

Text Books:

1.	Ramakant A Gayakward, "Op-Amps and Linear Integrated Circuits", Fourth Edition, Pearson Education, 2003.
2.	Donald.E.Neaman, "Electronic Circuit, Analysis and Design", Tata McGraw Hill Publishing Company Limited, Second Edition, 2002.
3.	D.Roy Chowdhury and Shail B. Jain, "Linear Integrated Circuits", Fourth Edition, New Age International (P) Ltd Publishers, 2014.
4.	M. Morris Mano, "Digital Design" , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .
5.	S. Salivahanan and S. Arivazhagan, "Digital Circuits and Design", Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 201

Reference Books:

1.	Jacob Millman, Christos C.Halkias, "Integrated Electronics - Analog and Digital circuits system", Tata McGraw Hill 2003.
2.	R.P.Jain, "Modern Digital Electronics", Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, "Digital Fundamentals", Pearson Education, Inc, New Delhi, 2015
4.	Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and Tadulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1											2		
CO2	3	2	1	1									3		
CO3	3	2		2	2								3	3	
CO4	3	2	3	1	2							2	3	3	1
CO5	3	2	3	1	2							2	3	3	1
Avg.	**2.8**	**1.8**	**2.3**	**1.25**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2.8**	**3**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM02	MICROPROCESSOR AND MICROCONTROLLER			SEMESTER			
PREREQUISTIES		**CATEGORY**		**PE**	**Credit**		**3**
C Programming		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To study the architecture of µP8085 and µC 8051.
2.	To study the Interrupt structure of 8085 and 8051.
3.	To do simple applications development with programming 8085 and 8051.

UNIT I	**8085 8 BIT MICROPROCESSOR**	**9**	**0**	**0**	**9**

Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.

UNIT II	**8051 8 BIT MICROCONTROLLER**	**9**	**0**	**0**	**9**

Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.

UNIT III	**INTERFACING WITH 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**

Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.

UNIT IV	**EXTERNAL COMMUNICATION INTERFACE**	**9**	**0**	**0**	**9**

Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

UNIT V	**APPLICATIONS OF MICROCONTROLLERS**	**9**	**0**	**0**	**9**

Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems.

Total (45L+0T)= 45 Periods

Text Books:

1.	R.S. Gaonkar, 'Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3.	Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003.

Reference Books:

1.	R. Kamal, "Embedded System", McGraw Hill Education, 2009.
2.	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

E-References;

1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of Microprocessor and Microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	1	1								1	1	1	
CO2	2	1	1	1								1	1	1	
CO3	2	3	2	3	2							1	1	1	2
CO4	2	3	3	3	2							2	2	2	2
CO5	2	3	3	3	2							2	2	2	2
Avg.	**2**	**2.2**	**2**	**2.2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1.4**	**1.4**	**1.4**	**2**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM03	CONTROL SYSTEMS			SEMESTER			3
PREREQUISTIES			CATEGORY	PE	Credit		3
Electrical Machines and Electric circuit analysis			Hours/Week	L	T	P	TH
				1	1	0	3

Course Objectives:

1.	To understand the methods of representation of physical systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the designing compensators for a feedback control system.

UNIT I	**MODELLING OF LINEAR TIME INVARIANT SYSTEMS**	**6**	**9**	**0**	**9**

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics - Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation– Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	**TIME RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Standard test signals – Time response of first order and second order systems –time domain specifications - Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	**FREQUENCY RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Correlation between time and frequency response: Second order systems – Frequency domain specifications - Polar plots – Bode plots – Computation of Gain Margin and Phase Margin — Constant M and N-circles – Nichols chart.

UNIT IV	**STABILITY OF CONTROL SYSTEM**	**6**	**3**	**0**	**9**

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	**COMPENSATOR AND CONTROLLER DESIGN**	**6**	**3**	**0**	**9**

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators – Design of compensators using root locus and Bode plot techniques-PID controller: Design using reaction curve and Ziegler - Nichols technique.

Total (30L+15T) = 45 Periods

Text Books:

1.	A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2.	I.J. Nagrath, and M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1.	K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 5th Edition, 2021.
2.	M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2018.

E-Reference

1.	https://nptel.ac.in/courses/107106081
2.	https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2							1	3	2	1
CO2	3	3	3	2	2							1	3	2	1
CO3	3	3	3	2	2							1	3	2	1
CO4	3	3	3	2	2							1	3	2	1
CO5	3	3	3	2	2							1	3	2	1
Avg	**3**	**3**	**2.8**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM04	MEASUREMENTS AND INSTRUMENTATION				SEMESTER			
PREREQUISTIES			**CATEGORY**		**PE**	**Credit**		**3**
Electric Circuit Analysis			**Hours/Week**		**L**	**T**	**P**	**TH**
					3	**0**	**0**	**3**

Course Objectives:

1.	To educate the fundamental concepts and characteristics of measurement System
2.	To introduce the fundamentals of electrical and electronic instruments for measurement of Electrical and Non-electrical quantities
3.	To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters					
UNIT II	**MEASUREMENT OF POWER , ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**
Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter					
UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**
Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell’s inductance capacitance bridge – Hay’s bridge – Anderson’s bridge – Schering bridge and De Sauty’s bridge					
UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**
DC Potentiometer- Crompton’s Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.					
UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**
Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors					
					Total (45L+0T)= 45 Periods

Text Books:

1.	A.K. Sawhney, ‘A Course in Electrical & Electronics Measurement & Instrumentation’, Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, ‘Measurements Systems- Application and Design’, Tata McGraw Hill publishing company, 2015.

Reference Books:

1.	D.V.S. Moorthy, ‘Transducers and Instrumentation’, Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, ‘Electronic Instrumentation’, Tata McGraw Hill, 2015.
3.	Martin Reissland, ‘ Electrical Measurements’, New Age International(P) Ltd., Delhi, 2011.

E-Reference:

1	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select an appropriate transducer for measurement of non-electrical quantities	L4: Analysing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	3				1		2		2	2	1	1
CO2	1	3			3					2		1	2	1	
CO3	1	1		2	1	1	2		1				1	2	1
CO4	1	1		1	1		2	2	1		2	2	1	3	1
CO5	2	2	3	1	2	2	1			1	3		1	2	
Avg	**1.4**	**1.8**	**2.5**	**1.75**	**1.75**	**1.5**	**1.67**	**1.5**	**1**	**1.67**	**2.5**	**1.67**	**1.4**	**1.8**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM05	ELECTRICAL MACHINES		SEMESTER			
PREREQUISTIES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To impart knowledge on construction, working and performance of DC generators and motors.
2.	To deliberate the construction, working and performance of single phase and three phase transformers.
3.	To impart knowledge on construction, working and performance of synchronous generators and motors.
4.	To impart knowledge on construction, principle of operation and performance of single and three-phase induction motors.

UNIT I	DC GENERATORS	9	0	0	9

Principle of operation, constructional details, types - EMF equation, armature reaction, demagnetizing and cross magnetizing Ampere turns, compensating winding, commutation, methods of improving commutation, interpoles, Open circuit and load characteristics of different types of DC Generators. Parallel operation of DC Generators, applications of DC Generators.

UNIT II	DC MOTORS	9	0	0	9

Principle of operation, significance of back emf, torque equation and power developed by armature, load characteristics of shunt, series and compound type motors, starting methods, speed control methods - losses and efficiency calculation, condition for maximum efficiency. Testing of DC Machines: Brake test, Swinburne's test, Hopkinson's test, Retardation test, Separation of core losses - applications of DC motors.

UNIT III	TRANSFORMER	9	0	0	9

Single phase transformer: Construction and principle of operation, working of practical transformer - equivalent circuit, voltage regulation, losses and efficiency- testing : polarity test, open circuit and short circuit tests, back-to back test, all day efficiency, parallel operation, applications.

Autotransformer: Construction and working, saving of copper - applications, **Three phase transformer**: construction, types of connections and their comparative features.

UNIT IV	SYNCHRONOUS GENERATOR AND MOTOR	9	0	0	9

Synchronous Generator: Constructional and working details – Types of rotors – EMF equation – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus - Synchronizing and parallel operation – Synchronizing torque - Voltage regulation – EMF, MMF and ZPF method – steady state power angle characteristics – Two reaction theory – slip test.

Synchronous Motor: Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed -Hunting – natural frequency of oscillations – damper windings- synchronous condenser.

UNIT V	THREE PHASE AND SINGLE PHASE INDUCTION MOTOR	9	0	0	9

Three phase induction motor: Constructional details – Types of rotors –- Principle of operation – Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Starters: DOL, Autotransformer and Star delta starters – Speed control methods: Voltage control, Frequency control and pole changing – V/f control – Slip power recovery Scheme.

Single phase induction motor: Constructional details – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – split phase, Capacitor-start, capacitor start and capacitor run Induction motor.

Total (45L+0T)= 45 Periods

Text Books:

1.	I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 5th Edition, 2017.
2.	P. S. Bimbhra, "Electric Machinery", Khanna Publishers, 2nd Edition, 2021.
3.	B.L.Theraja and A.K.Theraja," A text book of Electrical Technology - Volume-II", S.Chand & Company Ltd., New Delhi, 23rd Edition, 2009.

Reference Books:

1.	B.R.Gupta, 'Fundamental of Electric Machines' New age International Publishers,3rd Edition, Reprint 2015.

2.	Murugesh Kumar, ‘Electric Machines’, Vikas Publishing House Pvt. Ltd, First edition, 2010.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, ‘Electric Machinery’, Mc Graw Hill publishing Company Ltd, 6th Education, 2017.
4.	Stephen J. Chapman, ‘Electric Machinery Fundamentals’4th edition, McGraw Hill Education Pvt. Ltd, 4th Edition 2017.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explain the construction and working principle of DC machines, and Interpret various characteristics of DC machines.	L2: Understanding
CO2	:	Compute various performance parameters of the machine, by conducting suitable tests.	L5: Evaluating
CO3	:	Describe the working principle of transformer, auto transformer, three phase transformer connection, and determine the efficiency and regulation.	L3: Applying
CO4	:	Understand the construction and working principle of Synchronous Machines.	L3: Applying
CO5	:	Understand the construction and working principle, speed control of three phase and single phase induction motor.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	1	1	1			1				1	3	2	1
CO2	3	3	1	1	1			1				1	3	2	1
CO3	3	3	1	1	1			1				1	3	2	1
CO4	3	3	1	1	1			1				1	3	2	1
CO5	3	3	1	1	1			1				1	3	2	1
Avg.	**3**	**3**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**3**	**2**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM06	ELECTRICAL DRIVES AND CONTROL		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know about the operation analyse of chopper fed DC drive, both qualitatively and quantitatively.
2.	To understand the operation and performance of AC motor drives.

UNIT I	**DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES**	**9**	**0**	**0**	**9**

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	**MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE**	**9**	**0**	**0**	**9**

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	**INDUCTION MOTOR CHARACTERISTICS**	**9**	**0**	**0**	**9**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	**CONTROL OF SLIP RING INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery. .

UNIT V	**CONTROL OF SRM AND BLDC MOTOR DRIVES.**	**9**	**0**	**0**	**9**

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine - Sensing and logic switching scheme,-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlledd Brushless dc motor drive

Total (45L+0T)= 45 Periods

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3.	Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-Reference

1	https://www.iith.ac.in/~ketan/drives.htmL

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying

CO5	:	Analyze the SRM and BLDC motor drive control	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	3			1	1					1	3	2	
CO2	3	3	1	3		1	1					1	3	2	
CO3	3	3	3	3	1	1	1					1	3	2	
CO4	1	3	3	2	1	1	1					1	3	2	
CO5	3	3	3	3	1	1	1					1	3	2	
Avg.	**2.6**	**2.6**	**2.6**	**2.75**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**-**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM07	ELECTRIC VEHICLES AND CONTROL		SEMESTER			
PREREQUISTIES		CATEGORY	PE	Credit		3
Electrical drives and control		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	ELECTRIC VEHICLES	9	0	0	9
Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains					
UNIT II	**PLUG-IN HYBRID ELECTRICVEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**
Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy					
UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**
Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles					
UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**
Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages					
UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**
Energy Management System(EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS					
Total (45L+0T)= 45 Periods					

Text Books:

1.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles” CRC Press, 2016

Reference Books:

1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,“Vehicular Electric Power Systems”, Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010

E-Reference:

1	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding
CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1		1	3	1		1					1	1	2	1
CO2	1	2	3	1			2					2	1	2	
CO3	1	1			2		3						1	1	1
CO4	3	1	2	1	2		1					2	1	2	1
CO5	1	2	1	2	1							1	1	2	1
Avg	**1.4**	**1.5**	**1.75**	**1.75**	**1.5**	**-**	**1.75**	**-**	**-**	**-**	**-**	**1.5**	**1**	**1.8**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM08	ELECTRICAL ENERGY CONSERVATION AND AUDITING		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario of India.
2.	To familiarise the energy conservation methods.
3.	To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**

Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

UNIT II	**BASICS OF ENERGY**	**9**	**0**	**0**	**9**

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT III	**ENERGY MANAGEMENT AND AUDIT**	**9**	**0**	**0**	**9**

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

UNIT IV	**ENERGY EFFICIENCY**	**9**	**0**	**0**	**9**

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**	**9**	**0**	**0**	**9**

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45 L+ 0 T) = 45 Periods

Text Books:

1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2,	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
3.	Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018

Reference Books:

1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2,	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	Recognize the various forms of energy.	L1: Understanding
CO3	Interpret energy management methods and energy auditing.	L3: Applying
CO4	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	Familiar with the advanced energy efficient technologies.	L4: Analysing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1	2	3	2	2		3					1	2	2	1
CO2	1	2	2	2	2		3					1	2	2	1
CO3	2	2	2	3	2		3					1	1	3	1
CO4	2	3	2	2	3		3					1	3	3	1
CO5	2	2	3	1	2		3					1	3	2	1
Avg	**1.6**	**2.2**	**2.4**	**2**	**2.2**	**-**	**3**	**-**	**-**	**-**	**-**	**1**	**2.2**	**2.4**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM09	SMPS AND UPS		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge about modern power electronic converters and their applications in power utility.
2.	To impart knowledge about Resonant converters and UPS.

UNIT I	**DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.					
UNIT II	**SWITCHED MODE POWER CONVERTERS**	**9**	**0**	**0**	**9**
Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.					
UNIT III	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**
Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.					
UNIT IV	**DC-AC CONVERTERS**	**9**	**0**	**0**	**9**
Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.					
UNIT V	**POWER CONDITIONERS, UPS, AND FILTERS**	**9**	**0**	**0**	**9**
Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for power electronic applications – Selection of capacitors.					
					Total (45L+0T)= 45 Periods

Text Books:

1.	Simon Ang, Alejandro Oliva,” Power-Switching Converters”, Third Edition, CRC Press, 2010.
2.	M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1.	Ned Mohan, Tore.M.Undeland, William.P.Robbins, “Power Electronics Converters, Applications and Design”, 3rd Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, “Power Electronics circuits, devices and applications”, 3rd Edition, PHI, New Delhi, 2007.

E-References:

1.	NPTEL Course: Power Electronics, IIT-B.
2.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding
CO5	:	Identify the filters and UPS.	L2: Understanding

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	2	2			1					2	2	2	1
CO2	1	1	3	2			1					2	3	3	2
CO3	2	2	2	3			1					1	2	2	1
CO4	2	1	1	2			1					2	2	3	2
CO5	1	1	2	1			1					1	2	2	1
Avg.	**1.6**	**1.2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1.6**	**2.2**	**2.4**	**1.4**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM10	UTILIZATION OF ELECTRICAL ENERGY		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines, Power System, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the economics of power generation, tariff and energy conservation methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff –– availability based Tariff- (ABT) – Battery Energy storage system (BESS)- Frequency based energy measurement - need for electrical energy conservation – methods.- Introduction to energy audit

UNIT II	**ILLUMINATION**	**9**	**0**	**0**	**9**

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

UNIT III	**HEATING AND WELDING**	**9**	**0**	**0**	**9**

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

UNIT IV	**ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45L+0T)= 45 Periods

Text Books:

1.	C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt.Ltd, 2003.
2.	Eric Openshaw Taylor, “Utilisation of Electric Energy”, English Universities Press Limited, 1937
3.	J.B. Gupta, “Utilization of Electric Power and Electric Traction”, S.K.Kataria and Sons, 2002.

Reference Books:

1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, “A Course in Utilization of Electrical Energy”, Khanna Publishers, Delhi, 2003.
2.	H. Partab, “Art and Science of Utilization of Electrical Energy”, Dhanpat Rai and Co, New Delhi, 2004.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of power generation, tariff and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	1	1	2	1	2	2	1	1	1	2	2	3
CO2	2	3	2	3	1	1	2	1	1			1	3	3	2
CO3	3	3	1	3	1	1	2	1					2	2	3
CO4	1	2	2	3	3	1	2	1					2	3	2
CO5	3	1	1	2	1	1	2	1		1		1	2	2	3
CO6	1	3	3	3	3	1	2	2				1	3	3	2
Avg	**2.17**	**2.17**	**1.67**	**2.5**	**1.67**	**1.17**	**1.83**	**1.33**	**1.5**	**1**	**1**	**1**	**2.33**	**2.5**	**2.5**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

B.E. – MECHANICAL ENGINEERING - MINOR DEGREE

18MEM01	**ENGINEERING THERMODYNAMICS** *(Use of standard thermodynamic tables, Mollier diagram are permitted)*						
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart the knowledge on concepts of zeroth and first law of thermodynamics.
2.	To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.
3.	To teach properties of pure substance.
4.	To impart knowledge on the concepts of steam power cycle.
5.	To derive thermodynamic relations for ideal and real gases.

UNIT I	**BASIC CONCEPT AND FIRST LAW**	**9**	**0**	**0**	**9**

Role of Thermodynamics in Engineering and Science - Applications of Thermodynamics. Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems, Property, state, path and processes, quasi-static process, Thermodynamic equilibrium, Displacement work, P-V diagram. Zeroth law of thermodynamics – concept of temperature and heat. First law of thermodynamics – application to closed and open systems, steady flow processes with reference to various thermal equipment.

UNIT II	**SECOND LAW AND ENTROPY**	**9**	**0**	**0**	**9**

Heat engine – Refrigerator – Heat Pump, Second law of thermodynamics – Kelvin's and Clausius statements- Equivalence of these statements their corollaries. Reversibility and irreversibility. Carnot cycle, reversed Carnot cycle. Clausius inequality, Concept of entropy, principle of increase of entropy, T-s diagram, T-ds equations, Entropy.

UNIT III	**PROPERTIES OF PURE SUBSTANCES**	**9**	**0**	**0**	**9**

Steam - formation and its thermodynamic properties - p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.

UNIT IV	**STEAM POWER CYCLE**	**9**	**0**	**0**	**9**

Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	**IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS**	**9**	**0**	**0**	**9**

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro's law, Vander Waal's equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, Tds, relations, Clausius Clapeyron equations and Joule Thomson Coefficient.

Total (45L)= 45 Periods

Text Books:

1.	Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
2.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
3.	Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4.	Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:	
1.	Cengel, “Thermodynamics- An Engineering Approach”, 3rd Edition, Tata McGraw Hill, 2015.
2.	Merala C, Pother, Craig W and Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata McGrawHill, New Delhi, 2004.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concepts of zeroth, first and second law of thermodynamics.	Remember
CO2	Analyze the various work and heat interactions for different types of processes for closed and open systems	Evaluate
CO3	Evaluate the different properties of pure substances using steam tables and Mollier chart	Evaluate
CO4	Analyze the performance of steam power cycle.	Analyze
CO5	Derive thermodynamic relations for ideal and real gases.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2			1					1	3	1	1
CO2	3	3	2	2			1					1	3	1	1
CO3	3	3	3	2		1	1					1	3	1	1
CO4	2	3	2	2		1	1					1	3	1	1
CO5	3	3	2	2		1						1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**		**1**	**1**					**1**	**3**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM02	FLUID MECHANICS AND MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1.Engineering Physics 2.Engineering Chemistry 3.Engineering Mathematics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic concepts and properties of fluids.
2.	To analyze the kinematic and dynamic concepts of fluid flow.
3.	To understand the various incompressible fluid flow through pipes and between parallel plates.
4.	To apply the principles of fluid mechanics to design and operation of hydraulic turbines.
5.	To apply the principles of fluid mechanics to design and operation of hydraulic pumps.

UNIT I	**INTRODUCTION AND FLUID STATICS**	**9**	**0**	**0**	**9**

Basic concepts and units of measurement of physical quantities- Classification of fluids - Properties of fluids – density, relative density, vapour pressure, surface tension, Capillarity and viscosity. Fluid statics- hydrostatic pressure, buoyancy and Archimedes' principle.

UNIT II	**FLUID KINEMATICS AND DYNAMICS**	**9**	**0**	**0**	**9**

Classification of fluid flow - system and control volume - Lagrangian and Eulerian description for fluid flow - flow patterns- streamline, pathline, streakline and timeline. Velocity potential function and Stream function - continuity equation and its applications. Fluid dynamics - Bernoulli's equation and its applications. Dimensional analysis – Buckingham's theorem, dimensional homogeneity, similarity-laws and models.

UNIT III	**FLOW THROUGH PIPES AND PLATES**	**9**	**0**	**0**	**9**

Incompressible fluid flow-Laminar flow- Hagen-Poiseuille equation, shear stress, pressure gradient relationship - flow through pipes and flow between parallel plates. Turbulent flow – flow through pipes, friction factors in turbulent flow - total energy line, hydraulic gradient line, flow through pipes in series and parallel- Moody's friction factor chart. Power transmission-Boundary layer flows - Boundary layer thickness, momentum thickness, energy thickness-boundary layer separation.

UNIT IV	**HYDRAULIC TURBINES**	**9**	**0**	**0**	**9**

Hydraulic turbines classification-impulse and reaction turbines-Working Principle, work done-efficiency and performance curves for Pelton, Francis and Kaplan turbines (Only descriptive) - Comparison between impulse and reaction turbine-specific speed degree of reaction -draft tubes.

UNIT V	**HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Classification of hydraulic pumps- Centrifugal pumps - working principle, specific speed, performance curves and priming(Only descriptive) - Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps (Only descriptive) - Working principles of gear and vane pumps.

Total (45L)= 45 Periods

Text Books:

1.	Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed", Laxmi Publication Pvt Ltd, 2010.
2.	Rajput, R.K., "A Textbook of Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2011.
3.	Subramanya. K., "Fluid Mechanics and Hydraulic Machines", Tata McGraw Hill Publishing Company Ltd, 2011.

Reference Books:	
1.	White, “Fluid Mechanics, 8 Ed”, McGraw Hill India, 2017.
2.	Munson, Young and Okiishi, “Fundamentals of Fluid Mechanics 8 th Edition”, Wiley, 2016.
3.	Yunuscengel, John. M.cimbala, “Fluid Mechanics Fundamentals and Applications”, McGraw Hill, 2017.
4.	Som, S.K, Biswas.G and SumanChakraborty, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw Hill India, 2011.
5.	Dr.P.N.Modi, Dr.S.M.Seth, “Hydraulics and Fluid Mechanics including Hydraulic Machines”, Standard book house, 2018.
E-References:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on fluid mechanics.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Understand the basic concepts and properties of fluids.	Remember
CO2	Analyze the kinematic and dynamic concepts of fluid flow.	Analyze
CO3	Understand the various incompressible fluid flow through pipes and between parallel plates.	Understand
CO4	Apply the principles of fluid mechanics to design and operation of hydraulic turbines.	Apply
CO5	Apply the principles of fluid mechanics to design and operation of hydraulic pumps.	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1				2				1		2	2	1
CO2	3	3	1		2								2	2	1
CO3	2	3	2	2	1								2	2	1
CO4	3	3	3	2	1	2	1						2	2	1
CO5	3	3	3	2	1	2	1						2	2	1
Avg	**2.8**	**2.6**	**2**	**2**	**1.25**	**2**	**1.3**				**1**		**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM03	MANUFACTURING PROCESSES					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics 2. Engineering Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.
2.	To develop design concepts of various manufacturing processes.
3.	Gain knowledge to select appropriate manufacturing processes for various parts.
4.	To develop an entrepreneur skill among the students.
5.	To evaluate and select plastic deformation processes for various parts.

UNIT	TITLE				
UNIT I	**CASTING**	**9**	**0**	**0**	**9**

Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gating and risering design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.

UNIT II	**WELDING**	**9**	**0**	**0**	**9**

Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.

UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**

Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.

UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**

Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.

Total (45L) = 45 Periods

Text Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1.	Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.
2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe the operational features of various casting processes, design gate and riser and discover various defects in casting.	Understand
CO2	Explain various metal joining processes and compare them.	Understand
CO3	Summarize several types of metal forming processes and select suitable method for different applications.	Analyze
CO4	Analyze various manufacturing methods for plastics and their needs in industry.	Analyze
CO5	Describe various sheet metal forming processes, load estimation calculation and principles of powder metallurgy	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	1						1			1	2	1
CO2	2	1	2	1		1			1	1			1	2	1
CO3	1	1	1	1						1			1	1	1
CO4	1	1	1		1					1			1	1	1
CO5		1							1	1			1		1
Avg	**1.5**	**1**	**1.5**	**1**	**1**	**1**			**1**	**1**			**1**	**1.5**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM04	MATERIALS ENGINEERING					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering Physics 2. Engineering Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2.	To learn basic principles in metallurgy and materials engineering.
3.	To identity and select suitable engineering materials based on their applications.

UNIT I	**PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

Crystal structures, Phases, solid solution types, compounds, Hume- Rothery rules; Gibb’s phase rule; Binary isomorphous alloy systems – Eutectic, Eutectoid, Peritectic systems. Lever rule, Equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements – Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

UNIT II	**HEAT TREATMENT**	**9**	**0**	**0**	**9**

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation hardening. Heat treatment of HSS tools, gears, springs and gauges.

UNIT III	**FERROUS AND NON FERROUS METALS**	**9**	**0**	**0**	**9**

Plain carbon steels – Tool steels - maraging steels – HSLA steels .Stainless steels- ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray cast iron, white cast iron, malleable cast iron, S.G.Iron. Copper alloys – Brass, Bronze and Cupronickel, Aluminium alloys, Bearing alloys.

UNIT IV	**MECHANICAL PROPERTIES AND TESTING**	**9**	**0**	**0**	**9**

Mechanical properties of engineering materials - Mechanisms of plastic deformation, slip and twinning – Creep, Fatigue and Fracture - Types of fracture – Testing of materials - tension, compression and shear loads - fatigue and creep tests – hardness and its effects – testing for hardness (Brinell, Vickers and Rockwell) - Impact test - Izod and Charpy.

UNIT V	**NON DESTRUCTIVE TESTING AND SURFACE ENGINEERING**	**9**	**0**	**0**	**9**

Non Destructive Testing: Basic principles - Testing method - Radiographic testing, Ultrasonic testing, Magnetic Particle Inspection and Liquid Penetrant Inspections. Introduction to surface engineering - Definition, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics.

Total (45L) = 45 Periods

Text Books:

1.	Kenneth G. Budinski and Michael K. Buinski, “Engineering Materials”, Prentice Hall of India Ltd, 2002.
2.	Raghavan, V, “Materials Science and Engineering”, Prentice Hall of India (P) Ltd., 1999.
3.	Aswani.K.G, “A Text Book of Material Science”, S.Chand and Co. Ltd., New Delhi, 2001.
4.	Khanna O.P., “A Text Book of Materials Science and Metallurgy”, DhanpatRai Sons, 2004.

Reference Books:

1.	William. D.Callsber, “Material Science and Engineering”, John Wiley and Sons, 1997.
2.	Sydney.H.Avner, “Introduction to Physical Metallurgy” Mc Graw Hill Book Company, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the formation of materials and their classification based on atomic structure.	Understand
CO2	Understand the principles of various heat treatment processes in fabrication industry.	Understand
CO3	Describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry	Understand
CO4	Describe various types of failure and select methods for destructive testing	Understand
CO5	Select methods for non destructive testing	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	2	1	1	1						2	3	1
CO2	1		2	1	1	2	1						2	3	1
CO3		1	1	1	1		1						3	2	1
CO4		2	2	1	1	1	1						2	3	1
CO5		2	2	2	1		1						2	2	1
Avg	**1**	**1.5**	**1.8**	**1.4**	**1.0**	**1.3**	**1**						**2.2**	**2.6**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM05	KINEMATICS OF MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering graphics. 2.Engineering Mechanics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2.	To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3.	To understand basics of cam profile and its displacement.
4.	To understand the basic concepts of toothed gearing and kinematics of gear trains.
5.	Illustrate the effects of friction drives in transmission system.

UNIT I	**BASICS OF MECHANISMS**	**9**	**0**	**0**	**9**

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider-crank chains Limit positions- Mechanical advantage - Transmission angle- Description of some common mechanisms- Quick return mechanism, straight-line generators.

UNIT II	**KINEMATIC ANALYSIS**	**9**	**0**	**0**	**9**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centres - kinematic analysis of simple mechanisms- slider-crank mechanism dynamics Coincident points- Coriolis component of acceleration introduction to linkage synthesis three Position graphical synthesis for motion and path generation.

UNIT III	**KINEMATICS OF CAM**	**9**	**0**	**0**	**9**

Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical method for cam profile design.

UNIT IV	**GEARS AND GEAR TRAINS**	**9**	**0**	**0**	**9**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference / undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V	**FRICTION IN MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Surface contacts- sliding and rolling friction- friction drives- friction in screw threads – bearings and lubrication- friction Clutches- belt and rope drives.

Total (45L) = 45 Periods

Text Books:

1.	Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2.	Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:

1.	Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2.	Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.

3.	Erdman AG and Sandor G N, “Mechanism Design, Analysis and Synthesis”, Vol.I, PHI Inc., 1997.
4.	Ambekar A.G, “Mechanism and Machine Theory” Prentice Hall of India, New Delhi, 2007.
5.	John Hannah and Stephens R C, “Mechanisms of Machines”, Viva Low Price Student Edition, New Delhi, 1999.
E-References:	
1.	https://archive.nptel.ac.in/courses/112/104/112104121/
2.	https://nptel.ac.in/courses/112106270
3.	http://velhightech.com/Documents/ME8492 Kinematics of Machinery.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Demonstrate and understand the concepts of various mechanisms and pairs.	Apply
CO2	Analyze the velocity and acceleration of simple mechanisms.	Analyze
CO3	Construct the cam profile for various motion.	Create
CO4	Solve problems on gears and gear trains.	Evaluate
CO5	Evaluate the friction in transmission system	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1									3	1	
CO2	3	2	2	1									3	1	
CO3	3	2	2	1									3	1	
CO4	3	2	2	1									3	1	
CO5	3	2	2	1									3	1	
Avg	**3**	**2**	**2**	**1**									**3**	**1**	

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM06	HYDRAULICS AND PNEUMATICS						
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1.	To enable the students understand the basics of hydraulics and pneumatics
2.	Applying the working principles of hydraulic actuators and control components.
3.	Designing and develop hydraulic circuits and systems.
4.	Applying the working principles of pneumatic power system and its components.
5.	Solving problems and troubles in fluid power systems.

UNIT I	**FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque - Problems, Sources of Hydraulic power; Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II	**HYDRAULIC ACTUATORS AND CONTROL COMPONENTS**	**9**	**0**	**0**	**9**

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary actuators - Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories; Reservoirs, Pressure Switches – Filters – types and selection - Applications – Fluid Power ANSI Symbols – Problems.

UNIT III	**HYDRAULIC CIRCUITS AND SYSTEMS**	**9**	**0**	**0**	**9**

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double - Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail - Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications - Mechanical, hydraulic servo systems.

UNIT IV	**PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS**	**9**	**0**	**0**	**9**

Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – classification - single cylinder and multi cylinder circuits - Cascade method – Integration of fringe circuits, Electro Pneumatic System – Elements – Ladder diagram – timer circuits problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V	**DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING**	**9**	**0**	**0**	**9**

Servo systems, Hydro mechanical servo systems, electro hydraulic servo systems and proportional Valves, Introduction to electro hydraulic pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits, failure and troubleshooting. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs. Case studies: A simple sequence, synchronize circuits using hydraulic and pneumatics components.

Total (45L) = 45 Periods

Text Books:

1.	Manjumdar S.R, "Oil Hydraulics", Tata McGraw-Hill, December 2002.

2.	Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2013.
Reference Books:	
1.	Andrew Parr, “Hydraulic and Pneumatics”, Jaico Publications House, 2005.
2.	Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997
3.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 2010
4.	Shanmugasundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
5.	Srinivasan.R. “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Select the components as per the application	Evaluate
CO2	Apply the working principles of hydraulic actuators and control components.	Apply
CO3	Design and develop hydraulic circuits and systems.	Create
CO4	Apply the working principles of pneumatic power system and its components.	Apply
CO5	Solve problems and troubles in fluid power systems.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1										1	1	1
CO2		2	2	1									1	1	1
CO3	1	2	3			1							1	2	1
CO4	1	1	3	2	2								2	1	1
CO5	1	1	2										1	1	1
Avg	**1.25**	**1.4**	**2.2**	**1.5**	**2**	**1**							**1.2**	**1.2**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM07	DESIGN OF MACHINE ELEMENTS					
PRE-REQUISITE:	**CATEGORY**	**PE**	**Credit**		**3**	
1. Student should study engineering mechanics. 2. Student should study kinematic of machinery.	**Hours/Week**	**L**	**T**	**P**	**TH**	
		3	**0**	**0**	**3**	

Course Objectives:

1.	Understanding of background in mechanics of materials and design of machine components.
2.	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3.	An understanding the design of shafts and couplings.
4.	Familiarize the design of energy storing elements and engine components.
5.	An appreciation of the relationships between component level design and overall machine system design and performance

UNIT I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**	**9**	**0**	**0**	**9**

Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .

UNIT II	**DESIGN OF SHAFTS AND COUPLINGS**	**9**	**0**	**0**	**9**

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings.

UNIT III	**DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS**	**9**	**0**	**0**	**9**

Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.

UNIT IV	**DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS**	**9**	**0**	**0**	**9**

Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting rods and crank shafts.

UNIT V	**DESIGN OF BEARINGS**	**9**	**0**	**0**	**9**

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings.

Total (45L) = 45 Periods

Text Books:

1.	Bhandari V.B, “Design of Machine Elements”, Tata McGraw Hill Book Co, 2020
2.	Md.Jalaludeen.S, “A text book of Machine Design”, Anuradha Publications, 2006

Reference Books:

1.	Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2.	Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.

3.	Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4.	PSG Tech, "Design Data Handbook", M/s.DPV Printers, Coimbatore, 2009
E-References:	
1.	https://nptel.ac.in/courses/112105124
2.	Design of Machine Elements - V. B. Bhandari - Google Books
3.	A Textbook of Machine Design by R.S.Khurmi And J.K.Gupta [tortuka]_1490186411865.pdf | DocDroid

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Understand the influence of steady and variable stresses in machine component design.	Understand
CO2	Apply the concepts of design to shafts, keys and couplings.	Apply
CO3	Familiarize the design of temporary and permanent joints.	Understand
CO4	Design the various energy storing elements and engine components.	Analyse
CO5	Familiarize the design of various types of bearings.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**		**1.0**	**1.0**				**1.0**		**3.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM08	HEAT AND MASS TRANSFER						
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
1.The laws and basic concepts of thermodynamics 2. The concept of energy transfers and their conversion principles			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

COURSE OBJECTIVES	
1.	Understanding the science behind conduction heat transfer and its applications.
2.	Differentiating the concepts of forced and natural convection heat transfer.
3.	Describing the laws and concepts of radiation heat transfer.
4.	Understanding phase change processes and analyzing heat exchangers.
5.	Studying the concept of mass transfer process and its modes.

UNIT-I	**CONDUCTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

General Differential equation – Cartesian(derivation of General Differential Equation), Cylindrical (derivation of General Differential Equation) and Spherical Coordinates – One DimensionalSteady State Heat-Concepts of electrical analogy, Conduction — plane and Composite Systems – Conduction with Internal HeatGeneration., Critical thickness of insulation.

Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infiniteand Infinite Solids –Use of Heisler's charts.

UNIT-II	**CONVECTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Conservation equations, boundary layer concept – Forced convection: external flow – flow over plates, cylinders, spheres and bank of tubes. Internal flow – entrance effects.

Free convection –flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.

UNIT-III	**BOILING, CONDENSATION AND HEAT EXCHANGERS**	**9**	**0**	**0**	**9**

Regimes of Pool boiling and Flow boiling, Nusselt's theory of condensation- correlations in boiling and condensation. Heat Exchanger types - Overall Heat Transfer Co-efficient – Fouling Factors. LMTD and NTU methods.

UNIT-IV	**RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Radiation laws - Black Body and Gray body Radiation - Shape Factor - Electrical Analogy -Radiation Shields.

UNIT-V	**MASS TRANSFER**	**9**	**0**	**0**	**9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion - Equimolal counter diffusion. Basic Convective Mass Transfer Problems.

Total(45L) = 45 Periods

TEXT BOOKS:	
1	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2017
2	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, 2014.
REFERENCE BOOKS:	
1	Yunus A. Cengel, "Heat Transfer A Practical Approach" – Tata McGraw Hill, 5 th Edition - 2013
2	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2017
3	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 2012
4	Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.

COURSE OUTCOMES: On completion of the course the student will be able to:		Bloom's Taxonomy Mapped
CO1	Analyze the mechanism of heat conduction under steady and transient conditions.	Apply
CO2	Develop solutions to problems involving convective heat transfer.	Create
CO3	Design a heat exchanger for any specific application.	Understand
CO4	Adopt the concept of radiation heat transfer in real time systems.	Understand
CO5	Develop solutions to problems involving combined heat and mass transfer.	Apply

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2		1						3	3	1
CO2	3	3	3	3	2		1						3	3	1
CO3	3	3	3	3	2		1						3	3	1
CO4	3	3	3	3	2		1						3	2	1
CO5	2	2	2	2	1		1						3	1	
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**		**1**						**3**	**2.4**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

18MEM09	METROLOGY AND QUALITY CONTROL					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Horus/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES	
1.	Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty
2.	Applying the applications of linear and angular measuring instruments
3.	Interpretation of various tolerance symbols.
4.	Applying the SQC methods in manufacturing.
5.	Applying the advances in measurements for quality control.

UNIT-I	**BASICS OF MEASUREMENT SYSTEM AND DEVICES**	**9**	**0**	**0**	**9**
Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalized measurement system - mechanical loading – static characteristics of instruments – factors considered in selection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty.					
UNIT-II	**CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS**	**9**	**0**	**0**	**9**
Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000 quality standards. Comparators- mechanical, electrical, optical and pneumatic.					
UNIT-III	**GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS**	**9**	**0**	**0**	**9**
Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor‘s principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors, base pitch measurement. Principle of interferometry, laser interferometer, Machine vision, Fundamental of GD&T. Inspection of straightness, flatness, roundness deviations.					
UNIT-IV	**STATISTICAL QUALITY CONTROL**	**9**	**0**	**0**	**9**
Surface finish – terminology and measurements – Optical measuring instruments –Acceptance test for machines. Statistical Quality Control - Control charts - Sampling plans.					
UNIT-V	**SIX SIGMA**	**9**	**0**	**0**	**9**
Six sigma: Define measure, analyse, improve and control phases. Analyze phase tools: CommonTools: Histogram, Box Plot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA Multi variate analysis.					
					Total(45L) = 45 Periods

TEXT BOOKS:	
1	Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018
2	Beckwith.T.G, Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006
REFERENCE BOOKS:	
1	Jain.R.K, ―Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.
2	Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.

3	Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.
4	Alan S Morris, ―Measurement and Instrumentation Principles, Butterworth, 2006.
5	De Feo J A and Barnard W W, ―Six Sigma: Break trough and BeyondG, Tata McGraw-Hill, New Delhi, 2005.
E-REFERENCES:	
1	https://nitsri.ac.in/Department/Mechanical%20Engineering/MEC_405_Book_2,_for_Unit_2B.pdf
2	https://www.nist.gov/system/files/documents/srm/NIST-SRM-RM-Articlefinal.pdf
3	https://www.researchgate.net/publication/319587859_Computer-Aided_Metrology-CAM

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty.	Understand
CO2	Apply the working principle and the applications of linear and angular measuring instruments.	Apply
CO3	Interpret of various tolerance symbols.	Apply
CO4	Apply the SQC methods in manufacturing.	Apply
CO5	Apply the advances in measurements for quality control in manufacturing industries.	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1							2	1	2				2	1	
CO2							3	1	2				1	2	
CO3							2	1					2	1	
CO4				3			2		1				1	2	
CO5				2				3	1				2	1	
Avg				**2.5**			**2.25**	**1.5**	**1.5**				**1.6**	**1.4**	

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEMI10	DYNAMICS OF MACHINERY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work.
2.	To facilitate the students, to understand the concept of balancing of rotating and reciprocating masses.
3.	To teach concepts of free vibration analyses of one and two degree-of-freedom rigid body systems
4.	To teach concepts of forced vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects.
5.	To learn about the concept of various types of governors.

UNIT I	**FORCE ANALYSIS**	**9**	**0**	**0**	**9**

Static Force Analysis, Free Body Diagrams, Conditions of Two, Three and Four Force Members. Inertia Forces and D‘Alembert‘s Principle – Inertia Force Analysis in Reciprocating Engines – Crank Shaft Torque. Flywheels – Turning Moment Diagrams and Fluctuation of Energy of reciprocating engine mechanisms, Coefficient of Fluctuation of Energy and Speed, Weight of Flywheel Required.

UNIT II	**BALANCING**	**9**	**0**	**0**	**9**

Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines

UNIT III	**FREE VIBRATION**	**9**	**0**	**0**	**9**

Basic Features of Vibratory Systems – Types – Single Degree of Freedom System – Transverse Vibration of Beams – Natural Frequency by Energy Method, Dunkerly‘s Method - Critical Speed - Damped Free Vibration of Single Degree Freedom System -Types of Damping – Free Vibration with Viscous Damping, Critically Damped System, Under Damped System. Torsional Systems: Natural Frequency of Two and Three Rotor Systems.

UNIT IV	**FORCED VIBRATION**	**9**	**0**	**0**	**9**

Response to Periodic Force – Harmonic Force – Force caused by Unbalance – Support Motion - Logarithmic Decrement-Magnification Factor – Vibration Isolation and Transmissibility.

UNIT V	**GOVERNORS**	**9**	**0**	**0**	**9**

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors – Characteristics - Effect of friction - Controlling Force - other governor mechanisms.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2.	Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi

REFERENCE BOOKS:

1.	Ballaney, P.L., “Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2.	Shigley, J.E. and Uicker, J.J., “Theory of Machines and Mechanisms”, TMH ND, 1998.
3.	Amithabha Ghosh, and Ashok Kumar Malik., “Theory of Mechanisms and Machines”, 2nd Ed., Affiliated East and West Press Limited, 1998.
4.	Prof.Nakara, IIT-Delhi Reference Books

E-REFERENCES:	
1.	www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of-Machinery-ebook
2.	http://nptel.ac.in/courses/112104114/

COURSE OUTCOMES: On completion of the course the student will be able to		Bloom's Taxonomy Mapped
CO1	Apply basic principles of mechanisms in mechanical system.	Apply
CO2	Familiarize the static and dynamic analysis of simple mechanisms.	Understand
CO3	Analyze the mechanical systems subjected to free vibration.	Analyze
CO4	Analyze mechanical systems subjected to forced vibration.	Analyze
CO5	Analyze the various types of governors and its speed control mechanism.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	1					1		3	2	1	2
CO2	2	2	3	2	1					1		3	2	1	2
CO3	2	2	3	2						1		3	2	1	2
CO4	2	2	3	2	1					1		3	2	1	2
CO5	1	2	3	2						1		3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1**					**1.0**		**3.0**	**2.0**	**1.0**	**1.8**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

MINOR DEGREE: METALLURGICAL ENGINEEING

18MTM01	ADVANCED PHYSICAL METALLURGY		Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.					
Unit I	**CRYSTAL STRUCTURES**		**9**	**0**	**0**	**9**
Review of atomic bonds, Lattice, unit cell, crystal systems and Bravais lattices; Principal crystal structures – BCC, FCC, HCP and its characteristics; Miller indices for crystallographic planes and directions, interplanar spacing; Volume, planar and linear atomic density; Polymorphism and allotropy; CsCl, NaCl, Diamond structures; single crystal and polycrystalline and amorphous materials; isotropy and anisotropy; Simple problems in the above topics						
Unit II	**CRYSTALLINE IMPERFECTIONS**		**9**	**0**	**0**	**9**
Types of point defects, effect of temperature on vacancy concentration, interstitial sites-octahedral and tetrahedral sites; Line defects – dislocations – Edge, screw and mixed dislocations, Burger's vector, slip and twinning; Planar defects – grain boundaries, tilt boundaries, small angle grain boundaries; ASTM grain size number, grain size determinations; Volume defects; Simple problems in the above topics.						
Unit III	**ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL**		**9**	**0**	**0**	**9**
Diffusion mechanisms, steady state diffusion and non-steady state diffusion-Fick's first law and second law; Kirkendall effect and Darken's equation; Factors affecting diffusion; Industrial applications of diffusion processes; Simple problems in the above topics; Basic principles of solidification of metals and alloys; Growth of crystals– Planar growth, dendritic growth, Solidification time, dendrite size; Cooling curves; Cast or Ingot structure, Solidification defects – Control of casting structure; Directional solidification – single crystal growth; Simple problems in the above topics.						
Unit IV	**PHASE DIAGRAMS**		**9**	**0**	**0**	**9**
Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Phase diagram determination; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling- Coring and its effects, homogenization; Binary eutectic system - composition and amount of phases, development of microstructure; Eutectoid, Peritectic and monotectic reaction, Phase diagrams with intermediate phases and compounds; Ternary phase diagrams. Simple problems in the above topics.						
Unit V	**IRON-CARBON PHASE DIAGRAM**		**9**	**0**	**0**	**9**
Iron-carbon diagram, Phases in Fe-C system, Invariant reactions, Microstructure of slowly cooled steels, composition and amount of phases, Effect of Alloying elements on Fe-C system, Type, structure, properties and applications of Plain Carbon Steels and different types of Cast iron; IS Specification for Steels and Cast Irons, Simple problems in above topics.						
						Total (45+0) = 45 Hours

Text Books:	
1	Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition, 2007.
2	William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, JohnWiley & Sons, New York, USA, 1997.
Reference Books:	
1	Avner S H."An Introduction to Physical Metallurgy", McGraw Hill Book Co, New York, USA, 1997.
2	Donald R Askeland," Essentials of Material Science and Engineering ", Thomson Learning, India Edition, 2007
3	Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi, 199.
4	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-Hill Inc, New York, 1993.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic crystal structure, orientation and their influence on macroscopic properties.	L2: Understanding
CO2	:	Discuss the role of imperfections in strengthening the materials.	L2: Understanding
CO3	:	Diagonise the diffusion mechanism in solidification of materials under different conditions.	L4:Analysing
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3:Applying
CO5	:	Construct the Fe-Fe_3C phase diagram and discuss various properties of steel and cast iron.	L3:Applying

<u>COURSE ARTICULATION MATRIX</u>

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1		1	
CO2	1	1				1	1						1			1
CO3	1	1	1	1		1							1	1		
CO4	1	1		1	1								1			
CO5	1	1		1									1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM02	THERMODYNAMICS AND KINETICS IN METALLURGY			Semester		
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
Engineering physics and Engineering chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To learn the basic principles and concepts of thermodynamics in the field of Metallurgy and materials; and to learn about equations and their applications.

Unit I	**FUNDAMENTAL CONCEPT AND INTERNAL ENERGY**	**9**	**0**	**0**	**9**
Introduction: System and surrounding, Classification of systems, Path and state properties, Thermodynamic processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics: Heat and work, Internal energy, Heat capacity of materials, Cp-Cv relations, Nernst Equation, Enthalpy, Thermochemistry Hess's law, Kirchoff's law, Maximum flame temperature.					
Unit II	**ENTROPY AND AUXILARY FUNCTIONS**	**9**	**0**	**0**	**9**
Second law of thermodynamics: Carnot cycle, Entropy - Statistical interpretation of entropy, Free energy, Combined statement of first and second laws, Thermodynamic functions - Maxwell's relations, Gibbs Helmholtz equation. Third and Zeroth laws of thermodynamics : Definition, concept and applications					
Unit III	**THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA**	**9**	**0**	**0**	**9**
Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon equation, Troutons rule. Le Chatelier's principle, Vant Hoff's equation. Equilibria in phase diagrams: Phase rule, Phase stability, Thermodynamics of surfaces, interfaces and defects, P-G-T diagrams, Application of free energy - composition diagrams to the study of alloy systems.					
Unit IV	**THERMODYNAMICS OF SOLUTIONS**	**9**	**0**	**0**	**9**
Gibbs - Duhem equation, Partial and integral molar quantities, chemical potential, Ideal solutions - Raoult's law, Real solutions, Activity coefficient, Henry's law, Alternative standard states, Sievert's law, Mixing functions and excess functions, Regular solutions, Applications of Gibbs - Duhem equation.					
Unit V	**THERMODYNAMICS OF REACTIONS AND KINETICS**	**9**	**0**	**0**	**9**
Electro chemical process: Cells, Interconversion of free energy and electrical work, Determination of thermodynamic quantities using reversible cells, Solid electrolytic cells. Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction.					
					Total (45+0) = 45 Hours

Text Books:	
1	Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon, 1977.
2	Ahindra Ghosh, Text book of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002
3	. David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis, 2008
Reference Books:	
1	David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995.
2	Dr S.K Dutta,Prof A.B.Lele – Metallurgical thermodynamics kinetics and numericals,S.Chand& co Ltd.,New Delhi 2011
3	Darken LS and Gurry R W,"Physical Chemistry of Metals", CBS publications and distributors, 2002.
4	Parker R H, "An introduction to chemical metallurgy", Pergamon press, New York, second edition, 1978.
5	Kapoor M.L., "Chemical and Metallurgical Thermodynamics Vol. I and II", Nem Chand, 1st Ed., 1981

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the fundamental concepts of thermodynamics and internal energy	L2: Understanding
CO2	:	State the thermodynamics entropy and auxilary functions.	L2: Understanding
CO3	:	Identify the basic laws, chemical potential and phase equilibria.	L4:Analysing
CO4	:	Describe the thermodynamics of the solution and various important equations.	L2: Understanding
CO5	:	Apply to solve problems related to electrochemical processes and kinetics.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		
CO2	1	1	1										1		1	
CO3	1	1		1	1								1			
CO4	1			1	1								1		1	1
CO5	1	1				1	1						1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM03	MECHANICAL BEHAVIOUR OF MATERIALS		Semester			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To know the fundamental concepts of deformation behaviour for structural engineering applications.

Unit I	**DISLOCATIONS AND PLASTIC DEFORMATION**	**9**	**0**	**0**	**9**

Strength of perfect crystal and need for dislocations; Characteristics of dislocations – Edge dislocation, Screw dislocation, Burger's vector, mixed dislocation, dislocation loops; Movement of dislocation – Pierls stress, Cross slip, Climb; Dislocations in FCC, HCP and BCC lattice; Stress fields and energies of dislocations, forces on and between dislocations; Dislocation density; Intersections of dislocations – Jogs and kinks; Dislocation multiplication; Dislocation pile-ups; Deformation by slip and twinning; Critical resolved shear stress; Deformation bands and kink bands.

Unit II	**STRENGTHENING MECHANISMS**	**9**	**0**	**0**	**9**

Strain hardening; Grain boundary strengthening; Solid solution strengthening - yield-point phenomenon, strain ageing; Precipitation hardening - Conditions for precipitation hardening, Ageing, Formation of precipitates, coarsening of precipitates, Mechanism of strengthening; Dispersion strengthening; Fiber strengthening; Martensite strengthening - examples for above strengthening mechanisms from ferrous and non-ferrous systems, Bauschinger effect; Preferred orientation; Sever plastic deformation.

Unit III	**FRACTURE AND FRACTURE MECHANICS**	**9**	**0**	**0**	**9**

Types of fracture – ductile and brittle fracture, Ductile to Brittle Transition Temperature (DBTT), Metallurgical factors affecting DBTT, determination of DBTT, Hydrogen embrittlement and other embrittlement, Theoretical cohesive strength of metals, Griffith's theory of brittle fracture, Orowan's modification. Fracture mechanics - introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD, J integral.

Unit IV	**FATIGUE BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**9**

Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermo-mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.

Unit V	**CREEP BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**9**

Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametetric methods of extrapolation. Deformation Mechanism Maps

Total (45+0) = 45 Hours

Text Books:	
1	George. E. Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004
2	Marc Andr’e Meyers, Krishan Kumar Chawla, “Mechanical Behavior of Materials”, Cambridge University Press, UK, 2009.
Reference Books:	
1	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
2	Davis.H.E. Troxell G.E., Hauck.G.E.W. “The Testing of Engineering Materials”, McGraw-Hill, 1982.
3	Wulff et al Vol. III “Mechanical Behavior of Materials”, John Wiley and Sons, New York, USA, 1983.
4	Honeycombe R.W.K., “Plastic Deformation of Materials”, Edward Arnold Publishers, 1984

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the mechanical behaviour of materials.	L2: Understanding
CO2	:	Discuss the strengthening mechanisms of materials.	L2: Understanding
CO3	:	List the various types of fractures and their mechanisms, fracture mechanics and various theories describing fracture mechanics.	L2: Understanding
CO4	:	Discuss the fatigue behaviour and the mechanism of fatigue, SN curve and fatigue testing machines.	L2: Understanding
CO5	:	Describe the creep behaviour and mechanism, factors affecting creep and creep testing machines.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1		1	1								1	1		
CO3	1	1	1		1										1	1
CO4	1	1				1	1								1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM04	RATE PROCESSES IN METALLURGY		Semester			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To learn the basic principles and concepts of kinetics in the domain of metallurgy and materials; to learn about equations and their applications; And to appreciate that metallurgical kinetics as a Knowledge base with abundant applications.

Unit	Title	L	T	P	TH
Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction: Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat and mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.

Unit	Title	L	T	P	TH
Unit II	**KINETICS OF SOLID-FLUID REACTION**	**9**	**0**	**0**	**9**

Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step, Concentration boundary layer, definition and significance of heat and mass transfer coefficient, Theoretical models for mass transfer coefficients, Correlations for heat and mass transfer coefficients

Unit	Title	L	T	P	TH
Unit III	**LIQUID-SOLID PHASE TRANSFORMATION**	**9**	**0**	**0**	**9**

Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing.

Unit	Title	L	T	P	TH
Unit IV	**SOLID STATE PHASE TRANSFORMATIONS**	**9**	**0**	**0**	**9**

Nucleation and growth Kinetics, homogeneous and heterogeneous transformation, Precipitation: Coherency, age hardening, particle Coarsening. Ostwald ripening, Order-disorder transformation, spinodal decomposition, massive transformations

Unit	Title	L	T	P	TH
Unit V	**SOLID STATE PHASE TRANSFORMATIONS IN STEEL**	**9**	**0**	**0**	**9**

Reconstructive and displacive transformations; Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology of pearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite and lower bainite; Martensitic transformation: Mechanism- diffusionless displacive nature; morphology of high carbon and low carbon martensite.

Total (45+0) = 45 Hours

Text Books:

1.	Ahindra Ghosh and Sudipto Ghosh, A Text book of Metallurgical Kinetics, PHI learning Pvt. Ltd., New Delhi, 2014
2.	H.S. Ray, Kinetics of Metallurgical Reactions, International Science publisher, 1993.
3.	F. Habashi, Kinetics of Metallurgical Processes, Metallurgy Extractive Québec, 1999.
4.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon, 1977.

Reference Books:

1.	Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Transformations in Metals, P.G. Shewmon, Mc-Graw Hill, 1969.
2.	Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997.
3.	Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
4.	Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the thermodynamic aspects of phase changes.	L2: Understanding
CO2	:	Discuss the fundamentals of solid –fluid reactions.	L2: Understanding
CO3	:	Explain the eutectic and peritectic solidifications and rapid solidification processes.	L2: Understanding
CO4	:	Describe the fundamentals of solidification.	L1: Remembering
CO5	:	Apply the solid state phase transformations in steel.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1			1
CO2	1	1			1	1									1	1
CO3	1	1		1	1								1	1		
CO4	1	1		1	1									1		1
CO5	1		1			1	1								1	1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM05	CORROSION AND SURFACE ENGINEERING			Semester			
PREREQUISITES				**OE**	**Credit**		**3**
Engineering chemistry		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Learning Objectives							
1	To understand the corrosion and surface engineering, with its application in engineering field.						
Unit I	**MECHANISMS AND TYPES OF CORROSION**			**9**	**0**	**0**	**9**
Principles of direct and Electro chemical Corrosion, Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion, Galvanic series-specific types of corrosion such as uniform, Pitting, Intergranular, Cavitations, Crevice Fretting, Erosion and Stress Corrosion, corrosion fatigue, hydrogen damage –Factors influencing corrosion							
Unit II	**TESTING AND PREVENTION OF CORROSION**			**9**	**0**	**0**	**9**
Corrosion testing techniques and procedures- Corrosion Testing ASTM Standards, Pitting Corrosion Test, Hydrogen Induced Cracking Test, Sulphide Stress Corrosion Cracking Test- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Special surfacing processes.							
Unit III	**CORROSION OF INDUSTRIAL COMPONENTS**			**9**	**0**	**0**	**9**
Corrosion in fossil fuel power plants, Automotive industry, Chemical processing industries, corrosion in petroleum production operations and refining, Corrosion of pipelines- wear of industrial components.							
Unit IV	**SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE**			**9**	**0**	**0**	**9**
Diffusion coatings –Electro and Electroless Plating –Hot dip coating –Hard facing-Metal spraying, Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.							
Unit V	**THIN LAYER ENGINEERING PROCESSES**			**9**	**0**	**0**	**9**
Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Coating of tools, TiC, TiN, Al_2O_3 and Diamond coating-Properties and applications of thin coatings.							
							Total (45+0) = 45 Hours

Reference Books:	
1.	Fontana. G., Corrosion Engineering, McGraw Hill,1985.
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prenticehall,1992.
3.	ASM Metals Hand Book –Vol. 5, Surface Engineering,1996.
4.	Denny A Jones, “Principles and prevention of corrosion”, 2nd edition, Prentice Hall, New Jersey,1995.
5.	ASM International, Surface Engineering for Corrosion and Wear Resistance,2005.
6.	Schweitzer. P.A., Corrosion Engineering Hand Book, 3rd Edition, Marcel Decker, 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Name the different types of corrosion and their mechanism.	L2: Understanding
CO2	:	Estimate corrosion resistance by different tests.	L4:Analysing
CO3	:	Explain the corrosion behavior of different metals in different industries.	L2: Understanding
CO4	:	Classify the different forms of processing techniques of surface engineering materials.	L1: Remembering
CO5	:	Select the type of deposition and spraying technique.	L3:Applying

<u>COURSE ARTICULATION MATRIX</u>

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		
CO2	1	1		1		1							1	1		
CO3	1	1	1	1			1								1	1
CO4	1	1		1	1										1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM06	MATERIALS CHARACTERIZATION			Semester		
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	To acquire knowledge on various characterizations, chemical and thermal analysis of metallurgical components using its analysis tools.

Unit I	**OPTICAL MICROSCOPY**	**9**	**0**	**0**	**9**
Metallographic specimen preparation. Macro-examination -applications. Metallurgical microscope - principle, construction and working, , Optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources, lens aberrations and their remedial measures, Various illumination techniques-bright field , dark field, phase-contrast, polarized light illuminations, interference microscopy, high temperature microscopy; Quantitative metallography – Image analysis.					
Unit II	**X-RAY DIFFRACTION**	**9**	**0**	**0**	**9**
Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method and powder method. Diffraction intensity – structure factor calculation. X-ray diffractometer -general features, filters and counters. Applications of X-ray diffraction in materials characterisation – Determination of crystallite size, crystal structure, precise lattice parameter, measurement of stress.					
Unit III	**ELECTRON MICROSCOPY**	**9**	**0**	**0**	**9**
Electron beam - specimen interactions. Construction and operation of Transmission Electron Microscopy – Diffraction effects and image formation, various imaging modes, selected area diffraction, applications, specimen preparation techniques. Scanning electron microscopy – principle, equipment, various operating modes and applications, Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis. Introduction to HRTEM, FESEM, EBSD.					
Unit IV	**SPECTROSCOPIC TECHNIQUES**	**9**	**0**	**0**	**9**
X-ray spectroscopy – EDS and WDS. Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy and Secondary ion mass spectroscopy / ion microprobe. Optical emission spectroscopy, Atomic Absorption spectroscopy and X-ray fluorescence spectroscopy - principle, construction, working and applications. UV-Vis, FTIR and Raman spectroscopy.					
Unit V	**THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES**	**9**	**0**	**0**	**9**
Thermal Analysis: Principles of differential thermal analysis, differential scanning calorimetry and thermo-graviometric analysis – Instrumentation and applications. Advanced characterization techniques: Scanning probe microscopy - STM and AFM - principle, instrumentation and applications. Field ion microscopy including atom probe - principles, instrumentation and applications.					
Total (45+0) = 45 Hours					

Text Books:	
1.	Cullity, B.D., Elements of X Ray Diffraction, Addison-Wesley Publishing Company Inc, Philippines, 1978
2.	Brandon, D. and W.D. Kaplan, Microstructural Characterization of Materials, John Wiley & Sons Ltd, England, 2013.
3.	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008

Reference Books:	
1.	ASM Handbook, Volume 10, Materials Characterization, ASM international, USA, 1986.
2.	Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
3.	Phillips V A, Modern Metallographic Techniques and their Applications, Wiley Eastern, 1971.
4.	Angelo, P. C., Materials Characterization, Reed Elsevier India Pvt Ltd, Haryana, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the principles of metallurgical microscope, optical properties and various illumination techniques.	L2: Understanding
CO2	:	Analyze the various diffraction methods, X-ray diffractometer and determination of crystal parameter.	L4:Analysing
CO3	:	Discuss the principles of TEM, SEM, EPMA.	L2: Understanding
CO4	:	Explain various spectroscopic techniques,	L2: Understanding
CO5	:	Discuss the chemical and thermal analysis using advanced methods.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	`1		1	1								1		1	
CO2	1	1	1	1		1							1			1
CO3	1		1			1	1					1	1			1
CO4	1	1		1	1							1	1			1
CO5	1	1		1	1								1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0					1.0	1.0		1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

18MTM07	AUTOMOTIVE, AEROSPACE AND DEFENCE MATERIALS		Semester			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives					
1	To understand the properties and applications various materials suitable for automobile, aircraft and defnce industries and its components.				
Unit I	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**	**9**	**0**	**0**	**9**
Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.					
Unit II	**MATERIALS FOR AUTOMOTIVE STRUCTURES**	**9**	**0**	**0**	**9**
Materials selection for bearings, leaf springs, chasis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and antifriction fluids, Tyres and tubes. Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.					
Unit III	**AEROSPACE METALS AND ALLOYS**	**9**	**0**	**0**	**9**
Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles. Heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – Effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys, powder metallurgy- application of materials in Thermal protection systems of Aerospace vehicles – super alloys					
Unit IV	**CERAMICS AND COMPOSITES**	**9**	**0**	**0**	**9**
Introduction – physical metallurgy – modern ceramic materials – cermet - cutting tools – glass ceramic –production of semi-fabricated forms - Plastics and rubber – Carbon/Carbon composites, Fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design.					
Unit V	**NUCLEAR WASTE AND RADIATION PROTECTION, IRRADIATION EFEFCTS**	**9**	**0**	**0**	**9**
Introduction-unit of nuclear radiation-Types of waste –disposal –ICRP recommendations-radiation hazards and prevention –radiation dose units - Irradiation Examination of Fuels, Irradiation behaviour of metallic uranium – irradiation growth, thermal cycling, swelling, adjusted uranium, blistering in uranium rods. Irradiation effects in ceramic oxide and mixed oxide fuels, definition and units of burn up, main causes of fuel element failure in power reactors and remedies to avoid failures.					
Total (45+0) = 45 Hours					

Reference Books:

1.	ASM Handbook, "Selection of Materials Vol. 1 and 2", ASM Metals Park, Ohio. USA, 1991.
2.	Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications Or Callister's Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley India, Edition -2010.
3.	Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4.	Engineering Metallurgy Applied Physical Metallurgy, R. A. Higgins, 6th Edition

5.	Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc. New Jersey USA, 1995.
6.	Charles J A and Crane. F A. A., "Selection and Use of Engineering Materials", 3rd Edition, Butterworths, London UK, 1996
7.	ASM Handbook. "Materials Selection and Design", Vol. 20- ASM Metals Park Ohio.USA, 1997
8.	Cantor," Automotive Engineering: Lightweight, Functional, and Novel Materials", Taylor & Francis Group, London, 2006

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the materials selection criteria for engine and transmission systems.	L2: Understanding
CO2	:	Analyze the different materials used for automotive structures and Different electronic materials for automotive applications.	L4:Analysing
CO3	:	Explain various topics such as elements of aerospace materials and mechanical behaviour of materials,	L2: Understanding
CO4	:	Compare the ceramics and composites of aerospace materials	L4:Analysing
CO5	:	Examine the fuels for nuclear materials.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1			1							1	1		
CO3	1			1	1								1		1	
CO4	1	1	1				1						1			1
CO5	1	1		1	1								1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)