NATIONAL INSTITUTE OF TECHNOLOGY
ANDHRA PRADESH

SCHEME OF INSTRUCTION AND SYLLABI

B.Tech. – Electrical and Electronics Engineering

Effective from 2020-21

Contents

Vision of the Department of Electrical Engineering:

Aiming to nurture globally competent electrical engineers in research and innovation through quality education and develop cutting edge technologies for the betterment of society

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Mission of the Department of Electrical Engineering:

M1. Effective Technology adoption into teaching and learning Strategies by faculty that result in observable students’ achievement

M2. Create an open platform for innovative research work in sustainable electrical power systems

M3. Nurture creative thinking with understanding engineering principles and develop real-time solutions for global problems with industry collaboration

M4. Deploy energy efficient and green energy technologies to address social, environmental, and economical effects

Programme Educational Objectives (PEOs) for the B.Tech. (EEE) Programme:

Within few years after the end of the B.Tech. in Electrical and Electronics Engineering programme, graduates will be able to:

PEO1	Design and develop innovative products and services in the field of electrical and electronics engineering and allied engineering disciplines.
PEO2	Apply the knowledge of electrical and electronics engineering to solve problems of social relevance pursue higher education and research.
PEO3	Work effectively as individuals and as team members in multidisciplinary projects.
PEO4	Engage in life-long learning, career enhancement and adopt to changing professional and societal needs.

Programme Articulation Matrix (PEO vs. Mission) for the B.Tech. (EEE) Programme:

PEO\Mission	M1	M2	M3	M4
PEO1	3	1	3	3
PEO2	3	2	3	3
PEO3	2	1	2	1
PEO4	2	3	2	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Programme Outcomes (POs) for the B.Tech. (EEE) Programme:

At the end of any B.Tech. program in NIT Andhra Pradesh, graduates will be able to:

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSO) for the B.Tech. (EEE) Programme:

At the end of the B.Tech. in Electrical and Electronics Engineering programme, graduates will be able to:

PSO1	Design, analyze, implement, verify and validate efficient solutions to complex engineering problems related to the ideation, development, testing and maintenance of electrical systems.
PSO2	Construct or leverage contemporary tools, techniques, and frameworks in developing or refactoring an electrical system or its component.

Degree Requirements for B.Tech. (EEE) Programme

	No. of Credits
Basic Science Core (BSC)	**19 (11.7%)**
Engineering Science Core (ESC)	**22 (13.58%)**
Humanities and Social Science Core (HSC)	**06 (3.7%)**
Program Core Courses (PCC)	**63 (38.8%)**
Departmental Elective Courses (DEC)	**15 (9.25%)**
Open Elective Courses (OPC)	**09 (5.55%)**
Program Major Project (PRC)/Skill Development (SD)/Foreign Languages	**22 (13.58%)**
EAA: Games and Sports (MSC)	**2 (1.2%)**
MOOCs (MOE)	**4 (2.46%)**
Total	**162**

NOTE: The no. of credits required to award B.Tech. degree is 162 as per the curriculum.

Credit Distribution in Each Semester										
	I	II	III	IV	V	VI	VII	VIII	TOT	REQ
BSC	8	8	3	0	0	0	0	0	**19**	**≥ 19**
ESC	4	10	4	4	0	0	0	0	**22**	**≥ 14**
HSC	3	0	0	0	0	0	3	0	**6**	**≥ 06**
PCC	0	0	13	16	16	11	7	0	**63**	**≥ 62**
DEC	0	0	0	0	0	6	6	3	**15**	**≥ 15**
OPC	0	0	0	0	3	3	0	3	**9**	**≥ 09**
PRC/ SD	5	2	0	2	0	3	4	6	**22**	**≥ 15**
EAA (MSC)	1	1	0	0	0	0	0	0	**2**	**≥ 2**
MOOCS (MOE)	0	0	0	0	2	0	0	2	**4**	**≥ 4**
Total	**21**	**21**	**20**	**22**	**21**	**23**	**20**	**14**	**162**	

I Year B.Tech. Course Structure
(Common for all branches)

Physics Cycle							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101/ MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	03	BSC
2	HS101	English for Technical Communication	2	0	2	03	HSC
3	PH101	Engineering Physics	3	0	0	03	BSC
4	EC101	Basic Electronics Engineering	2	0	0	02	ESC
5	CE102	Environmental Science and Engineering	2	0	0	02	ESC
6	CS101	Introduction to Algorithmic Thinking and Programming	3	0	0	03	SD
7	CS102	Introduction to Algorithmic Thinking and Programming Lab	0	1	2	02	SD
8	PH102	Engineering Physics Lab	0	1	2	02	BSC
9	EA101/ EA151	Physical Education/Health Education	0	0	3	01	MSC
		TOTAL	15	2	9	21	

Chemistry Cycle							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101/ MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	03	BSC
2	ME102	Engineering Graphics with Computer Aided Drafting	0	1	2	02	ESC
3	CY101	Engineering Chemistry	3	0	0	03	BSC
4	EE101	Elements of Electrical Engineering	2	0	0	02	ESC
5	BT101	Biology for Engineers	2	0	0	02	ESC
6	ME101	Basics of Mechanical Engineering	2	0	0	02	ESC
7	CE101	Engineering Mechanics	2	0	0	02	ESC
8	ME103	Workshop Practice	0	1	2	02	SD
9	CY102	Engineering Chemistry Lab	0	1	2	02	BSC
10	EA101/ EA151	Physical Education/Health Education	0	0	3	01	MSC
		TOTAL	14	3	9	21	

Summer Internship – I#

Note:

BSC: Basic Science Core	ESC: Engineering Science Core
HSC: Humanities and Social Science Core	PCC: Program Core Courses
DEC: Departmental Elective Courses	OPC: Open Elective Courses
PRC: Program Major Project/Skill Development (SD)/Foreign Languages	EAA (MSC): Games and Sports MOOCs (MOE)

II Year B.Tech. Course Structure

III – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA206	Complex Variables and Transform Techniques	3	0	0	03	BSC
2	EE201	Electric and Magnetic Circuits	2	1	2	04	ESC
3	EE202	Electromagnetic Field Theory	3	0	0	03	PCC
4	EE203	Analog and Digital Electronic Circuits	3	0	0	03	PCC
5	EE204	Measurements and Instrumentation	3	0	0	03	PCC
6	EE205	Analog and Digital Electronic Circuits Laboratory	0	1	2	02	PCC
7	EE206	Measurements and Instrumentation Laboratory	0	1	2	02	PCC
		TOTAL	15	3	8	20	

IV – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CS285	Data Structures and Algorithms	3	0	2	04	ESC
2	EE251	Energy Conversion Technologies	3	0	0	03	PCC
3	EE252	DC Machines and Transformers	3	0	0	03	PCC
4	EE253	Signals and Systems	3	0	0	03	PCC
5	EE254	Control Systems	3	0	0	03	PCC
6	EE255	Control Systems Laboratory	0	1	2	02	PCC
7	EE256	Numerical Methods and Programming Analytical Laboratory	0	1	2	02	PCC
8	EE299	Mini Project – I (EPICS based)	0	0	4	02	SD
		TOTAL	14	2	12	22	

Summer Internship – II$^{\#}$

III Year B.Tech. Course Structure

V – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	EE301	Embedded Systems	2	0	2	03	PCC
2	EE302	Electric Power Transmission	3	0	0	03	PCC
3	EE303	AC Rotating Machines	3	0	0	03	PCC
4	EE304	Power Electronics	3	0	0	03	PCC
5	EE305	Power Electronics Lab	0	1	2	02	PCC
6	EE306	DC Machines and Transformers Lab	0	1	2	02	PCC
7		Open Elective – 1 / Foreign language	3	0	0	03	OPC/SD
8		MOOCS-1 (DAC)	2	0	0	02	MOE
		TOTAL	16	1	8	21	

VI – Semester

S.No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		**Department Elective –1**	3	0	0	03	DEC
	EE361	Digital Signal Processing					
	EE362	Advanced Control Engineering					
	EE363	Introduction to Machine Learning					
	EE364	Computer Organization and Architecture					
2		**Department Elective – 2**	3	0	0	03	DEC
	EE370	Linear Integrated Circuits & Applications					
	EE371	Power Quality Improvement Techniques					
	EE372	Electronic and Magnetic Materials					
	EE373	Electrical Safety, Operations and Regulations					
3	EE351	Power Systems Distribution & Utilization	3	0	0	03	PCC
4	EE352	Power System Protection and Control	3	0	0	03	PCC
5	EE353	Electrical Power Drives	3	0	0	03	PCC
6	EE354	AC Rotating Machines Lab	0	1	2	02	PCC
7	EE390	Open Elective – 2 / Foreign language	3	0	0	03	OPC/SD
8	EE399	Mini Project – II	0	0	6	03	SD
		TOTAL	18	1	9	23	

Summer Internship – III$^{\#}$

#: The student can do Summer Internship with duration of minimum 45 days at Institutes / Organizations / Industries and produce the certificate of completion and copy of internship report to the department.

It is optional only, Not Mandatory.

IV Year B.Tech. Course Structure

VII – Semester							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	SM430	Entrepreneurship for Engineers	3	0	0	03	HSC
2		**Department Elective –3**	3	0	0	03	DEC
	EE411	Advanced Computer Methods in Power Systems					
	EE412	HVDC and FACTS Controllers					
	EE413	High Voltage Engineering					
	EE414	Power Systems Security and Reliability					
	EE415	Industrial Electrical Systems					
3		**Department Elective – 4**	3	0	0	03	DEC
	EE420	Microgrids and Smart grids					
	EE421	Special Electrical Machines					
	EE422	Switched Mode Power Converters					
	EE423	Soft Computing and Applications					
	EE424	Non-Conventional Energy Systems					
4	EE401	Power System Analysis and Stability	3	0	0	03	PCC
5	EE402	Electric Vehicle Technologies **	2	0	0	02	PCC
6	EE403	Power Systems & Renewable Energy Laboratory	0	1	2	02	PCC
7	EE449	Project-Work Part – A	0	0	8	04	PRC
		TOTAL	14	0	11	20	

**: The PCC Subject may be offered with the support of Industry.

VIII – Semester							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1		**Department Elective – 5***	3	0	0	03	DEC
	EE461	Artificial Intelligence Techniques in Power Systems					
	EE463	Design of Electrical Systems and Control					
	EE464	Energy Management and Auditing					
2		Open Elective – 3*	3	0	0	03	OPC
3		MOOCS-2	2	0	0	02	MOE
4	EE499	Project-Work Part – B (with option of Industrial Training /Internship)	0	0	12	06	PRC
		TOTAL	8	0	12	14	

*If the students are in Industrial training, the electives may be conducted online.

Open Elective Course Structure (offered to other departments):

Semester	Elective Number	Course Code	Course Title
V - Sem	1	EE340	Introduction to Renewable Energy Systems
VI - Sem	2	EE390	Introduction to Electric Vehicles
VIII - Sem	3	EE490	Introduction to Smart Grids

Minor in Electrical Vehicles: Course Structure

(offered to all the departments including Electrical Engineering)

Courses for Minor degree: Electric Vehicles

S.No	Course Code	Course Title	L	T	P	Credits	Offered Sem
1	EEM251	Principles of Energy Conversion and Transmission in Vehicles	3	0	0	03	IV
2	EEM301	E-Mobility Developments and Standards	3	0	0	03	V
3	EEM302	Battery Energy Storage and EV Charging Systems	3	0	0	03	V
4	EEM351	Electric Drives for EVs	3	0	0	03	VI
5	EEM352	EV Battery Charging Systems Lab	0	1	2	02	VI
6	EEM401	EV Propulsion Systems Lab	0	1	2	02	VII
		TOTAL	12	2	4	16	

B.TECH. – EEE COURSE STRUCTURE 2020 Batch onward

(Common for All Branches)

MA101	**Differential and Integral Calculus** I B.Tech. I Semester - all sections	**BSC**	**3-0-0**	**3 Credits**

Pre-requisites: None

Detailed syllabus:

Differential Calculus of functions of several variable: Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers. (14)

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals. (14)

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem. (14)

References:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson , 2010.
2. ErwinKreyszig,*"AdvancedEngineeringMathematics"*,EighthEdition,JohnWileyand Sons,2015
3. B.S.Grewal,*"HigherEngineeringMathematics"*, Khanna Publications,2015
4. R.K.JainandS.R.K.Iyengar,*"AdvancedEngineeringMathematics"*,FifthEdition, NarosaPublishing House,2016.
5. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.

MA151	**Matrices and Differential Equations** I B.Tech. II Semester - all sections	BSC	3-0-0	3Credits

Pre-requisites: Mathematics-I

Detailed syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices. (14)

Ordinary Differential Equations of Higher Order: Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc. (14)

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, Finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc. (14)

References:

1. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.
4. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
5. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.

HS101	**ENGLISH FOR TECHNICAL COMMUNICATION**	**HSC**	**2 – 0 – 2**	**3 Credits**

Pre-requisites: None.

Detailed syllabus:

Grammar Principles and Vocabulary Building: -Exposure to basics of grammar-tenses—active and passive voice- their usage-Concord -Error Detection-Idioms and Phrases-Phrasal verbs—their meanings and usage, Synonyms and antonyms

Developing paragraphs using mind mapping- Definition- structure- Types and Composition-unity of theme- coherence- organization patterns-essays and their structure-note-making

Letter Writing: Formal letters-- communicative purpose-strategy- letter format and mechanics- letters of request, complaint and invitation-writing emails
Reading Comprehension –skimming-scanning-intensive and extensive reading-reading to retrieve information ––techniques of comprehension -find clues to locate important points- answering objective type questions–inference, elimination

Delegation- steps involved in delegation-preparing delegation for a program
Preparing Questionnaire-Determine audience and content of each question-response structure-develop wording for each question-establish sequence of questions

Profiling Readers-Audience analysis- Identifying potential audience- Identifying primary, secondary, tertiary readers,and gatekeepers- Identifying the needs, values, and attitude of the readers
Resume Writing-Writing for Professional Networking-Academic writing-research proposals-Interpretation of Graphs.

Technical Report-Writing - kinds of reports-proposals, progress and final reports-their structure- features- process of writing a report-editing.

Language Laboratory
Introduction to basic phonetics: Vowels, Consonants, Diphthongs, phonetic symbols
Listening: Challenges in listening, enhancing listening skills, listening activities
Speaking: JAM using cue cards-role play-Group presentation-presentation with emphasis on body language- public speaking-extempore speech
Group discussion: Dos and don’ts, intensive practice
Mock interview: Interview etiquette, common interview questions

Text Books:

Emden, Joan van. *Effective Communication for Science and Technology*. Macmillan Education UK, 2001.

Mohan, Krishna and Meera Banerji. *Developing Communication Skills*. Macmillan India Limited, 2000.

Murphy, Raymond. *Intermediate English Grammar*. Cambridge University Press, 2014.

Narayanaswami, V. R. *Strengthen Your Writing*. Orient Longman Private Limited, 2005.

Soundaraj, Francis. *Speaking and Writing for Effective Business Communication*. Macmillan Publishers India Limited, 2007.
Ur, Penny. *Discussions that Work*. Cambridge University Press, 1981.

References:

Aarts, Bas. *Oxford Modern English Grammar*. Oxford University Press, 2011.

Anderson, Marilyn, Pramod K. Nayar, and Madhucchanda Sen. *Critical Thinking, Academic Writing and Presentation Skills*. Pearson Education, 2008.

Blake,Gary.*The Elements of Technical Writing*. Pearson,2000

Brown, Carla L. *Essential Delegation Skills*. Routledge, 2017.

Busan, Tony. *Mind Map Mastery*. Walkins, 2018.

Carlisle, Joanne and Melinda S. Rice. *Improving Reading Comprehension Research-based Principles and Practices*. York Press, 2002.

Carter, Ronald and Michael McCarthy. *Cambridge Grammar of English: A Comprehensive Guide*. Cambridge University Press, 2006.

Carter, Ronald, Rebecca Hughes, and Michael McCarthy. *Exploring Grammar in Context: Upper-intermediate and Advanced.* Cambridge University Press, 2000.

Eastwood, John. *Oxford Guide to English Grammar*. Oxford University Press, 1994.

Harris, David.F. *Complete Guide to Writing Questionnaires.* I& M Press, 2014.

Hering, Lutz and Heike Hering. *How to Write Technical Reports: Understandable Structure, Good Design, Convincing Presentation*. Springer; 2010.

HuckinN.Thomas and Leslie A.Olsen*Technical Writing and Professional Communication for Non-native Speakers*. McGraw-Hill Education,1991.

Laplante, Phillip A*. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals.* CRC Press, 2018.

McQuail, Dennis. *Audience Analysis*. Sage, 1997

Ogden, Richard. *Introduction to English Phonetics*. Edinburgh University Press, 2017.

Parker, Glenn M. *Team Players and Teamwork: New Strategies for Developing Successful Collaboration*. Wiley, 2011.

Seely, John. *Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly*. Oxford University Press: 2013.

PH101	Engineering Physics	BSC	3-0-0	3Credits

Detailed syllabus:

Waves and Optics

Interference: Superposition principle, coherence of light, methods to produce coherent light: division of amplitude and wave front division, Young's double slit experiment: concept, working principle, and applications, Newton's ring: concept, working principle, and applications

Diffraction: Fraunhofer's single-slit diffraction, diffraction grating, and resolving power of a grating.

Polarization: Types of optical polarization, various methods to produce polarized light, working and applications of retarder plates, and half-shade polarimeter: construction and working principle.

Lasers and Optical Communication

LASER: Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, modes of laser beam, construction and working principle of various types of lasers: Ruby, Helium-Neon, and semiconductor diode lasers.

Optical Fibre: Optical fibre and its working principle, total internal reflection, numerical aperture, modes of propagation, and classification of optical fibres.

Quantum Physics

Origin of quantum theory and related experiments: Black-Body radiation, photo-electric effect, and Compton effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, phase and group velocities, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations, particle in one-dimensional, infinite potential and finite potential wells, and quantum tunneling phenomena and their applications in alpha decay, and scanning tunneling microscopy (STM).

Magnetic, Superconducting and Dielectric Materials

Magnetic Materials: Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, Curie transition, hard and soft magnetic materials and their applications, magneto-resistance, GMR, and TMR.

Superconducting Materials: Introduction to superconductivity, Meissner effect, Type-I and Type-II superconductors and their applications.

Dielectric Materials: Introduction to dielectrics, dielectric constant, polarizability, frequency and temperature dependent polarization mechanism in dielectrics, dielectric loss, and applications.

Advanced Functional Materials & NDT

Smart Materials: Biomaterials, high-temperature materials and smart materials, applications of functional materials.

Nanomaterials: Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

Photovoltaic Materials: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

NDT: Methods of non-destructive testing

References:

1. A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2015).
2. Concepts of Modern Physics, Beiser A., Mc. Graw Hill Publishers (2003).
3. Optics, Ajoy Ghatak, Tata Mc Graw Hill (2012).
4. Materials Science and Engineering: An Introduction (Tenth edition), William D. Callister, John Wiley & Sons (2018).
5. Introduction to Solid State Physics, Charles Kittel, Wiley Publishers (2011).

EC101	**Basic Electronics Engineering**	**ESC**	**2 – 0 – 0**	**2 Credits**

Detailed Syllabus:

Introduction to electronics systems, diode circuit models and applications, Zener diode as regulator, photodiode.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications. FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive Feedback, Principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers Characteristics and applications, linear operations using Op-amps.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Sequential Circuits, Analog to Digital and Digital to Analog converters (ADC/DAC).

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO).

References:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, 2nd Edition, Tata McGraw Hill, 2013.
2. S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford University Press , 6th Edition
3. Leach ,Malvino, Saha, Digital Principles and Applications, McGraw Hill Education , 8th Edition
4. Boylestad, Robert L., Louis Nashelsky, Electronic Devices and Circuit, Pearson , 11th Edition
5. Helfrick and Cooper, — Modern Electronic Instrumentation and Measurement Techniques‖ PHI, 2011
6. Neil Storey, Electronics A Systems Approach, 4th Edition, Pearson Education Publishing Company Pvt Ltd.

CE102	**ENVIRONMENTAL SCIENCEAND ENGINEERING**	**ESC**	**2-0-0**	**2 Credits**

Detailed Syllabus:

Introduction to Environmental Science: Environment and Societal Problems, Major Environmental Issues, Global Climate Change Agreements, Montreal, Kyoto Protocol & Paris Agreement, Basics of Environmental Impact Assessment, Principles of Sustainability, and related indices, Population Dynamics, Urbanization. Identification and Evaluation of Emerging Environmental Issues with Air, Water, Waste water and Solid Wastes, Introduction to Environmental Forensics.

Water& Wastewater Treatment: Water Sources, constituents, potable water quality requirements (IS 10500), overview of water treatment, sources and types of pollutants, their effects, self-purification capacity of water bodies, principles of waste water treatment, 5R Concept.

Air & Noise Pollution: Sources, classification and their effects, national ambient air quality standards (NAAQS), air quality index, dispersion of pollutants, control of air pollution, understanding and improving indoor air quality, sources of noise pollution, effects, quantification of noise pollution.

Solid Waste Management: Sources and characteristics of solid waste, effects, 3R concept, sustainable practices in waste management, CPHEEO guidelines for solid waste management, transition to zero waste lifestyle.

Reading:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.
3. Benny Joseph, Environmental Science and Engineering, Tata McGraw-Hill, New Delhi, 2006.

References:

1. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous (1985), Environmental Engineering, McGraw Hill Inc., New York
2. WP Cunningham, MA Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, Eighth Edition, 2016.

CS101	Introduction to Algorithmic Thinking and Programming	SD	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Construct algorithms for solving problems that requires solutions involving searching, sorting, selection and / or a numerical method as a sub-routine.
CO2	Analyze the suitability of different algorithmic design paradigms for solving problems with an understanding of the time and space complexities incurred.
CO3	Construct algorithms for solving problems with an understanding of the internals of a computing system and its components like processor, memory and I/O sub-systems.
CO4	Construct efficient modular programs for implementing algorithms by leveraging suitable control structures.
CO5	Construct efficient programs by selecting and using suitable in-built Data Structures and programming language features available.

Course Articulation Matrix:

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

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Modern Computers, Hardware Components of a Computer, Data Representation in Computers, Introduction to Operating Systems, Software and Firmware, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithms, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms, Algorithm Analysis.

Basic Syntax in Python, Data Types, Variables, Assignments, immutable variables, Types of Operators, Expressions, Comments, Boolean Logic, Logical Operators in Python.

Conditional statements - If-else, Loops - while, for, Lazy Evaluation

Inbuilt Data Structures and their operations in Python: List, Tuples and Dictionaries.

Fundamental Algorithms: Swapping variables, Problems involving summation of a series, Sine function computation, Base Conversion, generation of sequences like Fibonacci, Reversing the digits of an integer, Character to number conversion.

Factoring Methods: Finding the square root, Finding the smallest divisor of an integer, finding the greatest common divisor using Euclid's algorithm, Computing the prime factors of an integer, generating prime numbers, Raising a number to a large power, Computation of the nth Fibonacci number.

Functions – Modular programming and benefits, user defined functions, library functions, parameter passing, Formal and Actual arguments, named arguments return values, Recursion.

Sorting algorithms: Bubble, Selection and Insertion sorts, Search algorithms: Linear and binary search

String processing: Algorithms for implementing String functions like Strlen, Strcpy, StrRev, Strcmp, Searching for a keyword or pattern in a text.

File and Directory Handling: Reading and Writing to/from a file, Formatted File creation and operations.

Simple 2D Graphics, drawing 2D objects using Turtle Graphics.

References:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.

CS102	Introduction to Algorithmic Thinking and Programming Lab	SD	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
CO2	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
CO3	Implement, refactor, test and debug functional programs in a shell-based run time environment.
CO4	Construct efficient programs by demonstrating problem-solving skills and out-of-the-box algorithmic thinking.

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	S	M	L		S				M			L
CO2	S	M	L		S				M			L
CO3	S	M	L		S				M			L
CO4	S	M	L		S				M			L

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

List of Experiments:

1. Familiarization with Python installation, basic syntax and running scripts in the shell.
2. Programs on conditional control constructs.
3. Programs on iterative constructs. (While, do-while, for).
4. Programs using user defined functions and in-built function calls.
5. Programs related to Recursion.
6. Programs involving in-built data structures like List, Tuples and Dictionaries.

7. Programs related to String processing.
8. Programs related to Files and I/O.

9. Implementation of Factoring methods.
10. Programs that require sorting, searching and selection as sub-routines.
11. Problems involving simple 2D graphics.
12. Implementation of a capstone application to unify the concepts learnt in the course.

References:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019.
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.
3. The Python Tutorial, Available at: https://docs.python.org/3/tutorial/.

PH102	Engineering Physics Lab	BSC	0-1-2	2 Credits

List of experiments (any eight of the following):

Exposure to virtual lab (any three of the following):

S. No	Name of the experiment
1	Determination of Planck’s constant using light emitting diode.
2	Determination of wavelength of monochromatic light in Newton’s ring experiment.
3	Determination of the width of narrow slit by diffraction method.
4	Determination of wavelength of He-Ne laser using diffraction by a metal scale.
5	Determination of capacitance and time constant of a capacitor using R-C circuit.
6	Determination of wavelength of mercury spectrum by normal incidence method (diffraction grating).
7	Determination of specific rotation of an optically active material-using Laurent’s half-shade polarimeter.
8	Determination of resonating frequency and bandwidth of an LCR circuit.
9	Determination of dielectric constant of various dielectric materials.
10	Studying B-H curve loop and permeability of magnetic materials.
11	Measuring spatial distribution of magnetic field between a pair of identical coils using Helmholtz coils.
12	Studying current-voltage characteristics of a photovoltaic material using solar cell.
13	Determination of numerical aperture of an optical fibre.
14	Determination of resistivities of various materials using four-probe method.

1. LCR – Series/Parallel
2. B-H Loop tracer
3. Planck's Constant
4. Numerical aperture of Optical Fiber
5. Newton's rings

Micro project:

This can be implemented in the subsequent semesters based on the facilities available. In the case of implementation, three or four experiments from the above listed eight experiments will be replaced with the project (~40 % of the experiments will be relaxed).

References:

1. *Physics Laboratory Manual*, School of Sciences (Physics), National Institute of Technology Andhra Pradesh (2020).

2. *Practical Physics (Electricity, Magnetism, and Electronics),* R. K. Shukla, A Srivastava, New age international publishers (2011).

3. *B.Sc. Practical Physics*, C. L. Arora, S. Chand & Co. Ltd. (2012).

EA101	Physical Education	MSC	0-0-3	1 Credit

Detailed Syllabus:

I. Introduction to Physical Education & EAA = Sports and Games

Meaning & Definition of Physical Education, Aims & Objectives of Physical Education, Importance of Physical Education

II. Physical Fitness & Wellness Lifestyle

Meaning & Importance of Physical Fitness, Components of Physical Fitness (Cardiovascular Endurance, Strength Endurance Muscular Endurance, Flexibility, Body Composition), Components of Motor Fitness (Agility, Balance, Power, Speed, Coordination), Development of Fitness Components

III. Training Methods in Physical Education

Circuit Training (Circuit Training), Continues Training (Endurance), Interval Training (Speed & Endurance), Fartlek Training (Speed Endurance), Weight Training (Maximum Strength), Plyometric Training (Power), Flexibility Training

IV. Test & Measurements

Measurements: Height, Weight, Age, Calculation of BMI, Motor Fitness and Physical Fitness Tests (Pre - Test & Post-Test), Cardiovascular Endurance - 9/12 Minute Run or Walk, Muscular Endurance – Sit Ups for abdominal strength, Strength Endurance – Flexed arm hang for girls / Pull ups for boys, (Speed – 50m Dash or 30mts Fly Start, Strength – Broad Jump, Vertical Jump for Lower Body, Medicine Ball Put for Shoulder Strength, Endurance - 800mts, Flexibility - Bend and Reach, Agility (Coordination)) – Shuttle Run and Box Run

V. Formal Activities

Calisthenics (free hand exercises), Dumbbells, Woops, Wands, Laziums (Rhythmic activities), Aerobic Dance and Marching

VI. Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport, Latest General Rules of the Game/Sport.

Specifications of Play Grounds and Related Sports Equipment

EA151	Health Education	MSC	0-0-3	1 Credit

Health Education & Personal Hygiene

Introduction & Meaning of Health Education, Definition of Health Education, Principles of Health Education, Importance of Health Education, Meaning of Personal Hygiene, Importance of Personal Hygiene, Personal cleanliness (teeth, ears, eyes, nose & throat, nails & fingers, skin, cloths, and hair).

Nutrition

Introduction of Nutrition, Balanced Diet, Daily Energy Requirements, Nutrient Balance, Nutritional Intake, Eating and Competition, Ideal Weight

First Aid & Injury Management

Introduction, Types and Principles of First Aid, Functions of First Aider, Reasons for Sports Injuries, The First Aid and Emergency Treatment in Various cases (drowning, dislocation & fractures, burns, electric shock, animal bite, snake bite, poison, etc.

Human Posture

Introduction, Meaning of Posture, types of Good Posture, causes of Poor Posture, preventive and Remedial Poor Posture, common Postural Deformities, Body Types, Advantages of Good Posture

Yoga

Introduction, Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (standing asanas, sitting asanas, supine and prone postures.), Relaxation Techniques for improving concentration – Yoga – nidra, Pranayama

Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc.,Teaching& Coaching of the Game/Sport., Latest General Rules of the Game/Sport, Specifications of Play Grounds and Related Sports Equipment.

ME102	**Engineering Graphics with Computer Aided Drafting**	**ESC**	**0-1-2**	**2 Credits**

Note: 50% of the Practice through manual drawing and 50% of the Practice through a Computer Aided Drafting Package.

Detailed Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Construction of Polygons, Scales. Introduction to Computer Aided Drafting (CAD), DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES, etc.

Orthographic Projection: Principles, of Orthographic projection, Four Systems of Orthographic Projections.

Projection of Points: Projections of points when they are situated in different quadrants.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Sections of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views - simple objects.

References:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.

2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23 rd Edition, 2016.

CY101	Engineering Chemistry	BSC	3-0-0	3 Credits

Detailed syllabus:

Basic Organic Chemistry

Reaction intermediates: carbocations, carbanions, free radicals and carbenes. Classification of organic reactions, examples and their mechanisms: substitution, addition, elimination and rearrangement reactions. Reimer–Tiemann reaction, Kolbe-Schmidt reaction, Cannizzaro reaction. Pinacol-Pinacolone, Hofmann and Beckmann rearrangements. Diels-Alder reaction.

Spectroscopic Techniques for Chemical Analysis

Introduction of spectroscopy, Quantum aspects of electronic, vibrational and nuclear energy levels. UV-Visible spectroscopy: Principle, Instrumentation, Beer-Lambert's law, Effect of conjugation, Woodward-Fieser empirical rules for acyclic/cyclic dienes. IR spectroscopy: Principle, Factors that affect vibrational frequencies and functional group detection. Proton NMR spectroscopy: Principle, Instrumentation, Chemical equivalency, Chemical shift and spin-spin splitting. Applications of UV-Vis, IR and proton-NMR spectroscopy in determining the structure of small organic molecules.

Coordination Chemistry

Introduction of coordination chemistry, Valence bond (VB) theory and shapes of Inorganic Compounds, Spectrochemical series, Crystal Field theory (CFT): octahedral and tetrahedral complexes, Crystal field splitting energy (CFSE); Molecular Orbital (MO) Theory: Molecular orbital diagrams for octahedral complexes (strong and weak ligand fields).

Electrochemistry

Electrodes, Electrochemical Cells, Electrochemical series and Nernst equation; Conductometry and Potentiometry; Batteries: Types of batteries, Ni-Cd and Lithium (Li)-ion batteries; Fuel Cells: Hydrogen-Oxygen, Methanol-Oxygen fuel cells; Corrosion - Theories of corrosion, Wet corrosion, Types of wet corrosion, Factors affecting the rate of corrosion, Corrosion control methods: Sacrificial anode method and Impressed current method.

Engineering Materials and Applications

Polymers: Introduction, Types of polymerization, Functionality in polymers, Number and Weight average molecular weight, Polydispersity index, Biodegradable polymers; Conductive polymers: classification, examples and applications; Organic light emitting diode (OLED): structure, principle and applications; Optical fibres: principle and Applications.

References:

1. Organic Chemistry, Clayden, Greaves, Warren and Wothers, Oxford University Press, 2014.
2. Organic Spectroscopy, William Kemp, 2nd edition, Macmillan publishers, 2019.
3. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo and Manfred Bochmann, 6th Edition, 1988.
4. Physical Chemistry, P. Atkins and Julio de Paula, 8th Edition, Freeman & Co. 2017.
5. A Textbook of Engineering Chemistry, Shashi Chawla, 2017.
6. Polymer Science and Technology, Premamoy Ghosh, 3rd edition, McGraw-Hill, 2010.

EE101	Elements of Electrical Engineering	ESC	2-0-0	2 Credits

Detailed Syllabus:

Basic Concepts

Electric Charge, Current and Electromotive force, Potential and Potential Difference; Electrical Power and Energy; Ohm's Law, Resistance, Capacitance and Inductance, Series and Parallel Connection of Resistances and Capacitances, Kirchoff's Laws and Their Applications

AC Fundamentals:

Concept of Alternating Voltage and Current, RMS and Average Values, Single Phase and Three Phase Supply; 3-ph Star-Delta connections, Alternating Voltage applied to Pure Resistance, Inductance, Capacitance and their combinations, Concept of Power and Power Factor in AC Circuit.

Measuring Instruments:

Principle and Construction of Instruments used for Measuring Current, Voltage, Power and Energy, Methods and precautions in use of these.

Electromagnetic Induction:

Concept of Magnetic Field, Magnetic Flux, Reluctance, Magneto Motive Force (MMF), Permeability; Self and Mutual Induction, Basic Electromagnetic laws, various losses in magnetic circuits;

Electrical Machines:

Elementary concepts of an electrical machine, Basic principle of a motor and a generator, Classification of Electrical machines; Principles, Construction and Working of a machine; Starters: Need, Construction and Operation; Transformer: Classification, Principles, Construction and Working of a Transformer, Applications of Transformers;

Utilization of Electricity:

Utilization concepts of Electricity for electrolysis process, Electrochemical Cells & Batteries; Application of Electricity, Energy Conversation and Efficiency

Basic Troubleshooting:

Basic Testing and faults diagnosis in electrical systems, various tools and their applications, replacement of different passive components.

Electrical Safety:

Electrical Shock and Precautions against it, Treatment of Electric Shock; Concept of Fuses and Their Classification, Selection and Application; Concept of Earthing.

References:

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12 th Edition, 2016.
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2 nd Edition, 2015.
3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2005.
4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.
5. B.L.Theraja , Fundamentals of Electrical Engineering and Electronics volume -I, SChand & Company 2005.
6. Ashfaq Husain, Fundamentals of Electrical Engineering, Dhanpat Rai & Sons 4 th edition,2010.
7. H.Partab: Art & Science of Utilization of Electric Energy, Dhanpat Rai & amp; Sons, 1998.
8. Fundamentals of Electrical Circuits by Charles k. Alexander, Mattew N.O.Saidiku, TataMcGraw Hill company.

BT101	BIOLOGY FOR ENGINEERS	ESC	2-0-0	2 Credits

Pre-requisites: None

Detailed Syllabus:

Importance of biology to engineers, Molecules of life: Water and Carbon, Evolution and origin of life, Darwins theory, Diversity of life, Chemical basis of life, Nucleic acids, Amino acids and Proteins, Carbohydrates, Lipids and Membranes.

Cell structure and function:

Prokaryotic, Eukaryotic cell and Virus, Sub cellular organelles and their functions, Regulation of cellular metabolism: Cellular respiration and Fermentation, Photosynthesis, Cell division (differences between mitosis and meiosis), Mendel’s Law and Patterns of inheritance.

Gene structure and expression

Difference between prokaryotic and eukaryotic gene structure, DNA replication, Transcription, RNA processing and Translation, Control of gene expression (lac operon).

Applications of Biology in Engineering

Genetic engineering (microbe, plant and animal cells for improvement), Industrial Biotechnology (Primary and Secondary metabolites), Environmental engineering, Biopharmaceuticals, Tissue engineering, Biomaterials, Stem cell engineering, Biosensors, Bioinformatics.

References:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.

2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

ME101	Basics of Mechanical Engineering	ESC	2-0-0	2 Credits

Detailed Syllabus:

Evolution of Mechanical Engineering: Introduction, Definition and scope of Mechanical Engineering, relation of Mechanical Engineering with other Engineering Disciplines, Revolutionary Inventions in wheels, tools, windmills, steam engine, CNC machines, Rapid Prototyping, Air-conditioning and Refrigeration, History of Mechanics, Thermodynamics and Heat Transfer, Production and Industrial Engineering, Mechatronics.

Engineering Materials: Introduction to Engineering Materials, Classification and Properties, Alloys. Composites, Micro and Nano Materials.

Manufacturing Processes: Castings - Patterns & Moulding, Metal forming, Hot Working and Cold Working Extrusion, Drawing, Rolling, Forging. Welding - Arc Welding & Gas Welding, Soldering, Brazing. Introduction to Machining processes – Lathe, Milling, Shaping, Drilling, Grinding, Introduction to NC/CNC Machines, 3D Printing.

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains - Simple Problems, **Fasteners and Bearings:** Fasteners - Types and Applications, Bearings - Types and Selection,

Thermodynamics: Introduction to Energy Sources - Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State, Cp, Cv, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

Introduction to Steam Turbines and I.C. Engines: I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences.

Introduction to Heat Transfer and Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants. Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient – problems.

References:

1. Dixit, U.S., Hazarika, M. and Davim, J.P, A Brief History of Mechanical Engineering, Springer, 2017.
2. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
3. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
4. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
5. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.
6. B.S. Raghuvanshi, Workshop Technology, Vol. 1&2, Dhanpath Rai & Sons, New Delhi, 1989.

CE101	Engineering Mechanics	ESC	2-0-0	2 Credits

Prerequisites: None

Detailed syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space,

Equillibrium of force system- Degrees of freedom - Equilibrium Equations, Degree of Constraints – Free body diagrams.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems

Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of members.

Friction in rigid bodies- Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Centroid & Moment of Inertia - Centroid and M.I – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles– Introduction to kinematics- Equations of rectilinear motion, D'Alembert's principle -Simple problems- Introduction to kinetics- Work and Energy.

Reading:

1. J.L.Meriam, L.G. Kraige, Engineering Mechanics, Statics, John Wiley &Sons,7th Edition, 2012.
2. A.K. Tayal, Engineering Mechanics, Umesh Publications, 14th Edition, 2010.
3. S SBhavikatti and K G Rajashekarappa, Engineering Mechanics, New Age International Publication, 4th Edition.

Reference:

1- Dietmar Gross, Werner Hauger, Jorg Schroder, Wolfgang A. Wall, Nimal Rajapakse, Engineering Mechanics 1, Statics, Springer, 2nd Edition, 2013.
2- S. Timoshenko, D.H. Young, Pati Sukumar, J V Rao, Engineering Mechanics, Mc-Graw Hill, 5th Edition.

ME103	Workshop Practice	SD	0-1-2	2 Credits

Detailed Syllabus:

Fitting Shop: Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaping operation. Demonstration of the working of CNC and 3D Printing Machines.

Power Tools: Study of different hand operated power tools, uses and their demonstration and Practice of Power tools.

Carpentry: Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, half lap Dovetail joint and Mortise Tenon Joint.

Welding: Study of welding tools and welding equipment, Arc Welding Practice (Lap and Butt joint).

CY102	Engineering Chemistry Lab	BSC	0-1-2	2 Credits

List of experiments (any eight of the following):

Exp. No	Name of the experiment
1	Standardization of $KMnO_4$ solution
2	Determination of Iron in Haematite
3	Determination of Hardness of Water
4	Determination of available chlorine in bleaching powder and of iodine in Iodized salt
5	pH-metric titration of an acid vs a base
6	Conductometric titration of an acid vs a base
7	Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$
8	Colorimetric determination of Potassium Permanganate
9	Determination of rate of Corrosion of mild steel in acidic environment in the absence of presence of an inhibitor
10	Determination of Chlorophyll in Olive oil by using UV and Fluorescence spectroscopic techniques
11	Functional group analysis of organic compounds by using IR spectroscopic technique
12	Organic solvent evaporation by using rotary-evaporation technique

Virtual labs

1. Determination of unknown concentration of analyte by using the Beer-Lambert's law.
2. Identification of unknown components using spectroscopic techniques.
3. Nuclear magnetic resonance spectroscopy and evolution of simple ^1H NMR spectra of organic compounds
4. Study of kinetics of a reaction by using spectrophotometric methods.

References:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

MA206	Complex Variables and Transform Techniques	BSC	3-0-0	3 Credits

Pre-requisites: Matrices and Differential Equations (MA151)

Course Outcomes: At the end of the course the student will able to:

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function and Z-transform of a sequence
CO3	Determine the solution of a PDE by variable separable method
CO4	Understand and use of complex variables and evaluation of real integrals

Detailed syllabus:

Fourier series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Z-transforms: Z- transform and Inverse Z-transforms – Properties – convolution theorem simple illustrations.

Partial Differential Equations: Method of separation of variables - Solution of one-dimensional wave equation, one dimensional heat conduction equation and two-dimensional steady state heat conduction equation with illustrations.

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions -
Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, use of residue theorem to evaluate the real

integrals of the type $\int_0^{2\pi} f(Cos\,\theta, Sin\,\theta)\,d\theta$, $\int_{-\infty}^{\infty} f(x)dx$ without poles on the real axis.

References:

1. R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics,* Narosa Pub. House,Fifth edtion, 2016.
2. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, *Higher Engineering Mathematics*, Khanna Publications, 44th edition, 2017.

II Year B.Tech. Courses offered by EED

EE201	**Electric and Magnetic Circuits**	**ESC**	**2-1-2**	**4 Credits**

Pre-requisites: EE101- Elements of Electrical Engineering, EC101- Basic Electronics Engineering, PH101- Engineering physics, MA101- Differential and Integral Calculus and MA151-Matrices and Differential Equations

Course Outcomes: At the end of the course the student will able to:

CO1	Analyze and solve DC and AC circuits using the circuit theorems.
CO2	Determine the transient response and steady state response of First-Order and Second-Order Circuits.
CO3	Analysis of three phase circuits and solution of magnetic circuits
CO4	Understanding the Frequency Response of AC Circuits.
CO5	Understand the importance of Two-Port Networks

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	1	1	1	1	2	2	2	1
CO2	3	3	2	2	2	2	3	1	1	1	2	2	2	1
CO3	3	2	3	2	2	2	1	1	1	1	2	2	3	3
CO4	3	2	2	2	2	2	1	1	1	1	2	2	3	2
CO5	3	3	3	2	2	2	1	1	1	1	2	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

A. DC Circuits:

Circuit Theorems: Basic concepts and Laws, Circuit elements, Mesh analysis, Nodal analysis, Linearity property, Superposition theorem, Reciprocity theorem, Source transformation, Thevenin’s theorem, Norton’s theorem, Maximum power transfer theorem, Millman’s theorem, and Tellegen’s theorem

First-Order Circuits: Source-Free RC Circuit, Source-Free RL Circuit, Singularity Functions, Step Response of an RC Circuit, Step Response of an RL Circuit

Second-Order Circuits: Finding Initial and Final Values, Source-Free Series RLC Circuit, Source-Free Parallel RLC Circuit, Step Response of a Series RLC Circuit, Step Response of a Parallel RLC Circuit, General Second-Order Circuits

B. AC Circuits:

Basics: AC Power Basics, Sinusoids, Phasors, Phasor Relationships for Circuit Elements, Impedance, Admittance, Kirchhoff's Laws in the Frequency Domain, Impedance Combinations, Sinusoidal Steady State Analysis

Three-Phase Circuits: Balanced Three-Phase Voltages, Balanced Star-Star Connection, Balanced Star-Delta Connection, Balanced Delta- Delta Connection, Balanced Delta-Star Connection, Power in a Balanced System, Unbalanced Three-Phase Systems

Magnetically Coupled Circuits: Self and Mutual Inductances, Energy in a Coupled Circuit, Coefficient of Coupling, Linear Transformers, Ideal Transformers, Ideal Autotransformers, Three-Phase Transformers

Frequency Response: Resonance, Series Resonance, Resonant Frequency, Bandwidth, Quality Factor, Parallel Resonance, Passive Filters, Active Filters

Two-Port Networks: Impedance Parameters, Admittance Parameters, Hybrid Parameters, Transmission Parameters, Relationship between Parameters, Interconnection of Networks

References:

1. Charles K. Alexander and Matthew N.O. Sadiku "Fundamentals of Electric Circuits" 6th Edition, McGraw-Hill Higher Education, 2019
2. M.E.Van Valken Burg "Network Analysis", 3rd Edition, Pearson Education,2015.
3. Hayt, W. H, Kemmerly J. E. & Durbin, "Engineering Circuit Analysis", McGraw Hill Publications, 8th Edition, 2013.

EE202	Electromagnetic Field Theory	PCC	3-0-0	3 Credits

Pre-requisites: EE101- Elements of Electrical Engineering, EC101- Basic Electronics Engineering, PH101- Engineering physics, MA101- Differential and Integral Calculus

Course Outcomes: At the end of the course the student will able to:

CO1	Understanding the scalar and vector fields & Electric and Magnetic boundary conditions
CO2	Analyze the electrostatic principles and Laws
CO3	Analyze the magneto static principles and Laws
CO4	Understanding Time varying fields and Maxwell equations.
CO5	Analyze the application of electromagnetic in Wave Propagation

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Review of vector analysis: Cartesian, Cylindrical and Spherical co-ordinates systems- Coordinate transformations. Vector fields: Divergence and curl- Divergence theorem- Stokes theorem. Static electric & Magnetic field: Electrical scalar potential- different types of potential distribution- Potential gradient- Energy stored-Boundary conditions Capacitance-Steady current and current density in a conductor-Equation of continuity- energy stored in magnetic fields- Magnetic dipole- Electric and Magnetic boundary conditions- vector magnetic potential-Magnetic field intensity.

Electrostatics: Coulomb’s law and field intensity, Electric fields due to continuous charge distributions, Electric flux density, Gauss’s law and its applications, Electric Potential, Relationship between E and V, Electric dipoles and flux lines, Energy density in Electrostatic fields; Electric fields in material space – Properties of materials, Convection and conduction currents, Conductors, Polarization in Dielectrics, Dielectric constant and strength, Linear, Isotropic and Homogeneous Dielectrics, Continuity equations and Relaxation time, Electric Boundary conditions; Electrostatic Boundary value problems – Poisson’s and Laplace equations, Uniqueness theorem, Resistance and capacitance, Method of images.

Magneto statics: Magneto static fields – Biot-savart's law, Ampere's circuit law and its applications, Magnetic flux density, Maxwell's equations for static EM fields, Magnetic scalar and vector potentials, Magnetic Forces, Materials and Devices – Forces due to magnetic fields, Magnetic torque and moment, Magnetic dipole, Magnetization in materials, Classifications of magnetic materials, Magnetic boundary conditions, Inductors and Inductances, Magnetic energy

Maxwell's Equation: Faraday's law, Transformer and motional EMFs, Displacement current, Maxwell equations in final forms, Time varying potentials, Time-Harmonic Fields.

Electromagnetic Wave Propagation: Waves in general, Wave propagation in lossy dielectrics, Plane waves in lossless dielectrics, Plane waves in free space, Plane waves in good conductors, Power and Pointing vector, Reflection of a plane wave at normal and oblique incidence.

References*:*

1. Bhag Singh Guru and Huseyin R. Hiziroglu, "Electromagnetic Field Theory Fundamentals", 2nd Edition, Cambridge University Press, 2009
2. William H. Hayt *and John A. Buck "Engineering Electromagnetic"* 8th Edition, McGraw-Hill, 2011.
3. Nannapaneni Narayana Rao "*Elements of Engineering Electromagnetic"* 6th Edition, Pearson Education, 2004.
4. MatthewN. O. Sadiku "Elements of Electromagnetics", Oxford University Press, 5th Edition, 2010.

EE203	Analog and Digital Electronic Circuits	PCC	3-0-0	3 Credits

Pre-requisites: Basic Electronics Engineering

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

CO1	Understand operation of analog devices and circuits.
CO2	Examine the operation of oscillators and amplifiers.
CO3	Understand operation of digital logic, gates and circuits.
CO4	Understand the operational principle and design of combinational logic, sequential logic, semiconductor memories and data conversion circuits.

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Analog Electronics: Energy bands in intrinsic and extrinsic silicon. Carrier transport: diffusion current, drift current, mobility, and resistivity, Generation and recombination of carriers, Poisson, and continuity equations. P-N junction diode, Zener diode, BJT, JFET, MOS capacitor, MOSFET, LED, photo diode and solar cell.

Analog Circuits: Diode circuits: clipping, clamping, and rectifiers. BJT and MOSFET amplifiers: biasing, ac coupling, small-signal analysis, frequency response. Current mirrors and differential amplifiers. Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers, and oscillators

Digital Electronics:
Boolean algebra, minimization of Boolean functions using Boolean identities and Karnaugh map, logic gates (AND, OR, NOT, NAND, NOR, Ex–OR and Ex–NOR); digital IC families (DTL, TTL, ECL, MOS, CMOS).

Digital Circuits: Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders. Sequential circuits: latches and flip-flops, counters, finite state machines, propagation delay, setup and hold time, critical path delay, Sample and hold circuits, ADCs, DACs. Semiconductor memories. Computer organization:

Machine instructions and addressing modes, ALU, data-path, and control unit, instruction pipelining

References:

1. ‘Integrated Electronics’, Jacob Millman& Christos C. Halkias,Tata McGraw Hill, 2nd Edition, 2010
2. “Electronic Devices and Circuits”, David A. Bell, PHI, 4th Edition,2004
3. “Analog Electronics Circuits: A Simplified Approach”, U.B.Mahadevaswamy, Pearson/Saguine, 2007.
4. "Digital Logic Applications and Design”, John M Yarbrough, Thomson Learning, 2001.
5. “Digital Principles and Design “, Donald D Givone, Tata McGraw Hill Edition, 2002.
6. “Hands- On Electronics: A Practical Introduction to Analog and Digital Circuits” Daniel M. Kaplan and Christopher G. White, Cambridge University Press, 2003.
7. “Foundations of Analog and Digital Electronic Circuits” Anant Agarwal and Jeffrey Lang, Morgan Kaufmann Publishers, 2005.
8. “The Art of Electronics”, Paul Horowitz and Winfield Hill, Cambridge University Press, 2nd Edition, 1989.
9. “Device Electronics for Integrated Circuits” Richard S. Muller, Theodore I. Kamins, Wiley, 3rd Edition, 2002.

EE204	**Measurements and Instrumentation**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EE101- Elements of Electrical Engineering, EC101- Basic Electronics Engineering, PH101- Engineering physics.

Course Outcomes: At the end of the course the student will able to:

CO1	Understanding the principles of Measurement and errors during process
CO2	Analyze the performance characteristics of Different Instrument Types
CO3	Measurement of Different Elements – Electrical and Mechanical related.
CO4	Selection of Sensors/ Transducers / Instruments for the particular measurement
CO5	Understand calibration principles and Display, Recording & Presentation of Measurement Data

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	1	1	1	1	2	2	2	1
CO2	3	3	2	2	2	2	3	1	1	1	2	2	2	1
CO3	3	2	3	2	2	2	1	1	1	1	2	2	3	3
CO4	3	3	3	2	2	2	1	1	1	1	2	2	1	2
CO5	3	3	3	2	2	2	1	1	2	1	2	2	3	1

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Introduction to Measurement

Definition, Measurement units, Measurement system applications, Elements of a measurement system, Choosing appropriate measuring instruments.

Instrument Types and Performance Characteristics

Review of instrument types, Static characteristics of instruments, Dynamic characteristics of instruments.

Errors during the Measurement Process

Sources of systematic error, Reduction of systematic errors, Quantification of systematic errors, Aggregation of measurement system errors.

Measurement of Different Elements

Bridge circuits, Measurement of Resistance, Inductance, Capacitance, Voltage, Current, Power, Energy, Power Factor, Frequency, Phase, Temperature, Pressure, Flow, Level, Mass, Force, Torque, Angle, Volume, Sound, Vibration.

Measurement Sensors and Instruments

Different Sensor technologies, Electrical indicating and test instruments – Potentiometers, Instrument transformers, Digital meters, Analogue meters, Multimeters, Cathode ray oscilloscope, Digital storage oscilloscopes

Calibration of Measuring Sensors and Instruments

Principles of calibration, Control of calibration environment, Calibration chain and traceability, Calibration records.

Display, Recording & Presentation of Measurement Data

Display of measurement signals, Data Acquisition and logging/ recording of measurement data, Presentation of data.

References*:*

1. Alan S Morris "*Measurement and Instrumentation Principles*" Butterworth-Heinemann, 2001.
2. Dominique Placko "*Fundamentals of Instrumentation and Measurement*" John Wiley & Sons, 2013.
3. John G. Webster "*Electrical Measurement, Signal Processing and Displays*" CRC Press, 2003.

EE205	Analog and Digital Electronic Circuits Lab	PCC	0-1-2	2 Credits

Pre-requisites: EC101 - Basic Electronics Engineering

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

CO1	To learn and understand the basic concepts of electronic devices and circuits.
CO2	Design electronic circuits to meet specific requirements.
CO3	Understand operation of analog and digital devices and circuits.
CO4	To learn and understand the basic concepts of digital electronics
CO5	Understand the importance and need for verification and testing of digital logic circuits.

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

List of Experiments

Analog Electronics:

1) Explain the function of a Zener diode and Zener Diode as Voltage Regulator. (For the experiment go to Vlab-IITKGP: zener diode as voltage regulator experiment)
2) Study of basic properties of Operational Amplifier: Inverting and Non-Inverting Amplifiers. (For the experiment go to Vlab-IITKGP: Inverting and non-inverting OPAMP)
3) Study of Differentiator and Integrator using Operational Amplifier (For the experiment go to Vlab-IITKGP: Differentiator and integrator using OPAMP)
4) To analyse Voltage comparator circuit. (For the experiment go to Vlab-IIT Roorkee: Analyse Voltage comparator circuit)
5) To study log and antilog amplifier. (For the experiment go to Vlab-IIT Roorkee: Log and antilog amplifier)
6) To study voltage to current converter. (For the experiment go to Vlab-IIT Roorkee: Voltage to current converter)

7) To analyse Function generator using operational amplifier (sine, triangular and square wave). (For the experiment go to Vlab-IIT Roorkee: Function generator using OPAMP)
8) To study astable and monostable multivibrator using IC 555. (For the experiment go to Vlab-IIT Roorkee: Astable and monostable multivibrator using IC 555.)

Digital Electronics:

1) To verify and interpret the logic and truth table for AND, OR, NOT, NAND, NOR, Ex-OR, Ex-NOR gates using RTL (Resistor Transistor Logic). (For the experiment go to Vlab-IIT RoorkeeRTL interpret the logic gates)
2) To verify the truth table of half adder and full adder by using XOR and NAND gates. (For the experiment go to Vlab-IIT Roorkee: Half adder and full adder circuit) (For the experiment go to Vlab-IITG: How to design on breadboard and logic ICs)
3) To verify the truth table of half adder and full adder by using XOR and NAND gates. (For the experiment go to Vlab-IIT Roorkee:)
4) To implement the logic functions i.e. AND, OR, NOT, Ex-OR, Ex- NOR and a logical expression with the help of NAND and NOR universal (For the experiment go to Vlab-IIT Roorkee: Implement the logic functions by universal gates)
5) To verify the truth table and timing diagram of RS, JK, T and D flip-flops by using NAND & NOR gates ICs. (For the experiment go to Vlab-IIT Roorkee: Analysis of various Flip-flops)
6) To study a BCD to 7 Segment LED display decoder as an example of a multiple input and multiple output combinational digital circuit. (For the experiment go to Vlab-IITG: BCD to 7 Segment LED display decoder)

References:

1. J. Millman, Microelectronics, McGraw-Hill,1987.
2. Robert L. Boylested, Electronic Devices and Circuit Theory, 9th Edition, Pearson.
3. Mano, M Morris, Ciletti, Michael D, Digital design, Pearson 2012

EE206	Measurements & Instrumentation Lab	PCC	0-1-2	2 Credits

Pre-requisites: EE101 – Elements of Electrical Engineering

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

CO1	Understand the usage of various types of Analog and Digital Meters and Oscilloscopes
CO2	Measure the Resistance, Inductance and Capacitance using AC& DC bridges
CO3	Measure the quality factor of a Coil using different bridges
CO4	Understand the characteristics of various transducers for Temperature, Weight, Position

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	1	1	1	1	2	2	2	1
CO2	3	3	2	2	2	2	3	-	-	-	2	2	2	1
CO3	3	2	3	2	2	2	1	1	-	-	2	2	2	3
CO4	3	2	2	2	2	-	1	1	-	-	2	2	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

List of Experiments

1. Determination of the capacitance of an unknown capacitor in-terms of standard mutual inductance.
   For the experiment go to: Measurement of Capacitance by Carey Foster Bridge
2. Determination of the self-inductance of a high-quality factor unknown coil.
   For the experiment go to: Measurement of Self Inductance of High-Quality Factor Coil by Hay's Bridge
3. Measurement of low resistance using Kelvin Double Bridge
   For the experiment go to: To study the Kelvin Double Bridge for Low resistance measurement
4. Measurement of Self-Inductance by Maxwell's inductance -capacitance Bridge.
   For the experiment go to: Measurement of Self Inductance by Maxwell's Bridge
5. To determine accurate Quality Factor of an unknown coil.
   For the experiment go to: Q meter Experiment
6. To determine the capacitance of an unknown capacitor by Wien’s bridge.
   For the experiment go to: Measurement of Capacitance by Wien Series Bridge
7. To determine the capacitance of an unknown capacitor by De Sauty's bridge.
   For the experiment go to: Measurement of Capacitance by De Sauty's (Modified) bridge
8. To determine the self-inductance of an unknown coil using Owens bridge.
   For the experiment go to: Measurement of Self Inductance by Owen Bridge

9. To determine the self-inductance of an unknown coil using maxwell’s inductance bridge.
   For the experiment go to: Measurement of Self-Inductance by Maxwell Bridge
10. To Determine the Capacitance of an unknown Capacitor by Schering bridge
    For the experiment go to: Measurement of Capacitance by Schering Bridge
11. To determine the self-inductance of an unknown coil using Anderson’s bridge.
    For the experiment go to: Measurement of Self Inductance accurately by Anderson's Bridge
12. To determine the High Resistance by Megohm Bridge method.
    For the experiment go to: To determine the High Resistance by Megohm Bridge method
13. To Study Wien Robinson's frequency Bridge.
    For the experiment go to: To study the Wien Robinson's Frequency Bridge
14. To understand the working principle of RTD.
    For the experiment go to: Characterize the temperature sensor (RTD)
15. Measurement of level in a tank using capacitive type level probe
    For the experiment go to: Measurement of level in a tank using capacitive type level probe
16. Characterize the strain gauge sensor.
    For the experiment go to: Characterize the strain gauge sensor
17. Characterize the temperature sensor (Thermocouple).
    For the experiment go to: Characterize the temperature sensor (Thermocouple)
18. Characterize of LVDT.
    For the experiment go to: Characterize the LVDT

References:

1. Alan S Morris “*Measurement and Instrumentation Principles*” Butterworth-Heinemann, 2001.
2. Dominique Placko “*Fundamentals of Instrumentation and Measurement*” John Wiley & Sons, 2013.
3. John G. Webster “*Electrical Measurement, Signal Processing and Displays*” CRC Press, 2003.

EE251	**Energy Conversion Technologies**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EE101- Elements of Electrical Engineering, PH101- Engineering physics, and EE202-Electromagnetic Field Theory

Course Outcomes: At the end of the course the student will able to:

CO1	Understanding the energy types and related concepts in energy engineering
CO2	Study of natural and fundamental phenomena's involved in energy conversion processes
CO3	Analysis on working principles of various energy conversion devices/equipment and their performance
CO4	Understanding the energy conversion process in conventional power generating systems
CO5	Understanding the energy conversion process in renewable power generating systems

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	1	1	1	1	2	2	2	1
CO2	3	3	2	2	2	2	3	1	1	1	2	2	2	1
CO3	3	2	3	2	2	1	1	1	1	1	2	2	2	3
CO4	2	2	2	2	2	2	1	1	1	1	2	2	3	2
CO5	2	2	2	2	2	2	1	1	1	1	2	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Introduction to Energy

What is Energy, Types of Energy, Forms of Energy, Measures of Energy - Units & Equivalences, Energy Transformation Matrix, Energy balance, Energy storage, Energy Dissipation, Energy Efficiency.

Principles of Energy Conversion

Introduction to Energy, Laws - Thermodynamics, Faraday's law, Ampere's law, Conversion processes - Direct: Single-step conversion process, Co-energy, Indirect: Multi-step conversion process, singly excited magnetic systems, Multiple excited magnetic systems, elementary concepts of rotating machines.

Energy Conversion Devices and their working principles and efficiency

Transformers, Transducers, Motors, Generators, Turbines, Engines, Boilers, Heater, drier, Battery, Furnace, Lamp etc.

Conventional Energy Conversion Technologies

Fossil fuel power systems – Coal, Gas and Oil, Nuclear energy, Hydro Energy

Non-Conventional Energy Conversion Technologies

Solar thermal, Solar PV, Fuel Cell, Ocean Energy, Wind Energy, Geothermal energy, Wave energy, Bio-fuel.

References:

1. Edward S. Cassedy, Peter Z. Grossman "Introduction to Energy: Resources, Technology, and Society" Cambridge University Press, 1998
2. Merlin H. Kleinbach, Carlton E. Salvagin "Energy technologies and conversion systems" Prentice Hall, 1986
3. Harry A. Sorenson "Energy Conversion Systems" Wiley, 1983
4. Charles R. Russell "Elements of Energy Conversion" Elsevier, 2013
5. Archie W. Culp "Principles of energy conversion" McGraw-Hill, 1979
6. Reiner Decher "Energy Conversion: Systems, Flow Physics, and Engineering" Oxford University Press, 1994
7. Reiner Decher "Direct Energy Conversion: Fundamentals of Electric Power Production" Oxford University Press, 1997
8. Fang Lin Luo, Ye Hong "Renewable Energy Systems: Advanced Conversion Technologies and Applications" CRC Press, 2012
9. *Yogi Goswami* and Frank Kreith "Energy Management and Conservation *Handbook"* CRC Press 2007

EE252	**DC Machines and Transformers**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EE101- Elements of Electrical Engineering, PH101- Engineering physics, EE251- Energy Conversion Technologies

Course Outcomes: At the end of the course the student will able to:

CO1	Understand the construction and principle of operation of DC machines
CO2	Analyze starting methods and speed control of DC machines.
CO3	Evaluate the performance of DC machines
CO4	Evaluate the performance single phase and three phase transformers and auto transformers.
CO5	Analyze parallel operation of single phase and three phase transformers

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

DC Machines: Constructional details, Simplex and multiplex lap and wave windings; Methods of excitation, torque equation, back emf, characteristics of saturated and un-saturated series, shunt, cumulatively and differentially compound excited machines operating as motors and generators; Armature reaction, demagnetizing and cross magnetizing ampere turns, compensating windings, commutation, inter poles.
Speed control methods of D.C. shunt & series motors, losses and efficiency; 3 point starter, 4- point Starter for D.C. motors. Testing of D.C. machines: No-load test, Direct load test, Hopkinson’s and Field’s test, Retardation test.
Single Phase Transformers: Construction, principle of operation, ideal transformer, EMF equation, phasor diagram; Equivalent circuit, determination of equivalent circuit parameters, Losses, calculation of efficiency and regulation by direct and indirect methods; Predetermination of performance by Sumpner’s test, Load sharing and operation of transformers in parallel, Separation of no load losses by experimental method, principle of auto transformer, Saving of copper compared to two winding transformer and its application.
Three Phase Transformer: Construction**,** Type of connections, Relation between line and phase voltages and currents, use of tertiary winding, On-load tap changing, Scott connection of transformers for phase conversion.

References:

1. A.E Fitzgerald, Charles Kingsley, Stephen D Umans Electrical Machines–TMH Publishers, 6th Edition, 2003.
2. Nagarath & D.P. Kothari: Electrical Machines, TMH Publishers, 4th Edition, 2004
3. P.C. Sen, “Principles of Electric Machines and Power Electronics”, Wiley Student Edition, 2008.
4. Irving L. Kosow, “Eectric Machinery and Transformers”, PHI, Second Edition, 2007.
5. A.E. Clayton & C.I. Hancock Performance and Design of DC Machines, CBS Publishers, 2018.
6. P. S Bimbhra, Electrical Machines, Khanna Publishers, 2002

EE253	**Signals and Systems**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EC101-Basic Electronics Engineering, MA101- Differential and Integral Calculus, MA151- Matrices and Differential Equations

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

CO1	Understanding the types of signals and systems and applications.
CO2	Analyze the signals in Continuous time and Discrete time signals
CO3	Analyze signals and systems using Fourier analysis.
CO4	Determine convolution in time domain and Frequency domain and understand the correlation
CO5	Apply transform techniques to analyze continuous-time and discrete-time signals and systems.

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Introduction to Signals and Systems:

Signals: Definition of a Signal, real life examples for signals, Types of signals, Signal representation, classification of signals, properties, Elementary Continuous Time Signals, Elementary discrete Time Signals, basic operations on signals, Sampling theorem, shifting and scaling properties

Systems: definition of a Systems, real life examples for systems, Types of systems, classification of systems, system viewed as interconnection of operations, properties of systems, Continuous and Discrete Time Systems.

Introduction to Fourier Analysis and Signal Transmission through Linear Systems

Fourier Series, Fourier Transforms, Introduction to linear system, impulse response of linear system, Response of a linear system, linear time invariant (LTI) system, Transfer functions of a LTI system, Filter characteristics of linear systems. Distortion less transmission through a system, Ideal filter characteristics, Causality and Poly-Wiener criterion for physical realization.

Convolution and Correlation of Signals

Convolution: Concept of convolution in time domain and Frequency domain, Graphical representation of convolution, convolution sum, convolution integral.

Correlation: Cross correlation and auto correlation of functions, properties of correlation function, Relation between convolution and correlation, Detection of periodic signals in the presence of noise by correlation, Extraction of signal from noise by filtering.

Laplace Transforms: Review of Laplace transforms (L.T), relation between L.T‘s, and F.T. of a signal, Concept of region of convergence (ROC) for Laplace transforms, Constraints on ROC for various classes of signals, Properties of L.T‘s. Laplace transform of certain signals using waveform synthesis, Inverse Laplace transform.
Z–Transforms: Concept of z-transform of a discrete sequence, Distinction between Laplace, Fourier and z-transforms, Region of convergence in z-transform, constraints on ROC for various classes of signals, properties of z-transforms, Inverse z-transform, analysis of LTI discrete time systems using z-transforms.

References:

1. Signals and Systems - A.V. Oppenheim, A.S. Willsky and S.H. Nawab, PHI, 2nd Ed, 2009.
2. Signals & Systems - Simon Haykin and Van Veen, Wiley, 2nd Edition, 2019.
3. Linear Systems and Signals – B. P. Lathi, Second Edition, Oxford University press, 2008.
4. Fundamentals of Signals and Systems Michel J. Robert, MGH International Edition, 2008.
5. Signals, Systems and Transforms - C. L. Philips, J. M. Parr and Eve A. Riskin, Pearson education. 4th Ed, 2008
6. Robert A. Gable, Richard A. Roberts, Signals & Linear Systems, 3rd Edition, John Wiley, 1995.
7. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, 4th Edition, PHI, 2007.

EE254	Control Systems	PCC	3-0-0	3 Credits

Pre-requisites: EE101- Elements of Electrical Engineering, EC101- Basic Electronics Engineering,

Course Outcomes: At the end of the course the student will able to:

CO1	Understanding the concepts and representation of control systems
CO2	Analyze the response of First order systems and Second order systems
CO3	Modeling of control systems in Time domain analysis
CO4	Modeling of control systems in Frequency domain analysis
CO5	Analyze linear systems for steady state errors, and stability using time domain and frequency domain techniques

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction to Control Systems and its representations: General introduction, History of control systems, Open-loop control, Closed-loop control, Some examples of control systems, Definitions of standard terminology, Effect of Feedback, Classification of Control systems, Transfer functions, Block diagrams, Signal flow graph.

Time Response Analysis: Introduction, Poles, Zeros, System response, First order systems, second order systems, System response with additional Poles and with Zeros

Modeling in the Time Domain

State space representation of Continuous Time systems, State variables, State equations, converting a transfer function to state space, converting from state space to a transfer function, Laplace transform solution of state equations, Time domain solution of state equations, Effect of P, PI & PID controllers, Concept of controllability and observability

Modeling in the Frequency Domain: Review of Laplace transforms, Electrical Network Transfer functions, Translational Mechanical system transfer function, Transfer functions for systems with Gears, Electric Circuit analogs, polar plots, Nyquist stability criterion, Frequency domain indices (gain margin, phase margin, bandwidth), Bode plots, Introduction to lag and lead compensation.

Steady State Errors: Introduction, steady state errors (SSE) for unity and non-unity feedback systems, static error constants, system type, SSE specifications, SSE for disturbances, SSE for systems in state space, Sensitivity.

Stability Analysis: Introduction to Stability, Routh-Hurwitz Criterion, Special cases and examples, Stability in State Space, Root Locus, Problems.

References:

1. Norman S. Nise “Control Systems Engineering”, 7th edition, Wiley, 2015
2. William Bolton “Control Systems” Newnes, 2002
3. William S. Levine “Control System Fundamentals” CRC Press, 2010
4. K. Warwick “Control systems: an introduction” Prentice Hall, 1989
5. M. Gopal “Control Systems: Principles and Design” Tata McGraw-Hill Education, 2002
6. Katsuhiko Ogata: Modern Control Engineering, Pearson Education India, 5thEdition, 2015.

CS285	**Data Structures and Algorithms**	**ESC**	**2 – 1 – 2**	**4 Credits**

Pre-requisites:

i. Introduction to Algorithmic Thinking and Programming (CS101)
ii. Introduction to Algorithmic Thinking and Programming Lab (CS102)

Course Outcomes: At the end of this course, students will be able to:

CO1	Construct solutions for problems using linear data structures such as Linked List, Stacks and Queues. (Apply)
CO2	Construct solutions for problems using non-linear Data Structures such as Trees and Graphs. (Apply)
CO3	Implement solutions for problems that requires sorting and searching as a sub-routine. (Apply)
CO4	Analyze, evaluate and choose appropriate data structures and algorithms for a specific application. (Analyze)
CO5	Analyze algorithms with respect to their time and space complexities. (Analyze)

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	S	M	L		S			S	S	M		
CO2	S	M	L		S			S	S	M		
CO3	S	M	L		S			S	S	M		
CO4	S	M	M	L	S			S	S	M		
CO5	S	M	M	L	S			S	S	M		

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

Introduction to Data Structures, Algorithm Analysis and Examples based on Asymptotic Notations, Abstract Data Types (ADTs), Stacks, Queues, Circular Queues and Linked List (Singly Linked, Doubly Linked and Circular).

Trees: Representation of Trees, Binary Trees, Binary Search Trees.

Priority Queues, Binary Heap and applications, Hash Tables and Operations, Collision Resolution: Open Addressing and Chaining.

Graphs: Representation of Graphs, Graph Traversal Techniques, Minimum Cost Spanning Trees: Prim’s and Kruskal’s Algorithms, Shortest Path Algorithms: Dijkstra’s Algorithm and Floyd-Warshall Algorithm.

Sorting Algorithms: Merge Sort, Heap Sort, Quick Sort and Counting Sort.

List of Experiments:

1. Implementation of Stacks and Queues using arrays.
2. Implementation of Stack and Queue based applications.
3. Implementation of Single Linked List, Double Linked List and Circular Linked List.
4. Implementation of Stacks and Queues using Linked List.
5. Implementation of Circular Queues.
6. Implementation of Binary Search Trees with its operations.
7. Implementation of Priority Queues.
8. Implementation of Hashing with open addressing and separate chaining methods.
9. Implementation of Graph Traversal techniques: BFS and DFS.
10. Implementation of Minimum cost spanning tree algorithms.
11. Implementation of Dijkstra and Floyd-Warshall Algorithms.
12. Implement the following sorting algorithms: Merge sort, Heap sort, Quick sort, Counting sort.

Reading List:

1. Data structures and Algorithm Analysis in C++, Mark Allen Weiss, Pearson Education. Ltd., Fourth Edition, 2014.

2. Data structures and algorithms in C++, 4th Edition, Adam Drozdek, Thomson, Cengage, 2012.

3. Data structures and Algorithms in C++, Michael T. Goodrich, R. Tamassia, and Mount, Second Edition, Wiley, 2011.

4. Data Structures: A Pseudocode Approach with C++, Richard F. Gilberg, Behrouz A. Forouzan, Pacific Grove, CA: Brooks/Cole, 2001.

EE255	CONTROL SYSTEMS LAB	PCC	0-1-2	2 Credits

Pre-requisites: EE254 – Control Systems

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

CO1	Derive the transfer function of physical systems and determination of overall transfer function using block diagram algebra and signal flow graphs
CO2	Determine time response specifications of second order systems and to determine error constants
CO3	Analyze absolute and relative stability of LTI systems using Rouths stability criterion and the root locus method
CO4	Analyze the stability of LTI systems using frequency response methods

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	3	3	1	3	2	3	1	3	2	2
CO2	3	3	2	2	2	2	3	3	3	3	3	2	2	2
CO3	3	3	3	1	3	2	1	1	1	1	1	2	1	2
CO4	3	3	3	3	3	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

List of experiments

1. Basics of MATLAB in Control Systems: Introduction to Polynomials in MATLAB Block Reduction, Input Responses
   a) Block diagram reduction technique using MATLAB
   b) State model for classical transfer function & vice versa using MATLAB.
2. Mathematical modeling of Physical Systems using MALAB script and Simulink
3. Time-response of first and second order systems.
   a) Simulation of a typical second order system and determination of step response and evaluation of time-domain specifications.
   b) Evaluation of the effect of additional poles and zeroes on time response of second order system.
4. Analysis of steady state error on different types of systems
5. Evaluation of effect of pole/zero location on stability
   a) Effect of loop gain of a negative feedback system on stability
   b) Effect of open loop and zeroes on root locus contour
   c) To estimate the effect of open loop gain on the transient response of closed loop system by using Root locus

6. To study the effect of P, PI, PD and PID controller on the step response of a feedback control system
7. Frequency-response of second order system. study of Bode, Nyquist and Root locus with respect to Stability.
8. Design and study of lag, lead and Lag-lead compensator networks
9. Study on DC Position Control
10. Study of DC Motor Speed Control
11. Hard-ware implementation of PID controllers
12. Study of Stepper motor with different step cases

References:

1. Norman S. Nise “Control Systems Engineering”, 7th edition, Wiley, 2015
2. William Bolton “Control Systems” Newnes, 2002
3. William S. Levine “Control System Fundamentals” CRC Press, 2010

EE256	NUMERICAL METHODS AND PROGRAMMING ANALYTICAL LAB	PCC	0-1-2	2 Credits

Pre-requisites: None

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

CO1	Understand the basic concepts of MATLAB commands and equation solving techniques
CO2	Analyze the Matrix operations and differential equation in MATLAB
CO3	Examine the polynomial using different methods in MATLAB
CO4	Apply to engineering problems such as R-L-C circuit and Simultaneous Equation solving in MATLAB

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	3	3	1	3	2	3	1	3	2	2
CO2	3	3	2	2	2	2	3	3	3	3	3	2	2	2
CO3	3	3	3	1	3	2	1	1	1	1	1	2	1	2
CO4	3	3	3	3	3	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

List of experiments

1. Study of Introduction to MATLAB
2. Study of basic matrix operations
3. To solve linear equation
4. Solution of linear equations and different case studies.
5. Determination of Eigen values and Eigen vectors of a square matrix.
6. Solution of Difference Equations.
7. Solution of Difference Equations using Euler Method.
8. Solution of differential equation using 4th order Runge- Kutta method.
9. Determination of roots of a polynomial.
10. Determination of polynomial using method of Least Square Curve Fitting.
11. Determination of time response of an R-L-C circuit.
12. Simultaneous Equations: Gauss Seidel Method
13. Simultaneous Equations: Gauss Elimination Method

References:

1. Steven C. Chapra and Raymond P. Canale, “Numerical methods for Engineers”, 7th edition, Tata McGraw Hill.
2. D.V. Griffiths and I.M. Smith, “Numerical methods for Engineers”, 2nd edition, CRC press.

III Year B.Tech. Courses offered by EED

EE301	**Embedded Systems**	**PCC**	**2-0-2**	**3 Credits**

Pre-requisites: None

Course Outcomes: At the end of the course the student will able to:

CO1	Identify the applications, design metrics and hardware-software code sign challenges of Embedded system
CO2	Understand Microcontroller architecture and Instruction set
CO3	Implement interfacing through hardware or software or hardware-software code sign
CO4	Apply efficient programming practices for Embedded system software development

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	1	2	1	2
CO4	3	3	3	3	3	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Embedded Software Development: Microprocessor & Microcontroller Fundamentals; Embedded Systems- Introduction, Build, Functions, Constraints and their impacts; Software Development- Concurrency, Static Schedule, Dynamic Schedule, Waterfall & V Development Model, Architecture, Design, Coding and Software unit testing.

Cortex-M4 Core: ARM- Architectures, Processors, Cortex-M Series; Cortex-M4 - Processor, Block Diagram, Registers, Memory Map, Bit-band Operations and Program Image; ARM and Thumb Instruction Set; Cortex-M4 Instruction Set - Memory access, General data processing, Arthematic, Bitfield, Branch, Control and Float point.

Interfacing: Interrupts – Entering & Exiting Exception, Microcontroller interrupts and Timing Analysis; GPIO - Basic Concepts, Port Circuitry and Alternate Functions; A/D conversion; D/A conversion; Peripherals, Comparator; Timers- Interrupt Timer, PWM Module, Low-Power Timer and Real-Time Clock; Serial Communication.

Programming: High-level & Low-Level programming Techniques for Power Efficient Computing; C program and assembly language subroutines for the microcontroller;

Call assembly subroutines in a C function, control application of ARM Cortex-M4 processor in industry.

References:

1. Shibu K.V : Introduction to Embedded Systems, McGraw Hill
2. Ariel Lutenberg, Pablo Gomez, Eric Pernia: A Beginner's Guide to Designing Embedded System Applications on Arm Cortex-M Microcontroller, arm Education Media.
3. Muhammad Tahir and Kashif Javed: ARM® Microprocessor Systems Cortex®-M Architecture, Programming, and Interfacing, CRC Press 2017.
4. Perry Xiao: Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™, Wiley
5. Mark Fisher: Arm® Cortex® M4 Cookbook, O'Reilly.

EE302	Electric Power Transmission	PCC	3 – 0 – 0	3 Credits

Pre-requisites: EE101 – Elements of Electrical Engineering
Course Outcomes: At the end of the course the student will be able to:

CO1	Determine the parameters of transmission lines
CO2	Analyze the performance of transmission lines and cables
CO3	Understand the role of per unit quantities
CO4	Determine the fault currents for symmetrical and unsymmetrical faults

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	1	2	1	2
CO4	3	3	3	3	3	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Calculation of inductance and capacitance: Introduction, types of conductors, calculation of inductance and capacitance - single phase and three phase lines with symmetrical and unsymmetrical spacing, Composite conductors-transposition, bundled conductors, and effect of earth on capacitance.

Performance of Lines: Representation of lines - short transmission lines, medium length lines- nominal T and PI-representations, long transmission lines. The equivalent circuit representation of a long line, A, B, C, D constants, Ferranti Effect, Power flow through a transmission line, receiving end power circle diagram.

Corona and Insulators: disruptive critical voltage, corona loss, factors affecting corona loss, methods for reducing corona loss, disadvantages of corona, interference between power and Communication lines. Types of insulators, voltage distribution in suspension insulators, string efficiency, improvement of string efficiency.

Line Sag calculations and Insulated Cables: Sag tension calculations, supports at different levels, stringing chart, cables -Introduction, insulation, insulating materials, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cable s, Overhead lines versus underground cables.

Per Unit System and Fault Analysis: The one line diagram, impedance and reactance diagrams, per unit quantities, changing the base of per unit quantities, advantages of per unit system. Symmetrical Components - Introduction, relation with phase quantities (voltages and currents), Sequence impedances and sequence networks. Types of faults in power systems - causes and effects, symmetrical component analysis of Unsymmetrical faults - Single Line to Ground (LG) Fault, Line to Line (LL), Double Line to Ground (LLG) Fault, Open Conductor Faults calculations, symmetrical component analysis of symmetrical faults.

References:

1. W.D.Stevenson, Elements of Power System Analysis, Fourth Edition, McGraw Hill, 1984.
2. Ned Mohan “Electric Power Systems: A First Course” Wiley
3. B.M. Weedy, B.J. Cory, N. Jenkins, J.B. Ekanayake, G. Strbac “Electric Power Systems” 5th edition, Wiley
4. James L. Kirtley “Electric Power Principles: Sources, Conversion, Distribution and Use” Wiley.
5. C. L. Wadhwa, “Electrical Power Systems” New Age International Pvt Ltd, 6th Edition, 2007.
6. Luces M. Faulkenberry and Walter Coffer “Electrical Power Distribution and Transmission” Pearson Education
7. Mohamed E. El-Hawary “Introduction to Electrical Power Systems” 2008, Wiley-IEEE Press.
8. Syed A Nasar, “Electric Power Systems” Tata McGraw-Hill, 2006.
9. Setephen J. Chapman,“ElectricalMachinery and Power System Fundamentals” McGraw-Hill, 2002.

EE303	AC Rotating Machines	PCC	3–0–0	3 Credits

Pre-requisites: EE252- DC Machines and Transformers

Course Outcomes: At the end of the course the student will able to:

CO1	Understanding the construction and principle of operation of induction machines and synchronous machines.
CO2	Evaluate performance characteristics of induction machine and synchronous machines.
CO3	Analyze starting and speed control methods of induction machines and synchronous machines.
CO4	Analyze the effects of excitation and mechanical input on the operation of synchronous machine.

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	1	1	1	1	2	2	3	1
CO2	3	3	3	2	2	2	3	1	1	1	2	2	3	1
CO3	3	3	3	2	2	2	1	1	1	1	2	2	3	3
CO4	3	3	3	2	2	2	1	1	1	1	2	2	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction and Analysis of 3- Phase Induction motors: Classification of AC machines, Constructional details, types, production of rotating magnetic field-principle of operation and practical rating of induction motors. Phasor diagram, equivalent circuit, Torque equation-starting and maximum-torque, maximum-output, slip for maximum-output, Torque-slip characteristics, different speed control methods of induction motor, losses & efficiency and applications.

Starters and Testing of 3- Phase Induction Motors: Auto transformer, star delta and rotor resistance starters Testing-no load and blocked rotor tests-determination of equivalent circuit parameters, Pre-determination of performance from equivalent circuits and circle diagram.

Double cage Induction Motor and 3-phase Induction Generators: Construction, theory, equivalent circuit, Characteristics and applications of Double cage induction motor. Squirrel-Cage Induction Generator (SCIG) and Doubly-Fed Induction Generator (DFIG), their principle of operation, equivalent circuit and application.

Synchronous Machines: Construction, types, practical rating of synchronous generators, winding factors, production of emf, harmonics, armature reaction, Synchronous reactance, phasor diagram, load characteristics, open circuit and short circuit tests. Methods of pre-determination of regulation- Synchronous impedance, ampere turn, Potier triangle and ASA methods. Two reaction theory–analysis and its application for the pre-determination of regulation of salient pole alternator, phasor diagram. Slip test, power angle characteristics, synchronization and synchronizing power. Parallel operation and load sharing–operation on infinite bus-bar typical applications.

Synchronous Motor - Theory of operation–phasor diagrams, variation of current and power factor with excitation. Hunting and its suppression, determination and pre-determination of V and inverted V curves, method of starting, Synchronous Condenser.

References:

1. P.S. Bimbhra: Electrical Machinery – Khanna Publishers, Seventh Edition, 2011.
2. CharlesI. Hubert: Electric Machines – Pearson, Second Edition, 2003.
3. Stephen.J.Chapman: Electric Machinery Fundamentals–McGraw Hill Education,Fourth Edition,2007.
4. A.E. Fitzgerald, Charles Kingsley. Jr., Stephen D. Umans: Electric Machinery – Sixth Edition TMH 2003.
5. M.G. Say: Alternating Current Machines-Wiley, Fifth Edition-1984.

EE304	**Power Electronics**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: EE101 – Elements of Electrical Engineering, EC101 - Basic Electronics Engineering, and EE201 – Electric and Magnetic Circuits

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

CO1	Select switching devices for a given power converter.
CO2	Evaluate the performance of phase-controlled rectifiers.
CO3	Design DC-DC converter for a given performance
CO4	Analyze and evaluate the operation of Inverters and its control schemes
CO5	Evaluate the performance of ac voltage controllers and Cyclo converters

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	3	3	3	1	1	1	2	3	3	3
CO2	3	3	3	3	3	3	3	1	1	1	2	3	3	3
CO3	3	3	3	3	3	3	3	1	1	1	2	3	3	3
CO4	3	3	3	3	3	3	3	1	1	1	2	3	3	3
CO5	3	3	3	3	3	3	3	1	1	1	2	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction: Concept of power electronics, scope and applications, types of power converters, power semiconductor switches and their V-I characteristics Power diodes, SCR, TRIAC, power MOSFET, IGBT. Thyristor ratings and protection, methods of SCR commutation, gate drive circuits, switching and conduction losses in a generic power semiconductor device, understanding the data sheets.

Phase-Controlled Rectifiers: Principles of single-phase half and fully-controlled converter with R, RL, and RLE load with and without freewheeling diode, Principles of three-phase fully-controlled converter operation with RLE load, Effect of load and source inductances, Single phase and Three phase dual converters

Choppers

Introduction, Basic principles of step-down and step-up operation, chopper classification study of Buck, Boost and Buck-Boost regulators, Introduction to forward and fly back converters, concept of DC-DC converters.

Inverters: Introduction, principle of operation, performance parameters, single phase bridge inverters with R, RL and RLC loads, 3-phase bridge inverters- 180 and

120 degrees mode of operation, Voltage control of single phase inverters –single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation, unipolar and bipolar schemes

A.C. Voltage Controllers and Cycloconverters: Introduction, principle of operation of single phase voltage controllers for R, RL & RLE loads and its applications, principle of single-phase cycloconverter with R and RL load and its applications

References:

1. M.H.Rashid, Power Electronics - Circuits, Devices and Applications, PHI, 2009.
2. P.S.Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2016.
3. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2006.
4. M D Singh, K B Khanchandani, Power Electronics, 2009, Tata McGraw-Hill Publishing Company Limited, ISBN-13: 978-0-07-058389-4

EE305	**Power Electronics Lab**	**PCC**	**0–1–2**	**2 Credits**

Pre-requisites: EE252 – DC Machines and Transformers, EE 303 - AC Rotating Machines, EE304 - Power Electronics

Course Outcomes: At the end of the course the student will able to:

CO1	Understand the operation of rectifiers, Choppers, AC voltage controllers and inverter circuits.
CO2	Evaluate the various performance indices like ripple factor, THD.
CO3	Design the control circuit and the power circuit for DC-DC converters
CO4	Compare various options available for the drive circuit requirements

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	1	2	1	1	1	3	3	1	1	3	1
CO2	3	3	2	1	2	1	1	1	3	3	1	1	3	1
CO3	3	3	2	2	2	3	3	1	3	3	2	2	3	3
CO4	3	3	3	3	3	3	2	1	3	3	3	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

LIST OF EXPERIMENTS

1. Study of Characteristics of SCR, MOSFET &IGBT.
2. Study of single-phase half & fully controlled bridge converter with R, RL and RLE load.
3. Study of three-phase half & fully controlled bridge converter with R and RL load.
4. Study of single-phase dual converter with RL loads.
5. Study of AC voltage controller using TRIAC with R and RL load.
6. Study of Buck Chopper
7. Study of DC-DC Boost converter
8. Study of DC-DC Buck-Boost converter
9. Study of speed control of DC motor using H-bridge converter
10. Study of uni-polar and bi-polar PWM based single-phase inverter
11. Study of 3-Phase PWM & non-PWM inverter
12. Study of speed control of 3-Phase inverter fed induction motor based on open loop V/f control method
13. Study of speed control of 3-Phase inverter fed induction motor based on closed loop V/f (slip speed) control method

References:

1. M.H. Rashid: Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters and Applications, 3rd Edition, John Wiley & Sons, 2009.

EE306	DC Machines and Transformers Lab	PCC	0–1–2	2 Credits

Pre-requisites: EE252–DC Machines and Transformers

Course Outcomes: At the end of the course the student will able to:

CO1	Select apparatus based on the ratings of DC Machines and Transformers.
CO2	Determine equivalent circuit parameters and performance of transformers.
CO3	Evaluate the performance of DC machines and transformers by direct and indirect loading methods.
CO4	Select braking and speed control methods of DC machines

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	2	1	2	3	1	2	3	1
CO2	3	2	1	2	1	2	1	1	2	3	1	2	3	1
CO3	3	3	2	1	2	2	1	1	2	3	1	2	3	1
CO4	3	2	3	1	1	2	2	1	2	3	1	2	3	1

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

LIST OF EXPERIMENTS

1. Determination of open circuit characteristic of D.C. machine
2. Determination of Load characteristics of D.C. generators
3. Speed control of D.C. motors using Armature control and Field control Methods
4. Brake test on D.C. Shunt motor
5. Swinburne's Test on DC Machine
6. Retardation test on D.C. machines to determine the Moment of Inertia
7. Field's test on two identical D.C. Series machines
8. Hopkinson test on two identical D.C. machines
9. O.C. and S.C. tests on single phase transformer
10. Load test on single phase transformer
11. Sumpner's test on two single phase transformers
12. Scott connection of single phase transformers

References:

1. P.S. Bimbhra: Electrical Machinery – Khanna Publishers, Seventh Edition, 2011.

2. CharlesI. Hubert: Electric Machines – Pearson, Second Edition, 2003.
3. Stephen.J.Chapman: Electric Machinery Fundamentals–McGraw Hill Education,Fourth Edition,2007.
4. A.E. Fitzgerald, Charles Kingsley. Jr., Stephen D. Umans: Electric Machinery –Sixth Edition TMH 2003.

EE351	**Power System Distribution and Utilization**	**PCC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: EE302 – Electric Power Transmission

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

CO1	Understand the different methods of electric power distribution system.
CO2	Understand the basic principles of electric heating and welding.
CO3	Determine the performance of various lighting systems.
CO4	Evaluate speed-time curves for traction.

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	2	2	1	2
CO4	3	3	3	3	2	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

D.C Distribution System: Structure of electric power systems – one Line Diagram– generation, transmission and distribution systems- Methods of feeding a distributor – Ring distributor, Three-wire system – Comparison of 2-wire system and 3-wire distribution system- balancers, boosters.

A.C Distribution System: General layout of the system, Power systems and system networks, Different systems of distribution – Radial distribution system, Ring main distribution, current and voltage calculations in distributors with concentrated and distributed loads – Kelvin’s law for the design of feeders and its limitations.

Electric Heating and Welding: Advantages and methods of electric heating, resistance heating, induction heating and dielectric heating. Electric welding: resistance welding and arc welding, comparison between ac and dc welding.

Illumination: Terminology, Laws of illumination, Polar curves, photometry, integrating sphere, sources of light – fluorescent lamps, discharge lamps, mercury vapour lamps, sodium vapour lamps, neon lamps and LED lamps, Basic principles of light control, Types and design of lighting schemes, lighting calculations, factory lighting, street lighting and flood lighting.

Electric Traction: Systems of electric traction and track electrification, Mechanics of train movement, speed-time curves for different services, Trapezoidal and quadrilateral speed time curves, computation of tractive effort, power, specific energy consumption; effect of varying acceleration and braking retardation, coefficient of adhesion. Systems of train lighting, single battery system, Double battery parallel block system, coach wiring, lighting by making use of 25 kV AC supply.

References:

1. C. L. Wadhwa, “Electrical Power Systems” New Age International Pvt Ltd, 6th Edition, 2007.
2. W.D.Stevenson, “Elements of Power System Analysis”, Fourth Edition, McGraw Hill, 1984.
3. H.Partab: “Art & Science of Utilization of Electric Energy”, Dhanpat Rai & Sons , 1998
4. N.V.Suryanarayana: “Utilization of Electric power”, Wiley Eastern Ltd., 2001.

EE352	Power System Protection and Control	PCC	3 – 0 – 0	3 Credits

Pre-requisites: EE302 – Electric Power Transmission
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the need of protective schemes in Power System
CO2	Analyze the different protective devices used for protecting the elements of Power System
CO3	Understand the role of frequency controller in power system
CO4	Understand the voltage controlling methods used to maintain the acceptable voltage levels in Power System

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	2	2	1	2
CO4	3	3	3	3	2	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Fundamentals of Power System Protection
Review of Power System Faults, Zones of Protection, Primary and Secondary backup protection, Current Transformer, Voltage Transformer, Fuses, Thermal relays, Over-Current relays, Distance relays, Differential Relays, Static Comparators as Relays, Earth leakage protection, Numerical Relaying Fundamentals, Circuit Breakers.

Power System Component Protection
Transformer Protection, Busbar Protection, Transmission lines protection, Induction Motor Protection, Generator Protection, Capacitors and Reactors.

Control of Active Power and Frequency
Turbine speed governing system, Steady State analysis, Dynamic response, Proportional plus integral load frequency control. Control with Generation Rate Constraints (GRC), Automatic Frequency Control, Control of generating unit power output.

Control of Reactive Power and Voltage
Voltage profile control by generators, control by transformers, Automatic Voltage Control, Reactive power and voltage control by compensating devices (reactive power injection).

References:

1. Leonard L. Grigsby “Power System Stability and Control” CRC Press.
2. Kundur P “Power System Stability and Control”, McGraw-Hill.

3. L G Hewitson, Mark Brown, Ramesh Balakrishnan “Practical Power System Protection”, Elsevier, 2004
4. D.F.Warne “Newnes Electrical Power Engineer’s Handbook”, 2nd edition, Elsevier.
5. D P Kothari and I J Nagrath “Modern Power System Analysis”, McGraw-Hill.
6. C L Wadhwa “Electrical Power System”, Wiley Eastern.

EE 353	**Electrical Power Drives**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EE303-AC Rotating Machines, and EE304-Power Electronics

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

CO1	Understand the various drive mechanisms and methods for energy conservation.
CO2	Develop closed loop control strategies of drives and selection of motors for a specific application
CO3	Apply power electronic converters to control the speed of DC motors.
CO4	Evaluate the performance of induction motor drives and synchronous motor drives

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	3	3	3	2	1	1	2	3	3	3
CO2	3	3	3	3	3	3	3	2	3	1	2	3	3	3
CO3	3	3	3	3	3	3	3	2	3	1	2	3	3	3
CO4	3	3	3	3	3	3	3	2	3	1	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction to electric drives: Advantages of Electric drives, Parts of Electrical Drives, Electric Motors, Power Modulators, Sources, Choice of Electric Drives and selection of drives for various applications.

Dynamics of electrical drives: Fundamental torque equation, components of load torque, speed-torque characteristics of loads, Nature and classification of load torques, speed-torque convention & multi- quadrant operation. Equivalent values of drive parameters, loads with rotational motion, loads with translational motion, measurement of moment of inertia, components of load torques. Steady state stability, dynamic stability, load equalization. Basic principles of closed-loop control, Selection of motor power rating, Thermal model of motor for heating and cooling, Classes of motor duty.

DC Motor Drives: Torque-speed equation of dc motor, Speed control of DC motors using single-phase and three-phase fully controlled and half controlled rectifiers in continuous and discontinuous mode of operation. Single quadrant, two quadrant and four quadrant chopper controlled drives in continuous and discontinuous mode of operation, Applications.

Induction Motor Drives: Speed control of sq-cage induction motor with v/f control, static rotor resistance control, slip power recovery scheme, static Scherbius and Krammer methods. Variable frequency and variable voltage control using VSI and CSI, AC and DC dynamic breaking methods, Applications.

Synchronous Motor Drives: Speed control methods of synchronous motor drive, variable frequency control scheme, Applications.

References:

1. G.K. Dubey: Fundamentals of Electric Drives –Narosa Publishers, Second edition, 2007.
2. S.B. Dewan, G.R. Slemom, A. Straughen: Power semiconductor drives, John Wiley & Sons.
3. VedamSubramanyam: Electric Drives Concepts & Applications –Tata McGraw Hill Edn. Pvt.Ltd, Second Edition, 2011.
4. V. Subrahmanyam: Thyristor Control of Electric Drives, Tata McGraw Hill Edn. Pvt.Ltd, 2010.
5. Werner Leonhard: Control of Electric Drives, Springer international edition2001.
6. Nisit K.De and Swapan K.Dutta: Electric Machines and Electric Drives, PHI learning Pvt. Ltd, 2011.

EE354	AC Rotating Machines Lab	PCC	0–1–2	2 Credits

Pre-requisites: EE303–AC Rotating Machines

Course Outcomes: At the end of the course the student will able to:

CO1	Determine the performance of induction motor by direct and indirect loading methods.
CO2	Evaluate the parameters and performance of induction motor and synchronous motor.
CO3	Determine the V and inverted V curves of synchronous motor.
CO4	Determine the performance characteristics of Schrage motor.

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	2	1	2	3	1	2	3	1
CO2	3	2	1	2	1	2	1	1	2	3	1	2	3	1
CO3	3	3	2	1	2	2	1	1	2	3	1	2	3	1
CO4	3	2	3	1	1	2	2	1	2	3	1	2	3	1

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

LIST OF EXPERIMENTS

1. Determination of equivalent circuit parameters of three phase induction motor
2. Circle diagram of 3-phase induction motor
3. Brake test on 3-phase induction motor
4. Single phase operation of 3-phase induction motor
5. Speed control of 3-phase induction motor
6. Regulation of 3-phase alternator by E.M.F.method & MMF methods
7. Regulation of 3-phase alternator by Z.P.F.method
8. Determination of Xd and Xq of a Salient pole Synchronous Machine
9. Parallel operation of alternators
10. Determination of V and inverted V curves of 3-phase synchronous machine
11. Determination of equivalent circuit parameters of single phase induction motor
12. Determination of the performance of induction generator

References:

1. P.S. Bimbhra: Electrical Machinery – Khanna Publishers, Seventh Edition, 2011.

2. CharlesI. Hubert: Electric Machines – Pearson, Second Edition, 2003.
3. Stephen. J.Chapman: Electric Machinery Fundamentals–McGraw Hill Education, Fourth Edition,2007

EE361	Digital Signal Processing	DEC	3-0-0	3 Credits

Pre-requisites: EE253-Signals and Systems

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

CO1	Understand the sampling theorem and relationship between the time domain and frequency domain description of signals and systems
CO2	Find the DFT of a given signal through Fast Fourier Transform Techniques
CO3	Design FIR and IIR type digital filters and identify filter structures and evaluate the coefficient quantization effects
CO4	Apply TMS320LF2407 digital signal processor for control applications

Course Articulation Matrix:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO2	3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO3	3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO4	3	3	3	3	3	3	3	1	2	1	2	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Basic elements of digital signal Processing: Concept of frequency in continuous-time and discrete-time signals –Sampling theorem – Discrete-time signals. Discrete-time systems –Analysis of Linear time-invariant systems –Z transform –Convolution and correlation.

Discrete Transforms: DTFT, properties, applications, Efficient computation of DFT properties of DFT – FFT algorithms – Radix-2 and Radix-4 FFT algorithms – Decimation in Time – Decimation in Frequency algorithms – Use of FFT algorithms in Linear Filtering and correlation.

Digital Filters: Linear phase FIR filter, characteristic response, location of zeros, Design of FIR filter - Windowing, Frequency sampling, Design of IIR filters from Analog filters - Impulse invariance, Bilinear transformation, Matched z-transform.

Digital Filter Synthesis: FIR filters - Direct form realization, Cascade form, and Linear phase realization. IIR filter - Direct form I, Direct form II, cascade form, parallel form, Lattice form realization.

Introduction to Digital Signal Processor: Architecture, addressing modes, Basic Instruction set, and simple applications of DSP.

References:

1. Proakis and Manolakis: Digital signal processing principles –algorithms and applications- PHI–2003
2. Oppenheim and Schaefer: Discrete-time signal processing –PHI–1999
3. Reference Manuals of Texas TMS 320X and Analog Devices 21XX Processors

EE362	ADVANCED CONTROL ENGINEERING	DEC	3–0–0	3 Credits

Pre-requisites: EE254-Control Systems

Course Outcomes: At the end of the course the student will able to:

CO1	The students learn the advantages of discrete time control systems over continuous time control systems
CO2	The students can know z–transformations and their application in mathematical analysis and also different stability tests to find out the stability of a system
CO3	The students learn different state space methods to design a control system
CO4	The learners understand the concepts of intelligent control system and its design

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	1	1	1	1	2	2	3	1
CO2	3	3	3	2	2	2	3	1	1	1	2	2	3	1
CO3	3	3	3	2	2	2	1	1	1	1	2	2	3	3
CO4	3	3	3	2	2	2	1	1	1	1	2	2	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Digital Control System Design: Ideal sampling, The Z-transform, Stability in the Z-plane, Mapping from the S-plane into Z-plane, The Jury stability test, Lyapunov stability analysis, Root locus analysis in the z-plane, Root locus construction rules, Digital compensator types and design.

Optimal and Robust Control System Design: Types of optimal control problems, Selection of performance index, The linear quadratic regulator - Continuous form - Discrete form, The Kalman filter - state estimation process (single and multivariable) Robust Control - Internal Model Control, H_2- and H_∞- optimal control, Robust stability and robust performance, Multivariable robust control.

Intelligent Control System Design: Intelligence in machines, Fuzzy logic control systems, Neural network control systems, Genetic algorithms and their application to control system deign

References:

1. K.Ogata, “ Modern control Engineering”, PHI,

2. K.Ogata, “ Discrete time control systems”, Pearson Education, 1994.
3. M. Gopal, “ Digital control and state variable methods”, 2nd Edition, TMH, 2007.
4. Norman.S.Nise, “ Control system Engineering”, 7th edition, Wiley
5. B.C.Kuo, “Digital control systems” Holt Saunder’s International edition,1991.

EE363	Introduction to Machine Learning	DEC	3-0-0	3 Credits

Pre-requisites: CS101 **-** Introduction to Algorithmic Thinking and Programming, MA151 - Matrices and Differential Equations

Course Outcomes: At the end of the course the student will able to:

CO1	Identify design practices for efficient Machine Learning based solution.
CO2	Understand Machine Learning algorithms in practice
CO3	Implement strategies to boost existing Machine Learning model
CO4	Design Machine Learning architecture and modelling pipeline for a task

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Machine Learning Landscape: Introduction; Learning Paradigm; Machine learning algorithm attribution - Inductive learning, Online learning, Active learning, Unsupervised learning, Semi-supervised learning, Augmenting Machine Learning Algorithm - Inductive bias, Regularization, Loss function, Optimizers, Feature extraction, Subset selection, Ensemble Learning, Data Augmentation.

Classical Machine Learning: Review of Probability and Linear Algebra, Decision Trees; Random Forest; Bayes Classifier; Linear Regression; Logistic Regression; Artificial Neural Networks – Perceptron, Gradient descent and the Delta rule, Multilayer networks, Derivation of back propagation rule, Back propagation Algorithm, Convergence, Generalization; Support Vector Machine

Contemporary Machine Learning: Deep Learning - Convolutional layer, Relation between Convolution layer and Perceptron, Pooling, Dropout, Batch-normalization, Convolutional Neural Network; Long Short Term Memory; Auto-encoder; Convolution Neural Network based architectures; Transfer Learning for Classification; Transformers; Deep Reinforcement Learning

Practical Machine Learning: Machine learning pipelines for Classification and Regression Tasks, Evaluation of Pipelines, Deployment of Models on Cloud and Edge.

Machine Learning applications in electrical engineering.

References:

1. Tom.M.Mitchell, Machine Learning, McGraw Hill International Edition, 1997.
2. C Bishop – Pattern Recognition and Machine Learning – Springer, 2006.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville – Deep Learning, The MIT Press
   Cambridge, Massachusetts, London, England, 2016
4. Shai Shalev-Shwartz and Shai Ben David – Understanding Machine Learning: From Theory to algorithms.
5. Richard S Sutton & Andrew G Barto – Reinforcement Learning: An introduction.

EE364	Computer Organization and Architecture	DEC	3 – 0 – 0	3 Credits

Pre-requisites: EE203 – Analog and Digital Electronic Circuits
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the characteristics of components of a computer system
CO2	Determine the architectural features and functional inter-relationships between CPU, Memory, IO and operating system
CO3	Analyze the hierarchical structure of computer system components and design sub-systems to improve and influence performance.
CO4	Design a memory organization for a choice of memory chips

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction to Computer Systems: Function and structure of a computer, Functional components of a computer, Interconnection of components, Generations of a computer and Performance of a computer.

Representation of Instructions: Machine instructions, Operands, addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures.

Central Processing Unit: Organization of a processor - Registers, ALU and Control unit, Data path in a CPU, Instruction cycle, Organization of a control unit - Operations of a control unit, Hardwired control unit, Micro programmed control unit.

Memory Subsystem: Semiconductor memories, Memory cells - SRAM and DRAM cells, Internal Organization of a memory chip, Organization of a memory unit, Error correction memories, Interleaved memories, Cache memory unit - Concept of cache memory, Mapping methods, Organization of a cache memory unit, Fetch and write mechanisms, Memory management unit - Concept of virtual memory, Address translation, Hardware support for memory management.

Input/ Output Subsystem: Access of I/O devices, I/O ports, I/O control mechanisms - Program controlled I/O Interrupt controlled I/O and DMA controlled I/O I/O interfaces Program controlled I/O, Interrupt controlled I/O, and DMA controlled I/O, I/O interfaces

- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and InfiniBand, I/O peripherals - Input devices, Output devices, Secondary storage devices, Pipelining - basic concepts of pipelining, throughput and speedup, pipeline hazards.

Design of concepts: GPU, vector processor, multi processor, inter communication networks.

References:

1. Carl Hamacher, Zvonko Vranesic, Safwat Zaky "Computer Organization", 5th Edition, Tata McGraw Hill, 2002.
2. David A. Patterson, John L. Hennessy "Computer Organization and Design: the Hardware/Software Interface, 4th Edition, Elsevier, 2009.
3. William Stallings "Computer Organization & Architecture, 7th Edition, PHI, 2006.
4. Vincent P.Heuring &HarryF. Jordan "Computer Systems Design and Architecture" 2nd Edition, Pearson Education, 2004.
5. Mostafa Abd-El-Barr, Hesham El-Rewini "Fundamentals of Computer Organization and Architecture" John Wiley & Sons, 2005

EE370	Linear Integrated Circuits & Applications	DEC	3-0-0	3 Credits

Pre-requisites: EC101-Basic Electronics Engineering, EC203-Analog and Digital Electronic circuits

Course Outcomes: At the end of the course, student will be able to**:**

CO1	Understand the functioning of OP-AMP and design OP-AMP based circuits
CO2	Understand the functioning of voltage regulators and design IC based voltage regulators
CO3	Understand the functioning of active filters
CO4	Design ADC and DAC circuits

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	3	1	2	2	1	1	1	1	1	1	3	3	2
CO2	2	2	1	3	2	1	1	1	1	1	3	3	3	3
CO3	1	2	1	1	1	1	1	1	1	1	2	1	3	2
CO4	1	1	1	3	2	1	1	1	1	1	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Integrated Circuits: Introduction to Operational amplifiers – ideal characteristics, AC and DC characteristics, linear applications

Op-Amp Applications: Scale changer/inverter, Summing amplifier, Instrumentation amplifier, Instrumentation amplifier, DC and AC amplifiers, V to I and I to V converters, Precision rectifiers, Log and Antilog amplifiers, multiplier and divider, Analog multiplier, Differentiator, Integrator, Analog computation

Comparators and waveform generators: Comparator, Regenerative comparator (Schmitt Trigger), astable and mono-stable multi-vibrators using op-amp, Triangular wave generator, Sine wave generators using op-amp. IC waveform generator

Voltage regulators: Series op-amp regulator, IC voltage regulators, General purpose regulator, switching regulators.

Active filters: Low pass, high pass, band pass, band reject and all pass filters, transformation, State variable filter, Switched capacitor filters, Switched capacitor filter ICs

Phase Locked Loops: PLL- introduction, block schematic, principles and description individual blocks,IC PLL, Voltage controlled oscillator, PLL applications- Frequency multiplication,Frequency translation, FM & FSK demodulation

D-A and A-D Converters: Basic DAC Techniques, Weighted resistor DAC, R-2R ladder DAC, Inverted R-2R ladder, Monolithic DAC, A-D converters, direct type ADCs, the parallel comparator(flash) A/D converter, The counter type A/D converter, Servo tracking A/D converter, Successive approximation converter, Integrating type of ADCs, Charge balancing ADC, Dual-slope ADC, DAC/ADC specifications

References:

1. D.Roy Choudary, ShailBala Jain, “Linear Integrated circuits”, New Age International publishers, 2018.
2. Ramakant A.Gayakward, “Op-amps and linear Integrated circuits”, LPE, 4th edition, Pearson Education, 2015.
3. S.Salivahanan, V.S.Kanchana Bhaaskaran “Linear Integrated circuits”, TMH, 2008.
4. David A. Bell, “Operational amplifiers and Linear ICs”, PHI, EEE, 1997.
5. J.V. Wait, L.P. Huelsman and GA Korn, “Introduction to Operational Amplifier theory and applications”, McGraw Hill, 1992.

EE371	Power Quality Improvement Techniques	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Assess the severity of power quality problems in distribution system
CO2	Evaluate the power quality indices used in industrial power system
CO3	Understand various mitigation techniques and compensating devices to improve the power quality
CO4	Understand various mitigation techniques and compensating devices to improve the power quality

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	2	2	1	2
CO4	3	3	3	3	2	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Power Quality: Introduction; Power quality definition; Significance of power quality, Power quality terms: Transients, Long-duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuation, Power factor correction, CBEMA and ITI curves.
Waveform Distortion: Introduction, Voltage versus current distortion, Harmonics versus transients, Harmonics indices: Total Harmonics Distortion (THD) and Total Demand distortion (TDD); Harmonic standards; Harmonic analysis; Harmonic phase sequence; Triplen harmonics; Inter-harmonics.

Harmonic Sources: Introduction; Harmonics generated from electrical machines such as transformers and rotating machines; Arcing devices; Static power conversion: Phase controlled and uncontrolled rectifiers, AC voltage regulators, Cyclo-converters, Pulse width modulated inverters; Converter fed ac and dc drives.

Effects of Harmonic Distortion: Introduction; Resonances; Effects of harmonics on rotating machines; Effect of harmonics on static power plant; Power assessment with distorted waveforms; Effect of harmonics on measuring instruments; Harmonic interference with ripple control systems; Harmonic interference with power system protection; Effect of harmonics on consumer equipment; Interference with communication systems.

Passive and Active Power filters: Introduction; Passive power filters: Design, Advantages and disadvantageous; Shunt active power filters: Operating principle, Configurations, State of the art, Design and control strategies, Three-phase four-wire shunt active power filters, Series active power filters: Operating principle, Configurations, State of the art, Design and control strategies. Three-phase four-wire series active power filters.

References:

1. Dugan Roger C, Santoso Surya, Mc Granaghan , Marks F. Beaty and H. Wayre, “Electrical Power Systems Quality”, 3rd edition, McGraw Hill,2012.
2. Bhim Singh, Ambrish Chandra, Kamal Al- Haddad, “Power Quality: Problems and Mitigation Techniques”, Wiley, 2014.
3. J. Arrillaga, N.R. Watson, “Power System Harmonics”, John Wiley & Sons Ltd, 2nd edition, 2003.
4. H. Akagi, E. H. Watanabe, M. Aredes, “Instantaneous Power Theory and Applications to Power Conditioning”, Wiley-IEEE Press, 2007.

EE372	**Electronic and Magnetic Materials**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: EC101 **-** Basic Electronics Engineering, EE101- Elements of Electrical Engineering

Course Outcomes: At the end of the course, student will be able to

CO1	Understand the properties of available engineering materials and their usage in electrical systems
CO2	Know the fundamentals of dielectric materials
CO3	Know various Magnetic materials and their properties
CO4	Understand the properties of various semi-conducting materials

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	1	2	1	1	1	1	2	1	3	3	2
CO2	2	1	2	1	1	2	2	2	2	2	3	3	3	3
CO3	1	3	3	1	1	2	2	1	1	1	2	1	3	2
CO4	1	3	1	2	1	2	2	1	1	1	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Classification of Engineering Materials: Brief introduction and applications of different Engineering materials i.e. Metals, Conductors, Semiconductors, Insulators, polymers, Magnetic materials etc. Introduction to smart materials, high-performance materials and intelligent materials.

Conductivity of Metals: Introduction, factors affecting the resistivity of electrical materials, electron scattering and the resistivity of metals, equation of motion of an electron, current carried by electrons, mobility, energy levels of a molecule, emission of electrons from metals, thermionic emission, photo electric emission, field emission, effect of temperature on electrical conductivity of metals, electrical conducting materials, thermal properties, thermal conductivity of metals, thermoelectric effects. Superconductivity

Dielectric Properties: Introduction, effect of a dielectric on the behavior of a capacitor, polarization, the dielectric constant of monatomic gases, frequency dependence of permittivity, dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant, dielectric properties of polymeric system, ionic conductivity in insulators, insulating materials, ferroelectricity, piezoelectricity.

Magnetic properties of Materials: Introduction, Classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, magnetization curve, permeability, B-H curve, magnetic saturation, hysteresis loop (coercive force and residual magnetism), concept of eddy current and hysteresis loss, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance.

Semiconductors: Energy band structure in solids, conductors, semiconductors and insulators, types of semiconductors, Intrinsic semiconductors, impurity type semiconductor, Metal-Semiconductor Contacts, drift and diffusion currents, the Einstein relation, hall effect, thermal conductivity of semiconductors, electrical conductivity of doped materials.

References:

1. Ian P. Jones “Materials Science for Electrical and Electronic Engineers” Oxford University press, 2001
2. A.J. Dekkar “Electrical Engineering Materials” Pearson Education India; First edition, 1970.
3. Indulkar C.S. and Thiruvengadam S. “An Introduction to Electrical Engineering Materials” S Chand & Company, 4th edition, 2004.
4. Rolf E. Hummel “Electronic Properties of Materials” 3rd edition, Springer.
5. D. P. Kothari, Mahima Jain, Shefali Jagwani “Electrical and Electronics Materials” Alpha Science International Limited, 2015

EE373	**Electrical safety, Operations and Regulations**	**DEC**	**3–0–0**	**3 Credits**

Pre-requisites: EE101 – Elements of Electrical Engineering

Course Outcomes: Upon successful completion of the course, the student must be able to

CO1	Understand the Indian power sector organization and Electricity rules, electrical safety in residential, commercial, agriculture, hazardous areas and use of fire extinguishers.
CO2	Outline the electrical safety during installation, testing and commissioning procedure.
CO3	Make use of specification of electrical plants and classification of safety equipment for various hazardous locations.
CO4	Distinguish various fire extinguishers and their classification

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	1	2	2	2	2	2	1	2	2	1
CO2	3	1	2	2	1	2	2	2	2	2	1	2	2	1
CO3	3	2	2	2	1	2	2	2	2	2	1	2	2	1
CO4	3	2	2	1	1	2	2	2	2	2	1	2	2	1

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction To Electrical Safety, Shocks and Their Prevention: Terms and definitions, objectives of safety and security measures, Hazards associated with electric current and voltage, who is exposed, principles of electrical safety, Approaches to prevent Accidents, scope of subject electrical safety. Primary and secondary electrical shocks, possibilities of getting electrical shock and its severity, medical analysis of electric shocks and its effects, shocks due to flash/ Spark over's, prevention of shocks, safety precautions against contact shocks, flash shocks, burns, residential buildings and shop,

Fire Extinguishers: Fundamentals of fire-initiation of fires, types; extinguishing techniques, prevention of fire, types of fire extinguishers, fire detection and alarm system and Halogen gas schemes; foam schemes.

Electrical Safety in Residential, Commercial and Agricultural Installations: Wiring and fitting –Domestic appliances –water tap giving shock –shock from wet wall –fan firing shock –multi-storied building –Temporary installations –Agricultural pump installation–Do's and Don'ts for safety in the use of domestic electrical appliances.

Electrical Safety during Installation, Testing and Commissioning, Operation and Maintenance: Preliminary preparations –safe sequence –risk of plant and equipment –safety documentation –field quality and safety –personal protective equipment –safety clearance notice –safety precautions –safeguards for operators –safety.

Electrical Safety in Hazardous Areas: Hazardous zones –class 0, 1 and 2 –spark, flashovers and corona discharge and functional requirements–Specifications of electrical plants, equipment's for hazardous locations–Classification of equipment enclosure for various hazardous gases and vapors–classification of equipment/enclosure for hazardous locations.

Central Electricity Authority Regulations: Safety measures for operation and maintenance of electric plants, transmission, distribution systems, and The Indian electricity rules.

References:

1. Rao,S. and Saluja, H.L.,"Electrical Safety, Fire Safety Engineering and Safety Management", Khanna Publishers, 1988.
2. Cooper. W.F, "Electrical safety Engineering", Newnes-Butterworth Company,1978.
3. John Codick, "Electrical safety hand book", McGraw Hill Inc., New Delhi, 2000.
4. Nagrath,I.J. and Kothari,D.P., "Power System Engineering", Tata McGraw Hill,1998.
5. Wadhwa, C.L., "Electric Power Systems", New Age International, 2004.

IV Year B.Tech. (EEE) Courses offered by EED

EE401	Power System Analysis and Stability	PCC	3–0–0	3 Credits

Pre-requisites: EE302- Electric Power Transmission

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

CO1	Understand the planning studies of power system
CO2	Analyze economic operations of power system
CO3	Determine the stability of the power system.
CO4	Understand power system deregulation and restructuring

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	1	1	3	1	2	2	3	2
CO2	3	3	3	2	3	2	1	1	1	1	3	2	3	2
CO3	3	3	3	3	3	3	1	1	2	1	1	2	3	2
CO4	3	3	3	1	3	3	1	1	1	1	3	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Load Flow Studies: Introduction, Bus classification -Nodal admittance matrix - Load flow equations - Iterative methods - Gauss and Gauss-Seidel Methods, Newton-Raphson Method-Fast Decoupled method-Merits and demerits of the above methods-System data for load flow study. DC load flow analysis.

Distribution Load Flow Analysis, Backward-forward load flow, direct approach-based load flow analysis.

Economic Operation of Power Systems: Distribution of load between units within a plant-Transmission loss as a function of plant generation, Calculation of loss coefficients-Distribution of load between plants.

Power System Stability Analysis: The stability problem-Steady state stability, transient stability, and Dynamic Stability-Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step by step solution of swing equation-Factors affecting transient stability, Methods to improve steady-state and Transient stability, Introduction to voltage stability.

Power System Deregulation: Introduction, Power system restructuring models-responsibilities and functions of independent system operator (ISO) – Ancillary Services.

References:

1. C.L.Wadhwa, Electrical Power Systems, 3rd Edn, New Age International Publishing Co., 2001.
2. D.P.Kothari and I.J.Nagrath, Modern Power System Analysis, 4th Edn, Tata McGraw Hill Education Private Limited 2011.
3. Power SystemGeneration, Operation and Control, Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, John Wiley and Sons, 2013, 3rd Edition
4. Electric Energy System Theory – an Introduction, Elgerd.O.I, Tata McGraw Hill, NewDelhi, 2013

EE402	Electric Vehicle Technologies	PCC	2 – 0 – 0	2 Credits

Pre-requisites: EE303-AC Rotating Machines, EE304-Power Electronics, EE353-Electrical Power Drives

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

CO1	Understand the basic concept of electric vehicles and popular traction systems.
CO2	Understand the drive train topologies and advanced propulsion techniques.
CO3	Analyze the various energy storage methodologies
CO4	Analyze the different methods for battery charging

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	3	2	1	1	1	2	2	3	2
CO2	3	3	3	2	2	3	2	1	3	1	3	2	3	2
CO3	3	3	3	2	3	3	2	1	1	1	1	2	3	2
CO4	3	3	3	2	3	3	2	1	3	1	3	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction: Conventional vehicles - basics of vehicle performance - vehicle power source characterization - transmission characteristics - mathematical models to describe vehicle performance - History of electric vehicles - social and environmental importance of electric vehicles - impact of modern drive-trains on energy supplies.

Electric drive-trains: Basic concept of electric traction - introduction to various electric drive-train topologies - power flow control in electric drive-train topologies - fuel efficiency analysis

Electric propulsion unit: Introduction to electric components used in electric vehicles - Configuration and control of DC Motor drives - Configuration and control of Induction Motor drives - Configuration and control of Permanent Magnet Motor drives - Configuration and control of Switch Reluctance Motor drives - Drive system efficiency, Concept of Hybrid Electric Vehicles

Energy storage: Introduction to Energy Storage Requirements in Electric Vehicles - Battery based energy storage and its analysis - Fuel Cell based energy storage and its analysis - Super Capacitor based energy storage and its analysis - Flywheel based energy storage and its analysis - Hybridization of different energy storage devices

Power Electronic Converter for Battery Charging : Charging methods for battery, Termination methods, charging from grid, The Z-converter, Isolated bidirectional DC-

DC converter, Design of Z- converter for battery charging, High frequency Transformer based isolated charger topology, Transformer less topology.

References:

1. M. Ehsani, Y.Gao, S. E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
3. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

EE403	Power Systems & Renewable Energy Laboratory	PCC	0 – 1 – 2	2 Credits

Pre-requisites: EE352 – Power System Protection and Control

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

CO1	Understand the Reactive power control in a Tap Changing Transformer & long transmission lines
CO2	Understand the characteristics of PV array and wind power plants
CO3	Analyze the power system/distribution system status using different load flow solution methods
CO4	Determine the stability of power system

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	2	1	1	1	3	3	1	3	3	2
CO2	3	3	2	1	2	1	1	2	3	3	3	3	3	3
CO3	3	3	2	2	2	3	3	3	3	3	1	1	1	1
CO4	3	3	3	3	3	3	2	2	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

List of Experiments

1. Reactive Power Control using Tap Changing Transformer
2. Characteristics of Artificial Transmission Line
    (a) Regulation and efficiency Characteristics
    (b) Reactive Power compensation
3. Determination of Sequence Reactances of Alternator
4. Analysis of unbalanced voltages using Symmetrical Component Analyzer
5. Formation of Bus admittance matrix by using direct inspection method
6. Power flow solution by using a) Gauss-Siedel method b) Newton-Raphson method c) Fast Decoupled method
7. Load frequency control of Single area and Two area systems
8. Solution of Economic load dispatch problem using lambda logic method
9. Solution of Swing equation using point-by-point method
10. Distribution Load Flow Solution by using Backward/Forward Method
11. Characteristics of PV Array
12. Harmonic analysis of linear and non-linear Domestic and crest-factor loads and its mitigation using Passive filters
13. Simulation of wind power plant

References:

1. D.P. Kothari and I J Nagrath “Modern Power System Analysis” McGraw-Hill, 4th Edition, 2011.
2. C. L. Wadhwa, “Electrical Power Systems” New Age International Pvt Ltd, 6th Edition, 2007.
3. Kundur P “Power System Stability and Control”, McGraw-Hill.
4. IEEE Journal paper on Backward/Forward Method.
5. IEEE Journal paper on PV simulation and wind power plant simulation.

EE411	ADVANCED COMPUTER METHODS IN POWER SYSTEMS	DEC	3–0–0	3 Credits

Pre-requisites: EE302 - Electric Power Transmission, EE351- Power Systems Distribution & Utilization, EE352- Power System Protection and Control

Course Outcomes: At the end of the course the student willable to:

CO1	The students learn how to model a transmission network using different bus formation techniques
CO2	The students can know how to calculate the short circuit problems in a electrical power system using the above mentioned techniques
CO3	The students learn different stability issues occurring in the Power system and their mitigation techniques
CO4	The learners understand the concepts to overcome security issues and contingency problems in power systems

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	1	1	1	1	2	2	3	1
CO2	3	3	3	2	2	2	3	1	1	1	2	2	3	1
CO3	3	3	3	2	2	2	1	1	1	1	2	2	3	3
CO4	3	3	3	2	2	2	1	1	1	1	2	2	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Network Modeling and Power Flow

System graph, loop, cut set, Tie set, and incidence matrices, Y-bus formation, sparsity and optimal ordering, power flow analysis, formulation of three phase load flow, DC load flow, formulation of AC-DC load flow, sequential solution technique.

Short Circuit Studies: Introduction, short circuit calculation using Z-bus, short circuit calculation for balanced three-phase network using Z-bus, Short circuit calculation using Z-loop, Examples of short circuit calculation using Z-bus and Z-loop.

Load flow studies: Power system equation, Solution Techniques, Examples of Load flow calculations, Voltage controlled buses, Representation of Transformers, Tie-line control

Contingency analysis in Power systems

Contingency Calculations using Z_{BUS} and Y_{BUS} Table of Factors. State estimation – least square and weighted least square estimation methods for linear systems

References:

1. D P Kothari, I J Nagrath, “Modern Power System Analysis”, McGraw Hill.
2. George L Kusic, “Computer Aided Power System Analysis”, CRC Press.
3. M A Pai, “Computer Techniques in Power System Analysis”, McGraw Hill.
4. J Arrillaga, N R Watson, “Computer Modeling of Electric Power System”, Wiley.
5. Hadi Saadat, “Power System Analysis”, McGraw Hill.
6. G T Heydt, “Computer Analysis Methods for Power Systems”, Macmillan Company.

EE412	HVDC AND FACTS Controllers	DEC	3-0-0	3 Credits

Pre-requisites: EE352 – Power Electronics

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

CO1	Compare HVDC and EHVAC transmission systems
CO2	Analyze converter configurations used in HVDC and evaluate the performance metrics.
CO3	Understand controllers for controlling the power flow through a dc link and compute filter Parameters
CO4	Apply impedance, phase angle and voltage control for real and reactive power flow in ac transmission systems with FACTS controller
CO5	Analyze and select a suitable FACTS controller for a given power flow condition

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

HVDC Transmission: DC Power Transmission: Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC Transmission systems, Types of DC links, relative merits, Components of a HVDC system, Modern trends in DC Transmission systems

Analysis of HVDC Converters and control: Pulse number, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage wave forms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms, Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current Control, CEA Control, firing angle control of valves, starting and stopping of a dc link, Power control

Flexible AC Transmission Systems (FACTS): FACTS concepts and general system conditions: Power flow in AC systems, Relative importance of controllable parameters, Basic types of FACTS controllers, shunt and series controllers, Current source and Voltage source converters

Shunt and Series Compensators: Objectives of shunt compensation, Methods of controllable VAR generation, Static VAR Compensator, its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle, control approaches and characteristics; Objectives of series compensator, variable impedance type of series compensators, TCSC, TSSC-operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating, Capability to provide reactive power compensation, external control

Combined Compensators: Introduction to Unified Power Flow Controller, Basic operating principles, Conventional control capabilities, Independent control of real and reactive power

References:

1. K.R. Padiyar: HVDC Power Transmission Systems–Technology and System Interactions, New Age International Publishers.
2. Kimbark: Direct Current Transmission,1971.
3. Jos Arrillaga: High Voltage Direct Current Transmission, The institution of electrical Engineers,1998.
4. Narain G. Honorani, Laszlo Gyugyi: Understanding FACTS–Concepts and Technology of Flexible AC Transmission Systems, Wiley-IEEE Press, 2000.
5. Yong Hua Song, Allan TJohns: Flexible AC Transmission Systems, The Institution of electrical Engineers, 1999.

EE413	**High Voltage Engineering**	**DEC**	**3-0-0**	**3 Credits**

Pre-Requisites: None

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

CO1	Design the insulation of HV power equipment.
CO2	Estimate electric field intensity of different electrode configurations.
CO3	Understand the testing methods of high voltage equipment
CO4	Using Non-Destructive Test Techniques for assessing the quality of insulation of high voltage Equipment
CO5	Understand the Breakdown mechanism of Gas, Liquid and solid insulation

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed syllabus:

Overview of Electro Static Fields

Electric Field intensity, Electric strength, classification of Electric Fields, control of electric Field intensity, basic equations for potential and field intensity in electrostatic fields, Analysis of electric field intensity in homogenous and multi-dielectric electric fields, numerical methods for estimation of electric field intensity, Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings, breakdown strength of insulating materials

Generation Of High DC And AC Voltages

Introduction, Rectifier circuits, Cockcroft- Walton voltage multiplier circuit, electrostatic generator, generation of high ac voltages by cascaded transformers, series resonant circuit, Standard lightning, switching surge, associated parameters and their corrections.

Generation Of Impulse Voltages And Currents

Definitions, design and construction of impulse generator circuits, Analysis of impulse generator circuit, multistage impulse generator circuit, triggering of impulse generator, impulse current generation.

Measurement Of High Voltages And Currents

Introduction, sphere gap, uniform field spark gap, rod gap, electrostatic voltmeter, generating voltmeter, Fortes cue method, resistive and capacitive voltage dividers, measurement of high DC, AC and impulse currents.

High Voltage Testing of Electrical Equipment

Layout of high voltage laboratory with major testing and measuring equipment's, Determination of their ranges and ratings, earthing system, electromagnetic shielding and protective fencing. Testing of overhead line insulators, testing of cables, Testing of Bushings, Testing of power capacitors, testing of power transformers, testing of circuit breakers. IEC, ANSI, IEEE and Indian standards for testing electrical equipment.

Non-Destructive Test Techniques

Measurement of resistance, measurement of dielectric constant and loss factor, High voltage Schering Bridge, current comparator bridge, measurement of large capacitances, partial discharges measuring and diagnostic techniques. Time domain and Frequency domain analysis of dielectric materials subjected to an electric field.

Introduction, Mechanism of breakdown in gases, Townsend's first ionization coefficient, cathode processes, secondary effects, Townsend's second ionization coefficient, Townsend breakdown mechanism, streamer or kanal mechanism of spark, Paschen's law, Penning effect, Breakdown in non- uniform fields, principles of breakdown in solid and liquid dielectrics.

References:

1. Ravindra Arora & Wolfgang Mosch: High voltage Insulation Engineering, New Age International Publishers, 2016.
2. C.L. Wadhwa: High voltage Engineering, New Age International Publishers, 2012.
3. E. Kuffel, W.S. Zaengl, J. Kuffel, High voltage Engineering Fundamentals, Newnes Publishers, 2011.
4. M.S. Naidu & Kamaraju, High- voltage Engineering, McGraw Hill Education (India) Private limited, 2013.
5. M. Khalifa, "High Voltage Engineering-Theory and Practice", Marcel Dekker, Inc. New York and Basel,1990.

EE414	POWER SYSTEMS SECURITY AND RELIABILITY	DEC	3–0–0	3 Credits

Pre-requisites: EE302-Electric Power Transmission, EE352-Power System Protection and Control

Course Outcomes: At the end of the course the student willable to:

CO1	Understand the concepts to overcome security issues and contingency problems in power systems
CO2	Understand the importance of maintaining reliability of power system components.
CO3	Apply the probabilistic methods for evaluating the reliability of generation and transmission systems.
CO4	Assess the different models of system components in reliability studies and the reliability of single area and multi area systems.

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	1	2	2	1	1	2	2	2	2	2
CO2	3	3	3	1	1	2	2	1	1	2	2	2	2	2
CO3	3	3	3	1	1	2	2	1	1	2	2	2	2	2
CO4	3	3	3	1	1	2	2	1	1	2	2	2	2	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Preliminaries for Power System Security Problems

Per unit quantities - Modeling of generators, transformers, off nominal tap setting and phase shifting transformers, transmission lines and loads. Primitive parameters - Bus admittance matrix - bus impedance matrix - reduction due to zero bus currents and zero bus voltages - Solution through factored matrices - Solution of non-linear algebraic equation and non-linear differential equations.

Power System Security Assessment & Security Constrained Optimization

Network sensitivity factors, contingency selection, contingency ranking, performance indices and methods, direct methods, indirect methods, sensitivity factors, generation shift factors, line outage distribution factors, basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non- linear programming (NLP) and linear programming(LP)methods

Basic Reliability Concepts: The general reliability function, exponential distribution – Mean time to failures – series and parallel systems. Markov process – continuous Markov process – Recursive techniques – Simple series and parallel system models.

Generating Capacity – Basic Probability Methods

The generation system model – Loss of load indices – Capacity expansion analysis – scheduled outages. Load forecast uncertainty Loss of energy indices. The frequency and duration method.

Transmission Systems Reliability Evaluation: Radial configuration – Conditional probability approach – Network configurations – State selection.

References:

1. Roy Billinton and Ronald Allan Pitam: Reliability Evaluation of Power Systems,1996.
2. J. Endremyl: Reliability Modelling in Electric Power Systems, John Wiley, 2005.
3. G W Stagg and A H El Abiad, “Computer Methods in Power System Analysis”, McGraw Hill, 1968.
4. J J Grainger and W D Stevension, “Power System Analysis”, McGraw-Hill, Inc., 1994.
5. D P Kothori and I J Nagrath, “Modern Power System Analysis”, Tata McGraw Hill Education Private Limited, 2011. 4. Hadi Saadat, “Power System Analysis” McGraw-Hill, 2004.
6. M A Pai,” Computer Techniques in Power System Analysis”, Tata McGraw Publishing Company Limited, 2006.
7. K.R.PADIYAR , Power System Dynamics: Stability and Control, II Edition, B.S.Publications.
8. P.M. Anderson and A.A. Fouad, Power system control and stability, John Wiley & sons
9. B M Weedy , Electric Power Systems, III Edition, John Wiley & Sons
10. P.Venkatesh, B.V.Manikandan, S.Charlesraja, A.Srinivasan, Electrical Power Systems: Analysis, Security and Deregulation, PHI

EE415	Industrial Electrical Systems	DEC	3 – 0 – 0	3 Credits

Pre-requisites: EE351 – Power Systems Distribution & Utilization

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

CO1	Understand the electrical wiring systems for residential, commercial and industrial consumers.
CO2	Understand various components of industrial electrical systems and SLD
CO3	Analyze and select the proper size of various electrical system components
CO4	Understand the role of PLC in automation

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	1	3	2	3	1	3	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	1	3	2	1	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	3	3	3	3	3	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Electrical System Components: LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

Residential and Commercial Electrical Systems: 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.

Industrial Electrical Systems - I: 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.

Industrial Electrical Systems – II: DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

Industrial Electrical System Automation: Study of basic PLC, Role of PLC in automation, Advantage of process automation, PLC based control system design, Panel metering.

References:

1. S. L. Uppal and G. C. Garg, “Electrical Wiring, Estimating & costing”, Khanna publishers, 2008.
2. K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
3. S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
4. Web site for IS Standards.
5. H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

EE420	Microgrids and Smart grids	DEC	3-0-0	3 Credits

Pre-requisites: None

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

CO1	Understand different categories, features and operation of microgrid
CO2	Access the role of renewable energy systems in microgrid and Smart grid
CO3	Apply the control and artificial intelligence techniques for the Smart Grid operation
CO4	Understand operation and importance of communication technologies and control in Smart Grids

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	2	2	1	1	1	1	2	2	3
CO2	3	2	2	2	1	2	2	1	2	1	1	1	2	2
CO3	3	3	3	3	3	2	2	1	2	1	2	3	3	2
CO4	3	3	3	3	2	2	2	1	3	1	2	3	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Distribution Generation Technologies: Introduction to Renewable Energy Technologies – Review of Solar PV, Wind Energy systems, Fuel Cells, Energy storage elements: Batteries, ultra-capacitors, flywheels - Storage Technologies – Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

Introduction to Microgrid: Microgrid Configurations – CERTS Microgrid Test Bed – DC Microgrid- HFAC Microgrid –LFAC Microgrid – Hybrid DC- and AC- Coupled Microgrid

Control and Operation of Microgrid: Power Electronics based Microgrid - Grid Connected Mode – Islanded mode – Battery Charging mode – design of parallel inverters – Microgrid application, Local control – Centralized Control- Decentralized Control - Microgrid control for islanded operation – PQ Control - Droop control methods – Frequency/Voltage Control - protection issues, anti-islanding schemes - Power quality issues in microgrids and standards

Introduction to Smart Grid and Smart Grid Architecture: Smart Grid Working and Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid –Indian Smart Grid – Key Challenges for Smart Grid - Components and Architecture of Smart Grid Design – Fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation

Tools and Techniques for Smart Grid: Computational Techniques – Static and

Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms – Artificial Intelligence techniques.

Communication Technologies and Control of Smart Grid: Introduction to Communication Technology – Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS), Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.

References:

1. Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussai, "Power Electronic Converters for Microgrid" , Wiley-IEEE Press, 2014
2. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press,2013
3. Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2004.
4. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010.
5. T. Ackermann, Wind Power in Power Systems, Hoboken, NJ, USA, John Wiley,2005
6. John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, Second Edition, 2006.

EE421	Special Electrical Machines	DEC	3–0–0	3 Credits

Pre-requisites: EE303- AC Rotating Machines

Course Outcomes: At the end of the course the student will able to:

CO1	Analyze single phase induction motors and identify the suitable methods of starting.
CO2	Understand the operation principles of Reluctance motor, Stepper motor, Hysteresismotor, and Universal motor and identify the suitable applications.
CO3	Understand the operation principles and identify the suitable applications of PMDC, PMSM, BLDC, SR motors and Linear Induction motors.
CO4	Understand the energy efficient and super conducting machines.

Course Articulation Matrix:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	2	1	1	1	1	1	1	2	3	1
CO2	3	3	2	2	2	1	1	1	1	1	1	2	3	1
CO3	3	3	2	3	3	1	1	1	1	1	1	3	3	3
CO4	3	2	2	2	3	1	1	1	1	1	1	3	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Single Phase Motors: Principle of operation, Double revolving field theory, speed-torque characteristics, Equivalent circuit, Phasor diagrams, Determination of equivalent circuit parameters, Starting methods, Split-phase starting, Resistance starting, Capacitance starting, Shade pole starting, Speed control methods, Applications, Principle of cross field theory, Problem on all the above motors.

R**eluctance motors, Hysteresis motors, Sub-synchronous motors:** Construction, principle of operation and applications.

Single phase AC Series motors: Construction, Principle of operation, Phasor diagrams and Characteristics and Problems. Simple and compensated motors, Universal motors and their Applications, Problems on all the above motors

Special Purpose Machines: Construction and principle of operation of Stepper motors, Permanent magnet DC motors, Brushless DC motors, Permanent Magnet Synchronous Motors, Switched Reluctance Motors , Linear Induction motors and their Applications, Problems on all the above motors. Construction, Basic Concepts, losses minimization and efficiency calculations of Energy efficient AC machines.

Construction, Principle of operation and basic concepts of super conducting AC machines

References:

1. A. E. Fitzgerald, C. Kingsley Jr., and Stephen D. Umans: Electric Machinery, Tata McGraw - Hill Education, Sixth Edition, 2017.
2. P.S. Bimbhra: Generalized Theory of Electrical Machines, Khanna Book Publishing Co. P Ltd., Seventh Edition, 2021.
3. D.P. Kothari and I J Nagrath: Electric Machines: Tata McGraw - Hill Education, Fifth Edition, 2017.
4. T. Kenjo and S. Nagamori: Permanent-Magnet and Brushless DC motors, Oxford University Press, 1985.
5. J.B. Gupta: Theory and Performance of Electrical Machines, S. K. Kataria& Sons, 14th Edition, 2006.
6. H. Cotton: Advanced Electrical Technology, Reem Publications Pvt. Ltd., 2011.
7. Stephen J. Chapman: Electric Machinery Fundamentals, Tata McGraw - Hill Education, 4th Edition, 2017.

EE422	Switched Mode Power Converters	DEC	3–0–0	3 Credits

Pre-requisites: EE304- Power Electronics

Course Outcomes: At the end of the course the student will able to:

CO1	Analyze the operation of DC-DC converters with current and voltage mode control
CO2	Analyze resonant converters and their control techniques
CO3	Design DC-DC converters and evaluate the stability of the system
CO4	Understand the operation and control of multilevel inverters

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	1	1	1	2	1	2	3	3	3
CO2	3	3	3	2	3	1	1	1	2	1	2	2	3	3
CO3	3	3	3	3	3	1	1	1	3	1	3	3	3	3
CO4	3	3	3	2	3	1	1	1	2	1	2	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

DC/DC Converters and their Controls: Basic topologies of buck, boost converters, buck-boost converters and buck converter, isolated DC/DC converter topologies: forward, and fly-back converters, half and full bridge topologies, modeling of switching converters. Voltage mode and current mode control of converters, peak and average current mode control, its advantages and limitations, voltage and current fed converters.

Resonant Converters: Need for resonant converters, types of resonant converters, methods of control, phase-modulation technique with ZVS in full-bridge topology, series resonant converter and resonant transition converter.

Converter Transfer Functions: Application of state-space averaging to switching converters, derivation of converter transfer functions for buck, boost, and fly-back topologies.

Power Converter Design: Design of filter inductor & capacitor, and power transformer, Ratings for switching devices, current transformer for current sensing, design of drive circuits for switching devices, considerations for PCB layout.

Controller Design: Introduction, mechanisms of loop stabilization, shaping E/A gain vs. frequency characteristic, conditional stability in feedback loops, stabilizing a continuous mode forward converter and discontinuous mode fly-back converter, feed-back loop stabilization with current mode control, the right-half plane zero.

Multi-pulse converters: Generation of 6-phase AC voltage from 3-phase AC, 6- pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

Inverters: SVM technique, multilevel inverters and PWM methods.

References:

1. Ned Mohan, Tore M. Undeland, William P. Robbins: Power Electronics: Converters, Applications, and Design, Third Edition, John Wiley & Sons, 2007.
2. Abraham I. Pressman, Keith Billings, Taylor Morey: Switching Power Supply Design, McGraw Hill International, Third Edition,2009.
3. P.C. Sen: Modern Power Electronics, S.Chand& Company, Second Edition, 2005.
4. Andrzej M. Trzynadlowski: Introduction to Modern Power Electronics, Second Edition, illustratedPublisher John Wiley & Sons, 2010.
5. Muhammad H. Rashid: Power electronics hand book, Pearson Education; Fourth edition, 2017.
6. Bin Wu, Mehdi Narimani: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006.

EE423	**Soft Computing and Applications**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the concepts of population based optimization techniques
CO2	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution
CO3	Evaluate the importance of parameters in heuristic optimization techniques
CO4	Apply for the solution of multi-objective optimization

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Fundamentals of Soft Computing Techniques: Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Introduction to soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing. Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

Ant Colony Optimization and Artificial Bee Colony Algorithms: Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system- max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.

Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm: Bat Algorithm- Echolocation of bats- Behavior of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs- comparison of memes and genes - memeplex formation- memeplex updation, Application to multi-modal function optimization.

New Meta-heuristic Techniques: Water Wave Optimization Algorithm – Multi verse optimization algorithm – Symbiotic Organisms search algorithm - Invasive weed optimization – case studies.

Multi-Objective optimization: Introduction to Multi-Objective optimization -Concept of Pareto optimality.

References:

1. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation”, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb “Multi-Objective Optimization using Evolutionary Algorithms”, John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, “Swarm Intelligence”, The Morgan Kaufmann Series in Evolutionary Computation, 2001.
4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, “Swarm Intelligence-From natural to Artificial Systems”, Oxford university Press, 1999.
5. N P Padhy, “Artificial Intelligence and Intelligent Systems”, Oxford University Press,2005.

EE424	Non-Conventional Energy Systems	DEC	3-0-0	3 Credits

Pre-requisites: EE251- Energy Conversion Technologies

Course Outcomes: At the end of the course, student will be able to

CO1	Demonstrate the generation of electricity from various non-conventional sources of energy, have a working knowledge on types of fuel cells.
CO2	Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation
CO3	Explore the concepts involved in wind energy conversion system by studying its components, types and performance.
CO4	Illustrate ocean and geothermal energy and explain the operational methods of their utilization.

Course Articulation Matrix:

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

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Introduction: Need and overview of Non-conventional energy sources, Types of Non-Conventional energy sources

Solar Energy: Principles of solar radiation and its measurements, Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data.

Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors. Applications of Solar energy.

Biomass Energy: Definition-Biomass conversion technologies Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C. Engine operation and economic aspects.

Wind Energy: Sources and potentials, Nature of wind, Basic components of Wind Energy Conversion System(WECS),Wind energy collectors (Horizontal and vertical axis windmills)- performance characteristics, Betz criteria, Advantages and Disadvantages of WECS -Applications of wind energy.

Fuel cells: Definition-Design and Principle of operation with special reference to H2O2-Solid oxide electrolyte cells-Advantages and Disadvantages of fuel cells-Applications of Fuel cells.

Hydro energy: Basic components of hydro power plant, small/micro hydro power system, designing of small/micro hydro power system.

Ocean Energy: Ocean thermal electric conversion (OTEC) methods- Open cycle and Closed cycle-Principles of tidal power generation-Advantages and limitations of tidal power generation.

Geothermal Energy: Types of Geothermal resources, types of wells, methods of harnessing the energy, potential in India - Applications of Geothermal Energy

References:

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2011.

2. B H Khan, Non-Conventional Energy Resources, McGraw Hill, 2nd Edition, 2009.

3. Ashok Desai V, Non-Conventional Energy, Wiley Eastern Ltd, 1990.

4. Mittal K.M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, 1997.

5. Ramesh R, Kurnar K.U, Renewable Energy Technologies, Narosa Publishing House, New Delhi,1997.

SM430	Entrepreneurship for Engineers	HSC	3 – 0 – 0	3 Credits

Course outcomes: At the end of the course, the student will be able to:

CO1	Acquaint themselves with starting new ventures and introducing new products and service ideas
CO2	Explore the processes of establishing a start-up
CO3	Develop strategies and methods to mobilize resources
CO4	Create venture capitalists, consultants to new firms or new business development units of larger corporates

Detailed syllabus:

The Early Career Dilemmas of an Entrepreneur: Discover ourselves- The Entrepreneur's Role, Task and Personality- A Typology of Entrepreneurs: Defining Survival and Success, Entrepreneurship as a Style of Management- The Entrepreneurial Venture and the Entrepreneurial Organisation- Identify Problems Worth Solving-Customer Identification- Choosing a Direction Opportunity recognition and entry strategies- Business model identification- validation- New product Franchising-Partial Momentum- Sponsorship and Acquisition- The Strategic Window of Opportunity- Scanning-Positioning and Analysing, Intellectual Property-Creation and Protection

Gaining Commitment- Gathering the Resources- The Business Plan as an Entrepreneurial Tool- Financial Projections: how to do them the right way- Debt-Venture Capital and other forms of Financing-Sources of External Support-Developing Entrepreneurial Marketing-Competencies- Networks and Frameworks-ustaining Competitiveness- Maintaining Competitive Advantage- The Changing Role of the Entrepreneur- Mid- Career Dilemmas-Harvesting Strategies versus Go for Growth

Characteristics and special needs- Business/project planning- Business Plan preparation- Implementation Process- Planning support systems (enterprise operation)- Legal Issues (licensing, patents, contracts etc.)-Effectuation and Causation-Art of negotiation-Conflict Management

References:

1. B.D.Singh. Managing Conflict and Resolution. Excel Books.2008
2. R. Barringer and D. Ireland, Entrepreneurship, Prentice Hall,2009.
3. G. Kawasaki, L. Filby, The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything , Penguin,2015.
4. R. Bansal, Connect the Dots, Westland,2011.

5. Ries,Eric The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Business,2011.
6. S. S. Khanka, Entrepreneurial Development, S.Chand&Co.2006.
7. S. Blank and B. Dorf, Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, K&S Ranch Publishing,2012.

EE461	**Artificial Intelligence Techniques in Power Systems**	**DEC**	**3–0–0**	**3 Credits**

Pre-requisites: EE401- Power System Analysis and Stability

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

CO1	Understand concepts of ANNs, Fuzzy Logic, and Evolutionary Algorithms
CO2	Distinguish between knowledge-based systems and algorithmic-based systems
CO3	Understand the operation of Fuzzy Controller and Evolutionary Algorithms
CO4	Apply Artificial Intelligence techniques for Power System applications

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	1	1	1	1	1	1	1	1	3	1
CO2	3	3	2	2	3	1	1	1	1	1	1	1	3	1
CO3	3	3	2	1	2	1	1	1	2	2	2	1	3	1
CO4	3	3	3	3	3	1	1	1	2	2	3	3	3	2

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Artificial Neural Networks: Introduction, Models of Neuron Network, Architectures – Knowledge representation, Artificial Intelligence and Neural networks– Learning process, Error correction learning – Hebbian learning –Competitive learning – Boltzman learning –Supervised learning – Unsupervised learning – Reinforcement learning-Learning tasks.

ANN Paradigms: Multi-layer Perceptron using Back propagation Algorithm (BPA), Self–Organizing Map (SOM), Radial Basis Function Network (RBFN), Functional Link Network (FLN).

Fuzzy Logic: Introduction – Fuzzy versus Crisp, Fuzzy sets – Membership function – Basic Fuzzy set operations, Properties of Fuzzy sets – Fuzzy Cartesian Product, Operations on Fuzzy relations– Fuzzy logic – Fuzzy Quantifiers, Fuzzy Inference-Fuzzy Rule based system- Defuzzification methods.

Evolutionary Algorithms: Basic Introduction, Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms.

Applications of AI Techniques: Load flow studies, Load forecasting, Economic load dispatch, Load frequency control – Single area system and two area system, Reactive power control.

References:

1. Neural Networks, Fuzzy Logic & Genetic Algorithms, S.Rajasekaran and G.A.V. Pai PHI, New Delhi, 2013.
2. Neural Computing Theory & Practice, P.D.Wasserman, Van Nostrand Reinhold, New York,1989.
3. Genetic Algorithms, D.E.Goldberg, Addison-Wesley 2008.
4. Recent Advances in Swarm Intelligence and Evolutionary Computation, Xin-She Yang, Springer International Publishing, Switzerland, 2015.

EE463	Design of Electrical Systems and Control	DEC	3 – 0 – 0	3 Credits

Pre-requisites: EE252 – DC Machines and Transformers, EE302 – AC Rotating machines

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

CO1	Formulate mathematical modeling for electric, magnetic and thermal circuits of electrical machines.
CO2	Analyze design aspects of rotating electrical machines.
CO3	Understand optimum design procedure of transformers.
CO4	Evaluate Select suitable layout and rating of sub-station components.

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	2	1	1	1	1	1	1	1	3	2
CO2	3	3	3	2	2	2	2	1	1	1	1	1	3	2
CO3	3	3	3	2	3	1	2	1	2	2	3	2	3	3
CO4	3	3	3	2	2	3	3	1	3	2	3	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Fundamentals for design of Rotating Machines:

Magnetic Circuit: Magnetic leakage calculations, Effect of leakage flux, Slot leakage, tooth top leakage, Zig-Zag Leakage, over hang leakage. Leakage with fractional pitch windings, effect of saturation and load on leakage coefficient. Leakage reactance calculations of polyphase machines.

Electric Circuit: Design of DC-machine windings: Simplex, Duplex and Multiplex Lap and Wave Windings, Design of AC machine windings: Concentric windings, Mush windings, Double layer integral slot and fractional slot lap and wave windings.

Thermal Circuit: Theory of Solid body heating, Heating and Cooling Curves, Calculation of surface temperature rise and hotspot temperature. Methods of cooling: axial and radial, Induced & forced Ventilation. Cooling of DC machines and turbo alternators, Calculation of quantity of cooling medium.

Design of Rotating Machines: Relation between rating and dimensions of rotating machines, Choice of specific electric and magnetic loadings, Separation of main dimensions (D and L) for DC machines, Induction Machines and Synchronous Machines. Output equation for DC-machine, Selection of No. of Poles, No. of armature slots, Length of air-gap and field pole design. Stator design for induction and synchronous machine, design of rotor slots end rings and wound rotor for induction machine. Design of rotor for salient and non-salient pole synchronous machines.

Design of Transformers: Output equation, Choice of flux density, Design of rectangular, square and stepped cores, and Design for minimum cost and minimum losses. Design of windings. Cooling of transformers, Design of transformer tanks and cooling ducts.

Design of Substations: Layouts for indoor and out-door substations for single feeder, double feeder and multi-feeder. Design of Power Capacitors. Selection and design of circuit breakers and Isolators. Basic design aspects of gas insulated substations (GIS), Design of substation Grounding.

References:

1. A. K. Sawhney, A course in Electrical Machine Design, Dhanpat Rai & Co. New Delhi. 6thEdition, 2013.
2. J.Pyrhonen, T. Jokinen, V. Hrabovcova, Design of Rotating Electrical Machines, JohnWiley & Sons, New Delhi, India,2013.
3. Alexander Gray, Electrical Machine Design, McGraw Hill, New York, 2008.
4. M.G.Say, Performance and Design of Ac Machines, Pitman Pub.
5. E Clayton & N.N. Hancook, Performance and design of DC machines, CBS Pub. 3rdEdition, 1998.

EE464	Energy Management And Auditing	DEC	3–0–0	3 Credits

Pre-requisites: EE415 - Industrial Electrical Systems

Course Outcomes: At the end of the course the student will able to:

CO1	To understand the basics of Energy management and audit
CO2	To understand the energy management of lighting systems and cogeneration
CO3	To understand the metering for energy management
CO4	To impact concepts behind economic analysis and Load management

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	1	1	1	2	1	2	3	3	3
CO2	3	3	3	2	3	1	1	1	2	1	2	2	3	3
CO3	3	3	3	3	3	1	1	1	3	1	3	3	3	3
CO4	3	3	3	2	3	1	1	1	2	1	2	2	3	3

1- Low correlation; 2 - Medium correlation; 3 - Strong correlation

Detailed Syllabus:

Energy Management and Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

Energy Management for Motors and Co-generation: Energy management for electric motors – Transformer and reactors - Capacitors and synchronous machines, energy management by cogeneration – Forms of cogeneration –Feasibility of cogeneration – Electrical interconnection.

Energy Management in Lighting Systems: Task and the working space - Light sources –Ballasts – Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics, lighting and energy standards.

Metering for Energy Management: Metering for energy management – Units of measure - Utility meters – Demand meters –Paralleling of current transformers – Instrument transformer burdens – Multi tasking solid state meters, metering location vs requirements, metering techniques and practical examples.

Economic Analysis and Models: Economic analysis – Economic models - Time value of money - Utility rate structures – Cost of electricity – Loss evaluation, load management – Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification,

SCADA: Introduction to SCADA, Fundamental Principles of Modern SCADA Systems, Advantages and Disadvantages, SCADA Hardware and Software, Emerging New Technologies in SCADA System.

References:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
2. Abbi, Y.P. and Jain, S., Handbook on Energy Audit and Environment Management, The Energy and Resources Institute, TERI, (2009).
3. Eastop T. D & Croft D. R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.
4. Reay D.A, Industrial Energy Conservation, First edition, Pergamon Press, 1977.
5. Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.
6. Electricity in buildings good practice guide, McGraw-Hill Education, 2016.

Open Elective Courses offered by EED

Open Elective – 1 (offered to other departments – V Semester)

EE340	**Introduction to Renewable Energy Systems**	**OPC**	**3-0-0**	**3 Credits**

Pre-requisites: EE101- Elements of Electrical Engineering
Course Outcomes: At the end of the course the student will able to:

CO1	Understand the need and applications of renewable energy systems
CO2	Understand the types and latest developments in renewable energy systems
CO3	Analyze the energy conversion process in solar and wind energy generating systems
CO4	Analyze the energy conversion process in bio and ocean energy generating systems
CO5	Analyze the energy conversion process in fuel cell and geothermal energy generating systems

Detailed Syllabus:

Renewable Energy Capacity Statistics across India and Global
Fossil fuel energy usage, climate change and global warming, role of renewable energy in sustainable development, Introduction to renewable energy systems, types of renewable energy systems, differences between renewable energy systems and Conventional energy systems, potential and current installation of renewable energy systems across India and Global.

Solar Photovoltaic Systems
Introduction to Solar Photovoltaic Cell, solar panels, History of PV development and deployment, the solar resource: Spectra, insolation, diffuse vs. direct, atmospheric absorption, metrics for specifying system output, land area requirements, MPPT.

Wind Energy Systems
Introduction, Principle of wind energy conversion, types of wind energy systems, Advantages and disadvantages of wind mills, Applications of wind energy.

Bio-Energy Systems
Energy from biomass, Sources of biomass, Different species, Conversion of biomass into fuels, Energy through fermentation, Pyrolysis, gasification and combustion Biogas plants, Properties and characteristics of biogas.

Ocean Energy Systems
Introduction, Principle of ocean thermal energy conversion (OTEC), Tidal power generation, Tidal energy technologies, Energy from waves, Wave energy conversion, Wave energy technologies, advantages and disadvantages.
Other Renewable Energy Systems

Introduction to Fuel Cell and Geothermal energy systems, working principle, advantages and disadvantages, latest developments in fuel cell and Geothermal energy systems.

References:

1. Edward S. Cassedy, Peter Z. Grossman “Introduction to Energy: Resources, Technology, and Society” Cambridge University Press, 1998
2. Charles R. Russell “Elements of Energy Conversion” Elsevier, 2013
3. Archie W. Culp “Principles of energy conversion” McGraw-Hill, 1979
4. Fang Lin Luo, Ye Hong “Renewable Energy Systems: Advanced Conversion Technologies and Applications” CRC Press, 2012

Open Elective – 2 (offered to other departments – VI Semester)

EE390	**Introduction to Electric Vehicles**	**OPC**	**3–0–0**	**3 Credits**

Pre-requisites: NIL

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

CO1	Calculation of the energy losses and performance efficiency of a conventional vehicle
CO2	Identify the power flow in electric and hybrid electric vehicles
CO3	Understand the global developments, standards and emerging research in EV Sector
CO4	Analyze the performance of Battery energy systems for electric vehicles
CO5	Illustrate the configurations of different types of EV Charging Stations

Detailed Syllabus:

UNIT I: Basic Concepts of Vehicle Energy and Fuel Consumption

Main elements of the energy conversion scheme in vehicle, Energy domains in vehicle propulsion systems, upstream processes, Energy density of on-board energy carriers, Fuel Efficiency, Pathways to better fuel economy, Energy losses – Engine losses, Drive train losses, Aerodynamic Friction losses, Rolling Friction losses, Uphill Driving force, Inertial forces, Performance and Drivability – Vehicle Operating modes, Energy Demand in Driving Cycles.

UNIT II: Vehicle Power Management in Electric and Hybrid Electric Vehicles

Configurations of Hybrid Electric Vehicles (HEVs) and Electric Vehicles (EVs), Power flow in HEVs – Series, Parallel, Series-Parallel and Power flow in EVs, Regenerative Braking, Battery Technologies, Role of Power Electronics and Electric Machines, Advantages over conventional vehicles.

UNIT III: Global & National Developments and Technical Standards in EV Sector

Global EV Outlook – Trends and Developments in EV markets, Promotion, Polices, IEA Technology Road map on Electric and Plug-in Hybrid Vehicles, Updates of National Electric Mobility Mission Plan (NEMMP) and Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme and Energy Efficiency Services Limited, Progress and plans of OEMs, Developments in EV charging stations, International Electrotechnical Commission (IEC) Standards on Battery Back, Wired & Wireless Charging, Electric Vehicle Conductive DC & AC Charging Systems by Automotive Industry Standards Committee (AISC) India.

UNIT IV: Battery Technologies and their performance in EVs

Battery Parameters, Battery Types-Lead Acid, Nickel based, Sodium based, Lithium, Metal Air based batteries, Comparison, Battery modeling, Use of Batteries in EVs, Ultracapacitor, Flywheel, Battery Charging, Battery Fast Charging, Battery Discharging, Battery efficiency, Battery Performance, Battery Testing, Battery Management System – SOC, SoH, Factors affecting failures of Battery.

UNIT V: EV Charging Infrastructure

Wired Charging Station (Static): Electric vehicle supply equipment, classification of Electric vehicle supply equipments, DC Charging Station-configuration, performance, AC Charging Station-configuration, performance, advantages and disadvantages of wired charging station, IEC standards for wired charging Station.

Wireless Charging Station (Dynamic): Composition of the wireless charging system, Wireless charging challenges, IEC Standards for wireless charging Station.

References:

1. Lino Guzzella and Antonio Sciarretta "Vehicle Propulsion Systems", Springer, 2005
2. Xi Zhang and Chris Mi "Vehicle Power Management" Springer, 2011
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained," John Wiley & Sons Ltd.
4. Sandeep Dhameja, "Electric Vehicle Battery Systems," Newnes.
5. Naoui Mohamed, Flah Aymen, Mohammed Alqarni, Rania A. Turky, Basem Alamri, Ziad M. Ali, Shady H.E. Abdel Aleem, "A new wireless charging system for electric vehicles using two receiver coils," Ain Shams Engineering Journal, Volume 13, Issue 2, 2022.
6. Online: https://www.iea.org/, IEA Global EV Outlook 2022
7. Online: https://heavyindustries.gov.in/writereaddata/Content/NEMMP2020.pdf, National Electric Mobility Mission Plan (NEMMP) 2020,
8. Online: https://fame2.heavyindustries.gov.in/, National Automotive Board (NAB), Ministry of Heavy Industries, Govt of India
9. Online: https://www.iso.org/, International Organization for Standardization
10. Online: https://www.araiindia.com/, Automotive Research Association of India (ARAI),
11. Online: https://www.siam.in/, Society of Indian Automobile Manufacturers (SIAM)
12. Online: https://eeslindia.org/en/home/, Energy Efficiency Services Limited,

Open Elective – 3 (offered to other departments – VIII Semester)

EE490	**Introduction to Smart Grids**	**OPC**	**3-0-0**	**3 Credits**

Pre-requisites: None

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

CO1	Understand different categories, features and operation of Smart grid
CO2	Apply the control and artificial intelligence techniques for the Smart Grid operation
CO3	Understand operation and importance of communication technologies and control in Smart Grids

Detailed Syllabus:

Introduction to Smart Grid and Smart Grid Architecture: Smart Grid Working and Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid –Indian Smart Grid – Key Challenges for Smart Grid - Components and Architecture of Smart Grid Design – Fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation

Tools and Techniques for Smart Grid: Computational Techniques – Static and Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms – Artificial Intelligence techniques.

Communication Technologies and Control of Smart Grid: Introduction to Communication Technology – Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS), Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.

References*:*

1. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press,2013
2. A.G. Phadke and J.S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer Edition, 2010.

Courses for Minor in Electrical Vehicles

(for All Branches – IV Semester)

EEM251	**Principles of Energy Conversion and Transmission in Vehicles**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EE101 - Elements of Electrical Engineering

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

CO1	Understand the basic concepts of energy conversion in conventional vehicles
CO2	Understand the energy losses and performance efficiency of a conventional vehicle
CO3	Understand the power flow in electric and hybrid electric vehicles
CO4	Identify the advantages of electric vehicles over the conventional vehicles

Detailed Syllabus:

Vehicle Energy and Fuel Consumption – Basic Concepts

Main elements of the energy conversion scheme in vehicle, Energy domains in vehicle propulsion systems, upstream processes, Energy density of on-board energy carriers, Fuel Efficiency, Pathways to better fuel economy, Energy losses – Engine losses, Drivetrain losses, Aerodynamic Friction losses, Rolling Friction losses, Uphill Driving force, Inertial forces, Vehicle emissions, Performance and Drivability – Vehicle Operating modes, Energy Demand in Driving Cycles, Methods and Tools to estimate the fuel consumption, Power flow of a conventional vehicle, Basic Concepts of Internal Combustion Engine, Gear Box.

Vehicle Power Management in Electric and Hybrid Electric Vehicles

Configurations of Hybrid Electric Vehicles (HEVs) and Electric Vehicles (EVs), Power flow in HEVs – Series, Parallel, Series-Parallel and Power flow in EVs, Regenerative Braking, Battery Technologies, Role of Power Electronics and Electric Machines, Advantages over conventional vehicles.

References*:*

1. Lino Guzzella and Antonio Sciarretta “Vehicle Propulsion Systems”, Springer, 2005
2. Xi Zhang and Chris Mi “Vehicle Power Management” Springer, 2011

Minor degree in Electric Vehicles (for All Branches – V Semester)

EEM301	**E-Mobility Developments and Standards**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

Course Outcomes: At the end of the course the student will able to:

CO1	Understand the global developments and emerging research in EV Sector
CO2	Understand the faster adoption of electric mobility and development of its eco-system in the country
CO3	Understand the technical standards on Electric Vehicle Conductive DC & AC Charging Systems
CO4	Understand the technical standards on Electric Vehicle Wireless Charging Systems and Battery Packs

Detailed Syllabus:

Global Developments in EV Sector

Global EV Outlook – Trends and Developments in EV markets, Promotion, Polices, IEA Technology Road map on Electric and Plug-in Hybrid Vehicles, Progress and plans of OEMs, Developments in EV charging stations, Research in EV Sector, Grid to Vehicle (G2V), Vehicle to Grid (V2G) and Vehicle to Everything (V2X), Supply from AC Grid, DC Grid, and Renewable / Distributed Generation, Role of Emerging Technologies in EV Sector – Machine Learning, Artificial Intelligence, Internet of Things, Bigdata, Block-chain, Data Science, Cyber Physical Systems, Smart Grids.

National Developments in EV Sector

National Electric Mobility Mission Plan (NEMMP), Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme, Indian OEMs & Startups in EV Sectors, Developments in EV charging stations, EV tariffs, Electric Vehicle Policies issued by the State Governments, Latest Guidelines and Standards for Charging Infrastructure for Electric Vehicles issued by Ministry of Power, Latest reports of NITI Aayog, Central Electricity Authority, Ministry of Power, Department of Science and Technology, Bureau of Energy Efficiency, Convergence Energy Services Limited, Energy Efficiency Services Limited.

Technical Standards in EV Sector

International Electrotechnical Commission (IEC) Standards on Full Vehicle, Battery Back, Wired & Wireless Charging, Bureau of *Indian Standards* (BIS), Electric Vehicle Conductive DC & AC Charging Systems by Automotive Industry Standards Committee (AISC) India, Other international standards from SAE, SAC and ISO, Global and Indian Patens in EV Sector.

References:

1. Online: https://www.iea.org/, IEA Global EV Outlook 2022
2. Online: https://heavyindustries.gov.in/writereaddata/Content/NEMMP2020.pdf, National Electric Mobility Mission Plan (NEMMP) 2020,
3. Online: https://heavyindustries.gov.in/, Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises
4. Online: https://fame2.heavyindustries.gov.in/, National Automotive Board (NAB), Ministry of Heavy Industries, Govt of India
5. Online: https://www.niti.gov.in/, NITI Aayog
6. Online: https://www.iso.org/, International Organization for Standardization
7. Online: https://www.araiindia.com/, Automotive Research Association of India (ARAI),
8. Online: https://www.siam.in/, Society of Indian Automobile Manufacturers (SIAM)
9. Online: https://cea.nic.in/, Central Electricity Authority
10. Online: https://powermin.gov.in/, Ministry of Power, GoI
11. Online: https://beeindia.gov.in/, Bureau of Energy Efficiency
12. Online: https://www.convergence.co.in/, Convergence Energy Services Limited,
13. Online: https://eeslindia.org/en/home/, Energy Efficiency Services Limited,
14. Online: http://resourcecenter.smartgrid.ieee.org/, IEEE Smart Grid Resource Centre
15. Online: http://resourcecenter.ieee-pes.org/, IEEE Power & Energy Society Resource Centre
16. Online: https://vtsociety.org/, IEEE Vehicular Technology Society (VTS)
17. Online: https://ieeexplore.ieee.org/, IEEE Xplore digital library
18. Online: https://tec.ieee.org/, *IEEE Transportation Electrification Community*
19. Online: https://www.iec.ch/*,* International Electrotechnical Commission
20. Online: https://www.bis.gov.in/, Bureau of *Indian Standards*
21. Online: https://ipindia.gov.in/, Intellectual Property India
22. Online: https://patents.google.com, Google Patents
23. Online: https://www.sae.org/, SAE International

Minor degree in Electric Vehicles (for All Branches – V Semester)

EEM302	**Battery Energy Storage and EV Charging Systems**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

Course Outcomes: At the end of the course the student will able to:

CO1	Understand the necessity of Battery systems for electric vehicles
CO2	Understand the configuration of different types of Charging Stations
CO3	Understand the current developments in charging stations across national and global

Detailed Syllabus:

Introduction to Battery Technology:
Battery Parameters, Battery Types-Lead Acid, Nickel based, Sodium based, Lithium, Metal Air based batteries, Comparison, Battery modeling, Use of Batteries in EVs, Ultracapacitor, Flywheel.

Battery Performance:
Battery Charging, Battery Fast Charging, Battery Discharging, Battery efficiency, Battery Performance, Battery Testing, Battery Management System – SOC, SoH, Factors affecting failures of Battery.

Wired Charging Station (Static):
Electric vehicle supply equipment, classification of Electric vehicle supply equipments, DC Charging Station-configuration, performance, AC Charging Station-configuration, performance, advantages and disadvantages of wired charging station, IEC standards for wired charging Station.

Wireless Charging Station (Dynamic):
Wireless charging challenges, Composition of the wireless charging system, Some Standarads.

Current Developments in Charging Stations across National and Global:

References:

1. James Larminie, John Lowry, “Electric Vehicle Technology Explained,” John Wiley & Sons Ltd.
2. Sandeep Dhameja, “Electric Vehicle Battery Systems,” Newnes.
3. Naoui Mohamed, Flah Aymen, Mohammed Alqarni, Rania A. Turky, Basem Alamri, Ziad M. Ali, Shady H.E. Abdel Aleem, “A new wireless charging system for electric vehicles using two receiver coils,” Ain Shams Engineering Journal, Volume 13, Issue 2, 2022.

Minor degree in Electric Vehicles (for All Branches – VI Semester)

EEM351	**Electric Drives for EVs**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

Course Outcomes: At the end of the course the student will able to:

CO1	Understand the need of drive systems for electric vehicles
CO2	Understand the characteristics and control strategies of different drive systems
CO3	Analyze the performance of different drive systems

Detailed Syllabus:

Introduction to Drive System:
Need of Variable Speed Drives, Fundamental Principles, Torque –Speed curves for Variable Speed Drives, types of Variable Speed Drives, Electrical Variable Speed Drive methods, advantages, sizing of Drive Systems, Drive system efficiency, Drive system control.

DC Drives:
Basic Principle of DC Motor Drives, Configuration, Performance Analysis and Control of DC motor drives, Advantages and disadvantages.

Induction Motor Drives:
Basic Principle of Induction Motors, Equivalent Circuit of Induction Motor, Speed Control of Induction Machine, Performance Analysis and Control of induction motor drives, Variable Frequency, Variable Voltage Control of Induction Motors, Advantages and disadvantages.

Permanent Magnet Motor Drives:
Basic Configuration of PM Motors, Basic Principle and Operation of PM Motors, Performance Analysis and Control of Permanent Magnet motor drives, Magnetic Circuit Analysis of IPM Motors, Sizing of Magnets in PM Motors, Advantages and disadvantages.

Other Drives:
Basic Principle of SRM Motor Drives, Configuration, Performance Analysis and Control of SRM motor drives, Advantages and disadvantages. Doubly Salient Permanent Magnet Machines-Basic Principle and Performance Analysis.

References:

1. Malcolm Barnes, “Practical Variable Speed Drives and Power Electronics”, Elsevier.

2. Chris Mi, M. Abul Masrur, and Davis Wenzhong Gao “Hybrid Electric Vehicles-Principles and Applications with practical Perspectives”, A John Wiley & Sons, Ltd., Publication.
3. John M. Miller, “Propulsion Systems for Hybrid Vehicles”, The Institution of Engineering and Technology.

Minor degree in Electric Vehicles (for All Branches – VI Semester)

EEM352	**EV Battery Charging Systems Lab**	**PCC**	**2-0-0**	**2 Credits**

Pre-requisites: EEM302- Battery Energy Storage and EV Charging Systems

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

CO1	To learn and understand the basic concepts of battery modelling
CO2	Understand the impact of temperature and cell balancing on batteries
CO3	To determine the battery performance (SOC and SOH)
CO4	To learn the building of EV chargers for a two-wheeler
CO5	To learn and understand the experimental procedure on EV battery system

List of Experiments

1) To build a simple model of a Battery pack in MATLAB and Simscape
2) To analyse the impact of Temperature on Lithium-Ion Temperature Battery Module
3) To build model of Battery Pack with Cell Balancing Circuit
4) To predict Battery State of Charge using Machine Learning
5) To determine Battery charging and discharging using a constant current and constant voltage algorithm
6) To estimate the Battery State-of-Charge (SOC) by using a Kalman filter
7) To estimate the Battery internal resistance and State-of-Health (SOH) by using an adaptive Kalman filter
8) To build a model of an on-board charger for a two-wheeler vehicle
9) To Experiment on EV Battery Charging System with real-time conditions

References: https://in.mathworks.com/

- *https://in.mathworks.com/solutions/electrification/battery-systems.html*
- *https://in.mathworks.com/help/sps/ug/lithium-ion-temperature-dependent-battery-model.html?searchHighlight=battery%20model&s_tid=srchtitle_battery%2520model_4*
- *https://in.mathworks.com/help/simscape-battery/ug/build-battery-pack-cell-balancing.html?searchHighlight=battery%20model&s_tid=srchtitle_battery%2520model_6*
- *https://in.mathworks.com/help/stats/predict-battery-soc-using-machine-learning.html?s_tid=srchtitle_ev%20battery%20soc_10*
- *https://in.mathworks.com/help/simscape-battery/ug/battery-constant-current-constant-voltage.html*
- *https://in.mathworks.com/help/simscape-battery/ug/battery-state-of-charge-estimation.html*
- *https://in.mathworks.com/help/simscape-battery/ug/battery-state-of-health-estimation.html*
- *https://in.mathworks.com/help/sps/ug/on-board-charger-for-two-wheeler-electric-*

vehicle.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_7

Minor degree in Electric Vehicles (for All Branches – VII Semester)

EEM401	**EV Propulsion Systems Lab**	**PCC**	**2-0-0**	**2 Credits**

Pre-requisites: EEM351- Electric Drives for EVs

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

CO1	To learn and understand the electrical system of a vehicle
CO2	Understand the torque-speed characteristics of different motors
CO3	To analyse the basic architecture of a power-split hybrid vehicle
CO4	Understand the working phenomena of different EV motor drives
CO5	Developing power loss models of EV propulsion systems

List of Experiments

1) To simulate the electrical system of a vehicle using Simulink and Simscape
2) To study a comparison of the torque-speed characteristics for different motor types
3) To build the basic architecture of a power-split hybrid vehicle electrical transmission
4) To build a simulation model of DC Drive for EV application
5) To build a simulation model of Induction Motor Drive for EV application
6) To build a simulation model of PMSM Drive for EV application
7) To build a simulation model of Switched Reluctance Motor Drive for EV application
8) To experiment speed control techniques of EV motor drives
9) Developing power loss models and efficiency mapping of power converters used in EV drive systems

References: https://in.mathworks.com/

- *https://in.mathworks.com/help/simulink/slref/vehicle-electrical-system.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_6*
- *https://in.mathworks.com/help/sps/ug/motor-torque-speed-curves.html?searchHighlight=induction%20motor&s_tid=srchtitle_induction%20motor_17*
- *https://in.mathworks.com/help/mcb/gs/sensorless-foc-acim-using-smo-fo.html?searchHighlight=induction%20motor&s_tid=srchtitle_induction%20motor_11*
- *https://in.mathworks.com/help/sps/ug/power-split-hybrid-vehicle-electrical-network.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_9*
- *https://in.mathworks.com/help/sps/ug/hev-pmsm-drive-test-harness.html#d119e626*
- *https://in.mathworks.com/help/sps/ug/ipmsm-torque-control-in-a-series-parallel-hev.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_17*

- *https://in.mathworks.com/help/sps/ug/ipmsm-torque-control-in-a-parallel-hev.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_18*
- *https://in.mathworks.com/help/sps/ug/ipmsm-torque-control-in-a-series-hev.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_23*
- *https://in.mathworks.com/help/sps/ug/switched-reluctance-motor.html?searchHighlight=electric%20vehicle&s_tid=srchtitle_electric%2520vehicle_47*