NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

for B.Tech. Program in

Electrical and Electronics Engineering

(Effective from AY2021-22)

DEPARTMENT OF ELECTRICAL ENGINEERING

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Electrical Engineering

VISION

To excel in education, research and technological services in electrical engineering in tune with societal aspirations.

MISSION

- Impart quality education to produce globally competent electrical engineers capable of extending technological services.
- Engage in research & development in cutting edge and sustainable technologies.
- Nurture scientific temperament, professional ethics and industrial collaboration.

Department of Electrical Engineering:

Brief about the Department:

The Department of Electrical Engineering was established in the year 1959 in the Regional Engineering College Warangal, which was converted into a National Institute of Technology in the year 2003.

Since the inception of the Institute, the department has been developing state-of-the-art Infrastructure to cater to the needs of technical education and cutting-edge research. In its formative years, the department received considerable financial and logistical support from UNESCO. Later, the Department was funded principally by the MHRD, GOI, which is augmented by aid from various other agencies such as the Institutional Network Scheme (INS) and TEQIP. Well-qualified, well-trained and dedicated faculty propels the development of the department. The department enjoys a position of eminence in the field of technical education and research. The Department of Electrical Engineering started offering postgraduate programs since the year 1964. Currently, the Department offers three PG programs in Power Systems Engineering, Power Electronics and Drives, and Smart Electric Grid.

The establishment of postgraduate courses has significantly contributed towards the advancement of research and consultancy activities of the department. To fulfill the objectives stated in the mission and vision of the institute, the department organized several faculty development programs, conferences, and refresher courses, which cater to the needs of industries and utilities (DRDO, BHEL, TATA power companies, VSP to name a few). The department also organized several continuing education programs in emerging areas for faculty of educational institutions throughout the country. The Department is recognized as a QIP center for M. Tech programs in Electrical Engineering.

The Department of Electrical Engineering has always been a hub of active research. Several research projects, sponsored by MHRD, CSIR, DST, DRDO, SPARC, and other private and governmental organizations have successfully been executed by the faculty of the department. Currently, about 65 doctoral students are pursuing their Ph.D. degrees in various areas of research.

In its sixty-two years of journey, the department had quite a few academic and research accomplishments. A few of them are enumerated below:

- Several funded research projects, to the tune of Rs. 300 Lakhs, are currently under execution, promising high research outcomes.
- A Power System Study Cell was established by the erstwhile APSEB to train their engineers in software pertaining to power systems.
- A sponsored research project was successfully executed, which aims to study the impact of the electrical load of the Vizag Steel Plant on the grid. This project was awarded to the department despite stiff competition from several institutes of higher learning.
- The department has been awarded a center of excellence in power and energy systems, which is in the process of being established.
- All academic programs offered by the department had been accredited by NBA for a full-time period of 5 years in the years 2008 and 2013
- As many as 26 consultancy projects were completed for the vetting of electromechanical designs for lift irrigation projects by the Governments of Telangana and Andhra Pradesh.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Electrical and Electronics Engineering
BTech (Hons.)	Electrical and Electronics Engineering
	Minor in Electrical Engineering
M.Tech.	Power Electronics and Drives
	Power Systems Engineering
	Smart Electric Grid
PG diploma	Power Electronics and Drives
	Power Systems Engineering
	Smart Electric Grid
Ph.D.	Electrical Engineering

Note: Refer to the Rules and Regulations for B.Tech. program (weblink) given in the institute website.

B.Tech. – Electrical and Electronics Engineering

Program Educational Objectives

PEO-1	Design, develop, innovative products and services in the field of electrical and electronics engineering.
PEO-2	Apply the knowledge of electrical and electronics engineering to solve problems of social relevance,
PEO-3	Work effectively as individuals and as a team in multidisciplinary projects.
PEO-4	Engage in lifelong learning, pursue higher education and research, career enhancement and adapt to changing professional needs.

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4
Impart quality education to produce globally competent electrical engineers capable of extending technological services.	3	3	2	2
Engage in research & development in cutting edge and sustainable technologies.	1	2	1	3
Nurture scientific temperament, professional ethics and industrial collaboration.	3	3	2	2

1-Slightly; 2-Moderately; 3-Substantially

B.Tech. – Electrical & Electronics Engineering

Program Outcomes

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, electrical & electronics engineering 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 electrical & electronics engineering.
PO3	**Design/Development of solutions:** Design solutions for complex electrical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health, safety and the cultural, societal and environmental considerations.
PO4	**Conduct investigations of complex problems:** Adopt research-based knowledge including design of experiments, analysis and interpretation of data, synthesis of the information to provide valid conclusions to electrical & electronics engineering problems.
PO5	**Modern tool usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex electrical & electronics 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 electrical engineering practice.
PO7	**Environment and sustainability:** understand the impact of the professional electrical engineering solutions in societal and environmental contexts, demonstrate the knowledge of and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.
PO9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex electrical engineering activities with the 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 electrical engineering and management principles and apply these to electrical engineering work, as a member and leader in a team, to manage projects 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.

Program Specific Outcomes

PSO-1	Analyse, synthesize and design electrical and electronic equipment and systems to enhance the quality of human life.
PSO-2	Develop innovative and environment–conscious electrical and electronic technologies to sustain human life.

SCHEME OF INSTRUCTION

B.Tech. Electrical & Electronics Engineering – Course Structure

I - Year, I – Semester

S. No.	Course Code	Course title	L	T	P	Credits	Cat. Code
1.	EE101	Basic Electrical Circuits	3	0	0	03	ESC
2.	MA132	Calculus and Laplace Transforms	3	0	0	03	BSC
3.	HS131	English for oral Communication & Report Writing	2	0	2	03	HSC
4.	PH132	Engineering Physics	3	0	2	04	BSC
5.	ME133	Engineering Drawing	0	1	2	02	ESC
6.	CS131	Problem Solving & Computer Programming	3	0	2	04	ESC
7.	IC001	Induction Program				0	MNC
8.	IC101	EAA: Games and Sports	0	0	2	0	MNC
Total			**14**	**1**	**8**	**19**	

I- Year, II – Semester

S. No.	Course Code	Course title	L	T	P	Credits	Cat. Code
1.	EE151	Electrical Network Analysis	3	0	0	03	PCC
2.	EE152	Electric and Magnetic Fields	3	0	0	03	PCC
3.	MA182	Fourier Series, Matrices and Differential Equations	3	0	0	03	BSC
4.	CY185	Engineering Chemistry	3	0	2	04	BSC
5.	CE181	Basic Engineering Mechanics	2	0	0	02	ESC
6.	ME182	Thermodynamics for Electrical Engineering	3	0	0	03	ESC
7.	ME183	Workshop Practice for Electrical Engineering	0	0	2	01	ESC
8.	IC151	EAA: Games and Sports	0	0	2	0	MNC
Total			**17**	**0**	**4**	**19**	

Note: BSC – Basic Science Courses
ESC – Engineering Science Courses; PCC – Professional Core Courses
PEC – Professional Elective Courses; OEC – Open Elective Courses
HSC – Humanities and Social Science Courses
MNC – Mandatory Non-credit Courses

SCHEME OF INSTRUCTION

B.Tech. Electrical & Electronics Engineering – Course Structure

II- Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	EE 201	Electrical Machines – I	3	0	0	3	PCC
2.	EE 202	Power Systems-I	3	0	0	3	PCC
3.	EE 203	Python programming	2	0	2	3	ESC
4.	MA 232	Complex Variables and Partial Differential Equations	3	0	0	3	BSC
5.	EC 231	Analog Electronics	3	0	2	4	PCC
6.	CS 231	Data Structures	3	0	2	4	ESC
7.	EE 204	Electrical Networks Lab	0	1	2	2	PCC
8.		Mandatory Non-Credit course	1	0	0	0	MNC
Total			**17**	**1**	**8**	**22**	

II- Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	EE 251	Electrical Machines-II	3	0	0	3	PCC
2.	EE 252	Power Systems-II	3	0	0	3	PCC
3.	EE 253	Control Systems	3	0	0	3	PCC
4.	EE 254	Electrical Measurements & Instrumentation	3	0	2	4	ESC
5.	MA 282	Numerical Methods and Statistics	3	0	0	3	BSC
6.	EC 281	Digital Electronics	3	0	0	3	PCC
7.	SM 282	Power Economics & Accountancy	3	0	0	3	HSC
8.	EC 282	IC Applications Lab	0	1	2	2	PCC
Total			**21**	**1**	**4**	**24**	

SCHEME OF INSTRUCTION

B.Tech. Electrical & Electronics Engineering – Course Structure

III- Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	EE 301	Electrical Machines III	2	0	0	2	PCC
2.	EE 302	Power Electronics	3	0	0	3	PCC
3.	EE 303	Digital Signal Processing	3	0	0	3	PCC
4.	EC 331	Synthesis of Digital Systems	3	0	0	3	PCC
5.		Department Elective-I	3	0	0	3	PEC
6.	EE 304	Microprocessors & Microcontrollers	3	0	2	4	PCC
7.	EE 305	Electrical Machines Lab- I	0	1	2	2	PCC
8.	EE 306	Control Systems Lab	0	1	2	2	PCC
9.	EC 332	Digital Synthesis Lab	0	1	2	2	PCC
Total			**17**	**3**	**8**	**24**	

III- Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	EE 351	Smart Grid Technologies	2	0	0	2	PCC
2.	EE 352	Power System Operation & Control	3	0	0	3	PCC
3.	EE 353	Electric Drives	3	0	0	3	PCC
4.	EE 354	Power system protection	3	0	0	3	PCC
5.	EC 382	Analog & Digital Communication systems	3	0	0	3	PCC
6.		Open-Elective I	3	0	0	3	OEC
7.	EE 355	Electrical Machines Lab -II	0	1	2	2	PCC
8.	EE 356	DSP Lab	0	1	2	2	PCC
9.	EE 398	Seminar	0	0	2	1	SEM
10.		Mandatory Non-Credit course	1	0	0	0	MNC
Total			**17**	**2**	**6**	**22**	

SCHEME OF INSTRUCTION

B.Tech. Electrical & Electronics Engineering – Course Structure

IV- Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	EE 401	HVDC & FACTS	3	0	0	3	PCC
2.		Department Elective-II	3	0	0	3	PEC
3.		Open- Elective II	3	0	0	3	OEC
4.	EE 402	Power Electronics & Drives Lab	0	1	2	2	PCC
5.	EE 403	Electrical Simulation Lab	0	1	2	2	PCC
6.	EE 404	Power Systems Lab	0	1	2	2	PCC
7.	EE449	Summer Internship/ EPICS	0	0	4	2	PCC
Total			**9**	**3**	**10**	**17**	

IV - Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.		Department Elective –III	3	0	0	3	PEC
2.		Department Elective –IV	3	0	0	3	PEC
3.		Department Elective –V	3	0	0	3	PEC
4.	EE 499	Project Work	0	0	8	4	PW
Total			**9**	**0**	**8**	**13**	

**** Courses with the following codes are theory cum Lab with 2-0-2:3 credits**
HS131, EE203

Courses with the following codes are theory cum Lab with 3-0-2:4 credits
PH132, CS131, CY185, EC231, CS231, EE 304, EE254

Credits in Each Semester									
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Sem-V**	**Sem-VI**	**Sem-VII**	**Sem-VIII**	**Total**
BSC	7	7	3	3					**20**
ESC	9	6	7	4					**26**
PCC		6	12	14	21	18	11		**82**
PEC					3		3	9	**15**
OEC						3	3		**6**
HSC	3			3					**6**
MNC	0	0	0	0		0			**0**
Project								4	**4**
Seminar						1			**1**
Internship									
Total	**19**	**19**	**22**	**24**	**24**	**22**	**17**	**13**	**160**

Professional Elective Courses:

Department Elective-I (III Year, I Semester)		
S. No.	**Course Code**	**Course title**
1.	EE 311	Computer Organization
2.	EE 312	Utilization of Electrical Energy
3.	EE 313	Industrial Instrumentation and Automation
4.	EE 314	Basics of Internet of Things
5.	SM 332	Energy Analytics
Department Elective-II (IV Year, I Semester)		
S. No.	**Course Code**	**Course title**
1.	EE 411	AI Techniques in Electrical Engineering
2.	EE 412	Computer Methods in Power Systems
3.	EE 413	Discrete Time Control System
4.	EE 414	Energy Storage Systems and Applications
5.	EE 415	Modelling & Analysis of Electrical Machines
6.	EE 5104	Control and Integration of Renewable Energy Sources
7.	EE 5114	Electric Vehicles
8.	EE 5304	Restructured Power Systems
9.	MA 5331	Numerical Optimization Techniques
Department Elective-III, IV & V (IV Year, II Semester)		
S. No.	**Course Code**	**Course title**
1.	EE 461	Design of Electrical Systems
2.	EE 462	Switched Mode Power Conversion
3.	EE 463	High Voltage Engineering
4.	EE 464	Advanced Electrical Drive Systems
5.	EE 465	Planning an Entrepreneurial Venture
6.	EE 466	Illumination Engineering
7.	EE 467	Bio-Inspired algorithms and Applications
8.	EE 468	Optimal Control Theory
9.	EE 469	State Space Approach to Control Systems
10	EE 5165	Advanced Control Techniques for Power Converters
11.	EE 5252	Real Time Control of Power Systems
12.	EE 5261	Distribution System Planning and Automation

DETAILED SYLLABUS

B.Tech.

Electrical & Electronics Engineering

EE101	BASIC ELECTRICAL CIRCUITS	3-0-0: 3

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

CO1	Analyze electric DC circuits and identify the dual for a given electric circuit.
CO2	Analyze magnetic circuits, evaluate steady-state response and determine resonance characteristics of AC electric circuits.
CO3	Formulate the dynamic response, evaluate initial conditions and asses the time- domain response of RLC circuits.
CO4	Synthesize electrical excitations with standard signals and use Laplace Transformations and the convolution integral to solve electric circuits

Course Articulation Matrix:

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

Syllabus:

Circuit Elements and Relations: Types of circuit components, KVL and KCL, Types of Sources and Source Transformations, Star-delta transformation, DC circuit analysis, Formation of loop and node equations, Graph of a network, Incidence matrix, Dual-networks.

Magnetic Circuits: Concept of MMF, flux and magnetic reluctance, Self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

Steady State Analysis of Circuits for Sinusoidal Excitations: Concept of phasors, Single phase Series, Parallel, Series Parallel circuits, Concept of power factor, Solution of AC networks using mesh and nodal analysis, Phasor diagrams, 3-phase balanced and unbalanced network analysis, Neutral voltage calculations, complex power.

Resonance: Series and Parallel resonance, Bandwidth, Q-factor and selectivity.

Time Domain Analysis: Solution of network equations in time domain, Classical differential- equations approach, Initial conditions & evaluation, applications to simple RLC circuits only.

Applications of Laplace Transforms in Circuit Theory: Laplace transforms of various signals of excitation, Laplace transformed networks, determination and representation of initial conditions, Waveform synthesis, Response for impulse function and its relation to network admittance, Convolution integral and applications.

Learning Resources:

Text Books:

1. Network Analysis, M.E.Van Valken Burg, Pearson Education, 2015, 3rd Edition.

2. Engineering Circuit Analysis, William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Tata McGraw Hill, 2013, 8th Edition.
3. Linear circuit Analysis, De Carlo, Lin, Oxford University Press, 2010, 2nd Edition.

Reference Books:

1. Fundamentals of Electric Circuits, Alexander C.K., Sadiku M.N.O., McGraw Hill Education, 2019, 6th Edition.
2. Electric Circuits, Joseph A. Edminister, Mahmood Nahvi, Schaum's series, McGraw-Hill Education, 2017, 5th Edition.
3. Electric Circuit Analysis, S.R. Paranjothi, New Age International Publications, 2011, 4th Edition.
4. Network Analysis, G.K Mittal, Ravi Mittal, Khanna Publications, 2003, 14thEdition.
5. A course in Electrical Circuits Analysis, M.L. Soni, J.C. Gupta, Dhanpat Rai & Co., 2001

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/106/108106172/

MA132	CALCULUS AND LAPLACE TRANSFORMS	3-0-0: 3

Pre-Requisites: NIL

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

CO1	Apply Laplace transforms to solve differential equations arising in engineering
CO2	Find the maxima and minima of multivariable functions
CO3	Evaluate multiple integrals in various coordinate systems
CO4	Apply the concepts of gradient, divergence and curl to formulate engineering
CO5	Convert line integrals into surface integrals and surface integrals into volume

Course Articulation Matrix:

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

Syllabus:

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem; Applications of Laplace transforms - Elementary treatment of ODE required for LT, solving certain initial value problems, solving system of linear differential equations

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Functions of several variables - partial differentiation; total differentiation; Change of variables - Jacobians; maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers

Integral Calculus: Beta and Gamma integrals; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals

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; Stoke's theorem; Gauss Divergence theorem.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, **R. K. Jain and S. R. K. Iyengar**, Narosa Publishing House, 2016, Fifth Edition
2. Advanced Engineering Mathematics, **Erwin Kreyszig**, John Wiley and Sons, 2015, Eighth Edition

3. Calculus and Analytic Geometry, **George B. Thomas and Ross L. Finney**, Pearson, 2020, Ninth Edition

Reference Books:

1. Advanced Engineering Mathematics, **Dennis G. Zill**, Jones & Bartlett Learning, 2018, 6th Edition
2. Higher Engineering Mathematics, **B. S. Grewal**, Khanna Publishers, 2012, 42nd Edition.

HS131	ENGLISH FOR ORAL COMMUNICATION AND REPORT WRITING	2-0-2: 3

Pre-Requisites: English proficiency above B1 level as per the CEFR for languages.

Course Outcomes:

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

CO1	Develop the purpose, goal of writing and speech, and an approach of persuading the audience.
CO2	Order and structure the material and the flow of information to support argument in speech and writing.
CO3	Create a report outline to link sections to support the persuasive message.
CO4	Present experimental data using the principles of statistical analysis.
CO5	Edit technical documents by efficiently structuring the data and avoiding common infelicities of style.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module 1: Defining the Features of Technical Writing & Presentations

- Principles of a Technical Report
- Know Your Audience, Purpose and Length of Report
- Understand the cornerstones of a presentation
- Define the various purposes of presentations and plan the correct structure

Module 2: Plan and Structure: Writing & Speaking with Purpose

- Headings, Chapters and sections
- Running headers and footers
- Types of reports and templates to use
- Main Idea and Arranging Details in Logical Sequence
- Writing styles & techniques
- Focus on your audience's needs
- Word choice, tone, and what to include

Module 3: Audience Awareness & Editing

- Use correct grammar and punctuation to avoid common errors in reports & oral presentations
- Create a professional, readable and visually attractive report & oral presentation
- Follow a three-step editing process

Module 4: Style of Writing & Use of Graphics

- Writing Clear Sentences and paragraphs
- Remove Jargon, Redundancy and Wordiness
- Kinds of graphics and their messages
- Suitability for placement in a graphic representation

Module 5: Group Practice and Interactive Session

- Spotting common language problems (lengthy and confusing sentence structures, weak vocabulary, etc)
- Editing Content, Logic and Language in speech & writing
- Guided writing practice with examples (Participants are to bring along their reports for group learning, editing and discussion)
- Drafting – the mindset to avoid writer's block
- Checking your own reports and presentations
- Giving and receiving constructive feedback – what makes a review effective?

Module 6: From Written Report to Verbal Presentation

- Gather, analyse, organise and deliver technical information meaningfully
- Use rhetorical devices and elements of persuasion to engage your audience

Learning and Assessment:

Lectures, assignments, writing-groups, interactive quizzes and online/classroom discussion, instructor & peer evaluation will form teaching-learning mode. Learners are expected to work on written assignments, classroom tasks as part of fulfilling the course objectives. Assessment will be continuous and will be carried out through interactive quizzes, written work, instructor & peer evaluation. There will also be two minor tests followed by a mid-exam and an end semester exam.

Learning Resources:

Text Books: Recommended Reading

1. Powell, M. (2011). *Dynamic presentations. Student's book with audio CDs*. Germany: Cambridge University Press.

2. Allison J., Powell, M. (2014). *In Company 3.0: Upper Intermediate*. Germany: Macmillan.

Reference Books:

1. Mort, S. (2017). Professional Report Writing. United Kingdom: Taylor & Francis. **(drawn from the list prescribed by AICTE)**

2. Sharma, S., Raman, M. (2015). Technical Communication: Principles and Practice. India: Oxford University Press.

3. Effective Communication Skills. (2016). India: KHANNA Publishers.

4. Lata, P., Kumar, S. (2015). CommunicationSkills, Second Edition. India: Oxford University Press.

Online Resources:

1. Excelsior Online Writing Lab - https://owl.excelsior.edu/esl-wow/

2. The Purdue Writing Lab Resources - https://owl.purdue.edu/
3. Queen's University Student Academic Service Sources (SASS)- https://sass.queensu.ca/onlineresource/topics/#WC
4. Boise State University open source textbook on Technical Communication. https://boisestate.pressbooks.pub/anintroductiontotechnicalcommunication/front-matter/introduction/

PH132	ENGINEERING PHYSICS	3-0-2: 4

Pre-Requisites: none

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

CO1	Apply the concept of wave and particle duality of radiant energy in solving problems.
CO2	Understand the applications of lasers in electrical engineering.
CO3	Understand the utility of different materials for engineering applications.
CO4	Apply the concepts of interference, diffraction, and polarization in engineering measurements.
CO5	Make use of lasers and optical instruments for experimentation.
CO6	Demonstrate quantum nature of radiation using photoelectric effect.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	3	1	1	1	1	1	1	1	1	1	1	1	2	1
CO4	3	3	2	2	1	1	1	1	1	1	1	1	1	1
CO5	2	2	1	2	2	1	1	1	1	1	1	1	1	1
CO6	3	2	2	1	1	1	1	1	1	1	1	1	1	1

Syllabus:

Optics and Optical Devices

Interference and Diffraction: Concept of interference, working of Fabry-Perot Interferometer and its application as wavelength filter, concept of diffraction, single, double and multiple slit diffraction, circular aperture diffraction, working of diffraction grating and application of grating.

Polarization Devices: Principles, working and applications of wave plates, Half-shade polarimeter, polariscope.

Lasers: Fundamentals of Laser, Einstein coefficients, construction and working of He-Ne laser, qualitative treatment of Nd-YAG, CO2, semiconductor lasers, applications in electrical engineering.

Optical Fibers: Principle and working of optical fiber, structure, types, advantages of optical fiber, light guiding mechanism and properties, applications in electrical engineering.

Solar Cells: Solar spectrum, photovoltaic effect, structure and working principle of solar cell, I- V characteristics, power conversion efficiency, materials for PV, emerging PV technologies for alternative energy devices.

Materials and Devices for Electrical Engineering

Magnetic Materials: Introduction - Weiss Theory of Ferromagnetism –Properties – Domains – Curie Transition - Hard and soft magnetic materials – Spinel Ferrites – Structure – Classification – Applications in electrical engineering.

Superconductors**:** Introduction to superconductivity**,** Meissner effect - Type-I and Type-II Superconductors – Applications in electrical engineering.

Dielectric Materials**:** Introduction to Dielectrics, Dielectric constant, polarizability, properties and types of insulating materials, polarization mechanisms in dielectrics (Qualitative), frequency and temperature dependence of polarization, dielectric loss, Clausius – Mossotti equation (qualitative), dielectric breakdown, applications in electrical engineering (electrolytic capacitor)**.**

Piezoelectric materials**:** Properties, production and detection of ultra sonics, applications in electrical engineering.

Semiconductor Materials and Devices**:** Types of semiconductor materials, temperature and concentration effects on band gap, Hall effect, PN junction diode, photodiode, LED, junction transistor, phototransistor.

Quantum Mechanics

Introduction to quantum theory, concepts and experiments led to the discovery, wave particle duality-Davisson-Germer experiment, Heisenberg uncertainty principle, Schrodinger time independent wave equation, the free particle problem - particle in an infinite and finite potential well, quantum mechanical tunnelling, applications.

Functional Materials

Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, high temperature materials and smart materials, properties and applications.

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser – Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of capacitance by using R-C circuit.
6. Determination of resonating frequency and bandwidth by LCR circuit.
7. Measurement of half-life of radioactive source using GM Counter.
8. Diffraction grating by normal incidence method.
9. a) Determination of plank's constant by photo electric effect
   b) Study of V-I characteristics of photodiode by photoelectric effect
10. Determination of acceptance angle and numerical aperture of optical fiber

Learning Resources:

Text Books:

1. Fundamentals of Physics by Halliday, Resnic and Walker, John Wiley, Ninth Edition, 2011.
2. Concepts of Modern Physics by Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw Hill Publications, Sixth edition,2009.
3. Physics Laboratory Manual by Physics Department, NIT Warangal, 2021.

Reference Books:

1. Optics by Ajoy K.Ghatak ,Tata McGraw Hill, Sixth Edition, 2017.

2. Solid State Physics by S.O.Pillai, New Age Publishers, eighth edition,2018
3. Understanding Lasers An Entry-Level Guide, by Jeff Hecht ,Wiley Publications, Fourth edition,2018.
4. Practical Physics by G.L.Squire, Cambridge University press, fourth edition,2001.
5. Engineering Physics Practical by Dr.S.K.Gupta Krishna Prakashan Publications, ninth edition,2010.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/
2. Amrita Virtual labs

ME133	ENGINEERING DRAWING	0-1-2: 2

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

CO1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined in CAD environment
CO4	Analyse the internal details of an object through sectional views in CAD environment.

Course Articulation Matrix:

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

Syllabus:

Introduction:

Drawing instruments and their uses, Types of lines, Lettering, General rules for dimensioning, Geometrical constructions using instruments. (**Conventional**)

Orthographic Projection:

Methods of projection, Principles of Orthographic projection, First angle versus third angle of projection, Six views of an object, Conventions. (**Conventional**)

Projection of Points:

Projections of points when they are situated in different quadrants. (**Conventional**)

Fundamentals of AutoCAD:

Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES (**AutoCAD**)

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. (**AutoCAD**)

Projections of Planes:

Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes. (**AutoCAD**)

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. (**AutoCAD**).

Section of Solids:

Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section. (**AutoCAD**)

Learning Resources:

Text Books:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, 53rd Edition, Charotar Publishers, 2016.

Reference Books:

1. Agarwal, B, Engineering Drawing, Second edition, McGraw Hill Education, 2015
2. Prof. Sham Tickoo, *AutoCAD 2017 for Engineers & Designers*, 23ed, Dreamtech Press

CS131	PROBLEM SOLVING AND COMPUTER PROGRAMMING	3-0-2: 4

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

CO1	Understand algorithms for solving simple mathematical problems including computing, searching and sorting
CO2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO3	Explore the internals of computing systems to suitably develop efficient algorithms
CO4	Examine the suitability of data types and structures to solve specific problems
CO5	Apply control structures to develop modular programs to solve mathematical problems
CO6	Apply object oriented features in developing programs to solve real world problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	2	1	3	2	1	1	1	1	1
CO4	2	2	1	1	1	1	2	1	1	1	2	2	1	1
CO5	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO6	2	1	1	1	1	1	1	1	1	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus: Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.
Number systems and data representation, Basics of C++, Basic data types.
Numbers, Digit separation, Reverse order, Writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.
Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions.

Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays, String processing, File operations.
Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Laboratory Syllabus:

1. Programs on conditional control constructs.

2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

Text Books / Reference Books / Online Resources:

1. Walter Savitch, "*Problem Solving with C++*", Ninth Edition, Pearson, 2014.
2. Cay Horstmann, Timothy Budd, "*Big C++*", Wiley, 2nd Edition, 2009.
3. R.G. Dromey, "*How to solve it by Computer*", Pearson, 2008.

EE151	ELECTRICAL NETWORK ANALYSIS	3-0-0: 3

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

CO1	Simplify the analysis of electric circuits using network theorems
CO2	Determine the driving point immittance's of single-port networks in frequency domain using poles and zeros
CO3	Analyze and simplify two-port networks using their properties and interrelationships
CO4	Apply Fourier series and Fourier Transformation to analyze electric circuits with periodic and aperiodic excitations.

Course Articulation Matrix:

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

Syllabus:

Network Theorems: Superposition theorem, Reciprocity theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem.

Network Functions: Driving point impedance and transfer functions of 1-port RLC Networks, Natural frequencies of a network, Poles and Zeros of driving point impedances.

Two Port Networks: Impedance, admittance, transmission and hybrid parameters of two-port networks and inter-relationship.

Analysis of Electric Circuits with Periodic Excitation: Review of Fourier series and evaluation of Fourier coefficients, Trigonometric and complex Fourier series for repetitive waveforms, concept of harmonic power.

Applications of Fourier Transforms for Electrical Circuits: Amplitude and phase spectra, Fourier transforms and Parseval's theorem and application to network analysis with aperiodic excitations.

Learning Resources:

Text Books:

1. Network Analysis, M.E. Van Valkenburg, Pearson Education; 15 April 2019, Revised 3rd edition.
2. Network Theory, N.C. Jagan, C. Lakshminarayana, BS publications, 2015, 3rd edition.
3. Engineering Network Analysis and Filter Design Including Synthesis of One Port Networks, Durgesh C. Kulshreshtha Gopal G. Bhise, Prem R. Chadha, Umesh Publications, 1 January 2012.

Reference Books:

1. Engineering Circuit Analysis | 8th Edition , by William H. Hayt, Jack Kemmerly, & Steven
M. Durbin, McGraw Hill Education; August 2013, Eighth Edition.
2. Electrical Circuit Theory and Technology, John Bird, Routledge; November 2013, 5th Edition.

Online Resources:

1. https://www.digimat.in/nptel/courses/video/108105159/L01.html
2. https://www.digimat.in/nptel/courses/video/108102042/L01.html

EE152	ELECTRIC AND MAGNETIC FIELDS	3-0-0: 3

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

CO1	Compute electric and magnetic fields for symmetrical charge and current configurations and the force between charges and currents.
CO2	Calculate capacitance and inductance of common conductor configurations and the energy stored in them.
CO3	Analyze time varying fields using Maxwell's equations and compute the energy stored in electromagnetic fields
CO4	Understand the Electro-mechanical Energy conversion from the concepts of field- energy and coenergy

Course Articulation Matrix:

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

Syllabus:

Overview of Coordinate System and Vector Calculus: Scalar and vector fields, overview of coordinate system, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Review of the concepts of gradient, divergence and curl.

Electrostatics: Electrical and magnetic Fields in electrical apparatus, Coulomb's law, Electrical filed intensity, electric flux density, electric field due to point, line, sheet, spherical charge distributions, Gauss' law and its applications, Divergence and curl of electrostatic field, Energy expended in moving a charge in an electric field, electric potential, potential due to point, line, spherical charge distributions, potential gradient, Poisson's and Laplace' equations, Uniqueness theorem, Electric dipole, Dipole moment, potential and electric field due to an electric dipole, Torque on an Electric dipole in an electric field, resistance, capacitance, Dielectrics, Energy in electrostatic field, boundary conditions.

Magneto statics : Biot-Savart's law, magnetic flux density, magnetic field intensity, magnetic field due to straight wire, surface, solenoid, toroid carrying steady current Ampere's Law and its applications, Divergence and curl of Magnetic field, Comparison of magnetostatics and electrostatics, Magnetic scalar and vector potentials, Lorentz force, inductance, self and mutual inductance of solenoid, toroidal and other simple configurations, conductors, magnetic materials, Hall effect, energy in magneto static fields, boundary conditions.

Time Varying Fields: Equation of continuity, Faraday's law, Lenz's law, transformer emf and motional emf, inconsistency of Ampere's law, displacement current, electromagnetic waves and Maxwell's equations, Poynting theorem, energy in electro-magnetic fields.

Principles of Electromechanical Energy Conversion: Review of basic concepts, magnetizing inductance, Principles of energy flow, concept of field energy and co-energy, Derivation of torque expression for various machines using the principles of energy flow and the principle of coenergy.

Learning Resources:

Text Books:

1. Engineering Electromagnetics, William H. Hayt Jr., John A. Buck, and M Jaleel Akhtar, McGraw Hill, 2020, 9th Edition.
2. Introduction to Electrodynamics, David J.Griffiths, Pearson Education, 2013, 4th Edition .
3. Analysis of Electric Machinery & Drive systems, Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, and Steven D. Pekarek, Wiley-IEEE Press, 2013, 3rd Edition.

Reference Books:

1. Elements of Electromagnetics, Matthew Sadiku and S.V. Kulkarni, Oxford University Press, 2015, 6th Edition.
2. Engineering Electromagnetics, Nathan Ida, Springer, 2021, 4th Edition.
3. Electrical Machines, A.E Fitzgerald, C. Kingsely and S. Umans, McGraw Hill, 2017, 6th Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106073/
2. https://nptel.ac.in/courses/115/101/115101005/
3. https://nptel.ac.in/courses/108/106/108106023/

MA182	FOURIER SERIES, MATRICES AND DIFFERENTIAL EQUATIONS	3-0-0: 3

Pre-Requisites: MA132- Calculus & Laplace Transforms

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

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function
CO3	Apply orthogonal and congruent transformations to a quadratic form
CO4	Solve arbitrary order linear differential equations with constant coefficients
CO5	Apply in physical problems and electrical circuits.

Course Articulation Matrix:

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

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

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 and congruent transformation; Properties of complex matrices – Hermitian, Skew-Hermitian and Unitary matrices

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE $y' = f(x, y)$; Exact differential equations; integrating factors; orthogonal trajectories; 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.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, **R. K. Jain and S. R. K. Iyengar**, Narosa Publishing House, 2016, Fifth Edition.
2. Advanced Engineering Mathematics, **Erwin Kreyszig**, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. Advanced Engineering Mathematics, **Dennis G. Zill**, Jones & Bartlett Learning, 2018, Sixth Edition.
2. Higher Engineering Mathematics, **B. S. Grewal**, Khanna Publishers, 2012, Forty-second Edition.

CY185	ENGINEERING CHEMISTRY	3-0-2: 4

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

CO1	Understand the basic concept of physical chemistry and apply the concepts in developing batteries.
CO2	Understand the chemistry involved in the synthesis and characterization of nanomaterials **and** to develop various electrical engineering materials.
CO3	Understand the concepts of spectroscopy in material characterization.
CO4	Evaluate techniques to protect different metals from corrosion.
CO5	Design materials for green energy harvesting and storage to reduce environmental pollution.

Course Articulation Matrix:

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

Syllabus:

General Concepts of Physical Chemistry: Thermochemistry**:** Heat of Reaction, Types of Heats of Reaction, Kirchoff's Equation, Laws of Thermochemistry, Bond Energy and Bond Enthalpy. Electrochemistry and applications: Electrical conductance, migration of ions, theories of ionization, redox potentials and electrochemical cells, electroless plating and electro plating. *Batteries: Electrode potential, primary and Secondary cell, Lithium ion battery*.

Corrosion: Introduction, Dry corrosion, Wet corrosion, Factors influencing the rate of corrosion – Temperature, pH and Dissolved oxygen, Corrosion prevention by Cathodic protection.

Applications of Nanomaterials: Nanotechnology applications, Material self assembly, Molecular vs material self-assembly, synthesis - top down and bottom up, synthesis, properties
& potential applications of carbon nanotubes, fullerenes and graphene, nano catalysis).

Organo Electronics, Engineering materials and Fuel Cells: Conducting Polymers and its applications, organic Semi conductors and insulators: Semi conductivity in non elemental materials , Preparations of semiconductors, Chalcogen photoconductors, photocopying process, Molecular switches: characteristics of molecular motors and machines, Rotaxanes and Catenanes as artificial molecular machines. Thermoelectric Material and applications. Chemical Sensors and Transducers: Definition, Composition, Sensors of Glucose and gases (CO, O2 etc.,) and Introduction to Biosensors. Fuel cells: Introduction, Types of Fuel Cells, Methanol Fuel Cell, Alkaline Fuel Cell, Photochemical/Photoelectrochemical Water Splitting to generate Hydrogen and Oxygen.

Polymer Chemistry and Characterization of Materials using Spectroscopic Methods: Polymers: Introduction-classification, polymerization- Types, mechanisms of polymerization, Preparation, Properties and Engineering applications. UV-Vis spectroscopy, Infrared spectroscopy, NMR spectroscopy.

Green Chemistry: Principles of Green Chemistry. Green methods in electronic production. Green Materials for Electronics and Advanced Technologies (Aluminium Borosilicate, Glass Iron Alloys Graphene Biomaterials). Electronic-Waste: Plastics in Electronic-Waste, Impact of Electronic-Waste on Environmental Public Health.

Learning Resources:

Text Books :

1. A Text Book of Engineering Chemistry, Shashi Chawla, Danpathrao & Co. Publications, 6th India reprint edition, 2007
2. Text Book of Engineering Chemistry, Ashutosh Kar, ED-Tech Publications, 2018

Reference Books :

1. Inorganic Chemistry, Huheey, Pearson Publications India, 4th Edition 2006
2. Molecular Quantum Mechanics, Peter Atkins, Oxford University Press, 5th Edition, 2012
3. Advanced Organic Chemistry: Reaction Mechanism and Structure, Jerry March, John Wiley Publications, 4th Edition, 2003.

Lab Syllabus:

1. Introduction
2. Determination of Iron in Hematite.
3. Chemistry of Blue Printing.
4. Determination of Heat of Solution.
5. pH metric Titration of acid vs Base.
6. Conductometric titration of Acid vs Base.
7. Potentiometric Titration of an Acid vs Base.
8. Determination of Isoelectric point of an amino acid.
9. Determination of Rate of Corrosion of Mild Steel in Acidic Environment in the Absence and Presence of Inhibitor.
10. Synthesis of CdS nanomaterial.
11. Preparation of Phenol-formaldehyde resin.
12. Verification of Freundlich Adsorption Isotherm of Acetic Acid on Charcoal.
13. Determination of copper from Brass using colorimetry.

Text Books:

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

CE181	BASIC ENGINEERING MECHANICS	2-0-0 : 2

Pre-requisites: none

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

CO1	Determine the resultant force and moment for a given planar and spatial force system.
CO2	Derive the equilibrium equations for planar and spatial rigid bodies in equilibrium.
CO3	Evaluate the friction problems for planar bodies in equilibrium.
CO4	Analyze the kinetics and kinematic characteristics of rigid bodies in motion.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom
- Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints
– Free body diagrams.

Spatial Force systems - Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system – Problems.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Dynamics of Particles - Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

Text Books:

1. S. Timoshenko, D.H. Young, J.V. Rao and Sukumar Pati, Engineering Mechanics (In SI Units) McGraw Hill Publishers, 5th Edition, 2017.
2. Ferdinand P. Beer, E. Russell Johnston Jr., et al., Vector Mechanics for Engineers - Statics and Dynamics (12th Edition, SIE), McGraw Hill Publishers, 2019.

Reference Books:

1. J.L.Meriam and L.G. Kraige, Engineering Mechanics (Statics), John Wiley &Sons, 7th Edition, 2017.
2. J.L.Meriam and L.G. Kraige, Engineering Mechanics (Dynamics), John Wiley &Sons, 7th Edition, 2018.
3. R. C. Hibbeler, Mechanics of Materials (SI Edition), Pearson pub, 2018.
4. J. L. Meriam, L. G. Kraige, et al., Engineering Mechanics: Statics, SI Version, Wiley India Edition, 2017.
5. J.L. Meriam , L.G. Kraige, et al., Engineering Mechanics: Dynamics, SI Version, Wiley India Edition, 2018.
6. S S Bhavikatti, Engineering Mechanics, Eighth edition, New Age International Private Limited, 2021.

Online Resources:

1. https://nptel.ac.in/courses/122/104/122104015/
2. https://nptel.ac.in/courses/112/106/112106180/

ME182	THERMODYNAMICS FOR ELECTRICAL ENGINEERING	3-0-0: 3

Pre-Requisites: None

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

CO1	Understand the concepts of thermodynamics and the functions of components of a power plant
CO2	Understand the laws of thermodynamics to analyze boilers, steam turbines and refrigerators
CO3	Understand the basics of internal combustion engines and automobile engineering.
CO4	Apply the principles of heat transfer and analyze thermal equipment

Course Articulation Matrix:

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

Syllabus:

Thermodynamics: Introduction-Energy sources and conversion, Thermodynamics-System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law – cyclic process, simple change of state, Cp, Cv, PMM1, Limitations of First law, Thermal reservoirs, heat engine, Heat pump/Refrigerator, efficiency/COP, Second law, Carnot cycle, Entropy – T-s and P- V diagrams

Power plant : Layout of thermal power plant & Four circuits – Rankine cycle, T-s & P-v diagrams, Boilers – Babcock & Wilcox, Cochran Boilers, Comparison of fire tube & water tube boilers, Boilers in modern power plants (qualitative)

Steam Turbines – Impulse Vs. Reaction, Compounding – Pressure & Velocity compound, Condensers – Jet condenser and surface condenser; Cooling Towers; nozzle and diffuser.

Refrigeration: Refrigeration – Vapor compression Refrigeration cycle – Refrigerants, Desirable properties of refrigerants.

Internal Combustion engines: 2-stroke & 4 – stroke engines, p-v diagram; S.I. Engine, C.I. Engine, Differences

Automobile Engineering: Layout of an Automobile, Transmission, Clutch, Differential, Brakes

Heat Transfer: Basic modes of heat transfer: Conduction, Convection and radiation, General Heat Conduction Equation, Steady-state one-dimensional heat conduction problems (i) with and without heat generation, Convection: Force and free convection; Internal and external flows, Heat Exchangers: Classification, Analysis of Heat exchanger, Radiation: Fundamental principles, radiation exchange.

Learning Resources:

Text Books:

1. Engineering Thermodynamics, P.K.Nag, McGraw Hill Education, 2017, 6th Edition.
2. Fundamentals of Thermodynamics, Claus Borgnakke and Richard E. Sonntag, Wiley India pvt. Limited, 2009, 7th Edition.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., John Wiley and Sons, New York, 2006, 5th Edition.

Reference Books:

1. Thermodynamics-An Engineering Approach, Yunus A. Çengel, Michael A. Boles, and Mehmet Kanoğlu, McGraw-Hill Education, 2019, 9th Edition.
2. Basic Engineering Thermodynamics, A.Venkatesh, TMH, 2012.
3. Heat and Mass Transfer: Fundamentals and Applications, Yunus A. Çengel and Afshin Jahanshahi Ghajar, McGraw-Hill Education, 2020, 6th Edition.

Online Resources:

1. https://nptel.ac.in/courses/112/108/112108148/
2. https://nptel.ac.in/courses/112/101/112101097/
3. https://nptel.ac.in/courses/112/108/112108149/

ME183	WORKSHOP PRACTICE FOR ELECTRICAL ENGINEERING	0 - 0 - 2: 1

Pre-requisites: Nil.

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

CO1	Identify the hand tools and instruments to perform corresponding trades.
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding.
CO3	Identify and apply suitable tools for machining processes including turning, facing, taper turning, Groove cutting, thread cutting, Knurling and tapping.
CO4	Apply basic electrical engineering knowledge for House Wiring Practice.

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	2	1	2	2	1	1	2	1
CO2	3	3	1	1	2	1	3	1	2	2	2	2	2	1
CO3	3	3	1	1	2	1	2	1	2	2	1	2	2	1
CO4	3	3	1	1	1	1	1	1	2	2	2	1	2	1

Syllabus:

Demonstration of safety practices and precautions to be observed in workshop

Fitting Trade: Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint, Dissembling and Reassembling of Tail Stock, Bench vice etc.

Carpentry:. Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint/ Mortise Tenon Joint.

Plumbing: Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for same diameter and with reducer for different diameters.

Machine shop: Demonstration and practice on Lathe Machine, Preparation of work pieces involving Facing, Plane Turning, step turning, Taper Turning, knurling and parting operations.

House Wiring: Demonstration and practice on Electrical tools, wiring and earthing, Exercises on Staircase Wiring & Godown wiring.

Power Tools: Demonstration and practice on Power tools and Safety Practices.

Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.

Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

Learning Resources:

Text Books:

1. Basic Workshop Technology: Manufacturing Process, Felix W.; Independently Published, 2019.
2. Workshop Processes, Practices and Materials; Bruce J. Black, Routledge publishers, 5th Edn. 2015.

3. Engineering Practices Laboratory Manual, Ramesh Babu.V., VRB Publishers Private Limited, Chennai, Revised Edition, 2013 – 2014.

Reference Books:

1. A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015 & 2017.
2. Elements of Workshop Technology, Vol. I & Vol. II by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th Edition.
3. Engineering Practices Lab Manual; T.Jeyapoovan, Vikas Pub, 4th Edn.2008.
4. Wiring Estimating, Costing and Contracting; Soni P.M. & Upadhyay P.A.; Atul Prakashan, 2021.

Online Resources:

1. https://bharatskills.gov.in

Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India.

EE 201	ELECTRICAL MACHINES - I	3-0-0: 3

Pre-requisites: EE101: Basic Electrical Circuits, EE151: Electrical Network Analysis, EE152: Electric & Magnetic Fields

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

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

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	1	1	1	1	1	2	3	2
CO2	3	3	3	1	1	2	1	1	1	1	1	2	3	2
CO3	3	3	3	2	1	2	1	1	1	1	1	2	3	2
CO4	3	3	3	2	2	2	1	1	1	1	2	2	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Electromechanical Energy Conversion Principles: Principles of energy conversion, single excited and doubly excited magnetic systems, singly excited electric field systems. Constructional features of rotating electrical machines, generating emfs, emf polygon, mmf produced by distribution windings, concepts of torque production.

DC Machines: Constructional features, parts of DC machines, Simplex and multiplex lap and wave windings; Methods of excitation, characteristics of saturated and un-saturated series, shunt, cumulatively and differentially compound excited machines operating as motors and generators, applications of DC machines; Armature reaction, demagnetizing and cross magnetizing ampere-turns, compensating windings, commutation process and methods of commutation, role of inter poles and compensating winding. Problems on emf equation, torque equation and armature reaction.

Speed Control of DC Motors: Speed control of shunt & series motors, losses in DC machines and calculation of efficiency. Need for starters and Starters for DC series shunt and compound motors.

Testing of DC Motors: No-load test, load tests and regenerative tests such as Swinburne's Test, Direct load test, Hopkinson's test, Field's test and Retardation test. Calculation of efficiency based on all the above tests.

Single-Phase Two Winding Transformers: Construction, principle of operation, E.M.F. equation, phasor diagrams; Equivalent circuit, determination of equivalent circuit parameters, Predetermination of performance equivalent circuit parameters and Sumpner's test. Losses,

separation of no-load losses, calculation of efficiency and regulation by direct and indirect methods, conditions for maximum efficiency. Concept of all-day efficiency. Parallel operation of transformers and Load sharing.

Auto transformer: Principle of operation, saving of copper compared to two-winding transformer and its application.

Three-Phase Transformers: Merits of three phase Transformers over three phase transformer bank Type of connections such as Delta-Delta, Delta-Star, Star-Delta, Delta-Star, V-V connection and T-T Connections. Relation between line and phase voltages and currents, Vector Groups, use of tertiary winding. Three phase to Two phase connections and vice-versa. Problems on three phase transformers

Learning Resources:

Text Books

1. Electrical Machinery, Theory: Performance & Applications, Dr. P. S. Bimbhra, Khanna Publishers, 2021.
2. Fitzgerald and Kingsley's electric machinery by Stephen D. Umans–TMH Publishers, 7th Edition, 2020.
3. Nagarath & D.P.Kothari: ElectricalMachines,TMHPublishers,5th edition 2017.

Reference Books:

1. Theory& Performance of Electrical Machines by J.B. Gupta, S.K. Kataria & Sons, 5th Edition, 2013.
2. The Performance and Design of Direct Current Machines, A.E .Clayton & NN Hancock, CBS Publishers, 2004.
3. Electric Machines, P. S Bimbhra-2nd Edition, Khanna Publishers,2017.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105155/
2. https://nptel.ac.in/courses/108/105/108105017/
3. https://nptel.ac.in/courses/108/106/108106071/

EE 202	POWER SYSTEMS - I	3-0-0: 3

Pre-requisites**:** EE101: Basic Electrical Circuits, EE151: Electrical Network Analysis

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

CO1	Understand the operation of conventional generating stations and renewable sources of electrical power.
CO2	Analyze the power tariff methods and Power distribution systems
CO3	Understand line supporting insulators and Underground Cables.
CO4	Determine the parameters of transmission lines and understanding of corona

Course Articulation Matrix:

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

Syllabus

Introduction: Typical Layout of an Electrical Power System, Present Power Scenario in India.

Generation of Electric Power:
Conventional Sources Hydro Power stations, Steam Power Plants, Nuclear Power Plants, Geothermal Power Plants and Gas Turbine Power Plants.

Renewable energy Sources: Solar Energy, Wind Energy, Wave energy, Tidal Energy, and Fuel Cells.

Economics of Generation: Introduction, definitions of connected load, maximum demand, demand factor, load factor, diversity factor, Load duration curve, number and size of generator units. Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff on charge to customer.

AC Distribution: Introduction, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, Selection of site and layout of substation.

Overhead Line Insulators: Introduction, types of insulators, Potential distribution over a string of suspension insulators, Methods of equalizing the potential, testing of insulators.

Insulated Cables: Introduction, need for insulation, insulating materials, Extra high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables.

Transmission line sag calculation: The catenary curve, Sag tension calculations, Supports at different levels, Stringing Chart.

Inductance and Capacitance Calculations of Transmission Lines: Line conductors, inductance and capacitance of single phase and three phase lines with symmetrical and unsymmetrical spacing, Composite conductors-transposition, bundled conductors, and effect of earth on capacitance

Corona: Introduction, disruptive critical voltage, corona loss, Factors affecting corona loss and methods of reducing corona loss, Disadvantages of corona, interference between power and Communication lines. Numerical problems in corona.

Learning Resources:

Text Books

1. W. D. Stevenson, Elements of Power System Analysis, Fourth Edition(Indian edition), McGraw Hill, 2002.
2. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, 3rd Edition, New Age International, 2015.
3. M.V. Deshpande, Elements of Electrical Power Station Design, Third Edition, Wheeler Pub.2001.

Reference Books:

1. C.L. Wadhwa, Electrical Power Systems, 7th Edition, New Age International, 2016.
2. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Third Edition, ELBS,B.I.Pub.,1985.
3. D.P. Kothari and I.J. Nagrath, Power System Engineering-- Tata McGraw-Hill Pub. Co., New Delhi, 3rd Edition, 2019.

Online Resources:

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/content/storage2/courses/108105053/pdf/L-2(TB)(ET)((EE)NPTEL).pdf

EE 203	PYTHON PROGRAMMING	2-0-2: 3

Pre-Requisites: Nil

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

CO1	Understand the problem solving techniques using algorithms and procedures
CO2	Understand how to read, write and execute simple Python Programs
CO3	Apply Python data structures – lists, tuples and dictionaries
CO4	Develop Algorithms and Code in Python Language.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments; understanding error messages; Conditions, Boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation

Strings and text files; manipulating files and directories, OS and SYS modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab- separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers

Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments- Program structure and design- Recursive functions – Introduction to classes and OOP.

List of Programs for Laboratory

1. Programs using sequential constructs
2. Programs using selection constructs
3. Programs using Iterative constructs
4. Programs using nested for loops
5. Programs using lists
6. Programs using tuples and dictionaries
7. Simple Python functions

8. File input and output
9. Sorting and searching programs
10. Recursion

Learning Resources:

Text Books

1. Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
2. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd edition, Updated for Python 3, O'Reilly Media, Publishers, 2015.

Reference Books:

1. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
2. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, 2017.
3. John V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
4. Mark Lutz, "Learn Python"", 5th Edition, O'reilly Media, Inc, June, 2013.

Online Resources:

1. https:/ /npte l.ac.in/c ourse s/ 106106182/
2. https:/ /www .pyt hon.org
3. http://greenteapress.com/wp/thinkpython/

MA232	COMPLEX VARIABLES AND PARTIAL DIFFERENTIAL EQUATIONS	3-0-0: 3

Pre-requisites: MA132: Calculus and Laplace Transforms, MA182: Fourier Series, Matrices and Differential Equations

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

CO1	Understand ordinary differential equations and their solutions.
CO2	Find the Z-transform of a sequence
CO3	Determine the solution of a partial differential equations by variable separable
CO4	Understand the use of complex variables in engineering problems
CO5	Evaluate real integrals using functions of complex variables

Course Articulation Matrix:

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

1-Slightly; 2-Moderately; 3-Substantially

Syllabus:

Series Solutions: Series solution of Bessel and Legendre's differential equations - Bessel function of first kind, Recurrence formulae, generating function, Orthogonality of Bessel functions - Legendre polynomial, Rodrigues's formula, Generating function, Recurrence formula, Orthogonality of Legendre polynomials

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 equations 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 $\int_0^{2\pi} f(\cos\theta, \sin\theta)dx$, $\int_{-\infty}^{\infty} f(x)dx$ without poles on real axes.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, Fifth Edition.

2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, Sixth Edition.

2. Complex Variables and Applications, James W. Brown and Ruel V. Churchill, McGraw-Hill, 2009, Eighth Edition.

EC 231	ANALOG ELECTRONICS	3-0-2: 4

Pre-requisites: EE101: Basic Electrical Circuits, EE151: Electrical Network Analysis

Course Outcomes:

CO1	Understand the characteristics of semiconductor devices
CO2	Identify the applications of semiconductor devices
CO3	Comprehend the characteristics and parameters of operational amplifier
CO4	Analyse and design linear and non-linear application circuits of operational amplifier
CO5	Understand the principle of operation of 555 timer and 723 voltage regulator.
CO6	Implement analog electronic circuits using experimental boards.

Course Articulation Matrix**:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	1	3	3	3	1	1	1	1	3	1	1	1	2	2
CO3	3	3	3	1	1	1	1	1		1	1	1	1	1
CO4	1	3	3	3	1	1	1	1	3	2	1	2	2	2
CO5	3	3	3	1	1	1	1	2		1	1	1	1	2
CO6	1	1	1	1	1	1	1	1	3	1	1	1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to electronics: Overview of semiconductor physics, review of P-N junction operation, **Characteristics** of PN-Junction diode, Zener diode, Schottky diode, LED, LCD, Diac, Triac, SCR and Solar cell. Applications: Half wave, full wave and bridge rectifiers with filters (C, L, LC and π), Zener diode as a voltage regulator, Clippers and clampers.Problem solving

BJT- CE, CB and CC configurations, CE Transistor **Characteristics**, Low frequency h-parameter model and analysis, Transistor Biasing, Stability and Thermal Runaway; Transistor as switch. **JFET** Characteristics, **MOSFET**: Enhancement and depletion mode characteristics. **Applications:** Single stage & 2- stage RC coupled amplifiers and their frequency response, gain-band width product, tuned amplifier, differential amplifier, CMRR, DC amplifier, drift problem and compensation techniques, Problem Solving.

Feedback in Amplifiers: feedback topology-Voltage series, voltage shunt, current series, current shunt, stability, positive feedback, Bark hausen criterion, Oscillators- RC& LC oscillators and crystal oscillator.

Power Amplifiers: Classification of power amplifiers, analysis of class-A& class-B push- pull amplifiers, harmonic distortion and cross-over distortion in power amplifiers.

Integrated circuits: Introduction, Operational amplifiers(**μA 741**)-Ideal and practical **characteristics and linear applications**, V-I Converter and I-V Converters, Precision Rectifiers, Log and Antilog Amplifiers, Comparator Principle, Astable and Monostable multivibrators, Sine wave and Triangular wave generator.**555 Timer**: Functional block

diagram, astable and monostable multivibrators, pulse width modulator Problem Solving.

Regulated power supply, Shunt-regulator, Series Voltage Regulator and principles of uninterrupted power supply, Principle of operation of **723 Voltage regulator** IC, High and low voltage regulation designs, Current boosting and current holding operation, 3 terminal regulators.

List of Lab Experiments

1. Characteristics of PN junction diode:
   Aim: To plot V-I Characteristics of diode (Si and Ge) in forward and reverse bias and finding cut in voltage, static & dynamic resistances.
2. Rectifiers and filters.
   Aim: To find ripple factor of rectifiers with and without filters.
3. Clippers and Clampers
   Aim: To implement different types of clippers and clampers
4. Zener diode as a Voltage regulator
   Aim: i)To plot V-I Characteristics of Zener diode and find break down voltage.
   ii) To plot Zener diode voltage regulation characteristics.
5. CE-BJT Characteristics
   Aim: To plot Input and output characteristics of CE-BJT and find h-parameters
6. JFET Characteristics
   Aim: o plot drain &transfer characteristics & find JFET parameters
7. Single stage BJT-RC Coupled amplifier
   Aim: To plot frequency response and find band width
8. RC Phase Shift Oscillator
   Aim: To design and implement RC oscillator and find it's frequency
9. Operational Amplifier as an Inverting amplifier Aim: o plot frequency response of Inverting amplifier& find unity gain BW product
10. Operational Amplifier applications
    Aim: To design and implement i) Integrator and ii) Differentiator

Learning Resources:

Text Books

1. Millman's Integrated Electronics,McGraw Hill Education; 2nd edition,1 July 2017.
2. Basic Electronics & Linear Circuits ,Bhargava N. N., D C Kulshreshtha and S C Gupta, Tata McGraw Hill, 2nd Edition, 2013.
3. Linear Integrated Circuits 4th Ed by D. Roy Choudhury and Shail B. Jain, New Age International Pvt.Ltd. 11 June 2017.

Reference Books:

1. Ramakant A. Gayakwad, Operational amplifiers and Linear IC technology, PHI,1987.

Online Resources:

1. https://www.youtube.com/watch?v=IoDoW5kykkw&list=PLzJaFd3A7DZsA8xZg3tgoshboIIBY98cB

CS 231	DATA STRUCTURES	3-0-2: 4

Pre-requisites: CS131: Problem Solving and Computer Programming

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

CO1	Understand Abstract Data Type for stack and queue applications
CO2	Identify data structures suitable to solve problems
CO3	Develop and analyze algorithms for stacks, queues
CO4	Design and implement algorithms for binary trees and graphs
CO5	Implement sorting and searching algorithms
CO6	Implement symbol table using hashing techniques

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	3	1	1	1	1	1	1	2	3	2
CO2	3	3	1	1	3	1	1	1	1	1	1	2	3	2
CO3	3	3	1	1	3	1	1	1	1	1	1	2	3	2
CO4	3	3	1	1	3	1	1	1	1	1	1	2	3	2
CO5	3	3	1	1	3	1	1	1	1	1	1	2	3	2
CO6	3	3	1	1	3	1	1	1	1	1	-	2	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Theory:

Introduction to Data Structures, Asymptotic Notations, Linear and Nonlinear Data Structures, Stack Data Structure and its Applications, Queue Data Structure and its Applications, Singly, Doubly and Circular Linked Lists, Trees and tree traversals, Binary Search Tree and its Operations, Heap Data Structure, Priority Queue, Height Balanced Trees, Direct Addressing; Introduction to Hashing, Lower Bound for Comparison based Sorting Algorithms, Insertion Sort, Merge Sort, Quick Sort, Heap Sort and Counting Sort, Radix Sort, Disjoint Set s, Introduction to Graphs and Representation of Graphs, Depth First Search (DFS), Breadth First Search (BFS),Applications of BFS and DFS, Prim's Algorithm for finding Minimum Spanning Tree (MST), Kruskal's Algorithm for finding MST, Dijkstra's Algorithm for Single Source Shortest Paths, Floydd-Warshall Algorithm for All-Pairs Shortest Path Problem.

List of Experiments

1. Write a program to implement stack using arrays and evaluate a given postfix expression

2. Write a program to implement circular queue using arrays

3. Write a program to implement double ended queue (de queue) using arrays

4. Write programs for applications based on stacks and queues.

5. Write programs to implement the following data structures and their applications

(a) Single linked list (b) Double linked list

6. Write programs to implement a stack and a queue using linked lists

7. Write a program to create a binary search tree (BST) by considering the keys in given order and perform the following operations on it.

(a) Minimum key (b) Maximum key (c) Search for a given key

(d) Find predecessor of a node (e) delete a node with given key (f) applications of BST

8. Write a program to construct an AVL tree for the given set of keys. Also write function for deleting a key from the given AVL tree.

9. Write a program to implement hashing with (a) Separate Chaining and (b) Open addressing methods.

10. Implement the following sorting algorithms:

(a) Insertion sort (b) Merge sort (c) Quick sort (d) Heap sort

11. Write programs for implementation of graph traversals by applying: (a) BFS (b) DFS

12. Write programs to find out a minimum spanning tree of graph by applying:

(a) Prim's algorithm (b) Kruskal's algorithm c) any other algorithms

13. Write a program to implement Dijkstra's algorithm using priority queue.

Learning Resources:

Text Books

1. Thomas H.Cormen,Charles E.Leiserson,Ronald L.Rivestand Clifford Stein,Introduction to Algorithms, Second Edition,PHI,2009.
2. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Third Edition, Pearson Education, 2006.
3. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, Fundamentals of Computer Algorithms, Second Edition, Universities Press 2011.

Reference Books:

1. J. P. Tremblay and P. G. Sorenson, An Introduction to Data Structures with Application, TMH, 2017.
2. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, Second Edition, Wiley-India, 2006.
3. Sahni, S., Data Structures, Algorithms, and Applications in C++Silicon Press, 2/e, 2005.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106127/
2. https://nptel.ac.in/courses/106/106/106106130/
3. https://nptel.ac.in/courses/106/103/106103069/

EE 204	ELECTRICAL NETWORKS LAB	0-1-2: 2

Pre-requisites**:** EE101: Basic Electrical Circuits, EE151: Electrical Network Analysis

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

CO1	Validate network theorems
CO2	Evaluate the time response and frequency response characteristics of RLC series
CO3	Determine Z, Y and ABCD parameters for a given two port network
CO4	Simulate and analyze electrical circuits using MATLAB/ Pspice tools

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1	PO1	PO1	PSO	PSO
CO1	3	3	1	2	2	1	1	1	2	2	1	2	3	2
CO2	3	3	2	2	2	1	1	1	2	2	1	2	3	2
CO3	3	3	2	2	2	1	1	1	2	2	1	2	3	2
CO4	3	3	2	3	3	1	1	1	3	2	1	3	3	3

Syllabus:

1. Verification of Kirchhoff's laws
2. Verification of Tellegen's Theorem
3. Verification of Superposition and Thevenin's theorem
4. Verification of Maximum Power Transfer and Reciprocity theorems
5. Analysis of two port networks: Determination of Z,Y, and ABCD parameters using two port network.
6. Time response of First-order RC circuits and Second-order RLC circuits.
7. Frequency Response of Second-order RLC circuits.
8. Analysis of series and parallel coupled circuits
9. Power factor improvement and harmonic power analysis in single-phase AC circuit
10. Analysis of Single–phase series and parallel AC circuits using R-L,R-C and R -L-C elements through MATLAB/ PSPICE simulation
11. Elementary Matrix operations, simple calculations using array and vectors, creating script Files and function files, solution of circuits using mesh and loop equations, and 3- D surface plotting etc..

Learning Resources:

Text Books:

1. Network Analysis, M.E.VanValken Burg, Pearson Education,2015, 3rdEdition.
2. Engineering Circuit Analysis, William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Tata McGraw Hill, 2013, 8th Edition.
3. Linear circuit Analysis, De Carlo, Lin, Oxford University Press, 2010, 2nd Edition.

Reference Books:

1. A course in Electrical Circuits Analysis, M.L. Soni, J.C. Gupta, Dhanpat Rai& Co., 2001.
2. Fundamentals of Electric Circuits,Alexander C.K., Sadiku M.N.O., McGraw Hill

Education, 2019, 6th Edition.

3. Electric Circuits,Joseph A. Edminister, Mahmood Nahvi, Schaum's series, McGraw-Hill Education, 2017, 5th Edition.
4. MATLAB Programming for Engineers, Stephen J. Chapman, CENGAGE Learning, 2020, 6th Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/106/108106172/
3. https://ocw.mit.edu/search/ocwsearch.htm?q=laboratory

EE 251	ELECTRICAL MACHINES - II	3-0-0: 3

Pre-requisites: EE201: Electrical Machines– I

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

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

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Three Phase Induction Motors:

Introduction: Constructional details, classification, principle of operation, production of rotating magnetic field and rating of induction motors. Analysis of Induction Motors**:** Phasor diagram, equivalent circuit, Torque equations for starting, full load and maximum operating conditions, Condition for maximum-output, slip for maximum-output, Torque-slip characteristics, losses & efficiency and applications.

Starters and Testing of Induction Motors: Auto transformer, star delta and rotor resistance starters. No load and blocked rotor tests-determination of equivalent circuit parameters, Pre- determination of performance from equivalent circuits and circle diagram**.** Concepts of single phasing.

Double cage induction motor: Construction, theory, equivalent circuit, characteristics and applications**.** Problems on torque calculations, losses and efficiency of squirrel cage, double cage and slip induction motors.

Induction Generator: Principle of operation, equivalent circuit and application.

Synchronous Generator:

Constructional features, classification, ratings, winding factors, production of emf, harmonics, emf equation, armature reaction, Synchronous reactance, phasor diagrams for various operating conditions, 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 diagrams. 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 for various operating conditions, 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. Problems on emf equation, regulation calculations of salient and non-salient pole synchronous generators, parallel operation and load sharing, losses and efficiency of salient and non-salient pole synchronous motors.

Learning Resources:

Text Books:

1. Electrical Machinery, Theory: Performance &Applications Dr. P. S. Bimbhra, Khanna Publishers, 2021.
2. Nagarath & D.P.Kothari:ElectricalMachines,TMHPublishers,5th Edition,2017.

Reference Books:

1. Electric Machines, Charles A. Gross, CRC Press, 2007.
2. Electric Machinery, A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, Sixth Edition TMH, 2009.
3. Electric Machines, Charbs. I.Hubert, SecondEdition–Pearson, 2003.
4. Electric Machinery, Stephen. J.Chapman, McGrawHillInternationalEdition,2005.
5. Alternating Current Machines, M.G.Say, Wiley, 1983.
6. Theory of Alternating Current Machine, Alexander. S. Langsdorf, Tata McGrawHill, Second Edition, 2009.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105131/
2. https://nptel.ac.in/courses/108/106/108106072/

EE 252	POWER SYSTEMS - II	3-0-0: 3

Pre-requisites**:** EE202 : Power Systems-I

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

CO1	Understand transmission line performance and different methods of voltage control
CO2	Apply shunt compensation techniques to control reactive power
CO3	Understand the role of per unit quantities and travelling wave phenomenon on transmission lines
CO4	Determine the fault currents for symmetrical and unbalanced faults

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

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.

Voltage Control: Introduction methods of voltage control, shunt and series capacitors / Inductors, tap changing transformers, synchronous phase-modifiers.

Compensation in Power Systems: Introduction- Concepts of Load compensation Load ability characteristics of overhead lines uncompensated transmission line Symmetrical line Radial line with asynchronous load Compensation of lines.

Per Unit Representation of Power Systems: The one-line diagram, impedance and reactance diagrams, per unit quantities, changing the base of per unit quantities, advantages of per unit system.

Travelling Waves on Transmission Lines: Production of traveling waves, open circuited line, short circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at T-junction line terminated through a capacitance, capacitor connection at a T-junction, Attenuation of travelling waves.

Symmetrical Components: Significance of positive, negative and zero sequence components, Average 3-phase power in terms of symmetrical components, sequence impedances and sequence networks.

Fault Calculations: Fault calculations, sequence network equations, single line to ground fault, line to line fault, double line to ground fault, three phase fault, faults on power systems, and faults with fault impedance, reactors and their location, short circuit capacity of a bus.

Learning Resources:

Text Books**:**

1. John J.Grainger , W.D. Stevenson: Power System Analysis, McGrawHill International (Indian Edition) 2017.
2. C.L. Wadhwa: Electrical Power Systems New Age International Pub. Co. 7th Edition, 2016.
3. Hadi Saadat: Power System Analysis Tata Mc Graw Hill Pub.Co. 4th Edition 2011.

Reference Books:

1. D.P. Kothari and I.J. Nagrath, Power System Engineering-- Tata McGraw-Hill Pub. Co., New Delhi, 3rd Edition, 2019.
2. W.D. Stevenson: Elements of Power system Analysis, McGraw Hill International Student 4th Edition 2015.
3. D. Das- Electrical Power Systems New Age International Pub. Co. 3th Edition, 2016.

Online Resources:

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/courses/108/107/108107112/

EE 253	CONTROL SYSTEMS	3-0-0: 3

Pre-Requisites: MA132: Calculus & Laplace Transforms, MA232: Complex Variables and Partial Differential Equations, EE201: Electrical Machines-I

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

CO1	Understand and analyse electrical & electro-mechanical systems using transfer function approach
CO2	Determine transient and steady-state behaviour of dynamic systems.
CO3	Determine absolute and relative stability of dynamic systems using time & frequency domain analyses
CO4	Design compensators for liner control systems to derive the specified steady-state and dynamic responses

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Introduction: System, control system, types of control systems, Transfer Function, open-loop and closed loop systems, types of feedback, feedback and its effects.

Modelling of Physical Systems: Mathematical modelling of Electrical and Electro-mechanical elements, D.C. motors. Block diagram illustration.

Techniques to Develop Transfer Function of Systems: Introduction, Block diagram reduction technique and signal flow graph, Mason's gain formula.

Time Domain Analysis of Control Systems: Introduction- time domain indices, steady state error constants, concept of BIBO stability, absolute stability. Routh- Hurwitz Criterion.

Root Locus Techniques: Introduction, Root loci theory, Application to system stability analysis. Illustration of the effect of addition of zero and pole.

Frequency Domain Analysis of Control Systems: Introduction, Bode plots, Frequency domain indices, application of Bode plots, Polar plots. P, PI & PID controllers.

State-Space Representation of Dynamic Systems: State-Variables, State-Variable representation of Electrical Systems.

Learning Resources:

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 7th Edition, 2019.

2. I.J.Nagarath&M.Gopal: Control Systems Engineering, New Age Pub. Co, 6th Edition, 2017.
3. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 5th Edition, 2015.

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Reference Books:

1. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 13th Edition, 2015.
2. K. R. Varmah, Control Systems, McGraw Hill Education, 2010.
3. Dhanesh N Manik, Control Systems, Cengage Learning, First Edition, 2012.
4. B.C.Kuo: Automatic Control Systems, Wiley, 9th Edition, 2014.

Online Resources:

1. https://www.controleng.com
2. https://www.mathworks.com
3. https://nptel.ac.in/courses/108/102/108102043/

EE 254	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION	3-0-2: 4

Pre-Requisites: EE101: Basic Electrical Circuits, EE151: Electric Network Analysis, EE152: Electric & Magnetic Fields.

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

CO1	Understand the principle and performance of PMMC, MI, dynamometer type & induction type measuring instruments.
CO2	Determine the circuit parameters using AC and DC bridges
CO3	Compute and analyze the errors in CTs and PTs
CO4	Design sensors and analyze the operation of electronic measuring instruments

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Definitions**-** Accuracy, tolerance, sensitivity, reproducibility, absolute and secondary measuring instruments, recording instruments**.**

Analog Ammeters and Voltmeters: Permanent magnet Moving Coil (PMMC) & Moving Ireon(MI) instruments: construction, torque equation range extension, effect of temperature, classification, errors, advantages and disadvantages.

Analog Wattmeter and Power Factor Meters: Electrodynamometer type: wattmeter &power factor meter: construction, working, torque equation, advantages and disadvantages; Measurement of active and reactive power in single phase and in three phase with balanced loads.

Analog Energy Meter: Single phase induction type energy meters, construction, working, lag adjustments, errors; Maximum demand indicators.

Electrical Bridges: DC bridges: Wheatstone, Kelvin's, Kelvin's double bridge, Megger, Earth resistance measurement, loss of charge method for measurement of high resistance; AC bridges: Maxwell's bridges, De-Sauty, Anderson, Schering, Wien; for measurement of inductance and capacitance and their limitations.

Instrument Transformers: Construction, working, phasor diagram, ratio error and phase errors, testing & applications of current transformer and potential transformer.

Transducers: Thermistor, RTD, thermocouple, LVDT, strain gauge, piezoelectric transducers, digital shaft encoders, tachometer, Hall Effect sensors.

Electronic Instruments: Digital voltmeters, Dual trace and dual beam Cathode Ray Oscilloscopes (CRO), measurement of voltage and frequency, Lissajous patterns, wave analyzers, harmonic distortion analyzer, LCR meter and Q-meter.

Smart Energy Meter: Digital energy meter design components; circuit diagram; Digital meter software algorithm; meter working principle; Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI) environments.

Learning Resources:

Text Books

1. A Course in Electrical Measurements, Electronic Measurements and Instrumentation, A.K. Sawhney, Dhanpat Rai and Co., 2015.
2. Modern Electronic instrumentation and Measurements Techniques, William D.Cooper, Albert D. Helfrick, Prentice Hall of India Pvt. Ltd. 2002.
3. Electrical and Electronics Measurements and Instrumentation, Prithwiraj Purkait, Budhaditya Biswas, Santanu Das, Chiranjib Koley, McGraw Hill Education (India) Private Limited, 2013.

Reference Books:

1. Electrical Measurements and Measuring Instruments, E.W.Golding, F.C.Widdis, Reem Publications,2011.
2. Electronic Instrumentation and Measurements, H S Kalsi, McGraw Hill, Fourth Edition, 2019
3. Introduction to Measurements and Instrumentation, Arun K. Ghosh, Fourth Edition, Eastern Economy Edition, PHI Learning, 2012.
4. Dr. Shashikant Bakre, Electricity Metering in Easy Steps: An outline book on smart energy meters for everyone, 2015.
5. Ndinechi, M. C., O. A. Ogungbenro, and K. C. Okafor. "Digital metering system: a better alternative for electromechanical energy meter in Nigeria." International Journal of Academic Research 3.5 (2011): 189-192.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105153/
2. https://www.cdac.in/index.aspx?id=pe_pe_PEG_SMARTENERGY

List of Experiments:

1. Study and observe the oscilloscope as a test and measuring instrument.
   (Test the resistors, capacitors, diodes, transistors, measure AC/DC voltages, frequency, phase and study the Lissajous patterns).
2. Plot the B-H curve of a magnetic specimen to obtain its hysteresis loss and calculate its Steinmetz's constant & co-efficient.
3. Calibrate the single phase energy meter by phantom loading for various loads and power factors.
4. Measurement of low resistance using Kelvin double bridge.
5. Measurement of inductance and capacitance using Maxwell bridges.

6. Measurement of inductance using Anderson bridge.
7. Measurement of capacitance using Schering bridge.
8. Measurement of ratio error and phase error of a potential transformer
9. Measurement of ratio error and phase error of a current transformer.
10. Measurement of temperature using RTD and thermistor
11. Measurement of pressure and weight using piezoelectric transducer.
12. Measurement of power factor using two-watt meter method.
13. Measurement of reactive power in a balanced three phase system using single wattmeter method.
14. Measurement of active power in a balanced three phase system using two wattmeter method.

MA282	NUMERICAL METHODS AND STATISTICS	3-0-0: 3

Pre-Requisites: MA132: Calculus & Laplace Transforms,
MA182: Fourier Series, Matrices and Differential equations

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

CO1	Interpret an experimental data using interpolation / curve fitting
CO2	Solve algebraic/transcendental equations and ordinary differential equations numerically
CO3	Understand the concepts of probability and statistics
CO4	Perform testing of hypothesis
CO5	Analyze the goodness of curve fitting.

Course Articulation Matrix:

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

Syllabus:

Numerical Methods: Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves - Gauss-Seidal iteration method to solve a system of equations - Numerical solution of algebraic and transcendental equations by Regula- Falsi method and Newton-Raphson's method - Lagrange interpolation, Forward and backward differences, Newton's forward and backward interpolation formulae - Numerical differentiation with forward and backward differences -Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule - Taylor series method, Euler's method, 4th order Runge-Kutta method for solving first order ordinary differential equations

Probability and Statistics: Random variables, discrete and continuous random variables, Density function of distribution, Mean and variance of Binomial, Poisson and Normal distributions and applications. Distributions of Several Random Variables, Central limit theorem

Random Sampling, Confidence Intervals, Testing Hypotheses: Decisions – Null and alternate hypothesis, level of significance and critical region - Z-test for single mean and difference of means, t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit; Regression. Fitting Straight Lines. Correlation

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, Fifth Edition.
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. Miller & Freund's Probability and Statistics for Engineers, Richard A. Johnson, Pearson, 2018, Ninth Edition

EC 281	DIGITAL ELECTRONICS	3-0-0: 3

Pre-requisites: EC231: Analog Electronics

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

CO1	Examine the structure of number systems and perform the conversion among different number systems deployed in communication and computer systems.
CO2	Illustrate reduction of logical expressions using Boolean algebra, k-map and tabulation method
CO3	Understand Combinational Circuits for given Application
CO4	Design and analyze synchronous and asynchronous sequential circuits using flipflops
CO5	Implement combinational logic circuits using Programmable logic devices
CO6	Understand conversion of signals from analog to digital and digital to analog.

Course Articulation Matrix:

PO/PS CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	1	1	1	1	1	1	1	3	1
CO2	2	2	1	1	1	1	1	1	1	1	1	1	3	1
CO3	2	2	1	1	1	1	1	1	1	1	1	1	3	1
CO4	2	2	3	1	1	1	1	1	1	1	1	1	3	2
CO5	2	2		1	1	1	1	1	1	1	1	1	3	2
CO6	2	2	3	1	1	1	1	1	1	1	1	1	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Number system and codes:

Analog versus digital, merits of digital system, number systems, base conversions, complements of numbers weighted and unweighted codes and error detecting and correcting codes, Alpha numeric code (ASCII), Error detecting and correcting codes.

Switching algebra and switching functions: Boolean algebra, postulates, theorems and switching algebra, completely and incompletely specified switching functions, Representation of Boolean functions insum of products form and product of sums form, minimization of Boolean functions using Karnaugh map and Quine McCluskey methods. Problem solving**.**

Combinational logic circuits: Logic gates, Logic gates operation using discrete components, Universal Logic gates, Logic design of combinational circuits: adders, Code converters**,** Comparators, multiplexers, de-multiplexers, encoders, decoders, buffers, tri-state buffers.

Logic Families: Transistor as an inverter/switch. Classification of logic families and their developments. TTL NAND gate analysis, ECL and CMOS logic family. Comparison TTL CMOS and ECL logic families.

Introduction to Hardware Descriptive Languages: Examples of VHDL programs in Dataflow, Structural and behavioral.

Sequential Logic circuits:

Flip-Flops- RS Flip flop, Clocked RS flip-flop, JK flip-flop, T-flip-flop, JK flip-flops and M/S JK flip flop, Conversion of flip-flops.

Registers: Buffer Register, Controlled buffer register, Shift Registers(Left shift and Right shift register)
Universal shift register: SISO, SIPO, PISO, PIPO, Ring counter and twisted ring counter

Counters: Design of Asynchronous and Synchronous counters.

Introduction to finite state machines: Moore and Mealy machines

Semiconductor Memories: RAM, ROM (Cell Structures and Organization on Chip)

Data Conversion Circuits: D/A converters- specifications, A/D converters- specifications, D/A converters such as DAC 0808, DAC 1408/1508, Integrated circuit A/D Converters ADC 0808, ICL 7106/7107.

Study of Digital ICs

Logic gate ICs:7400,7402,7404,7408,7432.7486; Multiplexer ICs:74151, 74153 ; Decoder IC 74138; BCD to 7 segment decoder IC:7447; Flip-flop ICs:7474,7476; Asynchronous Counter ICs: 7490,7492,7493; Synchronous counter ICs: 74190,74192,74193, Register ICs:7491,7495,74195.

Learning Resources:

Text Books:

1. Digital Principles and Applications (SIE) | 8th Edition Paperback ,Donald P.Leach, Malvino and Saha , McGraw Hill Education; Eighth edition, 21 August 2014.
2. Switching and Finite Automata Theory By ZviKohavi, McGraw-Hill Eighth edition, 2017.

Reference Books:

1. Digital integrated electronics, Herbert Taub, Donald Schilling, McGraw-Hill, 2017.
2. Designing with TTL integrated circuits Robert L.Morris and John R.Miller MH, 1975.

Online Resources:

1. https://www.youtube.com/watch?v=BDq8-QDXmekM
2. https://nptel.ac.in/courses/108/105/108105132/.
3. https://www.tutorialspoint.com/digital_circuits/digital_circuits_flip_flops.htm

SM 282	POWER ECONOMICS & ACCOUNTANCY	3-0-0: 3

Pre-Requisites: -NIL

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

CO1	Understand Macro Economic Environment at National Level.
CO2	Understand the contemporary electricity act and its implications on power markets
CO3	Analyze the financial statements with ratio's for investment decisions
CO4	Apply various methods of Economic Analysis
CO5	Analyze costs and their role in pricing
CO6	Develop effective presentation skills with special emphasis on contemporary topics

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1	1	1	1	1	1	1	2	1	1	1
CO2	1	1	1	1	1	1	1	1	1	1	2	1	1	1
CO3	1	1	1	1	1	1	1	1	1	1	2	1	1	1
CO4	1	1	1	1	1	1	1	1	1	1	2	1	1	1
CO5	1	1	1	1	1	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	1	1	1	1	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

POWER ECONOMICS:

National Income Accounting: Introduction, Methods of Estimation, Various Concepts of National Income, Significance of National Income Estimation and its limitations

Inflation: Introduction, Definition, Process and Theories of Inflation and Measures to Control,

New Economic Policy 1991, LPG, Power sector reforms in India, present pricing strategies, role of private sector participation in India. Role of technology in nation growth.

Power reforms in India: Power regulatory authority of India,type of deregulation, solar power generation drives, Discom revival, Power Markets, energy exchange and power exchange.

Engineering Economics: Introduction, Fundamental concepts, Time value of money, Cash flow and Time Diagrams, Choosing between alternative investment proposals, Methods of Economic analysis (Pay back, ARR, NPV, IRR and B/C ratio),

Price determination: Demand supply and equilibrium price consumer surplus, producer surplus, latent demand.

Accountancy:

Analysis of financial statements: Introduction, income statements and balance sheet(simple ratio's).

Cost Accounting: Introduction, Classification of costs, Methods of Costing, Techniques of Costing, Cost sheet and preparation cost sheet, Breakeven Analysis, Meaning and its application, Limitation.

Presentations/ Group Discussions on current topics.

Learning Resources:

Text Books:

1. Managerial Economics, D N Dwivedi, Vikas Publishing House Private Limited, 8th Edition, 2015.
2. Indian Economy, Agrawal AN, Wiley Eastern Ltd, New Delhi, 2019.
3. Financial Managemen",R.K Sharma and Sashi K Gupta, Kalyani Publications, 8th Edition, 2016.

Reference Books:

1. Cost Accounting, Arora, M.N. Vikas Publication. 13th Edition 2021.

Online Resources:

1. Latest trends in Indian Economy.
2. Capitaline Plus Database – http://www.capitaline.com/
3. Ministry of Finance – http:/finmin.nic.in/
4. Database of Indian Economy - http://dbie.rbi.org.in
5. Statistics of India – www.indiastat.com/ or http://mospi.nic.in/

EC 282	IC APPLICATIONS LAB	0-1-2: 2

Pre-requisites: EC231 Analog Electronics

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

CO1	Understand, analyze and design applications using Op.Amp IC μA741.
CO2	Design and construct waveform generation circuits
CO3	Verify the functionality of combinational and sequential circuit ICs.
CO4	Design combinational and sequential circuits using Digital ICs

Course Articulation Matrix**:**

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

List of Experiments

1. Study and Operation of IC testers, pulse generator and digital trainer.

2. Measurement of Op Amp parameters:

Aim: To measure i) Input off set voltage ii)Bias current & Input Offset current iii) CMRR iv) Slew rate v) Open loop gain vi) Input impedance.

3. Op Amplifier applications

Aim: Design and implementation of i) Adder and difference amplifier using μA741 ii) Instrumentation amplifier using LM 321

4. Op Amp Multivibrators.

Aim: Design and implementation of monostable and astable multivibrators

5. 555 Timer as Multivibrators

Aim: Design and implementation of Monostable and astable multivibrators

6. Linear Voltage Regulator

Aim: Design and implementation of Voltage Regulator using 723IC

7. Combinational Logic Circuits

Aim: Design and implementation of adders, subtractors&code converters using gate ICs

8. Characteristics of TTL NAND gate:

Aim: To obtain (i) Sourcing (ii) Sinking (iii)Transfer characteristics of 7400

9. Adders, Multiplexers and Decoders

Aim: Implementation of i) 4-bit Adder/ Subtractor using 7483 and 7486

ii) Full adder and Full subtractor using Mux 74153 and 7404

iii) Full adder and Full subtractor using decoder 74138

10. Study of Flip-flops

Aim: i) To study functioning of 7474, 7476

ii) To implement a 4-bit buffer and 4-bit shift register using 7474 ICs

iii) To design and implement synchronous counter using 7476ICs

11. Applications of Counter ICs Aim: i) To implement various modes of counters using 7490, 7492 and 7493

ii) To implement up/down counters using 74190/74192/74193

12. Applications of Registers

Aim: i) To implement a 4-bit shift register, self-generating ring counter and Johnson counter using 74195/7495/7498/74198.

EE301	ELECTRICAL MACHINES – III	2 - 0 - 0: 2

Pre-Requisites**:** EE 251 - Electrical Machines-II

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

CO1	Understand the principle of single phase induction motors and identify the suitable methods of starting.
CO2	Understand the operating principles of special machines and their applications
CO3	Identify the suitable applications of special machines.
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

Syllabus:

Single Phase Induction 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.

Single Phase Synchronous Motors: Construction, principle of operation and applications of Reluctance motors, Hysteresis motors, Sub-synchronous motors

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

Schrage Motor: Construction, Principle of operation, Speed and power factor control, Applications

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

Energy Efficient Machines: Construction, Basic Concepts, losses minimization and efficiency calculations of Energy efficient AC machines

Super Conducting Machines: Construction, Principle of operation and basic concepts of superconducting AC machines.

Learning Resources:

Text Books:

1. A. E. Fitzgerald, C. Kingsley and Stepen D. Umans: Electric Machinery, Tata McGraw-Hill Pub., 7th Edition, 2020.
2. P.S. Bimbhra: Generalized Theory of Electrical Machines, Khanna Pub., 6th Edition, 2017.
3. D.P. Kothari and I J Nagarath: Electric Machines: Tata McGraw-Hill Pub., 5th Edition, 2017.

Reference Books:

1. P.S. Kenjo and S.Nagamori: Permanent Magnet DC motors, Clarendon Press, Oxford, 1985.
2. J.B. Gupta: Theory and Performance of Electrical Machines, S. K. Kataria & Sons, 14th Edition, 2006.
3. H. Cotton: Advanced Electrical Technology, Reem Publications, 2011.
4. Stephen J. Chapman: Electric Machinery Fundamentals, Tata McGraw - Hill Education, 4th Edition, 2017.

Online resources:

1. https://nptel.ac.in/courses/108/102/108102156/

EE302	POWER ELECTRONICS	3 - 0 - 0: 3

Pre-requisites: EE101 - Basic Electrical Circuits, EE151 - Electrical Network Analysis

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 ac voltage controllers

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

Syllabus

Introduction: Concept of power electronics, scope and applications, types of power converters, power semiconductor switches and their V-I characteristics 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.

Phase-Controlled Rectifiers: Principles of single-phase fully-controlled converter with R, RL, and RLE load, Principles of single-phase half-controlled converter with RL and RLE load, Principles of three- phase fully-controlled converter operation with RLE load, Effect of load and source inductances, Single phase and Three phase dual converters

DC-DC Converters: 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.

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.

A.C. Voltage Controllers: Introduction, principle of operation of single phase voltage controllers for R,R-L & R-L-E loads and its applications.

Learning Resources: Text Books:

1. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson, 4th Edition, 2018.
2. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 3rd Edition, 2002.

Reference Books:

1. P.S.Bimbhra, Power Electronics, Khanna Publishers, 6th Edition, 2016.

Online resources:

1. https://nptel.ac.in/courses/108/101/108101038/
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://nptel.ac.in/courses/108/101/108101126/

EE303	DIGITAL SIGNAL PROCESSING	3 - 0 - 0: 3

Pre-requisites: MA182- Fourier Series, Matrices and Differential Equations, MA232- Complex Variables and Partial Differential Equations

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

CO1	Understand the dynamics of a Linear, Time Invariant and Causal digital systems using convolution
CO2	Understand the sampling theorem and relationship between the time domain and frequency domain description of signals and systems
CO3	Determine the behavior of digital systems
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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Signals and Systems:
Introduction to digital systems, Definition of signal and system, Shannon's sampling theorem, Types of Discrete-Time signals, Aliasing Phenomena, Impulse Response, Linear Time Invariant systems, Linear convolution, Difference Equations, Solving Difference equations.

Fourier analysis and Z-Transform:
Definition of Continuous Time & Discrete Time Fourier Series and Fourier Transform (CTFS, CTFT, DTFS, DTFT), DTFT Properties and its application.
Definition of two-sided Z-transform, Properties of Z-Transform, Convolution using Z-transform, One-sided Z-Transform, Transform Analysis of Systems, System Function, Systems with Linear Phase.
Definition of Discrete Fourier and Fast Fourier Transforms, DFT properties, Sampling the DTFT, Linear convolution using DFT, Radix-2 FFT algorithms, decimation in time, decimation in frequency.

Digital Filters:
Basics of Digital Filters: Low pass, High pass, Band pass, Band Stop, Notch Filter, Comb Filter, All pass filters, Minimum phase systems, IIR and FIR filters.

Synthesis of Discrete Time Systems
Direct Systems, Indirect Systems, Cascade Structure, Transposed/Lattice Structures,

Parallel structures for IIR and FIR systems

Introduction to TMS320LF2407 Digital Signal Processor:

Architecture, addressing modes, Instruction set and simple applications

Learning Resources:

Text Books:

1. S Salivahanan, Digital signal processing, Mac Graw Hill, 4th Edition, 2019.
2. John G. Proakis and Dimitris K Manolakis, Digital signal processing principles – algorithms and applications, Pearson, 4th Edition, 2007.
3. Alan V Oppenheim and Ronald W. Schafer, Discrete time signal processing, Pearson, 3rd edition, 2010.

Reference Books:

1. Hamid A. Toliyat, Steven G. Campbell, DSP Based Electromechanical Motion Control- CRC press, 2019.

Online resources:

1. https://nptel.ac.in/courses/108/106/108106151/
2. https://nptel.ac.in/courses/108/105/108105055/

EC 331	SYNTHESIS OF DIGITAL SYSTEMS	3 - 0 - 0: 3

Pre-Requisites: EC 281 **-** Digital Electronics

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

CO1	Understand & design combinational and sequential logic circuits
CO2	Develop Verilog HDL models for combinational and sequential logic circuits
CO3	Synthesis of Verilog HDL models for combinational and sequential logic circuits
CO4	Understand the PLD/CPLD/FPGA organization and mapping of digital circuits on PLDs

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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Overview of Digital Design with Verilog HDL: Emergence of HDLs, Typical Design flow, Hierarchical modelling concepts, Lexical conventions, data types, Gate level Modeling, Dataflow Modeling, Behavioral Modeling, Structural Modeling, Logic Synthesis with Verilog HDL.

Combinational circuits design: Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carry-look ahead adder; Parallel prefix adders- Carry select Adder, Verilog models of combinational circuits.

Sequential circuit design: Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop Synthesis of synchronous sequential circuits, Mealy and Moore machines, state minimization. Registers, synchronous and asynchronous counters Verilog models of sequential circuits.

Memory and Programmable logic devices: RAM, ROM, Memory decoding, Error detection and correction, PAL, PLA, CPLD and FPGA

Learning Resources:

Text Books :

1. Digital Design with an introduction to the Verilog HDL, Morris. M. Mano, Michael D.Ciletti, Prentice-Hall India 2013 Fifth Edition.
2. Fundamentals of Logic Design, Charles H. Roth, Jr, Thomson Brooks /Cole, 2005 Fifth Edition.
3. Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Pearson Education, 2004, Second Edition.

Reference Books :

1. Fundamentals of digital logic with Verilog design S. Brown and Z. Vranesic, McGraw-Hill, 2013 Third Edition.
2. Digital System Design using VHDL Charles, H. Roth, Jr, Thomson Brooks /Cole, 2006 , Indian Edition.
3. Digital Design, Mohammad A.Karim, Xinghao Chen, CRC press 2008.
4. Digital Design Principles and Practices , J.F. Wakerly, Prentice Hall, 2008 Fourth Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106177/

EE 304	MICROPROCESSORS AND MICROCONTROLLERS	3 - 0 - 2: 4

Pre-requisites: **NIL**

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

CO1	Develop assembly level programs of 8086 microprocessor
CO2	Develop real-time systems on 8086-microprocessor platform using external interface peripherals
CO3	Develop assembly level programs on the 8051 and PIC 18F-microcontroller platforms.
CO4	Develop real-time systems on the 8051- microcontroller platform using external interface peripherals

Course Articulation Matrix:

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

Syllabus:

Introduction: Overview of the course, Functional elements of a microprocessor, overview of architecture of a general purpose microprocessor.

8086 Microprocessor: Internal Architecture of 8086, BIU and EU- Registers in of 8086- Memory segmentation- Addressing modes-register related and memory related- Instruction formats, Instruction set of 8086- Assembler directives, Tutorial- Problems on assembly language programming- Pin diagram of 8086 , Modes of operation- Timing diagrams of typical instructions- Fundamentals of I/O data transfer, Polling, Handshaking, interrupts-Steps in an interrupt process, Interrupt structure in 8086- Fundamentals of interfacing peripheral chips, Interfacing memory & I/O devices- Interfacing I/O- Programmable peripheral interface-8255, Modes of operation of 8255, Interfacing examples with 8255- Interfacing 8254 timer, Interfacing Digital to analog converters, Analog to Digital converters- Interfacing USART 8251.

8051 Microcontroller: 8051 architecture, memory organization, addressing modes & port structure, external memory access, counters and timers, Interrupts, serial communication, Microcontroller instructions -, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns. Microcontroller programming – Assembly Language Programming, timer and counter programming, Interrupt programming- Interfacing examples.

PIC Microcontrollers (PIC 18F): Introduction - Architecture – Memory organization – Assembly Language Programming and programming with Embedded C – simulation using Integrated Development Environment (IDE) - Programming of I/O ports – Addressing modes.

Bank switching – Look-up Table and Table processing – Timers and its programming – Interrupt sources- analog-to-digital converter (ADC) module-Brown-out-reset (BOR), Power-on-reset (POR),Capture/Compare/PWM modules, USART, Master Synchronous Serial Port (MSSP) Module -Interfacing examples.

Advanced Microprocessors: Multi-User/Multi-Tasking Operating System, Memory

Management, qualitative analysis in architectural features of Intel 80286, 80386, Pentium, Pentium-pro, and Power PC **(Qualitative treatment).**

List of Lab Experiments

1. 8086 Assembly language programs and coding of instructions.
2. Interfacing of 8255 PPI and applications with 8086Microprocessor
3. Interfacing of 8254 and serial data transfer using 8251 USART with 8086Microprocessor.
4. Programming exercises on 8051 and PIC Microcontroller
5. Interface I/O devices with and handle external interrupts using 8051microcontroller
6. PIC Serial Communication using Serial Peripheral Interface (SPI) and Interface PIC 18F45K22 Microcontroller with an LCD using PIC microcontrollers simulator (IDE)

Learning Resources:

Text Books:

1. Douglas V Hall ,SSSP Rao, "Microprocessors and Interfacing", McGraw Hill Education Publications, 3rd Edition, 2017.
2. Ray A.K., Bhurchandi K.M., "Advanced Microprocessor and Peripherals", McGraw Hill Education Publications, 3rd Edition, 2017.
3. Kenneth J Ayala, 'The 8051 Microcontroller', Cengage Learning Publications, 3rdEdition, 2007.

Reference Books:

1. Barry B Brey, "The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64 bit extensions, Architecture, programming and Interfacing", Pearson Education, 2009.
2. Yu-Cheng Liu, Glem A. Gibson, "Microcomputer systems: The 8086/8088 Family Architecture programming and design", Pearson Education India' 2nd edition, 2015.
3. Ajay V. Deshmukh: Microcontrollers – Theory and Applications, McGraw Hill Education Publications, 2017.
4. Nicolas K. Haddad, "Microcontroller System Design using PIC18F Processors", IGI Global Publishers, 2017.
5. M. Rafiquzzaman, Microcontroller Theory and Applications with the PIC18F, 2nd Edition, Wiley, 2018.

Online resources:

1. https://nptel.ac.in/courses/106/108/106108100/
2. https://nptel.ac.in/courses/117/104/117104072

EE 305	ELECTRICAL MACHINES LAB-I	0 - 1 - 2: 2

Pre-requisites: EE201 - Electrical Machines - I

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

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
13. Separation of no load losses of a single phase transformer

EE 306	CONTROL SYSTEMS LAB	0 - 1 - 2: 2

Pre-requisites: EE253 – Control Systems, EE151- Electrical Network Analysis

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

CO1	Evaluate the characteristics of a given AC and DC servo motor and design and analyze the performance of controllers for DC servo-motor applications.
CO2	Determine the performance of first and second order systems in time domain and analyze second order systems using frequency domain analysis.
CO3	Design of feedback control systems
CO4	Simulate and analyze various control system approaches using MATLAB/SIMULINK tools.

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	3	2
CO2	3	3	2	2	2	1	1	1	2	1	1	2	3	2
CO3	3	3	3	2	3	1	1	1	2	1	1	3	3	3
CO4	3	3	3	2	3	1	1	1	3	1	1	3	3	3

List of Experiments

1. Speed-torque characteristics of AC servo-motor
2. Time-response of first and second order systems
3. Frequency-response of second order system
4. Study of P, PI & PID controller
5. Design and study of lag, lead and Lag-lead compensator networks
6. Determination of transfer function of DC servo
7. Stability Analysis of the DC servo motor for speed and position output functions.
8. Analysis the second order response of the DC Servo Motor
9. Evaluation of position control of DC Servo motor using PV controller
10. Design of two loop systems
    a) Mathematical Models & Time Domain Analysis of LTI Systems
    b) Block diagram reduction technique
    c) Time domain analysis and steady state errors
    d) State space analysis

11. 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
    c) Evaluation of effect of pole location on stability
    d) Effect of loop gain of a negative feedback system on stability

12. a) To examine the relationships between open-loop frequency response and stability, open loop frequency and closed loop transient response.
    b) To study the effect of addition closed loop poles and zeroes on the closed loop

transient response

13. a) Effect of open loop and zeroes on root locus contour

b) To estimate the effect of open loop, gain on the transient response of closed loop system by using Root locus

c) Comparative study of Bode, Nyquist and Root locus with respect to Stability.

14. To study the effect of P, PI, PD and PID controller on the step response of a feedback control system

15. a) Stability Analysis and SIMULINK Modelling.

b) Nonlinear system Analysis using MATLAB

EC 332	DIGITAL SYNTHESIS LAB	0 - 1 - 2: 2

Pre-requisites: EC281 - Digital Electronics

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

CO1	Understand verilog HDL models for combinational and sequential logic circuits
CO2	Develop digital circuits design flow using EDA tools
CO3	Develop the test bench models to simulate the Verilog HDL models
CO4	Understand FPGA design to map the given digital circuit

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	3	2
CO2	3	3	2	2	2	1	1	1	2	1	1	2	3	2
CO3	3	3	3	2	3	1	1	1	2	1	1	3	3	3
CO4	3	3	3	2	3	1	1	1	3	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

List of Experiments:

1. Develop dataflow Verilog models for
   a) Full adder/subtractor
   b) Decoders
   c) Encoders
   d) Multiplexers
   e) Comparators

2. Develop structural Verilog models for
   a) 16:1 mux realization using 4:1 mux
   b) 4-bit ripple carry adder using full adder
   c) 16-bit adder-cum subtractor using 4-bit ripple carry adder
   d) 4-bit carry look-ahead adder
   e) 8-bit comparator using 2-bit comparator

3. Develop behavioural Verilog models for

   a) 16:1 Multiplexer
   b) 16:4 Encoders
   c) 4:16 decoders
   d) 1:16 Demultiplexers
   e) 16-bit comparator
   f) Edge triggered T-FF/D-FF/JK-FF
   g) Mealy and Moore state machine examples
   h) 8-bit synchronous and asynchronous counters
   i) 8-bit shift registers

Learning Resources:

Text Books:

1. Digital Design with an introduction to the Verilog HDL, Morris. M. Mano, Michael D.Ciletti, Prentice-Hall India 2013 Fifth Edition.
2. Fundamentals of Logic Design, Charles H. Roth, Jr, Thomson Brooks /Cole, 2005 Fifth Edition.
3. Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Pearson Education, Second Edition 2004.

Reference Books:

1. Fundamentals of digital logic with Verilog design S. Brown and Z. Vranesic, McGraw-Hill, 2013 Third Edition.
2. Digital System Design using VHDL Charles, H. Roth, Jr, Thomson Brooks /Cole, 2006, Indian Edition.
3. Digital Design, Mohammad A.Karim, Xinghao Chen, CRC press 2008.
4. Digital Design Principles and Practices , J.F. Wakerly, Prentice Hall, 2008 Fourth Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106177/

EE 311	COMPUTER ORGANIZATION	3-0-0: 3

Pre-Requisites: EC 281 - Digital Electronics

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

CO1	Understand the characteristics of functional 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	-	-
CO2	3	3	1	3	1	2	2	2	2	2	2	2	2	1
CO3	3	3	3	3	3	3	3	3	3	3	-	3	2	1
CO4	3	2	3	3	2	2	2	2	2	2	-	1	1	1

Syllabus

Introduction: Historical review, evolution and design considerations, Computer evolution and performance organization and architecture, Computer structure and function, Computer interconnection structures.

Interconnection structures: Bus Interconnection structures, Elements of bus design, Example bus systems, Signals, operations-PCI Bus and Furture bus, Bus commands and timing diagrams, Future bus and other bus standards

Internal Memory: Characteristics of hierarchical memory systems, components and types, Memory organization- Design of a memory organization system, Cache memory organization and elements of cache design, Mapping functions, replacement algorithms and hardware

Operating system support: OS as a resource manager, Role of memory management and techniques, Virtualmemory, address translation and implementation

External memory: Types of external memory devices and characteristics, Input/output subsystem: Characteristics of I/O data transfer, External interfaces, Front system bus (FSB) and its implication in I/O datatransfer

CPU – Arithmetic unit- Number systems and representations, Functions of ALU, Floating point number operations

CPU – Processing Unit: Machine instruction formats, Instruction execution, CISC Vs RISC processors, superscalar processors

CPU – Control Unit: Internal organization of CPU, micro-operations, Micro-programmed

control unit, Minimization of control word size by grouping of control signals, Wide branch addressing, Advantages and disadvantages of Micro-programmed control unit, Hardwired control unit

Recent trends in computer systems: Parallel processing, Vector processing, optimization of main memoryacross processors

Learning Resources:

Text Books:

1. David Patterson John Hennessy, Computer Organization and Design-The HW/SW Interface: Peterson and Hennessey, Elsevier, 5th Edition, 2013.
2. William Stallings, Computer organization and Architecture: Designing for performance, PHI, 10th Edition, 2015.
3. Computer Organization: Hamacher, Vranesic and Zaky, McGraw Hill, ISE, 2011.

Reference Books:

1. Computer Organization: John P Hayes, McGraw Hill, ISE, 2017.

Online resources:

1. https://nptel.ac.in/courses/106/106/106106092/
2. https://nptel.ac.in/courses/106/105/106105163/

EE 312	UTILIZATION OF ELECTRICAL ENERGY	3-0-0: 3

Pre-requisites: EE201- Electrical Machines-I

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

CO1	Understand the principles of electric heating and welding and their requirements
CO2	Design the lighting schemes for residential, commercial and industrial applications
CO3	Understand the schemes of electric traction and traction mechanisms
CO4	Analyze the control of traction motors, train lighting schemes and coaching wiring

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	-	-
CO2	3	3	1	3	1	2	2	2	2	2	2	2	2	1
CO3	3	3	3	3	3	3	3	3	3	3	-	3	2	1
CO4	3	2	3	3	2	2	2	2	2	2	-	1	1	1

Syllabus:

Electrical Heating and Welding: Electric Heating**:** Methods and merits of electric heating, resistance heating, induction heating and dielectric heating. Electric welding: Welding equipment, resistance welding and arc welding, comparison between AC and DC welding. Electrolysis: principle of electrolysis, electroplating, metal extraction and metal processing, electromagnetic stirs. Problems on heating , welding and electrolysis.

Illumination Terminology: Terminology, Laws of illumination, coefficient of utilization and depreciation, Polar curves, photometry, integrating sphere, sources of light, filament lamps, fluorescent tubes, comparison between filament lamps and fluorescent tubes. Compact fluorescent lamps, LED lamps, discharge lamps: mercury vapour lamps, sodium vapour lamps and neon lamps, 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- DC system, single phase and 3-phase low frequency and high frequency system, composite system, kando system, comparison between AC and DC systems, Mechanics of traction movement, speed – time curves for different services, trapezoidal and quadrilateral speed–time curves, tractive effort, specific power, specific energy consumption, effect of varying acceleration and braking, retardation, adhesive weight and braking retardation, coefficient of adhesion. Schemes and speed control of traction motors, requirements of train lighting, systems of train lighting, methods of obtaining unidirectional polarity- Rosenberg Generator-single battery system, double battery parallel block system. Lighting by making use of 25KV AC supply. End-on generation, Coach wiring.

Learning Resources:

Text Books:

1. H. Partab: Modern Electric Traction, Dhanpat Rai & Co, 2017.
2. N.V. Suryanarayana:Utilisation of Electrical power including Electric drives and Electric Traction,New Age Publishers,2017

Reference books:

1. J. B Gupta: Utilization of Electric Power & Electric Traction S.K. Kataria & Sons 10th Edition, Reprint 2020.
2. E. Openshaw Taylor: Utilisation of Electric Energy, Universities Press, Penram International Publishers, 2010

3. H. Partab: Art & Science of Utilisation of Electric Energy, DhanpatRai & Sons, 1998.

Online resources:

1. https://nptel.ac.in/courses/108/104/108104140/
2. https://nptel.ac.in/courses/108/105/108105060/

EE 313	INDUSTRIAL INSTRUMENTATION AND AUTOMATION	3-0-0: 3

Pre-requisites: EE 254 - Electrical Measurements & Instrumentation

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

CO1	Understand the concepts and analyze the performance of physical systems using transducers for measurement of physical quantities.
CO2	Understand various Signal Conditioning operations and design Signal Conditioning circuitry of a measurement and instrumentation system
CO3	Exposure to the technology of Industrial Automation and Control
CO4	Implementation of various Programmable Logic Controllers (PLCs) to Automation problems in industries.

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	3	2	2	1	1	2	2	3	2
CO2	3	3	3	3	3	2	2	1	2	2	2	2	3	2
CO3	3	3	3	3	2	2	2	1	2	1	3	2	3	2
CO4	3	3	3	3	3	2	1	1	3	2	3	2	3	2

Syllabus:

Introduction: Static characteristics and static calibration and Dynamic characteristics of Instrument-Zero order, step, ramp and frequency response of first order and second order instrument. Displacement and proximity gauges. Linear Variable Differential Transformer (LVDT)-differential transformer, phase angle adjustment, methods for null reduction, filter frequency response, Hall-effect sensors.

Measurement of Temperature, Flow, Level and Viscosity: Thermocouple, Resistance Temperature Detector (RTD), Thermistor, Radiation Pyrometer, Differential Pressure flow-meter, Variable area flow- meter, Variable reluctance transducer, Turbine flow-meter, Ultrasonic flow-meter (Both transit time and Doppler Shift), electromagnetic flow-meter and Mass flow meter, Capacitance based and Float based method, pH -probe and viscosity measurement and associated Signal Conditioning circuitry.

Measurement of Pressure, strain & Vibration: Estimation of errors and Calibration, Fundamentals of 4-20 mA current loops and 3-15psi pressure loop, Regulators and power supplies for industrial instrumentation.

Signal Conditioning and Processing: Estimation of errors and Calibration, Fundamentals of 4-20 mA current loops and 3-15psi pressure loop, Regulators and power supplies for industrial instrumentation.

Basics of Data transmission: Synchro and Servo motor. IEEE-488 bus, RS 232 and RS 485 interface. Pneumatic and Hydraulic Instrumentation system

Automation: Benefits and Impact of Automation on Manufacturing and Process Industries; Architecture of Industrial Automation Systems. Data Acquisition systems and PC based automation.

Introduction to Automatic Control: P-I-D Control, Controller Tuning, Special Control Structures, Feed- forward and Ratio Control, Predictive Control, Control of Systems with

Inverse Response, Cascade Control. Process and Instrumentation Diagrams;

Sequence Control: Programmable Logic Controllers (PLCs) and Relay Ladder Logic, Scan Cycle, RLL Syntax, Structured Design Approach, Advanced RLL Programming, Hardware environment and distributed control systems (DCS); Control of Machine tools: Introduction to CNC Machines.

Learning Resources:

Text Books:

1. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems, McGraw Hill, 7th edition, 2019.
2. Albert D. Helfrick and Willium D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Pearson Education India, 1st edition, 2015.
3. Alok Barua , "Fundamentals of Industrial Instrumentation", Wiley India Pvt Ltd,2011.

Reference Books:

1. Chemical Process Control, An Introduction to Theory and Practice, George Stephanopoulos, Pearson Education India,2015.
2. Measurement & Instrumentation : Trends & Applications by M.K. Ghosh, S. Sen and S. Mukhopadhyay, Ane Books,2008.
3. Alan S Morris, "Measurement and Instrumentation Principles", Elsevier, 2006.
4. Frank. D, Petruzella, “Programmable Logic Controllers”, McGraw Hill, 5th Edition-2019.
5. S. Mukhopadhyay, S. Sen and A. K. Deb, "Industrial Instrumentation, Control and Automation", Jaico Publishing House, 2012.

Online resources:

1. http://www.nptelvideos.in/2012/11/industrial-instrumentation.html
2. https://nptel.ac.in/courses/108/105/108105088/

EE 314	BASICS OF INTERNET OF THINGS	3-0-0: 3

Pre-requisites: None

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

CO1	Understand IOT and its design requirements
CO2	Select appropriate Sensors and Actuators for desired application
CO3	Compare various technologies and protocols
CO4	Design and experiment various use cases with IoT

Course Articulation Matrix:

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

Syllabus:

Introduction to IoT: Characteristics of Internet of Things- Need of IoT, IoT architecture, Area of Applications, IoT applications in Smart Cities, Agriculture, Security, Transport and Medical & Health. **IoT Sensing and Actuation**: Introduction, Sensors, Sensor Characteristics, Sensorial Deviations, Sensing Types, Scalar sensing, Multimedia sensing, Hybrid sensing, Virtual sensing, Sensing Considerations. Actuators, Actuator Types, Hydraulic actuators, Pneumatic actuators, Electric actuators, Thermal or magnetic actuators, Mechanical actuators, Soft actuators, Actuator Characteristics.

IoT Connectivity Technologies (Fundamentals): Introduction, IEEE 802.15.4, Zigbee, RFID, DASH7, Z-Wave, LoRa, NB-IoT, Wi-Fi, Bluetooth. **Communication Technologies (Fundamentals)**: Introduction, Constrained nodes, Constrained Networks, Infrastructure Protocols, Discovery Protocols, Data Protocols, Identification Protocols, Device Management, Semantic Protocols.

Introduction to Arduino: Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi. **IOT Case Studies**: Agricultural IoT, Components of an agricultural IoT, Advantages of IoT in agriculture, Case Studies, Smart irrigation management system. Vehicular IoT, Components of vehicular IoT, Advantages of vehicular IoT, Crime assistance in a smart IoT transportation system. Healthcare IoT, Components of healthcare IoT, Advantages and risk of healthcare IoT, Case Studies. IoT Case Studies in Electrical Engineering: IoT application to Smart Grid, Smart Cities and Smart Homes, EV Connected Vehicles.

IOT Projects Demonstration: Beginning IoT Hardware Projects, Arduino installation and setup, Setting up Arduino IDE for NodeMCU, Writing an Arduino Sketch, Demo Experiments with Arduino, Printing on the serial console, LED interface with Arduino, DHT Sensor interface with NodeMCU, MQ-2 Gas sensor interface with NodeMCU, Ultrasonic sensor interface with NodeMCU, Obstacle detection using NodeMCU, Servo motor interface with NodeMCU, Relay interface with NodeMCU, Data transmission between NodeMCU and

remote server, Pulse sensor interface with NodeMCU.

IoT Analytics(Basics): Introduction, Machine learning, Advantages of ML, Challenges in ML, Types of ML, Selected Algorithms in ML, k-nearest neighbor (KNN), Decision tree, Random forest, k-means clustering, Agglomerative clustering, Density-based spatial clustering of applications with noise(DBSCAN), clustering, Performance Metrics for Evaluating ML Algorithms.

Paradigms, Challenges, and the Future: Introduction, Evolution of New IoT Paradigms (Discussion Only), Internet of battlefield things (IoBT), Internet of vehicles (IoV), Internet of underwater things (IoUT), Internet of drones (IoD), Internet of space (IoSpace), Internet of services (IoS), Internet of people (IoP), Internet of nano things (IoNT), Internet of everything (IoE). Challenges Associated with IoT, Mobility, Addressing -Power Heterogeneous connectivity, Communication range, Security, Device size.

Learning Resources:

Text Books:

1. Sudip Misra, Anandarup Mukherjee and Arijit Roy “Introduction to IoT” by, Cambridge University Press, 2021.
2. Dimitrios Serpanos, Marilyn Wolf, “Internet-of-Things (IoT) Systems - Architectures, Algorithms, Methodologies” Springer Publications, 2018.
3. Mansaf Alam • Kashish Ara Shakil, Samiya Khan, “Internet of Things (IoT)-Concepts and Applications” Springer Publications, 2020.

Reference Books:

1. Anandarup Mukherjee, Chandana Roy, Sudip Misra - Introduction to Industrial Internet of Things and Industry 4. 0-CRC Press, 2020.
2. Peter Hoddie, Lizzie Prader - IoT Development for ESP32 and ESP8266 with JavaScript_ A Practical Guide to XS and the Moddable SDK-Apress, 2020.
3. Mansaf Alam, Kashish Ara Shakil, Samiya Kha - Internet of Things (IoT)_ Concepts and Applications (S.M.A.R.T. Environments)-Springer, 2020.
4. Anuradha, J., Tripathy, B. K - Internet of things (IoT) _ technologies, applications, challenges and solutions-CRC Press_Taylor & Francis, 2018.

Online Resources:

1. NPTEL) Online course: https://nptel.ac.in/courses/106/105/106105166/

SM 332	ENERGY ANALYTICS	3-0-0: 3

Pre-requisites: Programming languages- C/C++/Java/Python/Octave/MATLAB etc.. Knowledge for mathematics and statistics. Knowledge on power economics, Electrical Networks, Generation, and network management.

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

CO1	Understand the basic concepts of descriptive, perspective, and predictive analytics
CO2	Adapt anyone programming language or software to apply statistics/mathematics concepts and machine learning for energy analytics
CO3	Understand application of machine learning techniques in the energy sector.
CO4	Discover and experiment energy predictions/forecasting in price/wind/solar
CO5	Discover and experiment prediction/forecasting in emerging topics – customer and utilities outage

Course Articulation Matrix:

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

Syllabus

Introduction to Machine learning - Introduction to machine learning; supervised and unsupervised learning

Supervised learning – Regression; Linear and multi-variate regression cost functions; Logistic cost function; Regularization; Neural networks; Introduction and cost functions; SVM- Support Vector Machine – Intuition; Applying Machine learning; Training and cross validation sets; Systems design.

Tree-based methods – Decision trees, Bagging, boosting, and stacked ensemble methods.

Unsupervised learning - Clustering – k-means algorithm and optimization functions **Anomaly detection -** Gaussian distribution; developing and evaluating an anomaly detection. **Forecasting** – Time series and components of time series data.

Accuracy measures – Mean absolute error, mean absolute percentage error, mean squared error, Root mean square error.

Techniques – Simple methods – average, naïve, and drift; Judgmental – Delphi, analogy, scenario; Theil's coefficient.

Regression-based models – linear, least squares, nonlinear and decomposition. Decomposition – autoregressive (AR), moving average (MA), autoregressive and moving average (ARMA), auto-regressive integrated moving average (ARIMA), auto-regressive integrated moving average with X (ARIMAX); Seasonal and Trend using Losses; Dynamic regression (apart from past observation of series include other data).

Exponential smoothening – Single, double (Holt), triple (Holt-Winter model); Croston's forecasting for intermittent demand.

Using datasets perform appropriate analytics in the following areas.

Energy predictions & forecasting – electric load/price; Renewable energy – solar/wind.

Energy trading and risk management

Emerging topics – demand response and customer analytics; utilities outage analytics.

Learning Resources:

Textbooks:

1. Fundamentals of Machine Learning for predictive data analytics: Algorithms, worked examples and case studies, Kelleher, J. D., Mac Namee, B., &D'arcy, A, 2020, MIT press.
2. Business Analytics, U Dinesh Kumar, 2017, Wiley.
3. Data Mining and predictive analytics, Larose, D. T., 2015, Wiley 2ed.

Reference Books:

1. Business Analytics: Data Analysis & Decision making, Albright, Christian. 2014, Cengage Learning.
2. Machine learning using Python, Manaranjan Pradhan and Dinesh Kumar, 2019, Wiley.

Online Resources:

1. https://towardsdatascience.com/ - A Medium publication sharing concepts, ideas, and codes.
2. https://machinelearningmastery.com/ by Jason Brownee
3. https://www.otexts.org/fpp Forecasting: Principles and Practice, Rob J. Hyndman and George Athanasopoulos, OTexts.

EE 351	SMART GRID TECHNOLOGIES	2-0-0: 2

Pre-Requisites: EE 202 - Power Systems-I, EE 252- Power Systems-II

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

CO1	Understand features of Smart Grid in the context of Indian Grid.
CO2	Analyze the role of automation in Transmission/Distribution
CO3	Apply Evolutionary Algorithms for the Smart Grid/Distribution Generation.
CO4	Understand operation and importance of PMUs, PDCs, WAMS, Voltage and Frequency control in Micro 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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Smart Grid: Introduction to Smart Grid - Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – dimensions of smart grid-Key Challenges for Smart Grid.

Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable and distributed energy Integration

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

Distribution Generation Technologies: Introduction to Renewable Energy Technologies – Micro grids– Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

Communication Technologies and Smart Grid: Introduction to Communication Technology-Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS).

Control of Smart Power Grid System and Smart Cities: 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, Smart Grids to the Smart Cities: New Paradigms for Future Networks.

Learning Resources:

Text Books:

1. Mani Vadari, Smart Grid Redefined: Transformation of the electric utility, Artech House, 2018.
2. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press,2013
3. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010.

Reference Books:

1. M. L. Scala, S. Bruno, C. A. Nucci, S. Lamonaca, U. Stecch, "Smart Grids to the Smart Cities: New Paradigms for Future Networks", Vol-II, Wiley publication, 2017
2. Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2004.
3. T. Ackermann, Wind Power in Power Systems, Hoboken, NJ, USA, John Wiley,2005
4. N. Ramesh Babu, Smart Grid Systems: Modeling and Control, 1st ed, CRC Press, 2019

Online Resources:

1. https://nptel.ac.in/courses/108/107/108107113/
2. https://www.coursera.org/lecture/electric-power-systems/smart-grid-utilities-consumers-TSfBn

EE 352	POWER SYSTEM OPERATION AND CONTROL	3-0-0: 3

Pre-requisites: EE252 - Power Systems-II

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

CO1	Understand load flow methods, economic operation and load frequency control of power system.
CO2	Analyze the functions of Energy Management System (EMS).
CO3	Determine the stability of power system.
CO4	Understand power system deregulation and smart grid technologies.

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

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

Control of Real-Power: Effect of synchronous machine excitation-Power angle of a synchronous machine-Specification of bus voltages, control by transformers.

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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.

Load Frequency Control: Introduction, load frequency problem-Megawatt frequency (or P-f) control channel, MVAR- voltages (or Q-V) control channel-Dynamic interaction between P-f and Q-V loops. Mathematical model of speed-governing system-Turbine models, division of power system into control areas, P-f control of single control area (the uncontrolled and controlled cases)-P-f control of two area systems (the uncontrolled cases and controlled cases)

Power System Stability: 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 (Qualitative Treatment Only): Introduction - Power system restructuring models- responsibilities and functions of independent system operator (ISO),

Ancillary Services

Learning Resources:

Text Books:

1. C.L. Wadhwa, Electrical Power Systems, 3rd Edition, New Age International Publishing Co., 2001.
2. D.P. Kothari and I. J. Nagrath, Modern Power System Analysis, 4th Edition, Tata McGraw Hill Education Private Limited 2011.

Reference Books:

1. Power SystemGeneration, Operation and Control, Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, John Wiley and Sons, 2013, 3rd Edition
2. Electric Energy System Theory – an Introduction, Elgerd.O.I, Tata McGraw Hill, NewDelhi, 2013

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104052/
2. https://nptel.ac.in/courses/108/105/108105133/
3. https://nptel.ac.in/courses/108/106/108106026/
4. https://nptel.ac.in/courses/108/102/108102080/

EE 353	ELECTRIC DRIVES	3-0-0: 3

Pre-requisites: EE201-Electrical Machines-I, EE251-Electrical Machines-II, EE302-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	Apply power electronic converters to control the speed of DC motors and induction motors.
CO3	Evaluate the motor and power converter for a specific application.
CO4	Develop closed loop control strategies of 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

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.

DC Motor Drives: 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.

Induction Motor Drives: Speed control of cage induction motor with *v/f* 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.

Synchronous Motor Drives: Speed control methods of synchronous motor drive.

Learning Resources:

Text Books:

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. Vedam Subramanyam: Electric Drives Concepts & Applications –Tata McGraw Hill Edn. Pvt.Ltd, Second Edition, 2011.

Reference Books:

1. Werner Leonhard: Control of Electric Drives, Springer international edition 2001.
2. Nisit K. De and Swapan K. Dutta: Electric Machines and Electric Drives, PHI learning Pvt. Ltd, 2011.
3. V. Subrahmanyam: Thyristor Control of Electric Drives, Tata McGraw Hill Edn. Pvt.Ltd, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104140/

EE 354	POWER SYSTEM PROTECTION	3-0-0: 3

Pre-requisites: EE252 - Power Systems-II

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

CO1	Evaluate electromagnetic, static and microprocessor based relays
CO2	Design protection schemes for power systems.
CO3	Select relay settings for overcurrent and distance relays.
CO4	Analyze quenching mechanisms used in air, oil, SF6 and vacuum circuit breakers

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	2	1	1	2	1	2	1	3	3
CO2	3	3	3	3	3	2	1	1	2	1	3	1	3	3
CO3	3	3	2	2	2	2	1	1	2	1	2	1	2	1
CO4	3	3	2	2	2	2	1	1	2	1	2	1	2	1

Syllabus:

Introduction: Introduction, Need for power system protection, effects of faults, Fuses Introduction, fuse characteristics, types of fuses, application of HRC fuses, discrimination

Overvoltage Protection and Insulation Coordination: Over voltage due to arcing ground and Peterson coil, lightning, horn gaps, surge diverters, rod gaps, expulsion type lightning arrester, valve type lightning arrester, ground wires, ground rods, counter poise, surge absorbers, insulation coordination, volt-time curves.

Protective Relays: Evolution of protective relays, zones of protection, primary and backup protection, essential qualities of protection, classification of protective relays and schemes, current transformers, potential transformers, basic relay terminology.

Operating Principles of Protective Relays: Electromagnetic relays, thermal relays, static relays, Amplitude and Phase comparators, Duality between AC and PC, Static amplitude comparator, integrating and instantaneous comparators, static phase comparators, coincidence type of phase comparator, introduction to microprocessor based protective relays.

Over-current Protection: Time-current characteristics, current setting, over current protective schemes, directional relay, protection of parallel feeders, protection of ring mains, Phase fault and earth fault protection, Combined earth fault and phase fault protective scheme, Directional earth fault relay.

Distance Protection: Impedance relay, reactance relay, MHO relay, input quantities for various types of distance relays, Effect of arc resistance, Effect of power swings, effect of line length and source impedance on the performance of distance relays, selection of distance relays, MHO relay with blinders, Reduction of measuring units, switched distance schemes, autore-closing.

Pilot Relaying Schemes: Wire Pilot protection, Carrier current protection.

AC Machines and Bus Zone Protection: Protection of Generators, Protection of transformers, Bus-zone protection, frame leakage protection.

Static Relays: Static over current relays, static directional relay, static differential relay, static distance relays, and Multi input comparators, concept of Quadrilateral and Elliptical relay characteristics.

Microprocessor Based Relays: Over current relays, directional relays, distance relays.

Circuit Breakers: Introduction, arcing in circuit breakers, arc interruption theories, re-striking and recovery voltage, resistance switching, current chopping, interruption of capacitive current, oil circuit breaker, air blast circuit breakers, SF6 circuit breaker, operating mechanism, selection of circuit breakers, high voltage d.c. breakers, ratings of circuit breakers, testing of circuit breakers.

Learning Resources:

Text Books:

1. Badri ram and D.N. Vishwakarma, Power System Protection and Switchgear, TMH, 2001.
2. U.A. Bakshi, M. V. Bakshi: Switchgear and Protection, Technical Publications, 2009.
3. L. Singh, Digital Protection: Protective relaying from Electromechanical to Microprocessors New Age International,1994.

Reference Books:

1. C.Russel Mason – —The art and science of protective relaying, Wiley Eastern,1995

Online Resources:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://nptel.ac.in/courses/108/105/108105167/
3. https://nptel.ac.in/courses/108/107/108107167/

EC 382	ANALOG AND DIGITAL COMMUNICATION SYSTEMS	3-0-0: 3

Pre-requisites: EE 303- Digital Signal Processing, MA282- Numerical Methods and Statistics

Course Outcomes: After the completion of the course the student will be able to:

CO1	Analyse a communication system, its noise and desired output
CO2	Identify the modulation scheme based on the time domain or frequency domain transformation to the signal or signal constellation description
CO3	Assess the bandwidth requirements of different modulation schemes
CO4	Propose end-to-end physical layer block diagram for a communication system
CO5	Determine the effect of noise in the digitization of an analog signal
CO6	Compare the performance of various modulation schemes

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	3	2	3	3	3	2	1	1	1	1	1	1
CO2	2	2	1	1	2	2	1	1	2	2	1	1	2	2
CO3	1	1	2	1	1	1	2	2	1	3	2	1	1	3
CO4	2	1	3	2	1	1	1	2	2	1	1	1	1	2
CO5	3	2	1	1	2	1	2	2	1	2	2	1	2	2
CO6	1	1	1	1	1	1	1	1	1	1	1	2	1	1

Syllabus :

Introduction: Elements of electronic communication system, classification of signals and systems, , basics of frequency domain representation of signals, signal transmission through linear system, probability distributions, random processes, representation of narrowband noise, SNR, Noise bandwidth, Noise temperature, Noise figure

Amplitude Modulation: Time and frequency domain representations and generation and detection of DSBFC, DSBSC, SSB, VSB

Angle Modulation: PM, FM, Time and frequency domain representations and generation and detection of NBFM, WBFM, comparison with amplitude modulation schemes

Sampling theorem and Pulse Modulation: Sampling theorem, Time domain representations and generation and detection of PAM, PWM, PPM, PCM, Noise performance of PCM systems, DPCM, ADPCM, DM, ADM, CVSDM, Vocoders, comparison with amplitude modulation schemes

Digital Modulation Techniques: Geometric representation of signals,Time domain representation, signal constellation and generation and detection of ASK, PSK, FSK, QAM, MSK, GMSK

Learning Resources:

Text book:

1. TL Singal, 'Analog & Digital Communications', TMH, New Delhi, 2012.
2. B. P. Lathi, Zhi Ding, 'Modern Digital and Analog Communication Systems', Fourth Edition, Oxford University Press, 2010.

Reference Books:

1. K. Sam Shanmugam, 'Digital and Analog Communication Systems', John Wiley, 2006.
2. Simon Haykin, 'Communication Systems', John Wiley, 2006.

Online Resources:

1. https://nptel.ac.in/courses/117/105/117105143/
2. https://nptel.ac.in/courses/117/101/117101051/
3. https://nptel.ac.in/courses/108/102/108102096/

EE 355	ELECTRICAL MACHINES LAB-II	0-1-2: 2

Pre-requisites: EE251 - Electrical Machines-II, EE301 - Electrical Machines-III

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

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
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. Characteristics of 3-phase Schrage motor
12. Determination of equivalent circuit parameters of single phase induction motor
13. Determination of performance of induction generator

EE 356	DSP LAB	0-1-2: 2

Pre-requisites: EE303 Digital Signal Processing

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

CO1	Develop software in assembly language for TMS320LF2407A
CO2	Configure interrupts for the implementation of real-time control applications using TMS320LF2407A
CO3	Interface the TMS320LF2407A processor with external circuitry for data acquisition
CO4	Generate PWM signals for motor drive applications using TMS320LF2407A

Course Articulation Matrix:

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

List of Experiments

1. Familiarization of IDE and code-composer studio for arithmetic and logical operations.
2. Addressing modes and instruction set – 1 of the TMS320LF2407A processor
3. Addressing modes and instruction set – 2 of the TMS320LF2407A processor
4. Study of fixed-point arithmetic for the TMS320LF2407A processor
5. Study of digital I/O lines of the TMS320LF2407A processor
6. Study of Interrupts of TMS320LF2407A processor to implement real-time applications
7. Study of ADC of TMS320LF2407A processor and DAC
8. Demonstration of Sampling Theorem and the aliasing phenomenon
9. Generation of PWM signals for power electronic applications using the TMS320LF2407A processor
10. Measurement of speed of a motor with shaft encoder using the capture units and QEP of the TMS320LF2407A processor
11. Implementation of Digital Filters using the TMS320LF2407A processor.

EE 401	HVDC AND FACTS	3-0-0: 3

Pre-Requisites: EE 302 - Power Electronics

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

CO1	Compare HVDC and HVAC transmission systems
CO2	Analyse converter configurations for HVDC and FACTS and evaluate the performance metrics.
CO3	Understand controllers for power flow control of dc links and analyse the harmonics introduced in a dc link.
CO4	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	1	1	1	3	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 Substantially

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: Pulse number, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms

HVDC Control: 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

Harmonics and Filters: Effects of Harmonics, sources of harmonic generation, Types of filters–Design examples

Power Flow Analysis in AC/DC Systems: Modelling of DC links, solutions of AC-DC Power flow

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 (qualitative treatment only).

Static Shunt 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

Static Series Compensators: 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.

Special FACTS devices: TCBR, NGH - SSR damper, SMES, TCPAR and D-FACTS (DSTATCOM & UPQC).

Learning Resources:

Text Books:

1. HVDC Power Transmission Systems –Technology and System Interactions,K.R.Padiyar, New Age International Publishers, 2017,Third edition.
2. Direct Current Transmission, Kimbark, Wiley–Blackwell Publishers, Vol.1, 1971.
3. Understanding FACTS –Concepts and Technology of Flexible AC Transmission Systems, Narain G. Hingorani, Laszlo Gyugyi, Wiley India Pvt Ltd, 2011.

Reference Books:

1. High Voltage Direct Current Transmission, Institution of Engineering and Technology,Jos Arrillaga, 1998,2nd edition.
2. Flexible AC Transmission Systems, Yong Hua Song, Allan T Johns, Institution of Engineering and Technology, 1999.

Online resources:

1. **HVDC Transmission**: https://nptel.ac.in/courses/108/104/108104013/
2. **FACTS**: https://nptel.ac.in/courses/108/107/108107114/

EE402	POWER ELECTRONICS & DRIVES LAB	0–1–2:2

Pre-requisites: EE201 – Electrical Machines – I, EE 251 – Electrical Machines - II, EE302 – Power Electronics , EE 353- Electric Drives

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

CO1	Control rectifiers, DC-DC converters, AC voltage controllers and inverter circuits.
CO2	Evaluate performance indices for power converters.
CO3	Design control and drive circuitry for power converters.
CO4	Implement control strategies for electric drives.

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

List of Experiments:

1. Study of Static Characteristics of SCR, MOSFET & IGBT.
2. Study of single-phase half-controlled bridge converter with R, RL and RLE load.
3. Study of single-phase fully controlled bridge converter with R, RL and RLE load.
4. Study of three-phase half-controlled bridge converter with R, RL and RLE load.
5. Study of three-phase fully controlled bridge converter with R, RL and RLE load.
6. Study of single-phase dual converter with RL loads.
7. Study of AC voltage controller using TRIAC with R and RL load.
8. Study of DC-DC Buck converter with CCM and DCM.
9. Study of DC-DC Boost converter with CCM and DCM.
10. Study of DC-DC Buck-Boost converter with CCM and DCM.
11. Study of speed control of DC motor using four-quadrant chopper.
12. Study of unipolar and bi-polar PWM based single-phase inverter using dSPACE-1104 controller.
13. Study of 3-Phase PWM & non-PWM inverter using Dspace-1104 controller.
14. Study of speed control of 3-Phase inverter fed induction motor based on open loop V/f control method using dSPACE-1104 controller.
15. Study of speed control of 3-Phase inverter fed induction motor based on closed loop V/f (slip speed) control method using dSPACE-1104 controller.

EE403	ELECTRICAL SIMULATION LAB	0-1-2: 2

Pre-Requisites: EE101 – Basic Electrical Circuits, EE201 - Electrical Machines - I, EE 202 – Power Systems - I, EE 253 - Control Systems, EE251 – Electrical Machines - II and EE252 - Power Systems-II

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

CO1	Simulate and analyse electrical and power electronic circuits.
CO2	Model, simulate and analyze the performance of DC Machines
CO3	Analyze performance of feedback and load frequency control systems
CO4	Evaluate the performance of transmission lines

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

List of Experiments:

1. Solution of first and second order differential equations using RK-4th order method.
2. Simulation of half wave and full wave bridge rectifiers with R-L, R-C and R-L-C Loads using MATLAB
3. Performance evaluation of medium and long transmission lines using MATLAB
4. Symmetrical component analysis using MATLAB
5. DC Motor Speed control using MATLAB/Simulink
6. Design and analyses the performance of feedback control system
7. Simulate and tune parameters of a PID controller for a Type 2 system
8. Load frequency control of single area and two area power system with MATLAB /Simulink
9. Performance of FC-TCR compensator using PSCAD/ EMTDC/MATLAB
10. Permanent Magnet DC motor simulation using MATLAB /Simulink
11. Transient stability studies of SMIB system using equal area criterion using MATLAB.
12. Analysis of 5-Bus system using Power World Simulator
13. Simulation and Analysis of Faults using PSCAD
14. Small signal stability studies of SMIB system using Phillips Hefron model
15. Speed Control of Induction Motor using V/f method.

EE404	POWER SYSTEMS LAB	0-1-2: 2

Pre-Requisites: EE252 - Power Systems-II, EE354- Power System Protection

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	Determine the sequence components of unbalanced voltages and fault currents of Power system elements
CO3	Understand the characteristics of PV array
CO4	Evaluate the breakdown strength of Electrical Insulation and design ground grid for Substation

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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 Reactance's and fault studies of Power System Elements (Alternator & 3- Φ Transformer)
4. Analysis of unbalanced voltages using Symmetrical Component Analyzer
5. Short circuit studies on a DC Network Analyzer
6. Determination of String efficiency of simulated string of insulators
7. Calibration of sphere gap arrangement for High voltage measurement using 100kV Test Transformer
8. Characteristics of PV Array
9. Grounding grid design for a two layers soil model using AUTOGRID PRO software simulation
10. Harmonic analysis of linear and non-linear Domestic and crest-factor loads and its mitigation using Passive filters
11. Dielectric test on Transformer oil
12. Tracking and Treeing test on surface of solid insulation
13. Generation of different Impulse waveforms
14. Flashover study of disc insulators and determination of string efficiency under a) Dry condition b) Wet condition
15. Testing of Electromechanical Under Voltage Relay and plot the graph between Operating Time Vs percentage of plug Setting voltage.
16. Testing of Electromechanical Over Voltage Relay and plot the graph between Trip Time Vs Plug Setting Multiplier (PSM).
17. Study of operating characteristics of microprocessor based over current relay and plotting a graph between trip time Vs multiple of set current (Is).

EE 411	AI TECHNIQUES IN ELECTRICAL ENGINEERING	3-0-0: 3

Pre-Requisites: EE351: Smart Grid Technologies, EE352 : Power System Operation and Control

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

CO1	Understand concepts of ANNs, Fuzzy Logic and Genetic Algorithm
CO2	Distinguish between knowledge-based systems and algorithmic based systems
CO3	Understand operation of Fuzzy Controller and Genetic Algorithm
CO4	Apply soft computing techniques for real world problems

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

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.

GENETIC ALGORITHMS: Introduction-Encoding –Fitness Function-Reproduction operators, Genetic Modeling –Genetic operators-Cross over -Single site cross over, Two point cross over –Multi point cross over- Uniform cross over, Matrix cross over - Cross over Rate – Inversion & Deletion, Mutation operator –Mutation –Mutation Rate-Bit-wise operators, Generational cycle-convergence of Genetic Algorithm

APPLICATIONS OF AI TECHNIQUES: Load forecasting, Load flow studies, Economic load dispatch, Load frequency control – Single area system and two area system, Reactive power control, Speed control of DC and AC Motors.

Learning Resources:

Text Books:

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.

Reference Books:

1. Neural Network & Fuzzy System, Bart Kosko; Prentice Hall,1992.
2. Fuzzy sets, Uncertainty and Information, G.J.Klir and T.A.Folger; PHI, Pvt.Ltd,1994.
3. Genetic Algorithms, D.E.Goldberg, Addison-Wesley 2008.
4. Fuzzy Set Theory Fuzzy Logic And Their Applications, A. K. Bhargava, S. Chand, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104157/
2. https://nptel.ac.in/courses/108/108/108108148/
3. https://nptel.ac.in/courses/112/105/112105235

EE412	COMPUTER METHODS IN POWER SYSTEMS	3-0-0: 3

Pre-Requisites: EE252 - Power Systems-II, EE151 – Electrical Network Analysis

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

CO1	Design mathematical models for power system components.
CO2	Analyze and pick the best algorithm for a selected power system problem.
CO3	Generate input data suitable for load flow, fault calculations and state estimation.
CO4	Understand application of Load flow methods, contingency analysis and SCADA in modern Power systems.

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Incidence and network matrices:
Introduction, Graphs, Incidence matrices, Primitive matrices, Types of network matrices, formation of network matrix, PI-representation of off-nominal tap transformers, Y-bus by singular transformation, examples of formation of incidence matrices, formation of Y-bus by inspection.

Algorithms for formation of Z-bus matrix:
Step by Step algorithm for formation of Z-bus. Modification of Z-bus matrix for changes in the network, example of formation and modification of Z-bus matrix.

Short Circuit calculations:

Introduction, Short circuit calculations using $Zbus^{012}$, z_f^{abc}, y_f^{abc}, z_f^{012}, y_f^{012} matrices for various faults, example of short circuit calculations using $Zbus^{102}$ for L-L-L and L-G faults.

Sparsity Technique in Load Flow Studies:
Introduction, Sparsity technique for Y-bus and Gauss-Seidel method.

Review and Comparison:
Gauss-Seidel, Newton - Raphson, Fast decoupled load flow methods. Concept of Contingency analysis. Forward – backward and substitution method for radial distribution systems.

Introduction to Real time control of Power System:
Introduction, linear State Estimation WLS equations, Types of measurements, D.C power flow based WLS equations, examples of D.C based WLS State Estimation, SCADA, communication systems. Role of PMUs in power systems.

Learning Resources:

Text Books:

1. Stagg and ElAbiad: Computer Methods in Power Systems Analysis, McGrawHill ISE, 2017.
2. M.A. Pai: Computer Techniques in Power System Analysis, Tata McGraw-Hill Education, 2005.
3. K.U. Rao: Computer Methods and Models in Power Systems, I.K. International Pvt. Ltd, 2009.

Reference Books:

1. Hadi Saadat: Power System Analysis, PSA Publishing, 2010.
2. William Stevenson and John Grainger: Power System Analysis, McGraw Hill Education, 2017.
3. Allen J. Wood and Bruce F. Wollenberg: Power Generation, Operation, and Control, Wiley Blackwell, 1996.

Online Resources:

1. https://www.youtube.com/watch?v=kxm0Prghn64
2. https://www.youtube.com/watch?v=dke92EPNNoA
3. https://www.youtube.com/watch?v=OLmfyXVcszc
4. https://www.youtube.com/watch?v=UL-3R9t_QUk
5. https://www.youtube.com/watch?v=8yPyyWFozbg
6. https://www.youtube.com/watch?v=_uoy5YV8C_8&list=PLbSEVsipX-JRnyo8DjIiPGVP3FbTBo6Ap

EE 413	DISCRETE TIME CONTROL SYSTEMS	3-0-0: 3

Pre-requisites: EE253 Control Systems

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

CO1	Evaluate the response of a digital system for a given input.
CO2	Describe the dynamics of a Linear, Time Invariant and Causal digital systems through difference equations
CO3	Analyze discrete time systems using the Z-transformation, State space Methods
CO4	Design the digital controllers for physical systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction : Discrete time system representation – Quantization and quantization error – Data acquisition- Principles of Signal Conversion- Sampling of continuous time signals- Principles of Discretization.

Z-Plane Analysis of Discrete-Time Control Systems : Impulse sampling and data hold - Pulse transfer function - Realization of digital controllers- Mapping between s-plane and z-plane - Stability analysis of closed loop systems in z-plane–Transient and steady state analyses

State Space approach to Discrete-time control systems : State space representation of continuous and digital control systems - Solution of continuous and discrete time state space equations -Pulse transfer function matrix - Discretization of continuous time state space equations

Analysis of Discrete-Time Systems : Concepts of Controllability and Observability in continuous / discrete time systems- Stability analysis of discrete time systems - Jury stability test, Stability analysis using bi-linear transformation- Lyapunov stability analysis.

Digital Controller Design Methods : Discrete PID controller-Discretization techniques- Position and velocity PID algorithms- Tuning rules for digital controllers- State feedback design - Pole placement by state feedback.

Learning Resources:

Text Books:

1. M.Gopal "Digital control engineering", New Age Int. Ltd., India, 2nd Edition, 2014.
2. K.Ogata "Discrete- Time control systems", Pearson Education, India, 2nd Edition, 2015.
3. B.C.Kuo, "Digital Control System", Oxford University Press; 2ndEdition, 2012.

References:

1. M. Gopal, “Digital Control and State Variable Methods”, McGraw Hill Education, 4th Edition, 2014.
2. Karl J Astrom, B. Wittenmark, “Computer-Controlled Systems: Theory and Design”, 3rd Edition, 2012.
3. Kannan M. Moudgalya, “Digital Control”, Wiley, 1st Edition, 2007.
4. G. F. Franklin, J. D. Powell and M. L. Workman, “Digital Control of Dynamic Systems”, 3rd Edition, Addison-Wesley Press, 2000.

Online Resources:

1. https://www.youtube.com/watch?v=Q9IKRDcN_jE
2. https://www.youtube.com/watch?v=-To4nPh-N2A
3. https://nptel.ac.in/courses/108/103/108103008/
4. https://nptel.ac.in/courses/108/103/108103008/

EE 414	ENERGY STORAGE SYSTEMS AND APPLICATIONS	3-0-0: 3

Pre-requisites: None

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

CO1	Understand Various energy storage technologies.
CO2	Develop an algorithm to estimate the state of charge and state of health of a battery
CO3	Develop the energy management control of a storage system in a grid connected
CO4	Develop the control algorithm to a grid-connected storage system to improve the grid reliability

Course Articulation Matrix:

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

Syllabus:

Development of energy storage technology: Basic concept, history of energy storage technologies, demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

Technology of energy storage systems: Electrochemical energy storage: lead-acid battery, lithium-ion battery, vanadium redox battery, zinc-bromine, sodium sulphur; physical energy storage: pump hydro storage compressed air energy storage, flywheel energy storage; electromagnetic energy storage: supercapacitor energy storage, superconducting magnetic energy storage; new type energy storage: advanced lead-acid batter, lithium-sulphur battery, sodium-ion battery, heat pump storage, gravity energy storage; comprehensive comparison of energy storage technologies: technical maturity, performance parameters, applications.

Technologies for battery management: Battery management systems: typical structures, main functions; state of charge (SOC) estimation method: definition, the methods of SOC estimation; state of health (SOH) estimation technology: definition, methods for SOH estimation; balance management technology; protection technology: overvoltage protection, under voltage protection, overcurrent protection, short circuit protection, over temperature protection.

Operation control technology of energy storage systems: grid connected operation control technology: AC/DC converter control, DC/DC converter control, island detection, low-voltage ride through; off-grid operation control technology: control of switching from on-grid to off-grid, synchronization control of the switching from off-grid to on-grid.

Application of energy storage technology in grid-connected energy power generation: Impact of energy storage system on gird-connected energy storage power generation: smooth power fluctuation: smooth power fluctuation, reduce power system's demand for peak regulation capacity, energy schedule, regulate frequency and voltage; design of an energy storage system in grid-connected power generation system: storage energy system's configuration, technical/ economic analysis of energy storage system, configuration of energy storage system capacity; control of hybrid integrated energy storage generation: smooth the power fluctuation, schedule output, frequency regulation.

Learning Resources:

Text Books:

1. Grid-scale Energy Storage Systems and Applications, Fu-Bao Wu, Bo Yang, Ji-Lei Ye, Elsevier - Academic Press, 2019, 1st edition.
2. Energy Storage Devices for Renewable Energy-Based Systems, Nihal Kularatna Kosala Gunawardane, Elsevier - Academic Press, 2019, 2nd edition.
3. Ultra-Capacitors in Power Conversion Systems: Applications, Analysis, and Design from Theory to Practice, Petar J. Grbovic, Wiley-IEEE Press, 2013, 1st edition.

Reference Books:

1. Energy Storage: A New Approach, Ralph Zito, Haleh Ardebili, Wiley, 2019, 2nd Edition.
2. Energy Storage for Power System Planning and Operation, Zechun Hu , Wiley, 2020, 1st edition.
3. Fuel Cell Systems Explained, Andrew L. Dicks, David A. J. Rand, Wiley, 2018, 3rd Edition.

Online Resources:

1. https://www.youtube.com/watch?v=uy9lZCdkQIM&t=9s
2. https://nptel.ac.in/courses/105/105/105105110/

EE 415	MODELING AND ANALYSIS OF ELECTRICAL MACHINES	3-0-0: 3

Pre-requisites: EE201 – Electrical Machines– I, EE251 – Electrical Machines-II

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

CO1	Understand the limitations of conventional models of electrical machines
CO2	Compute the torque produced in electrical machines using the concept of co- energy
CO3	Analyze the performance of machines using reference frame theory
CO4	Evaluate strategies to control the torque for a specific application

Course Articulation Matrix:

	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

Syllabus:

Principles for electrical machine analysis and magnetically coupled circuits
Review of basic concepts, magnetizing inductance, Modelling linear and non-linear magnetic circuits.

Electromechanical energy conversion
Principles of energy flow, concept of field energy and co-energy, Derivation of torque expression for various machines using the principles of energy flow and the principle of co-energy, Inductance matrices of induction and synchronous machines.

Theory of DC machines
Review of the DC machine, mathematical model of commutator, State-space model of a DC machine and reduced order model & transfer function of the DC machine.

Reference Frame Theory
Concept of space vector, components of space vector, direct and quadrature axis variables.

Transformation
Types of transformation, condition for power invariance, zero-sequence component, Expression for power with various types of transformation, Transformations between reference frames, Clarke and Park's Transformations, Variables observed from various frames, Simulation studies.

Theory of symmetrical Induction Machines
Voltage and torque in machine variables, Derivation of dq0 model for a symmetrical induction

machine, Voltage and torque equation in arbitrary reference frame variables, Analysis of steady-state operation, State-space model of induction machine in 'd-*q*' variables, Simulation studies.

Theory of synchronous machines

Derivation of *dq0* model for a salient pole synchronous machine with damper windings using Park's transformation, Torque expression of a salient pole synchronous machine with damper windings and identification of various components.

Learning Resources:

Text Books:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff: "Analysis of Electric Machinery and Drive systems", Wiley-IEEE Press, 3rd edition, August 2013.
2. E. Fitzgerald, Charles Kingsley, Stephen D. Umans: "Electric Machinery", McGraw Hill Education; 6th edition, July 2017.
3. Krishnan: "Electric Motor Drives: Modeling Analysis: Modeling, Analysis, and Control", Pearson Education India; 1st edition, January 2015.

References:

1. Mohammed Fazlur Rahman, Sanjeet K. Dwivedi: "Modeling, Simulation and Control of Electrical Drives (Control, Robotics and Sensors)", Institution of Engineering and Technology, 1st edition, October 2019.
2. Shaahin Filizadeh: "Electric Machines and Drives: Principles, Control, Modeling, and Simulation", CRC Press; 1st edition, April 2017.

Online Resources:

1. http://www.nptelvideos.com/course.php?id=493

EE 5104	CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES	3-0-0: 3

Pre-requisites: None

Course Outcomes:

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

CO1	Understand different renewable energy sources and storage devices.
CO2	Model and simulate renewable energy sources.
CO3	Analyze and simulate control strategies for grid connected and off-grid systems.
CO4	Develop converters to comply with grid standards to obtain grid integration.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Introduction: Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies.

Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

Control Issues and Challenges: Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.

Integration of Energy Conversion Technologies: Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations.

Learning Resources: Text Books:

1. Renewable and Efficient Electric Power Systems, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013,2nd Edition.
2. Microgrids and Active Distribution Networks, S. Chowdhury, S. P. Chowdhury, P. Crossley,IET Power Electronics Series, 2012.
3. Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali, Min Dai, John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1. Solar Photovoltaic: Fundamentals, technologies & Applications, Chetan Singh Solanki, PHI Publishers, 2019, 3rd Edition.
2. Solar PV Power: Design, Manufacturing and Applications from Sand to Systems, Rabindra Kumar Satpathy, Venkateswarlu Parmuru, Academic Press, 2020.
3. Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013,1st Edition.
4. Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, NavidZargari, IEEE- John Wiley and Sons Ltd. Publishers,2011,1st Edition.
5. Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity Authority, GoI, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/102/108102145/
2. https://nptel.ac.in/courses/103/103/103103206/

EE 5114	ELECTRIC VEHICLES	3-0-0: 3

Pre-requisites: None

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

CO1	Understand the concepts of electric vehicles, hybrid electric vehicles and their impact on environment
CO2	Analyze the drive-train topologies and advanced propulsion techniques
CO3	Analyze hybrid energy storage methodologies
CO4	Select suitable power converter topologies for motor control and hybrid energy storage

Course Articulation Matrix:

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

Syllabus:

Introduction: Conventional vehicle, basics of vehicle performance, History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies.

Hybrid Electric Vehicles: Micro hybrid vehicles, mild hybrid vehicles, full hybrid vehicles, Parallel hybrid vehicles, series Hybrid Vehicles, Series-Parallel Hybrid vehicles, plug-in hybrid vehicles, power flow diagrams for various operating modes. Plug-in Hybrid Vehicles: Operating principle, architectures: series-parallel-series-parallel, challenges related to grid connection. Range-extended Electric Vehicles: Classification and configurations, Fuel Cell Electric Vehicles, Solar electric Vehicles, Electric Bi-cycles and their propulsion systems, Vehicle-to- grid, vehicle- to-home concepts, Concept of Hybrid Electric Vehicles.

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: Electric components used in electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, Drive system efficiency.

Energy Storage: Storage requirements for Electric Vehicles, Battery based energy storage, Fuel Cell based energy storage, Super Capacitor based energy storage and their analysis. Power pack management systems, Cell balancing techniques, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices, compressed air storage systems, super conducting magnetic storage systems and Energy management systems.

Converters for Hybrid Energy Storage Systems: Converter configurations for hybrid energy systems based on Battery and Ultra Capacitors-cascaded converter, multiple parallel-connected converter, dual-active-bridge converter, multiple-input converter - multiple modes

single converter, interleaved converter, switched capacitor converter, converters for coupled inductor-based hybridization. Fundamentals of Chargers: Charger classifications and standards, selection of AC charging systems, DC charging systems, Converter topologies for charging, wireless chargers.

Learning Resources:

Text books:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, Taylor & Francis Group, 2015.
2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2003, 2nd Edition.

References:

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, CRC Press, 2005.
2. Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley, 2003.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/

EE5304	RESTRUCTURED POWER SYSTEMS	3-0-0: 3

Pre-Requisites: None

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

CO1	Understand the need for restructured power system and economics.
CO2	Analyse transmission congestion and Estimate loss allocation in Power System
CO3	Analyse demand response in smart grid systems
CO4	Evaluate economics and ancillary services within the Smart Grid

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Restructuring of power industry and Fundamentals of Economics: Introduction, Reasons for restructuring / deregulation of power industry, Fundamentals of Deregulation, Motivation of restructuring the power industries, restructuring process – unbundling & privatization, restructuring models, Components of restructured systems.

Transmission Pricing

Cost components, Postage Stamp Method, Megawatt Mile Method, Contract Path Method

Smart Grid in Power Market:

Independent System Operator (ISO): Functions and responsibilities, Smart Grid trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems, and Open Access Same time Information system (OASIS)

Definitions transfer capability issues: ATC, TTC, TRM, CBM calculations, methodologies to calculate ATC, Electricity Pricing

Smart Grid Bidding Strategies: Forward and Future market; Operation and control: Old vs New, Integrated bidding strategy in smart multi energy system, Smart grid Optimization with risk constraints-General risk measures, Portfolio selection problem, penalty formulation.

Transmission Congestion Management: Classification of congestion management methods, Calculation of ATC-TTC-CBM, Non-market methods, Market based methods, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management.

Demand Response in Smart Grid: Demand response, Potential benefits of demand response in smart grid, enabling smart technologies for demand response, control devices for demand response, Monitoring and communication system. Demand response for Electric Vehicles, Examples

Ancillary Services within Smart Grid framework: Reactive power as an ancillary services, Energy Storage System, Power Quality, Reliability analysis.

Smart Grid Economic and market operations: Energy and Reserve Markets, Market Power, Generation Firms, Locational Marginal Prices, Financial Transmission Rights. Concepts of block chain technologies in energy trading and power purchase agreements (PPA).

Learning Resources:

Text Books:

1. Power System Restructuring and Deregulation, L. L. Lai, John Wiley & Sons Ltd., 2012, 1st Edition.
2. Operation of restructured power systems, K. Bhattacharya, J. E. Daadler, and Math H.J Bollen, Kluwer Academic Pub., 2012, 1st Edition (Reprint).
3. Fundamentals of Power System economics, D. Kirschen and G. Strbac, John Wiley & Sons Ltd, 2019, 2nd Edition.

Reference Books:

1. Making competition work in electricity, S. Hunt, John Wiley & Sons, Inc., 2002, 1st Edition.
2. Power System Deregulation: Loss Sharing in Bilateral Contracts and Generator Profit Maximization, Ashikur Bhuiya: Publisher VDM Verlag, 2008
3. Restructured Electrical Power Systems, Mohammad Shahidehpour and Muwaffaqalomoush, Marcel Dekker, Inc., 2001, 1st Edition

Online Resources:

1. NPTEL – Restructured Power Systems – Prof. S.A. Khaparde , Dr. A.R. Abhyankar, IIT Delhi
2. www.isgf.com
3. www.iexindia.com
4. www.posoco.in
5. http://www.ferc.fed.us
6. http://www.nordpool.no
7. http://www.statnett.no
8. http://www.ofaem.gov.uk
9. http://www.caiso.com
10. http://www.nationalgrid.com
11. http://www.bmreports.com/bwx_home.htm
12. http://www.elexon.co.uk/
13. http://www.fingrid.fi
14. http://www.svk.se
15. http://www.ucei.berkeley.edu/ucei/datamine/datamine.htm

MA 5331	NUMERICAL OPTIMIZATION TECHNIQUES	3-0-0: 3

Pre-Requisites: None

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

CO1	Understand fundamentals of linear and non-linear optimization.
CO2	Analyse and solve single and multi-dimensional optimization problems
CO3	Apply the Simplex method to the linear programming
CO4	Apply the KKT conditions for non-linear optimization
CO5	Apply the distributed and stochastic optimization tools to real world problems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Basic Concepts: Formulating an Optimization Problem, review of Linear Algebra and Analysis, onedimensional optimality conditions, Convex Sets and Convex Functions.

Unconstrained Optimization: Multi-dimensional optimality conditions and conceptual algorithm, Line Search Methods, Steepest Descent method, Conjugate gradient method, Classical Newton Method, Trust-region and quasi-Newton methods, Nonlinear Least Squares Problem and Algorithms.

Linear Programming: Geometric Solution, Basic feasible solution, The Simplex Method, Dual problemand duality theorems, Karmarkar's Algorithm.

Constrained non-linear optimization: Local and global solutions, Feasible and descent directions; First Order KKT Conditions, Constraint Qualification, Second Order KKT Conditions; Quadratic Programming; Penalty, Barrier and Augmented Lagrangian Methods; Sequential Quadratic Programming; Interior-Point Methods; Distributed optimization; Stochastic programming.

Power System Optimization: Unit commitment, Economic load dispatch, Optimal power flow, Security constrained optimal power flow, State estimation problems.

Learning Resources:

Text Books:

1. Numerical Optimization, J. Nocedal, & S. Wright, Springer Science & Business Media,2006, Second Edition.
2. Linear and Nonlinear Programming, D. G. Luenberger & Y. Ye, 2016, Springer, Fourth Edition.

Reference Books:

1. Nonlinear programming: Theory and Algorithms, M. S. Bazaraa, H. D. Sherali, & C. M.Shetty, John Wiley & Sons, 2013, Third Edition.
2. Numerical Optimization with Applications, Suresh Chandra, Jayadeva, & Aparna Mehra, 2013, Alpha Science International Ltd, First Edition.
3. Engineering optimization: Theory and Practice, S. S. Rao, John Wiley & Sons, 2019, Fifth Edition.

EE 461	DESIGN OF ELECTRICAL SYSTEMS	3-0-0: 3

Pre-requisites: EE201 – Electrical Machines – I, EE251 – Electrical Machines - II

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

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

Course Articulation Matrix:

	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	2	2	2	1	1	1	1	1	3	2
CO4	3	3	3	2	3	1	2	1	2	2	3	2	3	3

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.

Learning Resources:

Text Books:

1. A course in Electrical Machine Design, A. K. Sawhney, Dhanpat Rai & Co., New Delhi. 2013, 6th Edition.
2. Design of Rotating Electrical Machines, Juha Pyrhonen, Tapani Jokinen, Valeria Hrabovcova, John Wiley & Sons, New Delhi,2013.

Reference Books:

1. Electrical Machine Design, Alexander Gray, McGraw Hill, New York, 2008.
2. Performance and Design of AC Machines, M. G. Say, Pitman Pub, 2002.
3. Performance and design of DCmachines, E Clayton & N. N. Hancook, CBSPub., 1998, 3rd Edition.
4. Arts and Science of Utilization of Electrical Energy, H. Partab, Dhanpat Rai & Co., 2017.

EE 462	SWITCHED MODE POWER CONVERSION	3-0-0: 3

Pre-requisites: EE302 – Power Electronics

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

CO1	Undesrstand & 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 feedback loop
CO4	Understand & Analyse the operation and control of multilevel inverters

Course Articulation Matrix:

	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 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

DC/DC Converters and Current Mode control

Basic topologies of buck, boost converters, buck-boost converters and cuk 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 ZV Sin 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.

Inverters

SVM technique, multilevel inverters and PWM methods.

Learning Resources:

Text Books:

1. Ned Mohan Tore M. Undeland: Power Electronics: Converters, Applications, and Design, 3rd Edition, John Wiley & Sons, 2007.
2. Abraham I. Pressman, “Switching Power Supply Design”, McGraw Hill International, Third Edition, 2009.
3. P. C. Sen: Modern Power Electronics, S.Chand - 2005.

Reference Books:

1. Krishna K Gupta and and Pallavee Bhatnagar, Multilevel Inverters: Conventional and Emerging Topologies an their Control, Elsevier Science, 5 December 2017.
2. Keng C. Wu , Switch-Mode Power Converters: Design and Analysis by,Elsevier Science, December 2005.
3. Andrzej M. Trzynadlowski Introduction to Modern Power Electronics, 2nd Edition, illustrated Publisher John Wiley & Sons, 2010.
4. Muhammad H. Rashid, Power electronics handbook, Butterworth-Heinemann, 4th Edition, 2018.
5. BinWu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006.

Online Resources:

1. https://www.youtube.com/watch?v=P0MK7sWfs9k
2. https://www.youtube.com/watch?v=SRVswRH5Q7E
3. https://nptel.ac.in/courses/108/102/108102157/
4. https://nptel.ac.in/courses/108/108/108108035/

EE 463	HIGH VOLTAGE ENGINEERING	3-0-0: 3

Pre-Requisites: None

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

CO1	Understand field intensity of different electrode configurations and design of insulation of HV power equipment.
CO2	Evaluate Performance of high voltage equipment using test methods
CO3	Assess quality of the insulation of high voltage Equipment
CO4	Understand the Breakdown mechanism of Gas, Liquid and solid insulation

Course Articulation Matrix:

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

Syllabus:

ELECTROSTATIC FIELDS, THEIR CONTROL AND ESTIMATION

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.

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.

GENERATION OF IMPULSE VOLTAGES AND CURRENTS

Definitions, 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, measurement of large capacitances, partial discharges measuring and diagnostic techniques. Time domain and Frequency domain analysis of dielectric materials subjected to an electric field.

BREAKDOWN MECHANISM OF GASEOUS LIQUID & SOLID INSULATING MATERIALS

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. Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings.

Learning Resources:

Text Books:

1. Ravindra Arora & Wolfgang Mosch "High Voltage and Electrical Insulation Engineering', Wiley-IEEE Press, 2011.
2. E. Kuffel, W.S.Zaengl, J.Kuffel, High voltage Engineering Fundamentals, Newnes Publishers, 2008.

References:

1. C. L. Wadhwa: High voltage Engineering, New Age International Publishers, 4th edition 2020.
2. M. S. Naidu & V. Kamaraju, High-Voltage Engineering, McGraw Hill Education (India) Private limited, 6th edition, 2020.

Online Resources:

1. High Voltage Engineering: https://nptel.ac.in/courses/108/104/108104048/

EE 464	ADVANCED ELECTRICAL DRIVE SYSTEMS	3–0–0:3

Pre-Requisites: EE415 Modelling and Analysis of electrical machines, EE 201-Electrical Machines I, EE 301- Electrical Machines III, EE 302-Power Electronics.

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

CO1	Design controllers for closed-loop operation of separately excited DC motor drives
CO2	Develop high performance induction motor drives using the principles of Scalar control, Vector control and Direct Torque Control
CO3	Develop the control strategies for doubly fed induction motor drives, VSI fed poly-phase induction motors.
CO4	Implement control schemes for PMSM, BLDC and Switched Reluctance Motor drives

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Separately Excited DC-motor Drives: Introduction, Review of DC-motor drives, Speed control of a Separately excited DC motor drive with controlled rectifiers and choppers, Review of controllers, need for anti-windup feature for integral controllers, Speed control of a separately excited DC drive with inner current loop and outer speed loop, Design of current loop with pole- zero cancellation, Design of speed loop with symmetrical optimization technique.

Induction Motor drives: Implementation of V/f control with slip compensation scheme, Review of dq0 model of 3-Ph IM with simulation studies, Principle of vector control of IM, Direct vector control, Indirect vector control with feedback, Indirect vector control with feed-forward, Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation, Direct Torque Control of IM, Control of wound rotor induction machine, introduction to five-phase induction motor drives.

Permanent Magnet Drives: Expression for torque, Model of PMSM, Implementation of vector control for PMSM, BLDC drives.

Switched Reluctance Motor Drives: Torque expression, converters for SRM drives, Control of SRM drives.

Learning Resources:

Text Books:

1. Modern Power Electronics & AC Drives, B.K. Bose, Pearson Education India, 2015,1st Edition.

2. Electric Motor Drives: Modeling, Analysis and Control; R. Krishnan, Pearson Education India, 2015, 1st Edition.

Reference Books:

1. High-power Converters and AC Drives, Bin-Wu, Wiley-Blackwell, 2017,2nd Edition. Simulation of Power Electronic Circuits, M.B. Patil, V. Ramanarayanan, V.T. Ranganathan, Narosa Publications, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104011/

EE 465	PLANNING AN ENTREPRENEURIAL VENTURE	3-0-0: 3

Pre-Requisites: None

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

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO3	Explore the opportunities in the domain of Electrical, Electronics and Computer Engineering for launching a new venture
CO4	Analyze the functional management issues of running a new venture

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Entrepreneur and Entrepreneurship: Entrepreneurship and Small-Scale Enterprises (SSE); Role in Economic Development, Entrepreneurial Competencies; Institution Interface for SSE.

Establishing the Small-Scale Enterprise : Opportunity Scanning in the domain of Electrical, Electronics and Computer Engineering; Opportunity Identification in the domain of Electrical, Electronics and Computer Engineering; Market Assessment for SSE; Choice of Technology and Selection of Site; Financing the New/Small Enterprises; Preparation of the Business Plan; Ownership Structures and Organizational Framework

Operating the Small-Scale Enterprises

Financial Management Issues in SSE; Operational Management Issues in SSE; Marketing Management Issues in SSE; Organizational Relations in SSE

Learning Resources:

Text Books:

1. New Venture Management: The Entrepreneur's Roadmap, Kuratko, Pearson, 2008.
2. Entrepreneurship: New Venture Creation, Holt, PHI(P) Ltd., 2001.

Reference Books:

1. Management of New & Small Enterprises, Madhulika Kaushik, IGNOU course material, 1995.
2. Entrepreneurship Development Training Material, B S Rathore, S Saini, TTTI, Chandigarh, 1988.
3. A Hand Book for New Entrepreneurs, P C Jain, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
4. A Manual on How to Prepare a Project Report, J B Patel, D G Allampalli, EDII, Ahmedabad, 1991.
5. A Manual on Business Opportunity Identification and Selection, J B Patel, EDII,

Ahmedabad, 1995.

Online Resources:

1. Champions Portal: www.champions.gov.in
2. Udyam Registration: https://udyamregistration.gov.in
3. MSME Databank: www.msmedatabank.in
4. National Small Industries Corporation: www.nsic.co.in
5. MSME Sambandh: sambandh.msme.gov.in
6. Government eMarket Place: www.gem.gov.in

EE 466	ILLUMINATION ENGINEERING	3-0-0: 3

Pre-requisites: EE101 – Basic Electrical Circuits, EE151 – Electrical Network Analysis, EC231 - Analog Electronics , and EE302-Power Electronics

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

CO1	Evaluate the characteristics of illumination sources / devices.
CO2	Understand and determine the performance of various lighting systems.
CO3	Design of lighting controls and management
CO4	Understand the standards of lighting systems and commissioning

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Ballast based Systems: Introduction - Magnetic and Electronic Ballast – Dimming Electronic Ballast for Fluorescent lamps - Lamp Ballast interactions – Electronic Ballast for HID Lamps - Pulse start metal halide system, Compact Fluorescent lamp.

Solid State Lamps: Introduction – Review of Light sources – white light generation techniques- Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs- Electrical and optical properties – LED driver considerations- Power management topologies- Thermal management considerations- Heat sink design- photometry and colorimetry - color issues of white LEDs- Dimming of LED sources -Designing usable lamp from white LEDs,- Luminaire design steps-SSL test standards. Dimming control scheme-Lighting controls for LED lamps.

Lighting Controls & management: Introduction to lighting control – lighting control strategies – Energy Management strategies– Switching Control–sensor technology- occupancy sensors– PIR–Ultrasonic location, coverage area & mounting configuration – special features – Application. Photo sensors –spectral sensitivity – Photo sensor-based control algorithms – Daylight-artificial light integrated schemes.

Commissioning of lighting controls: NASHRAE / IESNA standards & energy codes – international energy conservation code–compliance with controls Lighting Control Applications: Commercial lighting stage and entertainment lighting–Architectural lighting–Residential Lighting Energy Management and building control systems.

Learning Resources:

Text Books:

1. Arturas Zukauskus, Michael S. Shur and Remis Gaska, “Introduction to solid state lighting”, Wiley- Interscience, 2002.
2. E. Fred Schubert,“Light Emitting Diodes”, 2nd edition, Cambridge University Press, 2006.

3. Craig Di Louie, Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications, Fairmont Press, Inc.,2006.

Reference Books:

1. ILLUMINATION ENGINEERING, 1st Edition, S. M. Chaudhari, Nirali Prakashan
2. Applied Illumination engineering, 2nd Edition, Jack L. Lindsey, Fairmont Press, 2015.
3. Mohan, Undeland and Robbins, “Power Electronics: Converters, Applications and Design”, John Wiley and Sons, 1989.
4. Steve Winder, “Power Supplies for LED Driving” Newnens Publication, 2008.
5. Robert S Simpson, Lighting Control: Technology and Applications, Focal Press, 2003. IES Lighting Handbook, 10th Edition IESNA, 2011.

Online Resources:

1. www.aboutlightingcontrols.org
2. www.ti.com
3. https://youtube.com/playlist?list=PLbMVogVj5nJThs8VThC-DA8CZYsmaQypX/

EE 467	BIO-INSPIRED ALGORITHMS AND APPLICATIONS	3-0-0: 3

Pre-Requisites: None

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:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES

Definition - Classification of optimization problems, Unconstrained and Constrained optimization Optimality conditions, Introduction to intelligent systems Soft computing techniques, Conventional computing techniques versus Soft computing techniques – 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.

GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION

Genetic algorithms - 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, Application to ELD problem / SINX maximization problem

ANT COLONY OPTIMIZATIO 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, ACO and ABC algorithms for solving Economic Dispatch of Thermal Units / SINX maximization problem.

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, BA and SFLA algorithms for solving ELD and Optimal Placement and sizing of the DG problem / SINX maximization problem, Application to multi-modal function optimization, Introduction to Multi-Objective optimization, Concept of Pareto optimality.

Learning Resources:

Text Books:

1. Recent Advances in Swarm Intelligence and Evolutionary Computation, Xin-She Yang, Springer International Publishing, Switzerland, 2015.
2. Multi-Objective Optimization using Evolutionary Algorithms, Kalyanmoy Deb, John Wiley & Sons, 2001.

Reference Books:

1. Artificial Intelligence and Intelligent Systems, N P Padhy, Oxford University Press, 2005.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_bt06/preview

EE 468	OPTIMAL CONTROL THEORY	3-0-0: 3

Pre-Requisites: None

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

CO1	Formulate the optimization problem based on the requirements and evaluate the performance of optimal controller
CO2	Apply the variational approach for optimal control systems with conditions
CO3	Design finite time LQR, infinite time LQR and linear quadratic tracking system
CO4	Analyse discrete time optimal control systems used in different applications

Course Articulation Matrix:

	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	1	2	3	2
CO2	3	3	3	2	2	3	2	1	3	1	1	2	3	2
CO3	3	3	3	2	3	3	2	1	1	1	2	2	3	3
CO4	3	3	3	2	3	3	2	1	3	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to optimal control: Statement of optimal control problem, problem formulation and forms of optimal, performance measures, various methods of optimization, linear programming, nonlinear programming.

Calculus of variations: Basic concepts, variational problem, extreme functions with conditions, variational approach to optimal control systems.

Linear quadratic optimal control system: Problem formulation, finite time linear quadratic regulator (LQR), infinite time LQR system, stability issues, linear quadratic tracking system.

Discrete time optimal control system: Variational calculus for discrete time systems, discrete time optimal control system, discrete time linear state regulator system, discrete time linear quadratic tracking system

Pontryagin minimum principle: Pontryagin minimum principle, Dynamic programming, Hamilton - Jacobi - Bellman equation (HJB), LQR system using HJB equation, Time optimal control, fuel optimal control system, optimal control system with constraints.

Learning Resources:

Text Books:

1. Donald E. Kirk, Optimal Control Theory – An Introduction, Dover Publications, Inc. Mineola,
   New York, 2004.
2. Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012.
3. D. Subbaram Naidu, Optimal Control Systems, CRC Press, New York, 2003.

Reference Books:

1. B.D.O. Anderson and J. B. Moore, “Optimal Control – Linear Quadratic Methods”, PHI, 1991.

2. S. H. Zak, “Systems and Control” Oxford University Press, 2006.
3. R. T. Stefani, B. Shahian, C. J. Savant, J. G. H. Hosletter, “Design of Feedback Control Systems”, Oxford University Press, 2009.

Online Resources:

1. https://nptel.ac.in/courses/101/108/101108057/

EE 469	STATE SPACE APPROACH TO CONTROL SYSTEMS	3-0-0: 3

Pre-Requisites: EE 253 Control Systems

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

CO1	Model and analyze the dynamical systems using state space approach.
CO2	Determine the zero state and zero input response using the state equation solution
CO3	Evaluate and analyse the system properties such as controllability and observability
CO4	Design the state feedback controller to meet the desired specifications

Course Articulation Matrix:

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

Syllabus: Dynamical system representation: **Classical control review- Linear Time Invariant (LTI) system- Concept of State and State space (SS) approach- State variable selection- Advantages of State space approach- Linearization - Modelling of dynamical systems using SS approach – Different forms of state space representation- Similarity transformation-Invariance of Eigen values- Stability concepts.**

State space solution: Solution of the continuous time LTI state equation- Autonomous and Non-autonomous system- Scalar and Matrix cases- State transition matrix (STM) - Important properties of STM- Evaluation methods of the STM- Transfer function from State space model.

Controllability and Observability: Controllability concepts- State controllable and Output controllable- Reachability- Criterion for controllability: Controllability matrix Rank condition, Popov Belevitch Hautus (PBH) criterion- Controllability Gramian –Controllability index- Observability concepts- Constructability- Condition for observability: Observability matrix rank, PBH test- Observability Gramian- Observability index- Pole zero cancellation Vs Controllability and observability

State feedback control : State feedback design for regulator problem - Pole placement approach: Direct substitution, Bass-Gura Approach, Ackermann's formula- Guidelines for desired pole selection- Design of Type-I servo/tracking control: System with Integrator and without integrator- Closed loop stability of system with state feedback controller- Effect of state feedback on Controllability/Observability.

State observer based controller design: Need for state observer- Full order observer for regulator problem Observer pole placement methods: Direct substitution, Bass-Gura Approach, Ackermann's formula-- Guidelines for desired observer pole selection- Separation principle- Full order observer for Type-I servo problem- Minimum/reduced order observer design for regulator problem- Separation property- Stability of Observer based control system- Linear quadratic regulator (LQR) problem.

Learning Resources:

Text Books:

1. Linear System Theory and Design, Chi-Tsong Chen, Oxford University Press, Oxford, UK, 2013, 4th Edition.
2. Modern Control Systems Theory, M. Gopal, New Age International, 2014 and 3rd Edition.
3. Modern Control Engineering, K. Ogata, Pearson Education India, 2015 and 5th Edition

Reference Books:

1. Modern Control Systems, Richard C. Dorf, Robert H. Bishop, Prentice Hall, 2015 and 13th Edition
2. A Linear Systems Primer, P.J. Antsaklis and A.N. Michel, Springer, 2012 and 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/101/108/101108047/

EE 5165	ADVANCED CONTROL TECHNIQUES FOR POWER CONVERTERS	3-0-0:3

Pre-Requisites: None

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

CO1	Understand and analyze the different types of converter model and its usage
CO2	Design the advanced PID controller and its fractional version for converter control
CO3	Understand the resonant controller and its importance for DC-DC converter
CO4	Design the robust controller for converter using the loop-shaping methods

Course Articulation Matrix:

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

1 – Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Modeling of Power converters

Types of Models- Linearized Averaged models- Large signal and Small signal models- Switched models- Relation between various model types- Control goals in converter operation- Review of classical control methods.

Advanced PID controller

PID controller-Tuning methods of PID controller- Setpoint weighting-Integrator Windup-Controller degrees of freedom- Model based Design methods: Direct Synthesis (DS) method, Internal Model Control (IMC) method- Fractional Control System (FOS) -Design of Fractional PID controller- Case Study: PID controller design for DC-DC boost converter.

Resonant Controller

Necessity of resonant controller- Principle of Proportional Resonant (PR) control- Design methods of PR controller- Example of PR controller design for DC-DC boost converter.

Loop-shaping design

Concept of Loop shaping- Robust controller design using the loop shaping methods: H∞ Control, Quantitative feedback theory (QFT)- Case Study: Loop shaping methods to design the robust controller for DC-DC converter.

Sliding mode controller (SMC)

Nonlinear control preliminaries-Types of Uncertainty-Sliding surface design- Stability of SMC-Equivalent control concept- Integral Sliding Mode Control (ISMC) design- Case study: Application of SMC to design the robust controller for DC-DC converter.

Fuzzy logic control and artificial Intelligence (AI) techniques:

Introduction to fuzzy logic and AI techniques, application of fuzzy logic to power converters

and electric drives, hardware system description, application of AI techniques to electric machines and drives.

Learning Resources:

Text Books:

1. Power Electronic Converters Modeling and Control with Case Studies, S. Bacha, I. Munteanu, A.I. Bratcu, Springer- Verlag London, 2014, 1st Edition.
2. PID and Predictive control of Electrical Drives and Power Converters using MATLAB/Simulink, L. Wang, S. Chai, D. Yoo, L. Gan, K. Ng, Wiley Press, 2015, 1st Edition.
3. Robust Linear Control of DC-DC Converters: A Practical Approach to the Synthesis of Robust Controllers, C. Olalla, Ramon Leyva, I. Queinnec, VDM Verlag- Dr. Muller, 2010,1st Edition.

Reference Books:

1. Sliding Mode Control of Switching Power Converters: Techniques and Implementation,S-C. Tan, Y-M. Lai, C.K. Tse, CRC Press, 2012, 1st Edition.
2. Control Design Techniques in Power Electronic Devices, Hebertt Sira-Ramirez, Ramon Silva-Ortigoza, Springer- Verlag London, 2006, 1st Edition.
3. Control of Power Electronic Converters and Systems, Freede Blaabjerg, Academic Press, 2018, 11st Edition.
4. Control of Power Inverters in Renewable Energy and Smart Grid Integration, Q- C. Zhong, T. Hornik, Wiley Press, 2013, 1st Edition.
5. Sliding Mode controllers for Power Electronic Converters,A. Mehta, B. Naik, Springer Nature, 2019.

Online Resources:

1. https://nptel.ac.in/courses/101/108/101108047/
2. https://nptel.ac.in/courses/108/103/108103007/

EE5252	REAL-TIME CONTROL OF POWER SYSTEMS	3-0-0: 3

Pre-Requisites:

Course Outcomes:

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

CO1	Understand Real Time operation of Power System
CO2	Develop mathematical models for State Estimation and Contingency analysis
CO3	Understand the significance of Power System security
CO4	Investigate the optimal location of measurement devices

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

STATE ESTIMATION OF POWER SYSTEM:

Introduction to State Estimation (SE) in Power Systems: Weighted Least Square Estimation (WLS-SE). SE of AC networks: Types of measurements, Linear WLS–SE theory, DC Load flow based WLS–SE, Linearized model of WLS–SE of Non–linear AC power systems, typical results of SE on an AC network. Detection and Identification of bad measurements, Network Observability and Pseudo–measurements, optimal meter placement. Incorporation of PMU data in WLS-SE

SECURITY ANALYSIS OF POWER SYSTEM:

Concept of security, Security analysis and monitoring, Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma based approach, Network Sensitivity factors

REAL-TIME CONTROL OF POWER SYSTEMS:

Introduction, operating states of a Power System

SCADA FUNCTIONS:

Introduction to SCADA: Grid Operation & Control, advantages of SCADA operation. Lay out of substation, Main Equipment's in Sub Station, Instrument Transformers, and necessary parameters for Grid operation: Analog Points, Status Points, Alarms, Transducers & their connectivity

Data Acquisition, Monitoring and Event Processing, Control Functions, Time tagged data, Disturbance data collection and analysis, Reports and Calculations

Man – Machine Communication: Operator's Console, VDU Display, Operator Dialogs, Mimic Diagram Functions

Remote Terminal Unit (RTU), Phase angle Measurement unit (PMU) & Communication Practices

Major Components: RTU Panel, Interface Panel, D20M Main Processor, Analog Card, Status Card, Control Card, Modems. Types Of Communications: Power Line Carrier Communications, Microwave, Optical fibre, VSAT Communications. Types of Network Elements in LAN & WAN. Process of Data Communication

Introduction to SCADA PROTOCOLS and Communication Standards
Evolution of Protocol for Communication, Protocols -Modbus, Distributed Network Protocol (DNP), IEC 870-5 and 60870 series, Benefits from IEC (International Electro technical Commission) communication Standards

Sub-load Dispatch Centre (Sub- LDC)
Equipment in Sub LDC: Work Stations, FEPS, Routers, Functionalities of Sub LDC- Real Time Software
Classification of Programs, Structure of Real time Programs, Construction Techniques & Tools, Programming Language Requirements for Process Control

Overview of Computer control of Electrical Power Systems
Evolution of System Control, time scale of system control, online computer control, and Software Elements: State Estimation, Monitoring & Prediction, Generation & LoadControl, Security Analysis; Software Coordination & Systems Simulation

State Load Dispatch Centre (SLDC): Inter Connectivity of Sub-LDCs & SLDCs, Hierarchy of Data Transfer, Functions & Responsibilities of SLDC, Real Time Operationcarried at SLDC

Southern Regional Load Dispatch Centres (SRLDC) and National Load Dispatch Centre (NLDC)- Functions & Responsibilities of SRLDC, Operations carried at SRLDC,Overview of SCADA, Real Time operation in detail Operations carried out NLDC
.

Text Books:

1. Power SystemGeneration, Operation and Control, Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, John Wiley and Sons, 2013, 3rd Edition

2. Power System SCADA andSmart Grids, Mini S. Thomas and John D. McDonald, CRC Press, 2015, 1st Edition

Reference Books:

1. Power System Analysis, John J. Grainger and William D Stevenson Jr.: McGraw Hill, 2017, ISE
2. Power System control — Technology, Torsten Cegrell, Prentice –Hall International series in Systems and control Engineering, Prentice Hall International Ltd., 1986
3. Real – Time Computer Control, S. Bennett and D.A. Linkens (Editors): IEE Control Engineering series (24), Peter Peregrinus Ltd., 1984
4. Real — Time Systems, C.M. Krishna and Kangg. Shin: Mc Graw-Hill international companies
5. Special Issue on Computer Control of Power Systems, IEEE Proc. July 1974

EE5261	DISTRIBUTION SYSTEM PLANNING AND AUTOMATION	3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand and distinguish characteristics of distribution systems from transmission systems
CO2	To design, analyze and evaluate distribution system design based on forecasted data
CO3	Identify and select appropriate sub–station location
CO4	Design and evaluate a distribution system for a given geographical service area from alternate design alternatives

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Distribution System Planning: Planning and forecasting techniques – Present and future –Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy

Distribution Transformers: Types – Three phase and single phase transformers – connections – causes and types of failures in distribution transformers

Primary distribution systems and Distribution Sub–Stations: Distribution substations –Bus schemes –comparison of switching schemes- Substation location and rating- Types of feeders — voltage levels

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks

Capacitors In Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration –Automation – Communication systems – Sensors –Basic architecture ofDistribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff

Text Books:

1. Electric Power Distribution, Automation, Protection and Control, James A Momoh, CRCpress, 2001
2. Electric Power Distribution, A. S. PABLA, TMH,2000

Reference Books:

1. Electric Power Distribution Engineering, Turan Gonen, Mc-Graw Hill,1986
2. A Textbook of Electric Power DistributionAutomation, Dr. M.K. Khedkar, Dr. G.M. Dhole, Laxmi Publications Ltd., 2010

Online Resources:

1. https://www.youtube.com/channel/UCWKPXSjLRz-TAFgFWCfMmGg/videos

Open Elective Courses

Open Elective-I (III Year, II Semester)		
S. No.	**Course Code**	**Course**
1.	EE 395	Linear Control Systems
2.	EE 396	Swarm Intelligence Techniques
3.	EE 397	Introduction to Internet of Things (IoT)
Open Elective-II (IV Year, I Semester)		
S. No.	**Course Code**	**Course**
1.	EE 445	Entrepreneurial Venture Creation
2.	EE 446	Principles of Electrical Power Conversion

DETAILED SYLLABUS
Open Elective-I

EE 395	LINEAR CONTROL SYSTEMS	3-0-0: 3

Pre-Requisites: None

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

CO1	Model and Analyze the dynamical Systems using Transfer Function method.
CO2	Determine Transient & Steady-State behaviours of dynamical systems.
CO3	Analyze the steady state errors, absolute/relative stability of dynamical systems in time domain & in frequency domain.
CO4	Model the dynamical systems using the state space approach

Syllabus:

Introduction: System, control system, representation of control system types of control systems, Open-loop and closed loop systems, Types of feedback, feedback and its effects, Laplace transform.

Modelling of Dynamical Systems: Mathematical modelling of Electrical and Electro-mechanical systems, Liquid level system, Automotive Systems, Hydraulic systems, Linearization concept.

Techniques to Develop Transfer Function of Systems: Block diagram reduction technique, signal flow graph and Mason's gain formula.

Time Domain Analysis: Test signals, time domain indices, steady state error constants, concept of BIBO stability, absolute stability. Routh- Hurwitz Criterion.

Root Locus Techniques: Introduction, Root loci theory, rules to plot the root locus, application to system stability analysis.

State-Space Representation of Dynamical Systems: Importance of States and its advantages, state space representation of dynamical systems.

Frequency Domain Analysis: Introduction, Bode plots, Frequency domain indices, application of Bode plots, Polar/Nyquist plots, Principle of PID controller.

Learning Resources:

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 7th Edition, 2019.
2. I.J.Nagarath and M.Gopal: Control Systems Engineering, New Age Pub. Co, 6th Edition, 2017.
3. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 5th Edition, 2015.
4. B.C.Kuo: Automatic Control Systems, Wiley, 9th Edition, 2014.

Reference Books:

1. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 13th Edition, 2015.
2. K.J. Astrom, R.M. Murray, Feedback Systems- An Introduction for Scientists and Engineers, 2nd Edition, 2011.

Online Resources:

1. https://www.controleng.com/

EE 396	SWARM INTELLIGENCE TECHNIQUES	3-0-0: 3

Pre-Requisites: None

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.

Syllabus:

FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES: Definition - Classification of optimization problems, Unconstrained and Constrained optimization Optimality conditions, Introduction to intelligent systems Soft computing techniques, Conventional computing techniques versus Soft computing techniques – 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.

GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION: Genetic algorithms - 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, Application to SINX maximization problem,

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, ACO and ABC algorithms for solving SINX maximization problem.

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, BA and SFLA algorithms for solving SINX maximization problem, Application to multi-modal function optimization, Introduction to Multi-Objective optimization, Concept of Pareto optimality.

Learning Resources:

Text Books:

1. Recent Advances in Swarm Intelligence and Evolutionary Computation, Xin-She Yang, Springer International Publishing, Switzerland, 2015
2. Multi-Objective Optimization using Evolutionary Algorithms, Kalyanmoy Deb, John Wiley & Sons, 2001

Reference Books:

1. Artificial Intelligence and Intelligent Systems, N P Padhy, Oxford University Press, 2005

Online Resources:

1. https://nptel.ac.in/courses/103/103/103103164/
2. https://nptel.ac.in/courses/112/105/112105235/
3. https://nptel.ac.in/courses/106/105/106105173/

EE 397	Introduction to Internet of Things (IoT)	3-0-0: 3

Pre-Requisites: None

Course Outcomes: After completion of the course, students will be able to

CO1	Understand IOT and its design requirements
CO2	Select appropriate Sensors and Actuators for desired application
CO3	Compare various technologies and protocols
CO4	Design and experiment various use cases with IoT

Syllabus:

Introduction to IoT: Characteristics of Internet of Things- Need of IoT, IoT architecture, Area of Applications, IoT applications in Smart Cities, Agriculture, Security, Transport and Medical & Health. **IoT Sensing and Actuation**: Introduction, Sensors, Sensor Characteristics, Sensorial Deviations, Sensing Types, Scalar sensing, Multimedia sensing, Hybrid sensing, Virtual sensing, Sensing Considerations. Actuators, Actuator Types, Hydraulic actuators, Pneumatic actuators, Electric actuators, Thermal or magnetic actuators, Mechanical actuators, Soft actuators, Actuator Characteristics.

IoT Connectivity Technologies (Fundamentals): Introduction, IEEE 802.15.4, Zigbee, RFID, DASH7, Z-Wave, LoRa, NB-IoT, Wi-Fi, Bluetooth. **Communication Technologies (Fundamentals)**: Introduction, Constrained nodes, Constrained Networks, Infrastructure Protocols, Discovery Protocols, Data Protocols, Identification Protocols, Device Management, Semantic Protocols

Introduction to Arduino: Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi. **IOT Case Studies**: Agricultural IoT, Components of an agricultural IoT, Advantages of IoT in agriculture, Case Studies, Smart irrigation management system. Vehicular IoT, Components of vehicular IoT, Advantages of vehicular IoT, Crime assistance in a smart IoT transportation system. Healthcare IoT, Components of healthcare IoT, Advantages and risk of healthcare IoT, Case Studies. IoT Case Studies in Electrical Engineering: IoT application to Smart Grid, Smart Cities and Smart Homes, EV Connected Vehicles.

IOT Projects Demonstration: Beginning IoT Hardware Projects, Arduino installation and setup, Setting up Arduino IDE for NodeMCU, Writing an Arduino Sketch, Demo Experiments with Arduino, Printing on the serial console, LED interface with Arduino, DHT Sensor interface with NodeMCU, MQ-2 Gas sensor interface with NodeMCU, Ultrasonic sensor interface with NodeMCU, Obstacle detection using NodeMCU, Servo motor interface with NodeMCU, Relay interface with NodeMCU, Data transmission between NodeMCU and remote server, Pulse sensor interface with NodeMCU.

IoT Analytics(Basics): Introduction, Machine learning, Advantages of ML, Challenges in ML, Types of ML, Selected Algorithms in ML, k-nearest neighbor (KNN), Decision tree, Random forest, k-means clustering, Agglomerative clustering, Density-based spatial clustering of applications with noise(DBSCAN), clustering, Performance Metrics for Evaluating ML Algorithms.

Paradigms, Challenges, and the Future: Introduction, Evolution of New IoT Paradigms (Discussion Only), Internet of battlefield things (IoBT), Internet of vehicles (IoV), Internet of underwater things (IoUT), Internet of drones (IoD), Internet of space (IoSpace), Internet of services (IoS), Internet of people (IoP), Internet of nano things (IoNT), Internet of everything (IoE). Challenges Associated with IoT, Mobility, Addressing -Power Heterogeneous connectivity, Communication range, Security, Device size.

Learning Resources:
Text Books:

1. Sudip Misra, Anandarup Mukherjee and Arijit Roy “Introduction to IoT” by, Cambridge University Press, 2021
2. Dimitrios Serpanos, Marilyn Wolf, “Internet-of-Things (IoT) Systems - Architectures, Algorithms, Methodologies” Springer Publications, 2018
3. Mansaf Alam • Kashish Ara Shakil, Samiya Khan, “Internet of Things (IoT)-Concepts and Applications” Springer Publications, 2020

Reference Books:

1. Anandarup Mukherjee, Chandana Roy, Sudip Misra - Introduction to Industrial Internet of Things and Industry 4. 0-CRC Press (2020)
2. Peter Hoddie, Lizzie Prader - IoT Development for ESP32 and ESP8266 with JavaScript_ A Practical Guide to XS and the Moddable SDK-Apress (2020)
3. Mansaf Alam, Kashish Ara Shakil, Samiya Kha - Internet of Things (IoT)_ Concepts and Applications (S.M.A.R.T. Environments)-Springer (2020).
4. Anuradha, J., Tripathy, B. K - Internet of things (IoT) _ technologies, applications, challenges and solutions-CRC Press_Taylor & Francis (2018)

Online Resources:

1. National Programme on Technology Enhanced Learning (NPTEL) Online courses, Course-Introduction to Internet of Things
   https://nptel.ac.in/courses/106/105/106105166/

DETAILED SYLLABUS
Open Elective-II

EE 445	ENTREPRENEURIAL VENTURE CREATION	3-0-0: 3

Pre-Requisites: None (This course is not offered to Electrical Engineering Students)

Course Outcomes:

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

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO3	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
CO4	Understand the functional management issues of running a new venture

Syllabus:

ENTREPRENEUR AND ENTREPRENEURSHIP

Entrepreneurship and Small-Scale Enterprises (SSE); Role in Economic Development, Entrepreneurial Competencies; Institution Interface for SSE

ESTABLISHING THE SMALL-SCALE ENTERPRISE

Opportunity Scanning and Identification; Market Assessment for SSE; Choice of Technology and Selection of Site; Financing the New/Small Enterprises; Preparation of the Business Plan; Ownership Structures and Organizational Framework

OPERATING THE SMALL-SCALE ENTERPRISES

Financial Management Issues in SSE; Operational Management Issues in SSE; Marketing Management Issues in SSE; Organizational Relations in SSE

Learning Resources:

Text Books:

1. New Venture Management: The Entrepreneur's Roadmap, Kuratko, Pearson, 2008
2. Entrepreneurship: New Venture Creation, Holt, PHI(P) Ltd., 2001

Reference Books:

1. Management of New & Small Enterprises, Madhulika Kaushik, IGNOU course material, 1995
2. Entrepreneurship Development Training Material, B S Rathore, S Saini, TTTI, Chandigarh, 1988
3. A Hand Book for New Entrepreneurs, P C Jain, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986
4. A Manual on How to Prepare a Project Report, J B Patel, D G Allampalli, EDII, Ahmedabad, 1991
5. A Manual on Business Opportunity Identification and Selection, J B Patel, EDII, Ahmedabad, 1995

Online Resources:

1. Champions Portal: www.champions.gov.in
2. Udyam Registration: https://udyamregistration.gov.in
3. MSME Databank: www.msmedatabank.in
4. National Small Industries Corporation: www.nsic.co.in
5. MSME Sambandh: sambandh.msme.gov.in
6. Government eMarket Place: www.gem.gov.in

EE 446	PRINCIPLES OF ELECTRIC POWER CONVERSION	3-0-0: 3

Pre-requisites: None

Course Outcomes:

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

CO1	Understands the basics in the electric power conversion using power switching devices.
CO2	Analyse the control of electrical machines.
CO3	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives.
CO4	Analyze the different energy storage systems and Identify Industrial and domestic applications..

Syllabus:

POWER ELECTRONIC DEVICES AND CONVERTERS:

V-I Characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

APPLICATIONS TO ELECTRIC DRIVES:

Speed control of DC motor, Induction motors, PMSM and BLDC drives

APPLICATIONS TO RENEWABLE ENERGY:

Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

ENERGY STORAGE SYSTEMS:

Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

DOMESTIC AND INDUSTRIAL APPLICATIONS:

Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers

Learning Resources:

Text Books:

1. Power Electronics-circuits, Devices and applications, M.H. Rashid, Prentice Hall India, NewDelhi, 2009.
2. Power Electronics, P.S. Bhimbra, Khanna publishers, New Delhi, 2012.

Reference Books:

1. Power electronics converters, applications and design, Ned Mohan, Undeland and Robbin, John Willey & Sons, Inc. New York, 2006.

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