Programme Structure and Syllabi for B. Tech. Electrical Engineering (2023 batch onwards)

Department of Electrical Engineering

Punjab Engineering College

(Deemed to be University) Chandigarh, India

Semester Scheme B.Tech 3rd to 8th Semester 2023-24 Onwards

Semester-III

Course Code	Course Name	L	T	P	Credits
EEN3001	Networks and Systems	3	0	2	4
EEN3002	Measurement and Instrumentation	3	0	2	4
EEN3003	Electrical Machine-I	3	0	2	4
EEN3004	Power System Engineering	3	0	2	4
EEN4001	HSM-II/ Analog and Digital Electronics	3	0	2	3/4
Total					19/20

Semester-IV

Course Code	Course Name	L	T	P	Credits
EEN4001	Analog and Digital Electronics /HSM-II	3	0	2	4/3
EEN4002	Electrical Machine-II	3	0	2	4
EEN4003	Power System Analysis	3	0	2	4
EEN4004	Power Electronics	3	0	2	4
EEN4005	Control System	3	0	2	4
EEN4006	Renewable Energy Technologies	3	0	2	4
Total					24/23

Semester-V

Course Code	Course Name	L	T	P	Credits
EEN5001	Power System Protection and Switchgear	3	0	2	4
EEN5002	Electric Drives	3	0	2	4
EEN5003	Electric Vehicles	3	0	2	4
EEN5004	Microprocessor & Microcontroller	3	0	2	4
EEP5101	Minor Project	0	0	8	4
Total					20

Semester-VI

Course Code	Course Name	L	T	P	Credits
EEN6001	Internship Part-I	0	0	12	6
EEN6002	Internship Part-II	0	0	4	2
EEN6003	Internship Part-III	0	0	8	4
	or				
	Optional Courses Work				
	DEC	3	1	0	4
		3	0	2	

		4	0	0	
	OE	3	1	0	4
EEP6001	Project Work	0	0	8	4
Total					12

Semester-VII

Course Code	Course Name	L	T	P	Credits
	HSM-III/HSM-IV				3
	DEC-I	3	1	0	4
		3	0	2	
		4	0	0	
	DEC-II	3	1	0	4
		3	0	2	
		4	0	0	
	OE-I	3	1	0	4
	OE-II	3	1	0	4
EEP7001	Major Project-I	0	0	8	4
Total					23

Semester-VIII

Course Code	Course Name	L	T	P	Credits
	HSM-IV/HSM-III				3
	DEC-III	3	1	0	4
		3	0	2	
		4	0	0	
	DEC-IV	3	1	0	4
		3	0	2	
		4	0	0	
	OE-III	3	1	0	4
	Proficiency	-	-	-	2
EEP8001	Major Project-II*	0	0	8	4
	Total				21

Minor Specialization in Power Apparatus and Power Electronics

Semester	Course Code	Course Name	L	T	P	Credits
III	EEM1001	Industrial Electrical Machines	3	0	2	4
IV	EEM1002	Electric PowerSystem	3	0	2	4
V	EEM1003	PowerElectronics	3	0	2	4
VII	EEM1004	Minor Specialization Project-I	0	0	6	3
VIII	EEM1005	Minor Specialization Project-II	0	0	6	3

Minor Specialization in Renewable Energy and EV Management

Semester	Course Code	Course Name	L	T	P	Credits
III	EEM2001	Photovoltaics- Photon to Solar Farms	3	0	2	4
IV	EEM2002	Renewable Energy Technologies	3	0	2	4
V	EEM2003	Electric Vehicle and Battery Management System	3	0	2	4
VII	EEM1004	Minor Specialization Project-I	0	0	6	3
VIII	EEM1005	Minor Specialization Project-II	0	0	6	3

HonoursDegree

Semester	Course Code		Credits
V	EEH1001	Honours Project-I	3
VII	EEH1002	Honours Project-II*	4
VIII	EEH1003	Honours Project-III*	5
		TOTAL	**12**

Total Credits = 162+12 with Honors

Department of Electrical Engineering
Course Curriculum
B.Tech (Electrical Engineering)
Detailed Syllabus of Core Courses

Course Code	Course Name	L	T	P	Credits
EEN3001	Networks and Systems	3	0	2	4
EEN3002	Measurement and Instrumentation	3	0	2	4
EEN3003	Electrical Machine-I	3	0	2	4
EEN3004	Power System Engineering	3	0	2	4
EEN4001	Analog and Digital Electronics	3	0	2	4
EEN4002	Electrical Machine-II	3	0	2	4
EEN4003	Power System Analysis	3	0	2	4
EEN4004	Power Electronics	3	0	2	4
EEN4005	Control System	3	0	2	4
EEN4006	Renewable Energy Technologies	3	0	2	4
EEN5001	Power System Protection and Switchgear	3	0	2	4
EEN5002	Electric Drives	3	0	2	4
EEN5003	Electric Vehicles	3	0	2	4
EEN5004	Microprocessor & Microcontroller	3	0	2	4

NAME OF DEPTT : **Department of Chemistry**
Course name : Applied Chemistry I (CSE, ECE, EE, DS, VLSI, AI)
Course Code : CH2301
Year : 23-24 (2nd semester)
Credits : 4
L T P : 3 0 2 **Total No. of Lecture-42**

Objective: To teach the fundamentals and applications of Chemical Sciences essential for the development of electrical and electronic materials and technologies. Students will be learning various analytical techniques for the characterizations of electronic organic/inorganic materials.

Lecture wise breakup	***No. of Lectures = 42***

1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections, Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir–Hinselwood Mechanism, acid-base equilibria in non aqueous media, Introduction to Computational chemistry and open source softwares	**(10)**
2	**Polymeric Materials** Mechanism and methods of polymerization, structure-activity relationship, Conducting Polymers: types (n- or p- doping) and applications, Polymeric fibre materials	**(6)**
3	**Spectroscopic Methods for structural Analysis:** Principle and applications (UV, IR, NMR, SEM and TEM)	**(9)**
4	**Energy Storage and Sensing Devices:** Fundamentals of Electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Renewable energy (Artificial photosynthesis), Solar cells, Sensors for IoT	**(8)**
5	**Chemistry of Electronic and Electrical Materials** Semi-conductor and super conducting Materials, Carbon materials, Optical Materials (OLED), 2D Materials, Magnetic materials.	**(9)**

Outcomes: 1. To be able to apply the fundamentals of chemistry towards developing new Technologies based on new materials.
2. To attain the essential analytical skills and designing of materials for electrical and electronic applications.
3. Application of software as important tools in technological applications.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman& Co).
4. Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition,(Thomson learning, Indian Edition).
7. Computational chemistry: Introduction to theory and applications of molecular andquantum mechanics: Lewars Errol G. (Springer)
8. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Practicals	
Sr. No.	**Name of Experiment**
1.	To find the strength of the given sodium hydroxide solution by titrating it against standard solution of hydrochloric acid using pH meter.
2.	To determine the ferrous content in the supplied sample of iron ore by titrimetic analysis against standard $K_2Cr_2O_7$ solution using potassium ferricyanide $[K_3Fe(CN)_6]$ as external indicator.
3.	To find the strength of Sodium hydroxide (NaOH) solution by titrating it against 0.1 N hydrochloric acid conductometrically.
4.	Determination of reaction rate constant of acid catalyzed Hydrolysis of Ester.
5.	Verify Beer-Lambert's law for $KMnO_4$ colorimetrically.
6.	Synthesis of Polyaniline based conducting polymer.
7.	To determine the value of rate constant (k) for the inversion of sucrose by polarimeter.
8.	To prepare nickel dimethyl glyoxime complex, $[Ni(DMG)_2]$. Illustrate the structure of the complex using FTIR.
9.	Synthesis of iron oxide nanoparticles and characterization using FTIR.
10.	Predicting the best Molecular docking conformations of a protein with the help of Swiss Dock.

NAME OF DEPTT. : **Department of Chemistry**

Course name : Applied Chemistry II (Mech.,Prod.,Metta,Aero.,Civil Engg.)
Course Code : CH2302
Year : 23-24 (1st semester)
Credits : 4
L T P : 3 0 2 **Total No. of Lecture-42**

Objective: To teach the fundamentals and applications of Chemical Sciences essential for the development of engineering materials and processing technologies. Students will be learning various analytical techniques for the characterizations of composites and hybrid materials.

Lecture wise breakup	***No. of Lectures = 42***

1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections , Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir –Hinshelwood Mechanism, Acid -base equilibria in non aqueous media	**(8)**
2	**Polymer Chemistry** Mechanism and methods of polymerization, Structure-Activity relationship, High performance polymers and applications, Natural and synthetic fibers, biodegradable polymers	**(5)**
3	**Fuels and Catalysis** Petroleum processing**,** Solid and liquid Fuels for Propellants, Chemistry of combustion and equations, Catalytic convertors	**(5)**
4	**Electrochemistry and Corrosion:** Introduction to Electrochemistry, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Corrosion control and protective coatings	**(7)**
5	**Spectroscopic Methods for structural analysis:** Principle and Applications (UV, IR, NMR, AAS/ICP-AES, SEM, TEM, XRD).	**(10)**
6	**Chemistry of Engineering Materials** Ceramic and Cement Materials, Metals and Alloys ,Phase change materials, Bio-inspired materials, Composite materials, Smart materials: Chemical compositions and its applications	**(7)**

Outcomes:

1. To be able to apply the fundamentals of chemistry towards emerging materials to benefit the societal needs.
2. To attain the essential analytical skills and designing of materials for various applications.
3. To be able to identify the chemical compositions required for designing of high performance materials.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).
4. Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).

5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Practicals	
Sr. No.	**Name of Experiment**
1.	Measurement of acid base equilibria by pH meter in water sample.
2.	To determine the ferrous content in the supplied sample of iron ore by titrimetric analysis against standard K2Cr2O7 solution using potassium ferricyanide $[K_3Fe(CN)_6]$ as external indicator.
3.	Synthesis of polyaniline based conducting polymer.
4.	To find the strength of given NaOH solution by titrating it against 0.05 N Hydrochloric acid solution using a conductivity meter.
5.	Synthesis of iron oxide nanoparticles and characterization using various techniques (UV/ FTIR/ SEM/XRD).
6.	To determine the value of rate constant (k) for the inversion of sucrose by polarimeter.
7.	To verify Lambert Beer's law for $KMnO_4$ using UV-Visible Spectrophotometer.
8.	To determine the percentage of Cu in the copper alloy solution provided 0.1 N hypo solution.
9.	To prepare nickel dimethyl glyoxime complex, $[Ni(DMG)_2]$. Illustrate the structure of compound using FTIR.
10.	Determination of reaction rate constant of acid catalyzed hydrolysis of ester.

Course Name	**:**	**Introduction to Computer Programming**
Course Code	**:**	**ES 2301**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

- To develop logical skills so that students should be able to solve basic programming problems
- To use programming knowledge to develop small projects including basic GUI design

Total No. of Lectures: 42

Lecture wise Breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO PROGRAMMING** Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application softwares like editor. Flowcharts. Algorithm, specification of algorithm. Industrial uses of programming in various domains	**3**
Unit 2	**DATA TYPES and OPERATORS AND EXPRESSION** Storing integers, numbers with decimals, characters and strings, typecasting. User input and output, use of command line arguments Operators: arithmetic operators, relational operators, logical operators, bitwise operators, miscellaneous operators. Expressions and their evaluation. Precedence and associativity rules.	**7**
Unit 3	**ITERABLE CONTAINERS and STATEMENTS** List, set, tuple and dictionaries; range function; difference between various iterable containers Decision making statements: if, if-else, nested if and if-else. Control statements: for & while loops, nested loops; Role of statements like break, continue	**7**
Unit 4	**FUNCTIONS and CLASSES** Advantage of modularizing program into functions, function definition and function invocation. Function arguments: default, keyword and positional arguments. Scope and lifetime of a variable. Recurrence relations and Recursion Advantage of using classes, defining class data members & functions and accessing using objects. Constructors and destructors in a class, parameterized constructors.	**8**

Unit 5	**GUI design** Introduction to tkinter library, use of TK & mainloop methods, use of widgets like Button, Canvas, Checkbutton, Entry, Frame, MenuButton, Listbox, Menu, Scrollbar, Text, Message, Pack, Grid, place etc. for GUI design.	**5**
Unit 6	**SORTING AND SEARCHING** Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort. Time and space complexity of algorithms, comparing algorithms	**9**
Unit 7	**Problem Solving** Real-world programming problems	**3**

Total No. of Turns: 14

List of Experiments		**Number of Turns**
1	Implement programs to input/output various data types	**2**
2	Implement programs to use command line arguments and operators	**2**
3	Implement programs making use of conditional statements and loops	**2**
4	Implement programs making use of iterable containers	**2**
5	Implement programs making use of functions and recursion	**2**
6	Implement various searching and sorting algorithms	**2**
7	Project work including GUI design using tkinter	**2**

Course Outcomes: At the end of the course, students will be able to:	
1	Develop understanding of the fundamental concepts essential for programming.
2	Make efficient use of iterables, function and classes to programming problems
3	Develop simple GUI applications
4	Learn to compare algorithms and improve efficiency of algorithms

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Python Programming: An Introduction to Computer Science by John M. Zelle, Franklin, Beedle& Associates Inc	Latest Edition
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Think Python, How to Think Like a Computer Scientist, Version 2.0.17, Allen Downey Green Tea Press Needham, Massachusetts	Latest Edition
2.	Core python programming, Dr. R. Nageswara Rao, 2nd edition,	Latest

	Dreamtech press	Edition

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1.	Programming, Data Structures and Algorithms using Python, https://nptel.ac.in/courses/106106145	NPTEL
2.	Programming in Python, https://onlinecourses.swayam2.ac.in/cec22_cs20/preview	Swayam

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1	3	1	-	1	-	1	-	1	2	-	-
CO2	3	2	2	2	3	1	-	1	-	1	-	1	2	-	-
CO3	3	2	3	1	3	1	-	1	1	1	1	-	1	-	-
CO4	3	2	2	3	2	1	-	1	-	-	-	1	1	-	-

1: Low, 2: Medium, 3: High

Course Name	**Strength of Materials**
Course Code	**ES2306**
Credits	**4**
L T P	**3-0-2**

Course Objectives:
At the end of this course, the student should be able to understand the basic concept regarding the strength of material. The course will prepare the students to apply these concepts to engineering and applied sciences problems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Equations of static equilibrium, Concept of various forces/loads, stresses and strains developed due to these forces/loads, Uniaxial tensile test, Stress-strain diagrams for various types of ferrous and non-ferrous materials, isotropic and anisotropic materials, Compression test, impact test, fatigue test, hardness test, torsion and bending test as per ASTM standards	**4**
2	**SIMPLE STRESS & STRAIN:** Hooke's law, stress and elongation produced in various types of bars due to its own weight and applied axial force, Poisson's ratio, and relationship between elastic constants,stresses and elongation produced in simple & composite bars due to axial, thermal and combined loading.	**6**
3	**2-D STATE OF STRESS ANALYSIS:** Generalized 2-D state of stress accompanied by shear stress, stresses on an arbitrary plane under this state of stress, sign conventions for normal and shear stresses, complementary shear stress, principal stresses and principal planes, Different stresses determination through Mohr's stress circle approach in 2-D generalized state of stress.	**6**
4	**SHEAR FORCE AND BENDING MOMENT IN BEAMS:** Classification of beams, supports and loads, Shear force (SF) & Bending moment (BM) in beams and their sign conventions, Relation between rate of loading (w) with SF and BM. SF and BM diagrams of cantilevers, simply sported beams with or without overhang under different types of loading e.g. concentrate loads, uniformly distributed load, uniformly varying load, moment or its combinations, the point of contra-flexure	**6**
5	**BENDING & SHEAR STRESSES IN BEAMS**: Theory of pure bending, position of neutral axis, Bending equation, practical application of bending equation, review of moment of area concepts, variation of bending stress in various cross-sectional beams, shear stresses in beams, variation of shear stresses for different cross-sectional beams	**6**
6	**TORSION OF CIRCULAR SHAFTS:** Torsional equation of circular shafts, shear stress distribution, torsional rigidity, power transmitted by the shaft, comparisons of hollow & solid circular shafts, analysis of shafts in series and parallel mode, Equivalent bending moment and equivalent torque for a shaft subjected to bending moment and torque simultaneously	**5**
7	**COLUMN AND STRUTS**: Definitions, Euler's theory of columns buckling, Euler's equation for various end restraints, Rankine and other empirical formulae.	**4**
8	**DEFLECTION OF BEAMS**: Relationship between bending moment, slope and deflection, moment area method, method of integration, Macaulay's method, Use of these methods to determine slope and deflection for statically determinate and statically indeterminate beams under various loading conditions.	**5**

Sr. No.	List of Experiments	No. of Turns
1	To perform uni-axial Tensile Test on a given material and to determine its various mechanical properties under the uni-axial tensile loading.	2
2	To perform uni-axial compressive test on a given material and to determine its various mechanical properties under the uni-axial compression loading.	2
3	To perform shear test on a given material and to determine its shear stress of the material.	2
4	To perform torsion test on a given material and to determine its various mechanical properties under torsional load.	2
5	To perform Column test of a given material and to determine its Euler's buckling load and Young's modulus of elasticity of the material.	2
6	To perform Impact test on a given material and to determine its resilience.	2
7	To perform a test on close and open coil springs under axial loading on spring tester and determine its various mechanical properties.	2
8	To study and perform Fatigue test on a given material and to determine endurance strength and limit of the material.	2
9	To determine various Rockwell hardness of the given materials	2
10	To perform the Three point bending test on a given material and determine its Young's modulus of elasticity and bending strength.	2
11	To study the concepts of various strain gauges along with their areas of applications	2
12	To study the Creep test on the given material specimen and determine its creep strength.	2
13	To perform the various tests on the given wooden specimens by wood UTM and determineits various strengths.	2
14	To perform test on strain hardened specimen and to determine its effect on the Young'smodulus of elasticity.	2

Course Outcomes: By the end of this course, the student will be able to:	
1	Understand the concept of stresses & strains, various types of materials, its properties & testing processes as per ASTM standards.
2	Understand elastic constants and also be able to determine stresses & elongations in simple and composite bars under various types of loads.
3	Determine stresses on an arbitrary plane for a generalized 2-D state of stress accompanied by shear stressthrough analytical and graphical methods
4	Understand and be able draw shear force and bending moment diagrams for different types of beams under various types of loading.
5	Understand bending and shear stress equations and its application in determination of bending & shear stresses in different cross-sectional beams at any point across its length.
6	Understand the torsional stresses for solid, hollow and composite circular shafts and its importance inpower transmission.
7	Understand the Column and struts and determine the buckling load under various axial loadings.
8	Determine the deflections of various beams subjected to different loading by various methods.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Strength of Material - G. H. Ryder (MacMillan)	1969
2	An Introduction to the Mechanics of Solids – Crandall & Dahl (Mc-Graw Hill)	2012
3	Engg. Mechanics of Solids - E. P. Popav (Pearson Education)	2003
4	Strength of Material - D S Bedi, Fifth Ed.	2010
5	Strength of Material - R K Rajput, Fifth Ed.	2012

Course Name	**Engineering Drawing with CAD Software**
Course Code	**ES2302**
Credits	**3**
L TP	**2-0-2**

Course Objectives:

At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two- and three-dimensional objects. The student should also be able to understand the features associated with operations of the computer-aided design (CAD) software.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Introduction to Engineering Graphics, Concept of points and lines, System of Projections, Orthographic projections, Dimensioning.	**4**
2	Introduction to different types of CAD Softwares e.g. SolidWorks/AutoCAD/ CATIA etc., 2D-Sketching, Sketching Entities & Relation, 3D-Sketching, Editing and its Features, Dimensions, Sketch Tools, File handling.	**7**
3	Projections of planes / lamina on reference planes, classification of primary and secondary planes, use of auxiliary planes, Exercises using CAD software.	**5**
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes and Sectioning of solids, Exercises using CAD software.	**6**
5	Introduction to Perspective projection, isometric views, Isometric lines & Axes, conversion of orthographic views to isometric views and vice-versa, Exercises using CAD software.	**6**

List of Experiments:		**Number of Turns**
Exercises to be done using CAD software		
1	2D & 3D Sketching using various sketching tools.	2
2	Projection of planes.	2
3	Developments of 3D-parts.	2
4	Projection of solids.	2
5	Projection of Sectioning of solids.	2
6	Isometric and orthographic views.	2
7	Generating drawings of 3D-parts.	2

Sr. No.	**Course outcome** By the end of this course, the students will be able to:	**Knowledge Level (Blooms Level)**
1	Understand the basic concepts of Engineering Graphics, drawing standards, conventions and symbols that are in common usage.	**L2**
2	Apply the concepts of engineering drawing to create orthographic projections of points, lines, planes, solids with conventional and CAD software.	**L3 & L6**
3	Visualize the actual objects and convert them in to readable drawings with conventional and CAD software.	**L6**
4	Create new designs/engineering models with conventional and CAD software.	**L6**

CO-PO & PSO 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
CO2	3	2	3	3	3	-	-	-	1	-	-	1	3	2
CO3	3	2	3	3	3	-	-	-	1	-	-	1	3	2
CO4	3	2	3	3	3	-	-	-	1	-	-	1	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Drawing, P. S. Gill, S.K. Kataria& Sons.	2012
2	Engineering Drawing, D.A. Jolhe, Tata McGraw Hill	2010
3	Engineering Graphics with SOLIDWORKS, David C. Plan chard, SDC Publications	2020

Course Name	**:**	**Introduction to Mechatronics**
Course Code	**:**	**ES 2304**
Credits	**:**	**04**
L T P	**:**	**3-0-2**
Course Objectives:		
The objective of the course content is to: 1.Impart knowledge and information about mechatronics system. 2. Understand the concepts of signal conditioning and data acquisition for intelligent systems. 3.Develop the basics for mechatronic product design		

Total No. of Lectures-42

Introduction to Mechatronics : Introduction, Elements of Mechatronics system, Classificationof Mechatronics system,Mechatronic system intelligence, Components involved in intelligent system designand development,measurementsand control system as a part of mechatronics system,Application of Mechatronic systems(6)

Sensors and transducers : Introduction,Performance characteristics of transducers, Transducer for displacement (Potentiometer, strain-gauge, Optical encoder, LVDT, Hall effect sensor); velocity(Tachogenerator), force (load cell), pressure (Piezoelectric sensors, Tactile sensor), liquid level (Floats, Differential pressure), Temperature (Bimetallic strips, RTDs, Thermistors, Thermocouples) and light sensor (Photovoltaic- transducer, LDR, Photodiode, Photo Transistor). (8)

Signal conditioning: Operational amplifier (Inverting, Non-inverting, Summing, Integrating, Differential amplifiers, comparator), protection, filtering, digital signals (R-2R ladder DAC and Successive Approximation ADC), Concepts of multiplexers(7)

Controllers: Basics of number system, binary, octal and hexadecimal systems with their conversion from one system to other. Boolean algebra, logic gates, ICs, flip-flops& counters.Microprocessor, Microcontroller, PLC & their Architectures, Working Principle, Software Programs (Assembly/High Level), Interfacing Aspects (7)

Actuators and mechanisms:
Pneumatic and hydraulic actuation systems: Directional control valves, Pressure control valves, cylindersMechanical actuation systems: Kinematic chain, cam, gear, clutches, ratchet and pawl, belt and chain drive, bearings
Electrical actuation systems:Relays, Solid-state Switches (Diode, Thyristor, Triac, BJT, FET), DC and AC motors, brushless dc motor, stepper motors, servomotors (8)

Robotics: Types of motions, Function, Governing Laws, Classification, Features and Components of Robots, System Automation(6)

Topics to be thought through Flipped Learning (NPTEL MOOCs) -
***https://nptel.ac.in/courses/112107298*)**
Mechanical actuation systems: Kinematic chain, cam, gear, ratchet and pawl, belt and chain drive, bearings (Unit 3 Lecture 11)
Pneumatic and hydraulic actuation systems: Directional control valves, Pressure control valves, cylinders (Unit 3 Lecture 12)
Basics of number, binary, octal and hexadecimal systems with their conversion from one system to other. Boolean algebra, logic gates, ICs, flip-flops. (Unit 5 Lecture 21&22)
PLC Controller (Unit 7 Lecture 33)

LIST OF EXPERIMENTS		
1	**Experiment on Sensors & Transducers**	**Number of Turns**
(i)	To study the characteristics of LVDT using linear displacement trainer kit & compare with ideal characteristics.	01
(ii)	To measure the strain of the metal strip using strain gauge trainer kit & compare with ideal characteristics.	01
(iii)	To measure the angular displacement of resistive & capacitive transducer using angular displacement trainer kit & compare with ideal characteristics.	01
(iv)	To obtain the characteristics of RTD, thermistor, thermocouple with hot and cold junction thermal trainer kit & compare with ideal characteristics.	01
2.	**Experiments on Signal Conditioning**.	
(a)	Experiments on Analog Devices	
(i)	PN Junction Diode	01
(ii)	Zener Diode	01
(iii)	Half wave rectifier	01
(iv)	Full wave rectifier	01
(b)	**Experiments on Digital devices**	
(i)	Logic Gates (AND, OR, NAND, NOR etc)	01
(ii)	Flip Flop - RS Flip Flop, JK Flip Flop, T Flip Flop and D Flip Flop.	01
3	**Experiments on Controller**	
(i)	To perform the basic sequence programming using PLC.	01
4.	**Experiments on Actuators**	
(i)	To perform AND and OR logic using pneumatic actuators.	01
5.	**Project using Arduino**	
(i)	To build a line follower robot using Arduino.	02

Course Outcomes:

By the end of this course, the student will be able:
CO1: To understand the basic concepts, applications and components of mechatronic system.
CO2: To analyze sensing, signal conditioning and data acquisition circuits.
CO3: To design product and systems theoretically as well as practically with Intelligence.
CO4: To apply the knowledge of mechatronic system for industrial applications.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechatronics by W Bolton , 6thedition, Pearson Education	2019
2	Mechatronics by Tilak Thakur 1st edition, Oxford University Press	2016
3	Mechatronics by Dan Necsulescu, Pearson Education	2001
4	Mechatronics by H M T Limited,TMH	2017
5	Mechatronics Principles, Concepts & Applications by Nitaigour P Mahalik, TMH	2017

Course Name	**Introduction To Electronics & Electrical Engineering**
Course Code	**ES 2305**
Credits	**4**
L T P	**3-0-2**

Course Objectives:
To introduce to the students, the fundamental concepts of electronic devices, circuits and electrical systems for engineering applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Semiconductor Devices and applications**: Introduction to different semiconductor materials, familiarization with active and passive components, operation of p-n junction diode, applications of diodes, introduction to BJT and MOSFET, transistor as an amplifier, transistor as a switch, functional operation of OpAmp, concept of Oscillators, filters and their types	10
2	**Digital Electronics**: Number system, Binary arithmetic, Binary codes, introduction to logic gates, combinational circuits: adder, subtractor, multiplexer, demultiplexer, sequential circuit: flipflops.	9
3	**Communication Systems:** Basics of signals and systems, time and frequency domain analysis, various frequency bands used for communication, block diagram of Analog and Digital communication, need of modulation, Introduction to wired and wireless communication.	10
4	**Fundamentals of Electrical Engineering:** Introduction to circuit laws, amplitude, phase, phase difference, RMS value and average value of an AC signal, introduction and types of motors, Transformer: construction, working principle and applications	7
5	**Microprocessor and Microcontroller:** Introduction to microprocessor and microcontroller, architecture of 8086, functional diagram, register organization, memory segmentation	6

List of Experiments

S. No.	**Name of the experiment**	**No. of turns**
1	To familiarise with basic electronic components, oscilloscopes, power supply, multimeter etc.	2
2	To simulate and analyse the IV characteristics of PN junction diode	1
3	To simulate and analyse the functionality of opamp	2
4	To simulate and verify the truth tables of various logic gates	1
5	To simulate and analyse various combinational circuits	2
6	To simulate and verify the truth tables of various flip-flops	2
7	To familiarise with microprocessor and microcontroller kits	2
8	Write a MATLAB program for the generation of standard signals	1
9	To implement amplitude modulation and demodulation by using MATLAB	1

Course Outcomes: By the end of this course, the students will be able to	
1	Express the understanding of semiconductor devices (p-n Diode, BJT, MOSFET etc), and their applications.
2	Demonstrate the functional operation of various analog and digital electronic circuits.
3	Solve basic electronic circuits using circuit laws.
4	Describe various signals, systems and fundamentals of communication systems.

5	Describe the basic principle and working of fundamental electrical systems, ac dc motors and transformer etc.
6	Explain the fundamentals of microprocessors and microcontrollers.

Suggested Books:		
S. No.	**Name of Book/ Authors/ Publishers**	**Year of Publication/ Reprint**
1	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky (PHI)	2009
2	Circuits and Networks: Analysis and Synthesis, Sudhakar and Shyam Mohan, TMH	2009
3	Electronic Communication Systems by G. Kennedy, Mc Graw Hill, 4th Edition	2008
4	Digital Principles and Applications, 7th Edition, A. Malvino and D. Leach	2011
5	Alexander, Charles K., and Sadiku, Matthew N. O., Fundamentals of Electric Circuits, 5th Ed, McGraw Hill	2013
6	A course in Electrical and Electronic Measurements and Instrumentation, A K. Sawhney, 18th Edition, Dhanpat Rai & Sons	2001
7	Microprocessors and Microcontrollers Architecture, Programming and Interfacing Using 8085, 8086 and 8051, Soumitra Mandal, Tata McGraw-Hill	2017

Course Name	**:**	**Introduction to Product Design**
Course Code	**:**	**ES -2307**
Credits	**:**	**2**
LTP	**:**	**0-0-4**

Course Objectives:
To demonstrate the concepts Product Design and Development skills through: Additive Manufacturing, Reverse Engineering, CNC machining, Laser engraving and Robotic

Course Outcomes:	
1	Apply the fundamental concepts and principles of reverse engineering in product design and development.
2	Understand the processand applications of Additive Manufacturing for Product development
3	Understand the concepts and applications of CNC machines&Robot and its interface.

Practical's **Total: 56 hours**

Sr. No.	Name	No of turns
1	Prepare a CAD model of given Product using NX Software	4X2
2	Reverse Engineering (3D Scanning, Repair and measurement) of given product for development of CAD model	4X2
3	Converting CT/MRI scan data using MIMICS Software to Develop the CAD model	4X1
4	Tessellation of various CAD models into STL file and Simulation of process parameters using software and its validation	4X1
5	Fabrication of CAD model using polymers based 3D Printer for Product development	4X1
6	To study various CNC machine codes and addresses and write a programme for a given profile	4X1
7	To execute the part program on CNC trainer kit followed by product fabrication on CNC machine tool	4X1
8	Demonstrate the various components of industrial robots andprogramming the Robot for pick and place application	4X1
9	To design a circuit using the PLC concept for automated devices	4X1
10	To sketching given design using CorelDRAW and fabricate the product using Laser engraving	4X1
11	To measure the surface integrity of given Product using advance measurement techniques	4X2

Course Name	**:**	**Introduction to Environmental Sciences**
Course Code	**:**	**GS 2301 (Common to all branches)**
Credits	**:**	**1**
L T P	**:**	**1 0 0**

Course Objectives:
This course aims to (i) acquaint the students with the basics of Environmental Science (ii) make them aware of the importance of Environmental Science

Total No. of Lectures – 14

Lecture-wise breakup		**No. of Lectures**
Unit 1	Multi-disciplinary Nature of Environmental Studies; Environmental Problems and their Causes, Concept of Sustainability; Sustainable Development, Sustainable Development Goals (SDG).	2
Unit 2	Types of Ecosystems - System Dynamics - Understanding Ecosystems, Ecosystem Degradation, Ecosystem Delivery, Habitat Classification.	2
Unit 3	Natural Resources and Associated Problems, Non Renewable Resources, Renewable Resources, Resource Utilization.	2
Unit 4	Energy and Environment – Fossil Fuel, Geothermal, Tidal, Nuclear, Solar, Wind, Hydropower and Biomass.	2
Unit 5	Environmental Pollution – Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear Hazards ; Global Environmental Issues ; Solutions to Pollution Problems.	2
Unit 6	Cleaner Production and Life Cycle Analysis - LCA Methodology, Steps and Tools; EIA and Environment Audit.	2
Unit 7	Environment, Development and Society- Emerging Technologies for Sustainable Development and Environmental Management; Policies and Practices, Legislation; Disaster Management.	2

Course Outcomes (COs): At the end of the course, the students will be able to:	
1	Relate the importance of environmental science for sustainable development of society.
2	Apply the principles of environmental science and the concept of sustainable development in real life engineering problems.

Test Books		**Year of Publication/ Reprint**
S.No.	**Name of Book**	
1	"Environmental Science", Miller G.T. and Spool, Ceonage Learning Publications.	2021
2	"Environmental Studies", Banny Joseph, Tata Mcgraw Hill Publication.	2021
3	"Text book of Environmental Studies for U.G. Courses", Erach Bharucna , University Press.	2021
4	"Environmental Studies – from criteria to cure", R. Raogopalan, Oxford Univ. Press.	2022
5	"Principles of Environmental Science – Inquiry and applications", Mary Ann Cunningham, William P. Cunningham, TMH Edition.	2020

Course Name	**Universal Human Values**
Couse Code	**GS2302**
Credits	**1**
L T P	**1-0-0**

Objectives:
The course has the following objectives- CO1-To equip students with foundation in ethical decision-making, teamwork, and social responsibility. CO2-To emphasize the integration of technical skills with ethical principles to prepare students for responsible and ethical professional practices. CO3-To shape students into well-rounded individuals with strong ethical foundation that guides their actions, decision and interactions with world around them.

Total Number of Lectures: 14

Lecture wise Breakup	**Number of Lectures**
Course Introduction: Need, Basic Guidelines, Content & Process for Value Education Understanding ethics, morals, and values Ethical theories and their application in engineering and technology	2
Ethical Decision-Making Steps in ethical decision-making Identifying and analysing ethical dilemmas in real-world scenarios	3
Teamwork and Collaboration Characteristics of effective teams Conflict resolution and managing differences Collaboration tools and techniques for virtual teams	3
Social Responsibility and Sustainability Role of engineers in promoting social good Environmental ethics and sustainable development Corporate social responsibility and ethical considerations in technology choices	3
Ethical analysis of Technological Innovations Engineering Ethics Balancing short-term gains with long-term consequences	3

Course Outcomes:
Some of the key outcomes that students can expect after completing this course: CO1-Increased awareness of ethical issues in both personal and professional contexts. CO2-Encourages critical thinking skills, allowing students to analyse complex situations from multiple angles and evaluate the ethical implications of different actions. CO3-Promotes an understanding of diverse cultures, beliefs, and backgrounds, fostering an inclusive mindset. CO4-Engage in self-reflection and introspection, leading to personal growth and a better understanding of their own values, strengths, and areas for improvement.

Suggested Books:

S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publication/ Reprint***
1	"Engineering Ethics" (Includes Human Values), Govindarajan M, Pearson Education Inc.	2017
2	"Professional Ethics and Human Values", Govindarajan M, Learning India Private Limited.	2020
3	"Professional Ethics and Human Values (JNTU-Kakinada)", B Raghavan, McGraw Hill.	2021
4	"The Moral Status of Technical Artefacts (Philosophy of Engineering and Technology)", Peter Kroes and Peter-Paul Verbeek	2020
5	"Ethics and Professionalism in Engineering (Broadview Guides to Business and Professional Ethics)" by Richard H McCuen and Kristin L Gilroy., Pubs: W.W. Norton & Company.	2020
6	"Engineering Ethics: Challenges and Opportunities" by W Richard Bowen, Cengage Learning	2019

Additional Reading-

S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publication/ Reprint***
1	A Casebook in Interprofessional Ethics: A Succinct Introduction to Ethics for the Health Professions (SpringerBriefs in Ethics)", Jeffrey P Spike and Rebecca Lunstroth,2 Pearson Education Inc	2020
2	"Fundamentals of Ethics for Scientists and Engineers", Edmund G Seebauer and Robert L Barry,2020, Pearson Education Inc. .	2020

SYLLABUS

Course Name	**:**	**Communication Skills**
Course Code	**:**	**HS2351**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives
The objective of the course content is: CO1: To explain different aspects of communication process and enable the students to develop a strong theoretical base to handle various real-life communication tasks. CO2: To provide opportunities to the students to acquire and practice their LSRW skills in English for effective communication in professional life. CO3: To enable the students to articulate their ideas and perspectives using appropriate communication strategies and tools. CO4: To develop critical thinking and creative writing skills among the students and equip them with necessary analytical tools to achieve success in personal and professional domains.

Total No. of Lectures – 28

Lecture-wise Breakup		**No. of Lectures**
1	**Introduction to Communication** Concept, Process, Modes – verbal (oral and written) and non-verbal (kinesics, proxemics, chronemics), Types (formal, semi-formal, and informal), Channels (downward, upward, horizontal, diagonal), and Levels (extrapersonal, interpersonal, intrapersonal, organizational, and mass) of Communication, Barriers to Effective Communication with Solutions, Significance and Tools of Effective Communication.	**(4)**
2	**Developing Effective Listening and Speaking Skills** Hearing versus Listening, Listening Process (hearing, understanding, remembering, evaluating and responding), Note-taking, Barriers to Listening, and Strategies for Effective Listening. Tools and Techniques (linguisticand paralinguistic) of Effective Speaking at Various Levels (interpersonal, group, organization and society), Art of Conversation, Dialogue, Discussion, Public Speaking, Presentation, Negotiation, and Persuasion.	**(7)**
3	**Developing Reading and Technical Writing Skills** Concept, Strategies and Techniques (skimming, scanning, inferring, close reading) for Effective Reading and Comprehension, Understanding and Summarizing the Gist. Tips for Effective Technical Writing**,** Formal Letter Writing, Notice, E-mail Writing, Precis Writing, Statement of Purpose, and IMRD-Based Report.	**(8)**

4	**Critical and Creative Thinking Skills** Descriptive, Referential, Inferential, Discursive, Analytical, Evaluative, Creative and Lateral Using Texts and Various Media Forms like Books, Newspaper Articles, Films, and Social Visuals.	**(4)**
5	**Job Preparation** Sensitization to Building Portfolio, Job/Cover Letter and Resume, Interview Skills	**(3)**
6	**Digital Media for Effective Communication** Introduction, Current Trends in e-learning, Online Meetings, Digital Media Tools and Apps for Enhancing Communication Skills	**(2)**

Total No. of Practical Sessions: 14

Practical Session Wise Breakup		**No. of Practical Sessions**
1	**Organizational Communication** Verbal, Vocal and Non-Verbal Communication in Practice, Greetings and Self-Introduction, Speech, and JAM.	**(2)**
2	**Speaking Techniques at Different Forums** Group Discussion, Role-play, Making and Presenting Power Point Presentations.	**(3)**
3	**Practice on Reading and Technical Writing** Reading Comprehension, Formal Letter Writing, Précis Writing, Notice, Email Writing, Report Writing, and Statement of Purpose	**(3)**
4	**Applying Critical Thinking Skills** Book Review, Film Review, Social Visuals -Interpretation and Critical Analysis.	**(3)**
5	**Towards Job Preparation** Sensitization to Building Portfolio, Job/Cover Letter, Resume, Interview	**(2)**
6	**Use of Digital Media for Effective Communication** Training the students to use digital tools	**(1)**

OBJECTIVES OF THE COURSE

The objective of the course content is:

CO1: To explain different aspects of communication process and enable the students to develop a strong theoretical base to handle various real-life communication tasks.

CO2: To provide opportunities to the students to acquire and practice their LSRW skills in English for effective communication in professional life.

CO3: To enable the students to articulate their ideas and perspectives using appropriate communication strategies and tools.

CO4: To develop critical thinking and creative writing skills among the students and equip them with necessary analytical tools to achieve success in personal and professional domains.

OUTCOMES OF THE COURSE

By the end of this course, the students will be able to:

1. Understand the basic concepts of effective communication and learn the importance of communication skills for professional purposes.
2. Apply the four skills of language effectively by using latest learning strategies and digital tools to create and produce original pieces of technical writing and speech.
3. Analyse and evaluate critically what they listen, read and write to respond appropriately in different contexts of their personal and professional life.

Course Name	**:**	**CALCULUS**
Course Code	**:**	**MA2301**
Credits	**:**	**4**
L T P	**:**	**3-0-2**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	Understand the behavior of infinite series and their use.
2	Learn the concepts related to differential calculus of functions of several variables and their applications.
3	Learn the concept and methods of evaluating multiple integrals and their applications to various problems.

	Lecture wise breakup	**No. of Lectures**
1	**INFINITE SERIES** Limits of sequences of numbers, Theorems of calculating limits of sequences, Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1 – 8.9 of Text Book 1).	12
2	**DIFFERENTIAL CALCULUS** Functions of several variables, Limits and continuity, Partial Derivatives, Euler's Theorem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula**.** **(**Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Text Book 1).	14
3	**INTEGRAL CALCULUS** Parametrization of plane curves, Polar coordinates, Graphing in Polar coordinates, Cylinders and Quadric surfaces, Double integrals in Rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical Coordinates, Substitutions in Multiple integrals. Applications to practical problems. (Scope as in Chapter 9, Sections 9.4, 9.6 and 9.7 ,Chapter10, Sections10.6 and 10.7 and Chapter 13, Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Text Book 1).	16

Course Outcomes:
At the end of the semester, the students are able to

1	Test the behavior of infinite series.
2	Apply the concepts of differential calculus of functions of several variables.
3	Evaluate multiple integrals and apply them to practical problems.

Text Books:

1	Calculus and Analytic Geometry, Thomas and Finney, 9th edition, Pearson Education Asia.	2006

Reference Books:

1	Advanced Engineering Mathematics, Wylie and Barrett, 6th edition, Mc Graw Hill.	2003

Practical / Lab work to be performed using Mathematica/ Matlab

1. Study the convergence of sequences through plotting.
2. Analyze the convergence of infinite series by plotting their sequences of partial sums.
3. Study the convergence of infinite series using Cauchy's root test and Ratio test
4. Taylor and Maclaurin series of trigonometric, logarithmic, hyperbolic functions.
5. Plotting 2D curves in rectangular and polar coordinates.
6. Plotting 3D surfaces.
7. Find critical points and identify local maxima, local minima or saddle points
8. Draw the surfaces and analyze the existence of limits as they approach the specified points.
9. Check the continuity of functions
10. Draw the surfaces and find level curves at the given heights

Course Name	**:**	**LINEAR ALGEBRA, DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS**
Course Code	**:**	**MA2302**
Credits	**:**	**4**
L T P	**:**	**3-0-2**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	Learn the various concepts associated with real vector spaces and theory of matrices
2	Learn the methods to solve ordinary differential equations of various types.
3	Learn the various concepts of vector calculus and their applications to problems.

	Lecture wise breakup	**No. of Lectures**
1	**ALGEBRA** Vector spaces over reals, Linear dependence, Basis, Dimension, Co-ordinates with respect to a basis, Change of basis, Subspace, Linear transformation $R^n \rightarrow R^m$, Range space and Rank, Null space and Nullity, Rank and Nullity relation, Matrix representation of a linear transformation, Similar matrices, Invertible linear transformation, Eigenvalues and eigenvectors, Cayley Hamilton theorem, Diagonalization of a matrix.	16
2	**ORDINARY DIFFERENTIAL EQUATIONS** First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian. .	12
3	**VECTOR CALCULUS** Gradient, Divergence and Curl – their physical interpretation, Line, Surface and Volume integrals, Green's theorem in the plane, Stoke's theorem, Divergence theorem, Applications to Science and Engineering.	14

Course Outcomes:
At the end of the semester, the students are able to

1	Solve the various problems related to real vector spaces and theory of matrices
2	Solve ordinary differential equations of various types
3	Apply various concepts of vector calculus to problems.

Text Books:

1	Introductory Linear Algebra with Applications, Kolman, B. and Hill,D.R., 7th edition, Pearson Education	2001
2	Advanced Engineering Mathematics, Kreyszig, 8th edition, John Wiley and Sons.	2005

Reference Books:

1	Differential Equations, S. L. Ross, John Wiley and Sons, India	2004
2	Advanced Engineering Mathematics, Wylie and Barrett, 6th edition, Mc Graw Hill.	2003
3	Differential Equations, Frank Ayers, SI edition, Mc Graw Hill.	1972

Practical / Lab work to be performed using Mathematica/ Matlab

1. Perform basic Matrix operations.
2. Find rank, eigenvalues and eigenspace of matrices.
3. Check diagonalizability of matrices.
4. Solve ordinary differential equation.
5. Plotting of second order solution family of differential equation.
6. Plotting of third order solution family of differential equation.
7. Plotting of vector fields.
8. Find Gradient, Divergence and Curl.
9. Computation of line integrals and surface integrals.
10. Verify Green's theorem in the plane, Stoke's theorem, Divergence theorem.

Course Name	**:**	**Electromagnetic Theory and Quantum Physics**
Course Code	**:**	**PY2301**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

1. To familiarize the students with the concepts of electrostatics and boundary value problems.
2. To make the students able to understand the magnetostatics and their boundary value problems.
3. To make the students able to understand and apply the concepts of electromagnetic wave propagation.
4. To familiarize the students with the concepts and principles of Quantum Mechanics.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**VECTORS, FIELDS AND ELECTROSTATICS:** Cartesian coordinate System, Cylindrical and Spherical coordinate Systems, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stoke's theorem, Gauss's law & its applications, Maxwell's 1st eqn. (Electrostatics), Electric Energy and potential, Potential gradient, the dipole fields, Energy density in an electrostatic field. Current and current density, Continuity of current, Metallic conductors, Dielectric materials, Electrostatic boundary-value problems, Introduction to Laplace's and Poisson's equations.	12
2	**MAGNETOSTATICS:** Biot-Savart's law, Ampere's circuital law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials. Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, magnetic materials, Magnetic boundary conditions, Inductors and inductances.	10
3	**MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVE PROPAGATION:** Faraday's law, Displacement current, Maxwell's equations in point form, Maxwell's equations in integral form, EM waves in general, EM wave propagation in Lossy Dielectrics, Wave propagation in lossless dielectrics, Plane waves in free space, Plane waves in Good conductors, Power & Poynting Vector, Reflection of a plane wave at normal incidence.	10
4	**QUANTUM PHYSICS:** Need of Quantum theory, Photoelectric effect, The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, applications of Schrödinger wave equation for particle in one dimensional infinite potential well. Introduction to nanoscience, Quantum materials, and Superconductivity.	10

List of Experiments:		**Number of Turns**
1	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO3.	1
2	To determine coercivity of magnetic material using hysteresis loop tracer.	1
3	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
4	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
5	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials.	1
6	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1
7	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1

8	To plot I-V Characteristics of Solar cell.	1

Course Outcomes: By the end of the course	
1	Students will be equipped with the tools of electromagnetic theory.
2	Students will be able to solve numerical problems based on electrostatics, magnetostatics, electromagnetic wave propagation.
3	Students will be able to understand and apply the basic concepts of Quantum Mechanics.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Electromagnetics, William H Hyat, Jr., and John A. Buck, Tata McGraw Hill	2013 / 5th edition
2	Elements of Engineering Electromagnetics, Matthew N.O. Sadiku, Oxford University Press	2012 / 4th edition
3	Concepts of Modern Physics, Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013
4	Modern Physics, J. Bernstein, P.M. Fishbane and S.G. Gasiorowicz, Pearson, Education India Pvt. Ltd., New Delhi	2009

Course Name	**:**	**Mechanics and Optics**
Course Code	**:**	**PY2302**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
1. To inculcate the application of Mechanics concepts in engineering
2. To familiarize students with Statics, Kinematics, and Kinetics of rigid body.
3. To familiarize the students with Ultrasonics and their applications.
4. To familiarize students the basic concepts of LASER and Nanotechnology for possible industrial applications.

Total No. of Lectures – 42

	Lecture wise breakup	**Number of Lectures**
1	**STATICS AND DYNAMICS:**Analysis of system of forces, Equation of equilibrium in space and its applications, Center of gravity, Centroid, mass, area and Polar moment of inertia of simple and compound bodies. Kinematics of a Particle: Introduction, Motion of a projectile, Kinetics of a particle: Force and acceleration, Work and energy, Impulse and momentum.	10
2	**PLANAR KINEMATICS AND KINETICS OF A RIGID BODY:** Rigid-body motion, Translation, Rotation about a fixed axis, Absolute general Plane Motion analysis. Relative-Motion Analysis: Velocity, Instantaneous center of zero velocity, Acceleration. Moment of Inertia, Planar Kinetic equations of motion, Equations of motion: Translation, Rotation about a fixed axis and General Plane motion, Kinetic Energy, Work of a Force, Work of a Couple, Principle of Work and Energy, Conservation of Energy, Linear and Angular Momentum, Principle of Impulse and Momentum, Conservation of Momentum, Eccentric Impact.	12
3	**LASERS, OPTICAL FIBRES AND ULTRASONICS:** Basics of Interference, Diffraction and Polarization, Michelson–Morley Interferometer, Raman effect, Laser and its characteristics, He-Ne laser, Ruby laser, Semiconductor lasers, Ultra-fast lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibres. Production of ultrasonics, detection and uses of ultrasonics, reverberation.	12
4	**NANOTECHNOLOGY:** Introduction, Length Scale, Size Dependence, Synthesis of Nanoparticles: Mechanical Method, Sol-gel Technique, Physical Vapour Deposition, Chemical Vapour Deposition, Overview of Carbon-based nanostructures, X-ray Diffraction for nano-materials analysis, Applications of Nanotechnology, Introduction to Quantum Materials and Superconductors.	8

	List of Experiments	**No.of Turns**
1.	Familiarization of students with basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2.	(i)To determine the wavelength of He-Ne laser using transmissiongrating. (ii) To determine the slit width using the diffraction pattern.	1
3.	To find the specific rotation of sugar solution using a Bi-quartz Polarimeter.	
4.	To determine the acceleration of gravity using Kater's pendulum	1
5.	To determine the Moment of Inertia of a Flywheel.	1
6.	To determine the range of the projectile as a function of angle ofinclination and initial velocity.	1
7.	To determine the velocity of ultrasonic waves in a given liquid.	1
8.	To measure the centripetal force, F_c, and compare to $F_c = mv^2/r = m\omega^2 r$.	1

Course Outcomes:	
1	Students will be able to understand and implement the concepts of Mechanics, types of motions and characteristics of rigid body.
2	Students will learn about lasers and fibre optics which have important applications for societal needs.
3	Students are expected to develop capability to tackle problems in general and in the various areas covered in the course.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher/Edition**
1	Statics, R.C. Hibbeler, Pearson (11th Edition).
	Dynamics, R.C. Hibbeler, Pearson (11th Edition).
2	Dynamics, F.P. Beer et al.,McGraw Hill (8th Edition).
3	Dynamics, Merriam and Kraige, Wiley and Sons (5th Edition).
4	Engineering Mechanics, G. Ramamurthy, R. S. Walia and Rajesh Kumar,I K International (3rd Edition).
5	Optics, AjoyGhatak, McGraw-Hill (3rd Edition).
6	Physics for Engineers, N.K. Verma, Prentice Hall India (3rdEdition).
7	Engineering Physics, Satya Prakash, PragatiPrakashan (9th Edition)

Course Name	**:**	**CONDENSED MATTER PHYSICS**
Course Code	**:**	**PY2303**
Credits	**:**	**4**
L T P	**:**	**3 - 2/2**

Total No. of Lectures – 42

Course Objectives:	
1.	To familiarize the students with basic concepts of the condensed phase of matter especially solids.
2.	To make the students able to understand the crystal structure, lattice vibrations, electronic properties, dielectric and the magnetic properties etc. in relation to engineering applications.
3.	To make the students able to understand the basics concepts of semiconductors, superconductivity, and their applications in various fields.
4.	To familiarize students the basic concepts of LASER and Nanotechnology for possible industrial applications.

Lecture wise breakup	**No. of Lectures**

1	**Crystal structure and Band Theory of Solids: -**Space lattices crystal structures (cubic and hexagonal cells), close packed morphology (Hexagonal and cubic close packing), single and polycrystalline structures, crystal Structure analysis, X-ray diffraction and Bragg's law, Classical and Quantum Theory of free electrons, Fermi-Dirac Distribution Function, Density of States, Motion of electrons in magnetic field (Hall effect), Energy bands in solids. Introduction of Phonons, Vibrations of one dimensional monoatomic and diatomic lattices, Momentum of Phonons. Electron in a Periodic Potential (Qualitative idea of Kronig Penney Model), Energy versus wave vector,	(14)
2	**Dielectric and Magnetic Materials:** Fundamental of dielectrics, active and passive dielectrics, various polarization mechanisms, Frequency and temperature dependence on polarization of dielectrics, Internal field, Dielectric Loss Tangent, Dielectric Breakdown. Review of basic formulas, magnetic susceptibility, classification of materials, anti-ferromagnetism and ferrimagnetism, ferromagnetism in metals, ferromagnetic domains, hysteresis,antiferromagnetism.	(7)
3	**Semiconductors and Superconductivity:** Introduction, Pure or Intrinsic Semiconductors, impurity or Extrinsic semiconductors, Drift velocity, mobility and Conductivity of Intrisic Semiconductors, carrier concentration and Fermi level for Intrinsic and Extrinsic Semiconductors, Applications: P-N Junction diode, Zener diode and Tunnel diode.Introduction to superconductivity, Mechanism of superconductivity, Meissner Effect, Effect of current and magnetic field, Type1 and Type II superconductors, Thermal properties, Isotope effect, London Equations, Qualitative idea of BCS theory, Applications of superconductivity.	(14)
4	**Nanotechnology:** Introduction, Length Scale, Size Dependence, Synthesis of Nanoparticles: Mechanical Method, Sol-gel Technique, Physical Vapour Deposition, Chemical Vapour Deposition, Overview of Carbon-based nanostructures, X-ray Diffraction for nano-materials analysis, Applications of Nanotechnology, Introduction to Quantum Materials.	(7)

S.No	**List of Experiments**	**No. of**

		turns
1.	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO3.	1
2.	To determine coercivity of magnetic material using hysteresis loop tracer.	1
3.	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
4.	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
5.	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials.	1
6.	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1
7.	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1

Course Outcomes: By the end of the course	
1	Students will be able to understand the physics behind structural properties of the solids.
2	Students will be aware of latest developments in certain areas of condensed matter physics, which have important applications for societal needs.
3	Students are expected to develop capability to tackle problems in general and in various areas covered in the course.

Suggested Books:	
Sr. No	**Name of Book/ Authors/ Publisher**
1.	Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd., New Delhi (8^{th} Edition)
2.	Solid State Physics, S.O. Pillai, New Age International, Pvt. Ltd., New Delhi (5^{th} Edition)
3.	Solid State Physics, M. A. Wahab, Narosa Publishing House, Pvt. Ltd. New Delhi (3^{rd} Edition).
4.	Solid State Physics R.K. Puri, V.K.Babbar, S. Chand & Company, Pvt. Ltd. New Delhi (3^{rd} Edition).

CourseName	**:**	**NetworksandSystems**
CourseCode	**:**	**EEN3001**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to:

- Impart the knowledge of fundamentals of networks.
- Acquire the knowledge of fundamentals of networks analysis and synthesis.
- Apply the concept of two-port network and multi-port network.
- Design different types of filters.

TotalNo.ofLectures-42

LectureWiseBreakup		**NumberofLectures**
Unit 1	**Methods of Network Analysis** Review of Sinusoids, phasors, impedance and admittance, AC steady state analysis, AC power analysis. nodal and mesh analysis, dependent, independent voltage and current sources, source transformation, magnetically coupled networks, Thevenin and Norton equivalent. Network theorems: compensation, superposition, reciprocity, Millman's and Tellegen's theorem.Threephasecircuits:typesofloadandsourceconnections,powerin balanced three phase circuits, star delta transformations.	10
Unit 2	**TransientNetworkAnalysis** Continuous time and discrete time signals, systems and their properties: causality, stability, time invariance, linearity, invertibility, stability. complex frequency and laplace transforms, network analysisinsdomain,poles,zeros,transferfunctionsanddrivingpointimpedance sandconvolution. Step and impulse response, transient response of RL, RC, LC, RLC circuits for dc and ac excitation,initialandfinalconditions,Fourieranalysisofcircuitswithnon-sinusoidalperiodicexcitation.	12
Unit 3	**TwoPortNetworks** Impedanceparameters,admittanceparameters,hybridandtransmissionparameters,seriesparallel andtandemconnectionoftwoportnetworks	06
Unit 4	**NetworkSynthesis** Elements of realizability theory: causality and stability, Hurwitz polynomials, positive real functions, elementarysynthesis procedure, synthesis ofone port network withtwo kind ofelement: L-C driving point immitances, synthesis of R-L-C functions. Synthesis of transfer functions: propertiesoftransferfunctions,zerosoftransmission,synthesisofY21andZ21witha1-Ω termination,synthesisofconstantresistancenetworks.	10
Unit 5	**Filters** Series and parallel resonance, single and double tuned circuits. Bode Plots. Passive filters design with bode plots: low pass, high pass, band pass, band stop and notch filters, difference between actual and ideal frequency response.	04

ListofExperiments		**Numberof Turns**
1	ToverifysuperpositiontheoremandNorton'stheorems.	01
2	ToverifyThevenin'stheoremandmaximumpowertransfertheorems	01
3	TodeterminetransientresponseofcurrentinRLandRCcircuitswithstepvoltageinput.	01
4	Determination and simulation oftransientresponseofcurrentinRLCcircuitwithstepvoltageinputforunder damped,criticallydampedandoverdampedcases.	02
5	Tostudyresonanceinseries and parallel RLCcircuit.	01
6	Toverifythe line voltage andphase voltage, and line currentand phase current relationship ina star anddeltathreephasebalanced circuit.	01
7	Tofindvarioustwoportnetworkparameters(opencircuit,shortcircuit,transmissionand hybrid).	01
8	To determine real, reactive and apparent power in an AC circuit along with power factor	01
9	To design low pass, high pass filter, band-pass filter, band reject filter and notch filter of desired frequency response using bode plots and verify the design in MATLAB	01

Course Outcomes: By the end this course the students will be able to	
CO1	Acquireknowledgeofthefundamentals ofnetworkanalysis using matrices,two-portandmulti-port networks,networksynthesisandfiltercircuits
CO2	AnalyzeDCandAC(singleandthreephase)circuitsmakinguseofvariouscircuittechniques.
CO3	Analyzemagnetically coupled circuits.
CO4	Analyzevarioustypesoftwoportnetworksandtheirinterconnection.
CO5	Designandconductexperiments,aswellasanalyzeandinterpretdata.

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	MEVanValkenburg,"NetworkAnalysis",Pearsoneducation,3rd revisededition.	2019
2	CKAlexander&MatthewNOSadiku,"FundamentalsofElectricCircuits",McGrawHill,2nd edition.	2003

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	WHHayt,JEKemmerly&SMDurbin,"EngineeringCircuitAnalysis",TataMcGrawHill Education,6thedition.	2005
2	FFKuo,"NetworkAnalysis&Synthesis",WileyIndiaPrivateLimited;2ndedition.	2006

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Circuit Theory by Prof S.C. Dutta Roy (IIT Delhi) https://nptel.ac.in/courses/108102042	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	-	-	-	2	2	1	2	2	2	-
CO2	2	2	1	1	1	-	-	-	2	2	1	2	2	2	-
CO3	2	2	1	1	1	-	-	-	2	2	1	2	2	2	-
CO4	3	2	2	1	1	-	-	-	2	2	1	2	2	2	-
CO5	2	2	2	1	1	-	-	-	2	2	1	2	2	2	-

CourseName	**:**	**MeasurementandInstrumentation**
CourseCode	**:**	**EEN3002**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeableto

- Impart knowledge to make students understand types and selection of various measuring instruments.
- Understand the performance and calibration of various measuring instruments.
- Understand the concept of transducers, their classification and their applications for the measurement of physical quantities.
- Study various analog and digital recording and display devices use in measurement.

TotalNo.ofLecture -42

LectureWiseBreakup		**Number ofLecture**
Unit 1	**Introduction** Functionalelementsofaninstrument,staticanddynamiccharacteristics,errorsin measurement,statisticalevaluationofmeasurementdata,standardandcalibratio n.Measurementoferror,accuracy andprecision,significantfigures,typesoferror,statisticalanalysisofdata,probabi lityoferrors,limitingerrors.	04
Unit 2	**AnalogInstruments** Electromechanical instruments – moving coil, moving iron, electrostatic instruments, current, voltageand power measurements, induction type energy meter, frequency meter, power factor meter, megger,magneticmeasurements, instrumenttransformers.	10
Unit 3	**BridgeMeasurements** Wheatstonebridge,Kelvinbridge,ACbridgesandtheirapplicationforthemeasur ementofself-inductanceandmutualinductance,Wagnergroundconnection,measurementofc apacitance, measurementoflowandhighresistance.	07
Unit 4	**AnalogElectronicMeasurement** Analogelectronicvoltmeters,tunedandsamplingvoltmeters,analogelectronicw attmeterandenergymeter.	05
Unit 5	**SignalGeneratorsandAnalyzers** Introductiontosignalgenerators,characteristicsofsignalgenerators,multi-vibrators,CRO,harmonicdistortionandspectrumanalyzer	03
Unit 6	**DigitalElectronicMeasurement** Digitalcounter-timerandfrequencymeter,timestandards,digitalvoltmeterandMultimeter, accuracyand resolutionconsiderations,comparisonwithanalogelectronicinstruments.	05
Unit 7	**SensorsandTransducers & Introduction to SCADA** Classificationoftransducers,selectionoftransducers:resistive,capacitiveandin ductive,piezoelectrictransducers,opticalanddigitaltransducers,transducersfor measurementofdisplacement, temperature,level,flows,pressure,velocityandacceleration, introduction to SCADA.	08

ListofExperiments:		**NumberofTurns**
1	TocalibrateDCvoltmeterbydirectreadingofDCpotentiometer	01
2	Tomeasureactiveandreactivepower inasinglephasecircuitbyonewattmetermethod	01
3	Tomeasureactiveandreactivepowerinathreephasecircuitbytwowattmetermethod	01
4	Tomeasure power and power factor by two wattmeter method incorporating instrument Transformers	01
5	Tocalibrateasinglephaseenergymeterwiththehelpofawattmeter	01
6	Tomeasure voltage,currentand impedancebyoscilloscope	01
7	TomeasurefrequencyandphasedifferenceofasinusoidalACvoltage usingCRO	01
8	Tostudyastraingauge and plotitsresponsetoanapplicationusingWheatstonebridge	01
9	Toplotthecharacteristicsofathermistorandcalibrateitfortemperaturemeasurement	01
10	Tomeasureinsulationresistanceusingmegger	01
11	TomeasuresensitivityofWheatstonebridgeinhalfbridgeandfullbridgemodeusingstrain Gauge	01
12	ToplotI/Ocharacteristicsofvariousinductive,capacitiveandopticaltransducers	03

CourseOutcomes: By the end this course the students will be able to	
CO1	Understand the construction and operating principles of electrical instrumentswith their static and dynamic characteristics and error in measurements for engineering application.
CO2	Applyknowledgeofmeasuringinstrumentstootherareasofengineering applications.
CO3	Designandconductexperiments,as wellastoanalyzeandinterpretdata.
CO4	Design of electrical instruments for engineering applications.

Text Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	MeasurementSystems– ApplicationandDesignbyE.O.Doebelin,McGrawHillPublishing Company, 13th edition	2004
2	PrincipleofMeasurementandInstrumentationbyA.S.Mooris,PrenticeHallofIndia, 3rd Edition	2001
3	Instrumentation for EngineeringMeasurementbyDalley,J.W., Riley, W.F. and Meconnel,K.G.,JohnWiley&Sons, 3rd Edition	1999

Reference Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	AcourseinElectricalandElectronicsMeasurementsandInstrumentsbyA.K.Sawhney, DhanpatRai &Co.(Pvt.)Ltd., 9th Edition	2015
2	ModernElectronicInstrumentationandMeasurementTechniquesbyA.D.HelfrickandW.D. Cooper, 3rd Edition	2022
3	Mechatronics by Tilak Thakur, Oxford University Press, revised 1st Edition	2023
4	Electrical Measurements and Measuring Instruments by E.W Golding and F.C. Widdis, 6th Edition	2019

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Measurement and Instrument/A Chaterjee, IIT Kharagpur, NPTEL :: Electrical Engineering - NOC:Electrical Measurement and Electronic Instruments	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	-	1	1	-	2	3	2	2	1	2	1
CO2	1	2	2	1	-	1	1	-	2	3	2	2	1	2	1
CO3	2	2	1	1	-	1	1	-	2	2	2	2	2	2	1
CO4	2	2	1	1	-	1	1	-	2	2	2	2	2	2	1

Course Name	**:**	**Electrical Machines – I**
Course Code	**:**	**EEN3003**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Studentsshouldbeableto:

- Understand the fundamental laws that govern the operation of machines
- Explore the constructional features and principles of operation of various types of transformers and DC machines.
- Analyze magnetic circuits and evaluate the performance of transformers and DC machines.
- Develop technical skills to understand the principles and applications of various machines.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Magnetic Circuits** Magnetic Circuit properties, Magnetic materials, magnetic circuit calculation, comparison of electric and magnetic circuits, transformer magnetic circuit	3
Unit 2	**Single Phase Transformers** Introduction to transformer types, core, winding, insulation, induced voltage, transformer on open circuit, ideal transformer, dot convention, equivalent circuit of practical transformer, regulation and efficiency from the approximate equivalent circuit. Losses in transformer: calculation of eddy current and hysteresis losses, open circuit and short circuit tests. Parallel operation of single-phase transformers. Autotransformer.	10
Unit 3	**Three Phase Transformers** Two-phase transformations, three-phase transformations, transformer connection for three-phase circuits using three identical transformers, detailed analysis and operational benefits of different types of three-phase transformers: Y-Y, Y-Δ, Δ-Y, Δ-Δ. Open delta and tee-tee connection of transformers, three-phase connection for unbalanced loading.	8
Unit 4	**Principles of DC Machines** Operating principle and construction, armature winding, armature reaction, compensating winding, commutation, EMF and torque equation.	5
Unit 5	**DC Generators** Methods of excitation, different types of DC generators, external characteristics of series, shunt and compound generator, voltage regulation, applications.	8
Unit 6	**DC Motors** Types and operating characteristics of DC motor, different types of DC motors, different methods of starting, speed control and braking of DC motors, efficiency and testing, applications of DC motors, universal motor.	8

List of Experiments:		Number of Turns
1	To study various components of DC machine and plot Open Circuit Characteristics	02
2	To obtain performance characteristics of a D.C. Shunt motor.	01
3	To obtain external characteristics of a D.C. shunt generator	01
4	To obtain external characteristics of a D.C. series generator.	01
5	To obtain external characteristics of DC compound generator.	01
6	Speed control of a dc shunt motor by varying armature circuit and field circuit method	01
7	To perform open and short circuit test on a 1-phase transformer and determine a)equivalent circuit b) efficiency	01
8	To determine efficiency and voltage regulation of single phase transformer by direct loading.	01
9	Parallel Operation of two single-phase transformers.	01
10	Three phase to Two phase transformation using Scott Connection.	01
11	To verify voltage and current relationships for different types of three phase transformer connections.	01
12	To obtain performance characteristics of universal motor.	01

Course Outcomes: By the end this course the students will be able to	
CO1	Understand the concept of magnetic circuits.
CO2	Impart the knowledge of various transformers and DC machines
CO3	Analyze the performance and operating characteristics of DC machines.
CO4	Evaluate the performance of three-phase transformer, auto transformer and parallel operation of transformers.

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Electric Machinery and Transformers by Bhag S Guru &Huseyin R Hiziroglu, Oxford University Press	2000
2	Principles of Electric Machines And Power Electronics by P C Sen, Wiley India	2013
3	Electric Machines by D P Kothari and I. J. Nagrath, Tata McGraw Hill Education Private Limited	2004

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Electrical Machines by P S Bimbhra, Khanna Publishers	2011
2	Electric Machinery by A.E. Fitzgerald, Charles Kingsley, Jr. and Stephen D. Umans, Tata McGraw-Hill	2013
3	Alternating Current Machines by M.G Say, Pitman publishing Ltd	1976
4	Electrical Machines by J. B. Gupta, Katson Books	2018

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Electrical Machines – I by Prof. Tapas Kumar Bhattacharya, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc23_ee114/preview	Swayam
2	Electrical Machines By Prof. G.Bhuvaneshwari | IIT Delhi https://onlinecourses.nptel.ac.in/noc21_ee24/preview	Swayam

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	-	-	-	-	1	1	1	1
CO2	3	2	2	2	1	1	1	-	-	-	-	1	2	2	1
CO3	3	2	2	2	1	1	1	-	-	-	-	1	2	2	1
CO4	3	2	2	1	2	1	2	-	-	-	-	1	2	2	1

CourseName	**:**	**Power System Engineering**
CourseCode	**:**	**EEN3004**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeable to

- Understand the Power generation & economics.
- Understand & visualize the power systems infrastructure.
- Understand the performance of transmission.
- Explore the different types of distribution systems.

TotalNo.ofLectures– 42

Lecturewisebreakup		**NumberofLectures**
Unit 1	**GENERATIONSYSTEMS & ECONOMICS** Principles of hydro, thermal, nuclear and renewable generation. connected load, maximumdemand,demandfactor,diversityfactor,chronologicalloadcurve,loaddurationcurve,masscurve,loadfactor,capacityfactor,plantutilizationfactor;base,peak andstandbystations,selectionofnumberandsizeof units and cost analysis, typesofload, different types of tariffs.	08
Unit 2	**TRANSMISSIONSYSTEMS** Overheadandundergroundtransmission,transmissionvoltages.IntroductiontoHVDCtransmission. Conductor materials, solid stranded, ACSR, hollow and bundle conductors.Different types and supporting structures and towers for over-head transmission lines, mechanical design of line and support. Parameters oftransmissionlines:calculationofresistance,inductanceandcapacitancefordifferent configurationofoverheadtransmissionlines.Coronaanditseffect. Modern trends in Transmission system.	09
Unit 3	**PERFORMANCEANDMODELINGOFTRANSMISSIONLINES** Shorttransmissionlines,voltagedrop,regulationandefficiencycalculations,Mediumtransmissionlines.NormalTandPI,solutionforvoltagedrop,regulationandefficiency. LongTransmissionlines,currentandvoltagerelations,ABCDconstants,chargingcurrentandFerrantieffect. Graphical Methods (Smith chart, circle diagram).	05
Unit 4	**DISTRIBUTIONSYSTEM** Radial, ring main connected distribution systems. Distribution voltage levels, selection of conductorsizefordistributors.Typeandlocationofdistributionsubstations.Mainequipmentindistributionsub-station,supportingstructures.Distribution systemvoltageregulation, voltage and power factor improvement.	05
Unit 5	**INSULATORS** Insulatingmaterials,Types ofinsulators,voltagedistributionoveraninsulatorstring.String-efficiency, Equalizingvoltagedropsacrossinsulatorsofastring. New types of insulators.	04
Unit 6	**CABLES** Insulatingmaterials, Types of LV and HV cables, Three core solid, oil filled	04

	andGaspressurecables,Effectiveconductorresistance,inductivereactanceandcapacitanceofcables,gradingofcables,Sheathanddielectriclossincables,Elementaryideasaboutcable breakdown. EHV/HVDC Cables.	
Unit 7	**EARTHING** Earthing requirement and arrangements,differenttypesof neutralearthing,calculationofneutralvoltage, earthingresistanceof different rods/arrangements, earthingofsubstationequipments	04
Unit 8	**DEGERULATED POWER SYSTEM** Need and importance of restructuring, Components of deregulated power system, difference between integrated and restructured power system, different entities of deregulated power system, advantages and limitation of competitive system.	03

ListofExperiments:		**NumberofTurns**
1	Todesigndistributionnetworkandmeasurementofvoltageandcurrentdistributionin Distributors	1
2	TomeasurePotentialdistributionacrossdifferentunitsofastringofinsulatorswith and withoutguardring.	1
3	Tostudyofdifferentpartsofapowercableandmeasurementofinsulationresistance ofa cable.	1
4	Toplotequi-potentialcurveandvoltagegradientin a) Two/three-corecable b) Single-corecable.	2
5	ToobtainVoltageRegulationofalongtransmissionlinewithresistiveinductivean d capacitiveloads.	1
6	ToobtainVoltageProfileofalongtransmissionlinewhen: a. Opencircuited b. Usingshunt/seriescapacitive compensation c. Usingshuntinductivecompensation.	1
7	Todesigntransmission&distributionnetworkofacityusingsoftware.	1
8	Tomeasurecoretocore&coreto sheathcapacitanceofathreephasecable.	1
9	TosimulateasmallHydroPlantusingsimulationsoftware	2
10	ToplotVoltage/Currentcharacteristicsofasolar celland determinationofitsparameters.	1
11	TostudydifferenttypesofLineinsulatorsandobtainbreakdowncharacteristicsofa nyone typeofinsulator	1

CourseOutcomes: By the end this course the students will be able to	
CO1	Acquirebasicknowledgeof modern power system.
CO2	Modelandanalyzethetransmissionlinesinpowersystem.
CO3	Make selection of insulator and cables under different conditions and calculate performance parameters
CO4	Compare the different distribution system and analyze its performance

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	ElectricalPowerSystemsbyC.L.Wadhwa,NewAgeInternationalLtd	2010
2	ModernPower SystemanalysisbyI.J.Nagrath&D.P.Kothari, TataMcGrawHill	2003

Reference Books:		
Sr. No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	PowerSystemAnalysis&DesignbyB RGupta,SChand&Co	2001
2	ElectricalPowerGeneration, TransmissionanddistributionbySNSingh,PHIPublication	2008
3	Understanding Electric Utilities and De-Regulation by H. Lee Willis , Lorrin Phillip son, CRC Press; 2nd edition	2005

Equivalent MOOCs Courses

Sr. No.	**Course Links**	**Offered by**
1	Electrical Machines By Prof. G.Bhuvaneshwari | IIT Delhi https://nptel.ac.in/courses/108102047	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	-	2	-	1	1	1	1	1	-	1	1	1	1
CO2	2	1	-	2	-	-	1	1	-	-	-	-	1	1	1
CO3	1	1	-	-	-	-	1	-	1	1	-	1	1	1	1
CO4	1	-	-	-	-	1	-	1	-	-	-	1	1	-	-

CourseName	**:**	**AnalogandDigitalElectronics**
CourseCode	**:**	**EEN4001**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeableto:

- Acquiretheknowledgeoftransistors,theirbiasing and modelling of complex devices such as BJT.
- Understand the working principles ofamplifiers,oscillators,andpoweramplifiers.
- Applyvarious techniques in designing and implementation of digital circuits such as converters, counters etc.
- Analyzetheprinciplesofanalogganddigitalconverters.

TotalNo.ofLectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**BiasingandSmallSignalModelsofBJT** Stabilityandbiasing,biasingcircuits,biascompensation,h–parametermodelsoftransistor,transistoranalysis usingh-parameter.	06
Unit 2	**BJTFrequencyResponse** FrequencyResponseofsinglestageCEamplifier,multistageamplifiers,directcoupled,RCcoupled andtransformercoupledamplifiers,frequencyresponseofmultistageamplifiers.	05
Unit 3	**FieldEffectTransistors** FETConstruction andprinciple,typesofFET,characteristicsofFETs, MOSFET:typesandworkingprinciple	03
Unit 4	**PowerAmplifiers** Classificationofamplifiers,singletunedanddoubletunedamplifiers,analysisofclassA,B,Cand ABamplifiers,pushpullamplifier,amplitudedistortioninamplifiers,harmonics,and powerdistortion.	02
Unit 5	**Oscillator** Principleofsinusoidaloscillator,CollpitsandHartley, oscillator,crystaloscillator.	02
Unit 6	**MinimizationTechniques** Sumofproductsandproductsofsumforms,minterms&maxterms,Karnaughmapfortwo,three, fourfiveandsixvariables,quine-McCluskeymethod.	07
Unit 7	**CombinationalCircuitDesign** Halfadder,fulladder,subtractor,BCDadder,comparator,codeconverter,encoder-decoder, multiplexer,demultiplexer,paritydetectorandgenerator.	04
Unit 8	**Multi vibrators** 1-bitmemorycell,clockedandunclockedflipflops,S-RFlipflop,Dflipflop,JKFlipflop,Tflipflop,edgetriggeredflipflop,racearoundcondition,masterslaveflipflop,conversionofflipflops.	05
Unit 9	**Sequential LogicDesign:CountersandRegisters** Ripplecounter,designofMod-Nripplecounter,synchronouscounter,ringcounter,Johnsoncounter,seria	06

	linserialout shiftregister,serialinparalleloutshiftregister,parallelinserialoutshiftregisterandparallelinparalleloutshiftregister, bidirectionalshiftregister,universal shiftregister.	
Unit 10	**A/DandD/AConverters** WeightedresistorD/Aconverter,binaryladderD/Aconverter,A/Dconverters-flashtype, successiveapproximation,counterramptype,dualslopetype,characteristicsofADCandDAC.	02

ListofExperiments		**Numberof Turns**
1	TostudythecharacteristicsofBJTand FET.	02
2	Tosimulateand verifytheoperationofBJTasanamplifierand drawthefrequencyresponse.	02
3	Todesign,simulateandimplementAdderandSubtractorcircuits.	01
4	Todesign,simulateandimplementcodeconverters.	02
5	Todesign,simulateandimplementCombinationalcircuitsusingMultiplexers.	01
6	TosimulateandimplementFlip-flops usingNANDandNORGates.	02
7	Tostudytheoperationofvarioustypesofshiftregisters.	02
8	Todesign,simulateandimplementthe synchronoussequentialcircuits.	02

CourseOutcomes: By the end this course the students will be able to	
CO1	AnalyzetheperformanceofBJT usingsmallsignalanalysis.
CO2	Designof varioustypesofoscillators and amplifiers
CO3	Analyzeanddesigningofsequentialandcombinationalcircuits.
CO4	DesignvarioustypesofA/DandD/Aconverters.

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication /Reprint**
1	"IntegratedElectronics", Millman&Halkias , 2nd edition,TMH.	2017
2	"ElectronicsDevices&CircuitTheory",RLBoylestead&LNashelsky,11th edition,PHI	2016
3	"MicroelectronicCircuits", ASSedra&KCSmith, 8th edition,OXFORD	2020

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication /Reprint**
1	"ElectronicsCircuitAnalysisandDesign", DonaldA.Neamen, 4th edition,TataMcGrawHill	2010
2	"DigitalDesign", MorrisMano,PHI,5thedition	2013
3	"ModernDigitalElectronics",RPJain,TataMcGrawHill Publication,4thEdition	2010

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	PowerAmplifiers : Module 6 (Lectures 30 -33) https://www.youtube.com/watch?v=huDZjQcEBMg&list=PL708EEA8184EA8F53&index=30	NPTEL
2	A/D and D/A Converter : Lecture 51, 52, 53, 54 https://www.youtube.com/playlist?list=PLbRMhDVUMnge4gDT0vBWjCb3Lz0HnYKkX	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	1	-	2	2	3	3	3	2	3	3
CO2	2	2	1	-	-	-	-	2	2	3	2	2	2	2	3
CO3	2	1	1	-	-	1	1	2	3	3	3	3	2	3	3
CO4	1	1	-	-	-	-	-	2	1	1	1	2	1	1	1

Course Name	**:**	**Electrical Machines – II**
Course Code	**:**	**EEN4002**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able to

- Familiarize students with the fundamental laws that govern the operation of machines.
- Analyze the constructional features and principles of operation of various types of induction and synchronous machines.
- Acquire the knowledge of constructional features, principles of operation of various types of rotating AC machines.
- Develop technical skills to understand the principles and applications of various machines.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Three-Phase Induction Machines** General construction features, rotating field theory, per phase and approximate equivalent circuit, production of torque, torque speed characteristics, max power and max torque criterion, maximum efficiency criterion, no load and blocked rotor test, circle diagram. Starting: rotor rheostat starter, reduced voltage starting, star delta starting. Deep bar and double cage rotor. Speed control: pole changing, line voltage control, line frequency control, rotor resistance control, injection of emf in the rotor circuit. Braking: regenerative, plugging, dynamic braking. Physical phenomenon: time and space harmonics, cogging, crawling, locking, noise, voltage ripples, induction generator, Introduction to DFIG	14
Unit 2	**Single Phase Induction Motors** Double revolving field theory, analysis of single-phase induction motor, equivalent circuit diagram, torque-speed characteristics, types of single-phase induction machines	04
Unit 3	**Synchronous Generators** Constructional features, armature windings, pitch and distribution factor, winding connections, induced emf equation, equivalent circuit, synchronous and leakage reactance, cylindrical rotor machine performance with constant synchronous reactance, armature reaction, generator external characteristics and voltage regulation, generator excitation for constant voltage, direct and quadrature axis synchronous reactance, unsaturated and saturated synchronous reactance, open circuit and short circuit characteristics. calculation of saturated synchronous reactance from open circuit saturation curve, determination of direct and quadrature axis synchronous reactance. Efficiency, losses in synchronous generator, power angle, Concept of transient and sub-transient reactance, determination of transient,sub-transientreactance,paralleloperationofsynchronousgenerators,synchronizingpower,	14

	negative and zero sequence impedances of synchronous generator	
Unit 4	**Synchronous Motors** Construction and operation of synchronous motor, V-curves and inverted V-curves, effects of armature reaction, vector diagrams, effect of change in load and field excitation, vector diagram for salient pole synchronous motor, calculation of field current and efficiency. Relation between power developed and power angle, electromagnetic power in salient and cylindrical rotor motor, condition for maximum power, maximum power versus power angle, field excitation versus power angle, hunting, damping, methods of starting of synchronous motor, power factor correction using synchronous condensers, hunting.	10

List of Experiments:		**Number of Turns**
1	To perform open circuit test and block rotor test on a three-phase induction motor to draw equivalent circuit.	01
2	Determination of the performance characteristics of a three-phase induction motor by load test.	01
3	To obtain circle diagram of the given three phase induction motor by conducting no load and blocked rotor test and to determine the maximum torque, maximum power output.	01
4	To perform speed control of three phase induction motor using various methods.	02
5	To synchronize an alternator to an infinite bus.	01
6	Variation in the active and reactive power of an alternator connected to an infinite bus by (a) varying excitation and (b) varying mechanical power input.	02
7	To obtain the power angle characteristics of a two-generator system.	01
8	To determine the voltage regulation of a given alternator at specified loads by different methods	01
9	To predetermine the efficiency of an alternator at rated load and power factor and to verify the same by actual load test.	02
10	To perform the slip test to determine Z_d and Z_q, and hence to draw the power angle characteristics of the machine.	01
11	To Plot V and inverted -V curves of synchronous motor.	01

Course Outcomes: By the end this course the students will be able to	
CO1	Acquire the knowledge of construction and principle of operation of synchronous machines and induction machines.
CO2	Analyze and evaluate the performance of induction and synchronous machines in motoring and generating mode.
CO3	Understand, analyze and evaluate various types of AC machines.
CO4	Analyze the working of AC machines in different fields of applications.

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Electric Machinery and Transformers by Bhag S Guru &Huseyin R Hiziroglu, Oxford University Press	2000
2	Electrical Machinery by P S Bhimbhra, 7th Edition, Khanna Publishers	2011
3	Electric Machines by D P Kothari and I J Nagrath, Tata Mcgraw Hill Education Private Limited	2004

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Alternating Current Machines by M.G Say, Pitman publishing Ltd	1976
2	Electric Machinery by A.E. Fitzgerald, Charles Kingsley, Jr. and Stephen D. Umans, Tata McGraw-Hill	2013
3	Electrical Machines by J.B.Gupta, Katson Books	2018

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Electrical Machines – II by Prof. Tapas Kumar Bhattacharya, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc22_ee06/preview	Swayam
2	Electrical Machines By Prof. G.Bhuvaneshwari | IIT Delhi https://onlinecourses.nptel.ac.in/noc21_ee24/preview	Swayam

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	1	1	-	-	-	-	-	-	1	2	1	1
CO2	1	2	2	2	1	-	1	-	-	-	-	1	2	1	1
CO3	3	1	1	-	1	-	1	-	-	-	-	1	2	1	1
CO4	1	1	2	2	2	-	2	-	-	-	-	1	1	1	2

Course Name	**:**	**Power Systems Analysis**
Course Code	**:**	**EEN4003**
Credits	**:**	**04**
LTP	**:**	**3-0-2**

Course Objectives:

Students should be able to:

- Understand modelling and operation of power systems under steady state and abnormal conditions.
- Acquire the knowledge of suitable numerical methods tosolve the power flow problem, short circuit and stability problems.
- Acquire the knowledge and functioning of frequency & voltage control in Power system.
- Perform & apply the load flow and short circuit methods in simulation platform.

Total No. of Lectures – 42

Lecture wise breakup		**Number ofLectures**
Unit 1	**Introduction:** Singlelinediagramofpowersystem,modelingofsynchronousmachines, power transformer with tap, load models,transmission line, line & bus reactors, HVDC Links etc., per unit representation/conversion for interconnected power system.	**04**
Unit 2	**Power Flow Studies:** Formation of Z-bus & Y-bus matrices, power flow problem, power flow solution by Gauss- Siedel,Newton Raphson (Polar and Cartesian systems) and fast decoupled Power flow for balanced power systems, algorithm and flowchart, Comparison of the of different power flow methods. Power flow studies usingsoftware.	**09**
Unit 3	**Short Circuit Studies:** Symmetrical (or) balanced three phase faults, Symmetrical sequence components, positive sequence, negativesequence and zero sequence networks for major power systems elements with transformer tap/connection types, inter-connection of sequence networks for three phase single, line to ground, line to line, double line to ground and openconductor faults. Fault reactor, Fault calculation using software.	**09**
Unit 4	**Stability Analysis:** Stability Analysis: steady state, Transient stability, Dynamic stability, Rotor dynamics and swingcurve,Swingcurveequationrepresentationwithdifferentunits,Equalarea criteriaanditsapplications with different cases, Step by step method of analysis of transient stability, Factorsaffecting transient stability, Role of AVR on transient stability of system, Numerical methods oftransient analysis. Fundamentals of Voltage Stability.	**08**
Unit 5	**Frequency & Voltage Control:** Load frequency model of Turbine, generator and load, Automatic frequency control for single area and multiple areas with primary & secondly frequency control. Voltage-	**08**

	reactive power control with compensating devices.	
Unit 6	**Utility Power Systems Analysis:** Modelling, study and analysis of power flow, short circuit and stability studies for one power house and one extra high voltage transmission line.	**04**

List of Experiments:		**Number of Turns**
1	TocomputeZ-Busimpedancematrixofamultibuspowersystemnetworkusingstepby step method.	**1**
2	TocomputeY-BusAdmittancematrixofamultibuspowersystemnetworkusingNodal method.	**1**
3	TocomputeUnsymmetricalfaultinamulti-buspowersystemusingsoftwarefordifferent types of fault conditions.	**2**
4	TodevelopcomputercodeforLoadFlowstudyofpowersystemusingGauss-Siedalmethod.	**2**
5	Todevelopcomputercodefor LoadFlowstudyofpowersystemusingNewton-Raphson method.	**2**
6	TodevelopcomputercodeforLoadFlowstudyofpowersystemusingFast-Decoupledmethod.	**2**
7	Tosimulatesinglemachineinfinitebussystemincorporatingthelineopeningand closing, or fault removal features, for transient stability studies	**2**
8	To simulate Load-Frequency Control of single area network.	**1**
9	Any new lab. Practice power systems power, flow, and stability problem.	**1**

CourseOutcomes: By the end this course the students will be able to	
CO1	Modeling of power system components for power flow, short circuit and stability analysis.
CO2	Apply the power flow, short circuit and stability analysis techniques for large interconnected system
CO3	Understand the power systems frequency and voltage problems.
CO4	Evaluate and perform the power systems planning studies.

Text Books:		
Sr.No.	**Name of Book/ Authors/ Publisher**	**YearofPublication/ Reprint**
1	PowerSystemAnalysis byJ.J.GraingerandW.D.Stevenson,McGrawHillInt. Student Ed.	2003
2	ModernPowerSystemAnalysis byI. J. Nagarath&Kothari,McGrawHillInt.Student Ed.	2011

Reference Books:		
Sr.No.	**Name of Book/ Authors/ Publisher**	**YearofPublication/ Reprint**
1	PowerSystemAnalysisbyT. K. NagasarkarandM.S.SukhijaOxfordUniversity Press, 2007.	2007

2	Computer Methods in Power Systems by G W Stagg.	2010
3	Power System Analysis by HadiSaadat. McGraw-Hill Inc.,US;	2013

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1	Power systems Analysis: A Couse on Power System Protection, coordinated by IIT Kharagpur, https://archive.nptel.ac.in/courses/108/105/108105067/	NPTEL
2	Computer aided Power systems Analysis, coordinated by IIT Roorkee, https://archive.nptel.ac.in/courses/108/107/108107127/.	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	--	1	1	--	--	1	1	1	1
CO2	3	2	2	1	2	--	--	--	1	--	1	1	1	1	1
CO3	2	1	1	1	1	1	--	--	1	--	--	1	1	1	1
CO4	3	2	2	1	2	--	--	--	1	--	1	1	1	1	1

Course Name	**:**	**Power Electronics**
Course Code	**:**	**EEN4004**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be ableto:

- Explore the switching characteristics of various power electronics switches
- Analyze the operation of various power converters and their performance analysis.
- Apply the power converters for different applications such as motor drive, battery charging and renewable energy generation.
- Design and develop the power electronic circuits for various practical applications

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**PowerElectronic Devices** Introductiontopowerswitchingdevices,basic structureandphysicsofdeviceoperation,switchingandI-Vcharacteristics(Diodes,SCR,GTO, BJT,PowerMOSFET,IGBT), seriesandparallel Operationofthyristors, triggertechniques,opticalisolators,protectioncircuits,isolationtransformers, Snubber circuits: function and type of snubber circuits, turn off, turn on and overvoltage snubbers..	08
Unit 2	**AC-DCConversionCircuits** Line Commutated rectifiers: naturalcommutation of SCRS, 1ø and 3ø half and fully controlled rectifier configurations with R, RL and RLEload,continuousanddiscontinuousconductionmode,outputvoltageand sourcecurrentanalysis (THD,DPF,PF), dual converters.	08
Unit 3	**Choppers** ChopperCircuits: Typesofchopper:stepup,stepdown;differentclassesofchoppercircuits:Class A,B,C,D,EforR,RLandRLE load;typesofcommutationcircuits.	04
Unit 4	**DC-DC Converters** Introduction to power processing, principles of steady state converter analysis: inductor volt-secondbalance, capacitor charge balance and small ripple approximation. DC-DCSwitchModeConverters: IntroductiontoDC-DCconverters,typesofconverters:buck,boost, buck-boost, and Cuk converter.	05
Unit 5	**ACVoltageRegulators** AC Voltage Controller: Basic principle, analysis of 1-Ø operation with R and RL load (various modes ofoperation), load and supply current characteristics, integral cycle control and sequence control. Cycloconverter: Principle of operation, basic operationalfeatures,mathematicalrepresentation(outputvoltageand inputcurrent), and waveforms.	06
Unit 6	**DC-AC Convertors** Operation, control, and analysis of 1-Øand3-Øbridgeinverters,voltagecontrolofthreephaseinverters:sinusoidalPWM,60	07

	-degree PWM,thirdharmonicPWMandspacevectormodulation(SVM);relationship betweenPWMandSVM, comparisonofvariousPWM techniques,methodsofharmonicreduction.	
Unit 7	**Design aspects in Power Converter and Control** Design of inductor for DC-DC converter, power electronic switch selection, heat sink design, Design of gate driver circuits, closed loop control of DC-DC converter.	04

List of Experiments:		**Number of Turns**
1.	To obtain V-I characteristics of SCR and measure latching and holding currents.	1
2.	To obtain triggering waveforms of SCR using R and RC firing circuit.	1
3.	To simulate and experimentally validate voltage waveforms for single phase (i) fully controlled (ii) half controlled bridge rectifiers with R and RL loads.	2
4.	To simulate and experimentally validate voltage waveforms of single-phase ac voltage regulator with R and R-L load.	2
5.	To simulate and experimentally validate waveforms of different types of chopper circuits	2
6.	To simulate and experimentally validate single-phase inverter using unipolar and bipolar modulation techniques and obtain load voltage and loadcurrent waveformfordifferenttypesofloads.	2
7.	To simulate and experimentally validate three-phase inverter using various modulation techniques and obtain load voltage and loadcurrent waveformfordifferenttypesofloads.	2
8.	To simulate and experimentally validate inductor current and output voltage waveforms of buck, boost and buck boost convertors	2

Course Outcomes: By the end this course the students will be able to	
CO1	Tounderstand the operating characteristics of power electronics devices.
CO2	Toanalyzethe operation of power converters like DC-AC, DC-DC, AC-DC and AC-AC.
CO3	Apply the knowledge of switching operation to the formulation of control structures.
CO4	Design the power electronics circuits for various practical applications.

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	MHRashid,"PowerElectronics:Circuits,DevicesandApplications",3rdEdition,Prentice HallofIndiaPvtLtd.	2014
2	N.Mohan,T. M.UndelandandW. P. Robbins,"PowerElectronics:Convertersapplicationsand design",JohnWileyandsons.	2006
3	B. K. Bose, "Modern Power Electronics and AC Drives," Pearson Education (US) 2002.	2002
4	L. Umanand, "Power electronics: essentials and applications," Wiley India Pvt. Limited.	2009

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	GuySeguier,ChristianRombautandRobertBausiere“PowerelectronicConverters:Volume 2AC-ACConversion”,NorthOxfordAcademicPublishers.	1987
2	B.R.Pelly,“ThyristorPhaseControlledConvertersandCycloconverters”,JohnWileyand sons.	1971
3	LGyugyiandB.R.Pelly,“StaticPowerFrequencyChangers”,JohnWileyand Sons.	1976
4	OECbeling,E.O,“MeasurementSystems-ApplicationandDesign,”McGrawHillPublishing Company.	1990
5	R.S.Ramshaw,“PowerElectronicSemiconductorswitches”,Chapmanand Hall1994.	1994
6	R.W.EricksonandDraganMaksimovic,“FundamentalsofPowerElectronics”,KLUWERnAcademicPublishers2.	2004
7	MarianKKazimierczuk,“Pulse-widthModulatedDC–DCPowerConverters”,JohnWileynandSons.	2008

Equivalent MOOCs courses:

Sr. No.	**Course Links**	**Offered by**
1	Fundamental of Power Electronics By Prof. L Umanand | IISc Bangalore https://onlinecourses.nptel.ac.in/noc21_ee01/preview	NPTEL
2	Power Electronics, IIT Delhi Prof. G.Bhuvaneshwari, IIT Delhi https://archive.nptel.ac.in/courses/108/102/108102145/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	2	-	-	-	2	2	2	2	2	2	1
CO2	2	2	2	2	2	-	-	-	2	2	2	2	2	2	1
CO3	3	2	3	3	2	-	-	-	2	2	2	2	3	3	1
CO4	3	3	3	3	2	-	-	-	2	2	2	2	3	3	2

CourseName	**:**	**ControlSystems**
CourseCode	**:**	**EEN4005**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeableto:

- Impart the knowledge to model and design various systems to be controlled.
- Find various methods to study stability of given system.
- Analyze and evaluate the performance of the system using different techniques.
- Acquire knowledge about various control techniques to achieve a given target.

TotalNo.of Lectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction** Openloopandclosedloopcontrol systems, feedback,effects offeedback, linear andnon-linearcontrol systems,blockdiagrams,someexamples.	03
Unit 2	**Modeling** Modeling of physical system: electrical, mechanical, translational, rotational, electrical, mechanicalanalogies, Laplace transform, transfer function, characteristic equation, block diagram algebra, signalflowgraphs,errordetectorspotentiometer,synchros,steppermotor,servomotors,tacho-generators.	08
Unit 3	**TimeDomainAnalysis** Importanceoftimeresponseintransientandsteadystateanalysis,typicaltestinputsignals,transientresponse ofthe first order andsecondorder system, time responsespecifications,dominant closedloop polesofhigherordersystems, steadystateerroranderrorcoefficients.	06
Unit 4	**Stability** Conceptsofabsoluteandrelativestability,polezerolocation,RouthHurwitzcriteria.	02
Unit 5	**RootLocusTechnique** Introduction,rootlocusconcept,constructionofrootloci,stabilityanalysis.	04
Unit 6	**FrequencyResponse** Introductionandimportanceoffrequencyresponse,bodediagram,polarplots,Nyquiststabilitycriterion,stabilityanalysis,relativestability,gainmargin&phasemargin,closedloopfrequency response.	07
Unit 7	**ControlDesignTechniques** Necessityofcompensation,lagandlead compensation,PIDcontroller.	07
Unit 8	**StateSpaceAnalysis** Conceptofstate,statevariableandstatevector,statetransitionmatrix,controllabilityandobservability,solutionofstateequation.	05

ListofExperiments		**Number ofTurns**
1	Toobtainthetimeresponsesoffirstorder and secondorderRLCcircuits.	01
2	Tosimulatethevariousresponsesofthelinearsystemusinglinearsystemsimulator.	01
3	Tostudyandimplementthetemperaturecontrolledsystem.	01

4	Tostudytheperformancesofopenloopandclosedloopsystems.	01
5	Toimplementthecharacteristicsofstepper motorinterfacedwithmicroprocessor.	01
6	Tostudytheclosed loopperformances withP,PIandPIDcontrollers.	01
7	Toimplementlag,leadandlag-leadcompensators.	02
8	Tostudyand implementthevariouscharacteristicsofDCmotorpositioncontrolsystem.	02
9	Tostudysynchro-transmitterandreceiverandobtainoutput versusinputcharacteristics.	01
10	TostudytheACpositiontrainerkitandanalyzeitsperformances.	01
11	TodrawNyquistplotofopenlooptransferfunctionsandexaminethestabilityofthe closedloop system.	01
12	ToobtaintheBodefrequencyresponseforfirstandsecondordersystem.	01

CourseOutcomes:By the end this course the students will be able to	
CO1	Toacquiretheknowledgeofcontrolsystems.
CO2	Tomodelandanalyzethephysicalsystemsforcontrollingtheirresponses.
CO3	Todesignand analyzethestabilityandperformancesofcontrolsystems.
CO4	To be able to control any system to achieve a given target.

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublicati on/Reprint**
1	ControlSystemsEngineeringbyI. .JNagrathandM.Gopal,WileyEastern.	2008
2	LinearControlSystemsbyB.S.Manke.	2010

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication / Reprint**
1	AutomaticControlsystemsbyB CKuo.	2009
2	ModernControlEngineering byKOgata, PHI.	2009

Equivalent MOOCs courses:

Sr. No.	**Course Links**	**Offered by**
1	Control Systems; Prof. C. S. Shankar Ram | IIT Madras, Control systems - Course (nptel.ac.in)	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	3	-	-	-	1	1	-	1	3	2	1
CO2	3	2	1	1	3	-	-	-	1	1	-	2	3	2	2
CO3	3	2	1	1	3	-	2	-	1	1	-	3	3	2	3
CO4	3	2	1	1	3	-	2	-	1	1	-	3	3	2	3

Course Name	**:**	**Renewable Energy Technologies**
Course Code	**:**	**EEN4006**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be able –

- To explore the energy generation scenario and related policies for renewable energy generation.
- To analyze the operation of various renewable energy technologies.
- To apply the renewable energy generation technologies for existing electric grid.
- To design of renewable energy systems for domestic, commercial and industrial applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Introduction** Indian energy scenario, available renewable energy potential, government schemes and policies for renewable energy generation, sustainable energy resources: national and international scenario.	04
Unit 2	**SolarPhotovoltaic Energy Technology** Conversion of solar energy into electricity: Basic semiconductor physics, solar irradiations, fundamentals of PV cells, equivalent circuit of the photovoltaic cell,from cells to modules to array, performance characteristics of PV cells at STC, impact of temperature and insolation on I-V curves, shading impact on I-V curve, crystalline silicon technologies, thin film photovoltaic, perovskite cell technology.	08
Unit 3	**Solar Photovoltaic Systems** Grid connected PV system: Design of system, rating and sizing of different components, maximum power point tracking, control architecture, grid synchronization, and performance analysis. Standalone PV system: Standalone PV system components and design, solar water pumping system, solar street light system, and solar lanterns.	08
Unit 4	**WindEnergy Technology** Wind energy conversion: Operating principle, wind energy generation basics, power, torque-speed characteristics, maximum power coefficient, wind velocity measuring instrument, factors effecting the wind energy output, wind turbine architecture, fixed speed and variable speed wind turbines, DFIG and PMSG based wind turbines, types and classification of WECS, wind turbine controller, design of controller for grid side and rotor side converter.	08
Unit 5	**Hydrogen and Fuel Cell Technology** Introduction to hydrogen energy, various hydrogen production methods, types of electrolyzer, type of fuel cells, component of fuel cells, fuel cell calculations, design of integrated hydrogen energy systems, fuel-cell electric vehicle and applications.	07
Unit 6	**Recent Developments in Renewable Energy Technologies** Solar Thermal Energy: Absorption, radiations and thermal collectors	07

	Biomass energy conversion technologies, biomass co-generation, ethanolfrom biomass. Small hydropower systems: overview of micro, mini and small hydro systems. Energy generation from ocean waves: ocean thermal energy conversion and tidal energy conversion, introductionto geothermalenergyconversion.	

List of Experiments:		**Number of Turns**
1	To obtain I-V and P-V characteristics of solar PV module for different irradiation and temperature.	1
2	To obtain I-V and P-V characteristics solar PV modules when connected in (i) series and (ii) parallel.	1
3	To obtain the operational characteristics of wind energy system at different wind speed.	1
4	To simulate a standalone solar PV system for residential load applications using MPPT control.	1
5	To study and simulate a transformer-less single-phase grid connected roof-top photovoltaic (PV) system connected to the electrical utility grid.	2
6	To study and simulate three-phase grid-connected solar photovoltaic (PV) system.	2
7	To carry out a techno-economic analysis of grid connected solar PV system.	1
8	To study and simulate a wind energy conversion system.	1
9	To evaluate the performance of solar photovoltaic system using laboratory set-up	2
10	Study characteristics of fuel cell with the help of a resistive load.	1
11	To design a hybrid micro-grid system assisted with solar PV, wind and battery energy storage system.	1

Course Outcomes: By the end this course the students will be able to	
CO1	Understandthe requirement of sustainable energy resources in the present scenario.
CO2	Implement the knowledge of renewable energy technologies for energy generation and grid integration.
CO3	Analyze the operations of various renewable energy technologies and their performance analysis.
CO4	Design the standalone and grid connected renewable energy systems.

Text Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	C.S. Solanki, “Renewable Energy Technologies: A practical guide for beginner,” PHI.	2009
2	WagnerH.andMathurJ,“IntroductiontoHydroEnergySystems:Basics,Technology and Operation”,Springer.	2011

3	Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, Wiley Interscience, John Willey and Sons.	2004

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	C.S.Solanki, “SolarPhotovoltaics-FundamentalsTechnologiesandApplications,”PHI.	2015
2	JennyNelson,“ThePhysicsofSolarCells,”(ImperialCollege,UK).	2003
3	VaughnC.NelsonandKennethL.Starcher,“IntroductiontoRenewableEnergy, (Energyandthe Environment)2ndEdition,”.	2015

Equivalent MOOCs courses:

Sr. No.	**Course Links**	**Offered by**
1	**Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems, IIT Guwahati** Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi https://nptel.ac.in/courses/103103206	NPTEL
2	https://onlinecourses.nptel.ac.in/noc24_ch26/preview	SWYAM

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	2	2	3	2	1	2	2	2	2	2	1
CO2	3	2	3	2	2	3	3	2	2	2	2	2	2	2	1
CO3	3	2	2	2	2	2	2	1	2	2	2	2	3	2	2
CO4	3	3	3	2	2	3	2	1	2	2	1	2	3	3	2

CourseName	**:**	**Power System Protection & Switchgear**
CourseCode	**:**	**EEN5001**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to:

- Explore the conceptandnecessityof power system protection.
- Acquire the knowledge of different types of protections for major power systems components.
- Understand the working of different types of circuit breaking techniques and lighting & switching.
- Design the protection schemes for major power systems components.

Total No. of Lectures – 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Power system fault analysis:** Symmetrical component, symmetrical and unsymmetrical shunt faults, systems normal & abnormal operation and protection.	**03**
Unit 2	**General features of Protective mechanism**: Concept of Power systems operation, CT, PT/CVT features, Salient features of Power systems protection, constructional features and characteristics of electro-mechanical, Phase and amplitude comparator, static, digital-, Microprocessor based relays	**07**
Unit 3	**Generator Protection:** Four quadrant operation, Class of Protections/tripping, stator differential, restricted earth fault, rotor earth faults, thermal over load, loss of excitation, un-balance operation, pole slipping, over/under speeding, over/under voltage, reverse power & low forward power, Accidental inadvertent energization etc. Transformer protection like differential, restricted earth fault, over flux protection, over current phase & earth backup, Buchholz Protection.	**11**
Unit 4	**Transmission line Protection:** Impedance relay, mho relay, reactance relay, zone setting of distance relays, carrier tripping schemes, voltage unbalance protection, current carrier protection, and time graded over current protection for radial and parallel feeder, carrier assisted distance protection. Introduction to IEC 61850, SCADA for protection application, micro-grid protection, special protection schemes.	**07**
Unit 5	**Switchgear**: Isolator, fuse, HRC fuse, circuit breaker working principle, arc interruption theories, rate of rise of recovery voltage, classification, construction, operation, maintenance. Application of minimum oil, air blast, SF6 and vacuum circuit breaker, HVDC circuit breaker system	**07**
Unit 6	**Switching Protection:** Theory ofphysicsoflightningflashes&strokes,voltage-timetimecharacteristics,horngap, rod gap, impulse gap single diverters, groundwires, surge absorbers, shieldingangle etc,insulationco-ordination.	**04**
Unit 7	**Design of Relaying:** Protection practices as per IEEE/IEC/CIGRE/CBIP/Indian regional power committee. Relay setting calculations for powerhouse and substation through cases studies.	**03**

Listof Experiments		Number ofTurns
1	Tomeasuresymmetricalfaultlevel measurementonadcnetworkanalyzer	**01**
2	Tomeasureunsymmetricalfaultlevelmeasurementonadcnetworkanalyzerforvarioustypesof Faults	**02**
3	Tomeasuregroundresistivityandresistanceofagroundelectrode	**01**
4	Toplotinversedefinite minimumtimecharacteristicsofnumericalovercurrentrelay.	**01**
5	Toplotinversedefinite minimumtimecharacteristicsofnumericalEarthfaultovercurrentrelay.	**01**
6	Tostudyandanalyzetransformer protectionusingdifferentialrelayforinzonetripfaults.	**01**
7	Toplotcharacteristicsofpercentagebiasdifferentialrelay.	**01**
8	Tostudyand analyzetheperformanceofdistanceprotection	**02**
9	Toperformpick up testfordifferentialrelay.	**01**
10	TostudyandanalyzetheperformanceofMerz-priceprotectionforathreephasealternator.	**02**
11	Toplotinversedefinite minimumtimecharacteristicsofdirectionalovercurrentrelay.	**01**

CourseOutcomes: By the end this course the students will be able to	
CO1	Learn the protection schemes for generating, transmission and distribution systems.
CO2	Select & discriminate in functioning and applications of different types of relaying systems
CO3	Able to choose the suitable types of circuit breaker and protection against the switching.
CO4	Able to design the protection for major power components

Text Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Pathinkar, Y.G. and Bhide, S.R., Fundamentals of Power System Protection, PHI Learning Pvt. Limited	2008
2	B. Ravindranath, M. Chander, Power System Protection and Switchgear	2005
3	C L Wadhwa, 'Power Systems Analysis' by Wiley India Ltd.	2009
4	S.S. Rao, 'Switchgear and Protection', Khanna Publishers, Delhi	2008
5	Juan M. Gers, Edward J. Holmes , Protection of Electricity Distribution Networks, 2nd Edition	2004
6	Blackburn J L and Domin T J 'Protective Relaying: Principles &Applications', CRC Press	2010
7	Badri Ram, D. N. Vishwakarma, Power System Protection and Switchgear.	2017

Reference Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	P. M Anderson , Power Systems Protection, Wily , IEEE Press	2015

2	John D. McDonald, Electric Power Substations Engineering, Second Edition, CRC Press.	2007
3	Van A. R. and Warrington C., "Protective Relays - Theory and Practice", Vol. I and II, 3rd Ed., Chapman and Hall.	1982
4	Mason C. R., "The Art and Science of Protective Relaying", Wiley Eastern Limited.	1987

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1	A Couse on Power System Protection, coordinated by IIT Kharagpur, https://archive.nptel.ac.in/courses/108/105/108105167	NPTEL
2	Power System Protection, coordinated by IIT Bombay, https://nptel.ac.in/courses/108101039	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	--	1	1	--	--	1	1	1	1
CO2	3	2	1	1	1	--	--	--	1	--	1	1	1	1	1
CO3	3	2	1	1	1	1	--	--	1	--	--	1	1	1	1
CO4	3	1	1	1	1	--	--	1	--	--	1	1	1	1	1

Course Name	**:**	**Electric Drives**
Course Code	**:**	**EEN5002**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :

Students should be able to:

- To explore generalized theory of machines.
- To analyze the mathematical modeling of electrical machines.
- To apply the of power converters for controlling the DC and AC drives.
- To design and develop the closed loop control for controlling the electrical drives

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Generalized Theory of Electrical Machines** Kron's Primitive Machine Model (Two Axis Model), statically induced EMF, Rotational or Dynamically Induced EMF, Generalized Torque Expression of Kron's Primitive machine.	6
Unit 2	**Modeling and Control of DC Drives** Mathematical model of DC machine (shunt, series, separately excited), steady state characteristics with armature and field control, dynamic behavior with constant flux. Static convertor as power actuator for DC drives: single and three phase drives, chopper drives, convertors with reduced reactive power, control loop containing electronics power converters. Control of converter supplied DC drives, braking operation using power electronics converters.	12
Unit 3	**Modeling of Induction Machine** Modeling of three phases Symmetrical Induction Machines (IM) in abc variables, Co-Energy and Torque Expression. *d-q* (Transformation) Modeling of symmetrical 3 phase Induction Machine, Rotor Transformation, Torque expression in d-q Frame. Equivalent Circuit. Reference Frame Theory, Induction Machine Modeling in Arbitrary Reference Frame.	10
Unit 4	**Vector Control of Induction Machine** Vector Control of Induction Machine: Concept of Space Phasor, Principle of Decoupled Control, Rotor Flux Oriented Vector Control, Stator Flux Oriented Vector Control, Magnetizing Flux Oriented Vector Control. Torque Response. Flux Estimation Schemes.	14

List of Experiments:		**Number of Turns**
1.	To simulate and experimentally validate speedcontrolofDC machineusingthree phase fully controlled thyristorizedconverter.	02
2.	To simulate and experimentally validate speed controlofDCmachineusingfirstquadrantchopper.	02

3.	To simulate and experimentally validate reduced reactive power convertor based DC motor drive system.	02
4.	To simulate dynamic two axis model of induction machine.	02
5.	To simulate and experimentally validate rotor flux oriented vector control of induction machine	02
6.	To simulate and experimentally validate various flux estimation schemes for vector control of induction machine	02
7.	To design closed loop control scheme for control of DC motor drive system	02

Course Outcomes: By the end this course the students will be able to	
CO1	To understand the basic operation and principle of electric drive systems
CO2	To understand the mathematical modeling of AC and DC drives.
CO3	To analyze the control of aspects of AC and DC drives.
CO4	To apply the control aspect using power electronic converters for different electric drives

Text Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	P.C.Krause,O.Wasynezuk,D.S.Sudhoff,"AnalysisofElectricMachinery AndDriveSystems," McGraw-Hill Book Company	2013
2.	R. Krishnan, "Electric Motor Drives – Modeling, Analysis and Control," Prentice-Hall of India.	2015
3.	Power Semiconductor Controlled Drives by G.K. Dubey, Prentice Hall Englewood Cliffs, New Jersey.	
4.	P.Vas,"VectorControlofACMachines," ClarendonPressOxford.	1990

Reference Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	WernerLeonard,"ControlofElectricDrives,"Springer.	2000
2.	B. K. Bose, "Modern Power Electronics and AC Drives," Pearson Education (US) 2002.	2002
3.	VedamSubrahmanyam, "Electric Drives – Concepts and Applications," Tata McGraw Hill	1994

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	https://archive.nptel.ac.in/courses/108/104/108104140/	NPTEL
2	**Advanced Electric Drives (Prof S P Das, IIT Kanpur)**	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	1	1			2	2	2	2	2	2	2
CO2	2	3	3	2	2	1			2	2	2	2	2	2	1
CO3	3	3	2	2	2	1	1		3	2	2	2	3	2	1
CO4	3	2	3	3	1	1	1		2	2	2	2	3	3	2

CourseName	**:**	**ElectricVehicles**
CourseCode	**:**	**EEN5003**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to :

- Acquire the knowledge on hybrid and electric vehicle operation and architectures.
- Select appropriate motor, converter and energy storage system for the electric vehicles.
- Acquire the knowledge of energy management and control strategies used in hybridandelectricvehicles.
- Design a battery electric vehicle and hybrid electric vehicle.

TotalNo.ofLectures- 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**IntroductiontoElectricVehicles** Comparisonof BEV, HEV, FCEV and ICengine drivevehicles; social and environmental importance of hybrid and electric vehicles, impact of modern drive-trainsonenergysupplies,basicsofvehicleperformance,vehiclepowersourcecharacterization,transmission characteristics, Mathematical models to describe vehicle performance, basic concept ofhybridtraction,introductiontovarioushybriddrive-traintopologies,powerflowcontrolinhybrid drive-traintopologies,fuelefficiencyanalysis. Standards and government policies related to EVs and HEVs.	08
Unit 2	**ElectricPropulsionUnit** Introduction to electric components used in hybrid and electric vehicles, different types of motors usedinEVandtheirtorque-speedcharacteristics,configurationandcontrol:DCmotordrives,inductionmotor,permanentmagnetmotor,and switchreluctancemotordrives; drivesystemefficiency.	09
Unit 3	**EnergyStorageinVehicles** Introduction toenergy storagerequirements inhybridandelectricvehicles,storagetypes: battery,supercapacitor/ultra-capacitors,flywheel,andfuelcellbasedenergy storageanditsanalysis,hybridizationofdifferent energystoragedevices.	08
Unit 4	**BatteryChargers** FundamentalsofEVbatterypackdesign,ACandDCChargers,Alternatechargingsources–wireless&solar,*batterymanagement system*.	03
Unit 5	**PowerConvertersinElectricDriveVehicles** Convertertopologies:bidirectionalDC-DCconverters,bidirectionalT-typeconverter,resonantconverter,multilevel two-quadrantconverter, PWM inverters.	04
Unit 6	**EnergyManagementandControlStrategies** Introductiontoenergymanagementstrategiesusedinhybridandelectricvehicles,classificationofdifferentenergymanagementstrategies,comparisonofdifferentenergymanagementstrategies, implementationissuesofenergymanagementstrategies.	06
Unit 7	**ElectricVehicleCaseStudies** Designofabatteryelectric vehicle(BEV), design offuel cell electricvehicle,designofhybridelectricvehicle,designofmore electric aircraft, Electric metro.	04

ListofExperiments:		**Number ofTurns**
1	Toobtaintheperformance oflead-acid andli-ionbatteryenergystorage.	02
2	Toobtaintheperformanceofsupercapacitor.	01
3	Tosimulatelead-acid/li-ionbatteryandsupercapacitorhybridenergystoragesystem.	02
4	TosimulatetheI-Vcharacteristicsoffuelcell.	01
5	Toobtainthedifferenceinperformanceof ACand DCchargers.	01
6	TosimulatetheDCfastchargersforelectricvehicles(EV).	01
7	ToobtaintheperformanceofbidirectionalDC-DCconverter.	01
8	Toobtaintheperformanceofresonantconverter.	01
9	TosimulatesinePWMinverter.	01
10	Toobtaintheperformanceof – permanentmagnet,inductionandswitchedreluctancemotors.	02
11	TosimulatethebatterybasedEV.	02

CourseOutcomes: By the end this course the students will be able to	
CO1	Developtheelectricpropulsionunitanditscontrolforapplicationofelectricvehicles.
CO2	Analyzedifferentpowerconvertertopologyusedforelectricvehicleapplication.
CO3	Interpretworkingofdifferentconfigurationsofelectricvehiclesanditscomponents,hybridvehicle configuration,performanceanalysisandenergymanagementstrategiesinEVs.
CO4	Design a battery electric vehicle and hybrid electric vehicle

TextBook		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	MehrdadEhsani,YiminGao,StefanoLongo,KambizM.Ebrahimi,"ModernElectric ,Hybrid Electric,andFuelCellVehicles",Taylor&FrancisGroup,LLC.	2018

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	IqbalHusain, "ElectricandHybridVehicles:DesignFundamentals",3rdeditionCRCPress.	2021
2	TomDenton,"ElectricandHybridVehicles",Taylor&Francis.	2018
3	JohnMiller,"PropulsionSystemsforHybridVehicles,"InstituteofElectricalEngineers,UK.	2004
4	ChrisMi,MAMasrur,DWGao,"HybridElectricVehicles– Principlesandapplicationswith practicalperspectives,"Wiley.	2011
5	JamesLarminie,JohnLowry,"Electric VehicleTechnologyExplained",Wiley.	2003
6	C.M.Jefferson&R.H.Barnard,"HybridVehiclePropulsion,"WITPress.	2002
7	L. Ashok Kumar, S Albert Alexander," Power converters for Electric Vehicles," CRCPress.	2021
8	H. J. Bergveld, "Battery management systems : design by modelling" University Press Facilities, Eindhoven	2001

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1	Electric vehicles and Renewable energy, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, and Prof. L Kannan https://archive.nptel.ac.in/courses/108/106/108106182/	NPTEL
2	Electric Vehicles - Part 1, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, and Prof. L Kannan https://archive.nptel.ac.in/courses/108/102/108102121/	NPTEL
3	Introduction to Hybrid and Electric Vehicles, IIT Guwahati Dr. Praveen Kumar, Prof. S. Majh NPTEL :: Electrical Engineering - Introduction to Hybrid and Electric Vehicles	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	3	1	1	1	-	3	3	3	2
CO2	3	3	2	3	2	2	3	1	1	1	-	3	3	3	2
CO3	3	2	1	2	2	2	3	1	1	1	-	3	3	3	2
CO4	3	3	3	3	2	2	3	1	1	1	-	3	3	3	2

Course Name	**:**	**MicroprocessorsandMicrocontrollers**
Course Code	**:**	**EEN5004**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives :

Students should be able to-

- Acquiretheknowledgeofarchitecture ofIntelmicroprocessors.
- Explore instruction set and assemblylanguageprogramming with microprocessors.
- Apply interface basic peripherals with microprocessors.
- Design an instruction set for controlling the various applications using microcontroller.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Introductionto8085Microprocessor** Introductiontomicroprocessorsandmicrocomputers,Intel8085microprocessorarchitecture,pinconfiguration,CPU architecture,registers,controlunit..	**4**
Unit 2	**InstructionSetof8085Microprocessor** Machinelanguageinstructionformats,addressingmodesof8085,instructionsetof8085,timingdiagrams,T-states,machine cycles, instructioncycle. Exampleprogramminginassemblylanguageusing8085instructions,useofarithmetic,logical,datatransfer,stackandI/Oinstructionsinprogramming,interruptin8085	**6**
Unit 3	**PeripheralsDevices andTheirInterfacingwith 8085** Memoryinterfacing,programmableperipheralinterface(8255),programmableintervaltimer(8253),programmableinterruptcontroller(8259),keyboard/displaycontroller(8279),DMAcontroller(8237/8257).Interfacinganalogtodigitaldataconverters,interfacingdigitaltoanalogdata converters, serialcommunicationinterface (8251)	**8**
Unit 4	**Introductionto8086Microprocessor** Architecture,organizationandpinoutdetails,registerset,memorysegmentation,minimummodeandmaximummode ofoperation.	**8**
Unit 5	**Introductionto8051Microcontroller** Overviewofarchitectureandpindiagram,memoryorganization,registerbanks,externalcodememoryaccess, externaldatamemoryaccess,addressingmodes.	**8**

List of Experiments:		**Number of Turns**
1	Tostudyandinterface8255chipwith8085/8086/PentiumTrainersystem	01
2	Tostudyandinterface8251chipwith8085/8086/PentiumTrainersystem	01
3	Tostudyandinterface8259chipwith8085/8086/PentiumTrainersystem	01
4	Tointerfaceandcontrolasteppermotorusingthesteppermotorcontrollercardandsteppermotor drives	01

5	ToacquireaunipolaranalogsignalandconvertitintoadigitalvalueusingA/DCard	01
6	ToacquireabipolaranalogsignalandconvertitintoadigitalvalueusingA/DCard	01
7	8085/8086basedexperimentsfordatatransferoperations	01
8	8085/8086basedexperimentsforarithmeticoperations	01
9	8085/8086basedexperimentsforlogicaloperations	01
10	8085/8086basedexperimentsforsorting	01
11	8085/8086basedexperimentsfordataconversions	01
12	8085/8086basedexperimentsforinterfacingvariousaddoncards	03

Course Outcomes: By the end this course the students will be able to	
CO1	Explain theinternal architecture, organization and functioningofmicroprocessorand microcontroller
CO2	Understand assembly language programming of microprocessorand microcontroller
CO3	Interface the basic peripherals with microprocessors
CO4	Design different interfacing applications using microprocessor/microcontroller and peripherals.

TextBooks:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"MicroprocessorArchitecture,ProgrammingandApplicationswiththe8085",R.S.Gaonkar, 6thEdition,PenramInternationalPublishing	2013
2	AdvancedMicroprocessors&peripheralsbyK.M.Bhurchandi&A.K.Ray, 3rd edition,TMH Publication	2017
3	Microprocessor&InterfacingbyDouglasVHall, TMHPublication	2006

ReferenceBooks:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	TheIntelMicroprocessorsbyBarryB.Brey,8th edition, PrenticeHall	2013
2	The8051MicrocontrollerandEmbeddedSystemsusingassemblyandCbyMazidiMA,MazidiJGandMchinlayRD, 2nddition, PearsonEducation	2007

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Microprocessors and Microcontrollers By Prof. Santanu Chattopadhyay | IIT Kharagpur	Swayam
2	NPTELvideolectureonmicroprocessor&microcontroller https://nptel.ac.in/courses/108/105/108105102/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**

CO1	2	-	-	-	-	-	-	-	-	-	-	1	1	1	-
CO2	1	2	2	-	1	-	-	1	-	-	-	1	2	2	1
CO3	-	-	1	1	1	-	-	-	-	1	-	-	2	2	-
CO4	-	-	-	1	2	-	-	-	1	-	1	1	3	3	1

Department of Electrical Engineering
Course Curriculum
B.Tech (Electrical Engineering)

Detailed Syllabus of Departmental Elective Courses

Course Code	DEC – I, II, III, IV	L	T	P	Credits
EEE1001	Optimization Techniques in Engineering	3	1	0	4
EEE1002	CAD of Electrical Machines	3	0	2	4
EEE1003	Medical Instrumentation	3	0	2	4
EEE1004	Neural Network and Fuzzy Systems	3	1	0	4
EEE1005	Digital Signal Processing	3	1	0	4
EEE1006	Signals and Systems	3	1	0	4
EEE1007	PLC & SCADA	4	0	0	4
EEE1008	Energy Management and Energy Audit	3	0	2	4
EEE1009	Smart Grid Technologies	4	0	0	4
EEE1010	Advanced Control System	3	1	0	4
EEE1011	Digital Control System	3	0	2	4
EEE1012	Power Conditioning	3	1	0	4
EEE1013	Advance Power Electronics	3	0	2	4
EEE1014	Modelling and Control of Power Electronic Converters	3	0	2	4
EEE1015	Grid Integration of Renewable Systems	3	1	0	4
EEE1016	Advanced Electric Drives	3	0	2	4
EEE1017	Special Machine Drives	3	1	0	4
EEE1018	Power System Operation and Control	3	1	0	4
EEE1019	Restructured and Deregulated Power System	3	1	0	4
EEE1020	FACTS Devices and HVDC Transmission	3	1	0	4
EEE1021	Utilization of Electrical Energy	3	1	0	4
EEE1022	High Voltage Engineering	3	0	2	4
EEE1023	Numerical Protection & Protection Audit	3	0	2	4
EEE1024	Power System Dynamics modelling and Stability	3	0	2	4
EEE1025	EnergyStorageSystems	3	1	0	4

CourseName	**:**	**OptimizationTechniquesin Engineering**
CourseCode	**:**	**EEE1001**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentsshouldbeableto:

- Applytheknowledgeoflinear programming to linear problems.
- Applytheknowledgeof nonlinear programming to nonlinear problems.
- Applytheknowledgeofdynamic programming to multistage problems.
- Develop optimization algorithm for engineering problems using evolutionary techniquesnonlinear.

TotalNo.ofLecture-42

LectureWiseBreakup		**Number ofLecture**
Unit 1	**ClassicalOptimizationTechniques** Introductiontooptimizationanditsscopeinengineering,classicaloptimizationtechniques:singleandmulti-variableproblems,saddlepoint,Lagrange multiplier,Kuhn-Tuckercondition.	05
Unit 2	**LinearProgramming** Standardform,geometryofLPproblems,simplexmethod,dualityinlinearprogramming,quadraticprogramming	06
Unit 3	**NonlinearProgramming** Exhaustivesearch,intervalhalvingmethod,goldensectionmethod,interpolation methods,unconstrainedoptimizationtechniques:directsearchmethods,indirect search(descent)methods,constrainedoptimizationtechniques:sequentiallinear programming,sequentialquadraticprogramming,penaltyfunctionmethod,augmentedLagrangemultipliermethod	14
Unit 4	**DynamicProgramming** Multistagedecisionprocesses,conceptofsub-optimizationandprincipleofoptimality,linearprogrammingasa case ofdynamicprogramming	05
Unit 5	**ModernOptimizationTechniques** Geneticalgorithm,simulatedannealing,particleswarmoptimization– applicationtoengineeringproblems,no free lunchtheorem, introductiontomulti-objectiveoptimization	12

CourseOutcomes: By the end this course the students will be able to	
CO1	Form optimization lmodelof linear problems
CO2	Form optimization lmodelof nonlinear problemsandalso distinguishbetweenlinearandnonlinearmodels
CO3	Solvecomplexproblemsbybreakingthemdownintosub-problems usingdynamicprogramming
CO4	Solverealworldconstrainedoptimizationproblemsusinggeneticalgorithm,simulatedannealingand particle swarmoptimization

TextBooks:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Optimization: Theory and Practice by Singrieshu S. Rao	2013

ReferenceBooks:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Convex Optimization by Stephen byodCambridge University Press	**2004**

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://nptel.ac.in/courses/111105039	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	-	1	2	1	-	-	-	-	-	2	2	2	-
CO2	2	2	-	1	2	1	-	-	-	-	-	2	2	2	-
CO3	1	1	-	1	2	1	-	-	-	-	-	2	2	2	-
CO4	2	1	-	1	2	1	-	-	-	-	1	2	2	2	-

Course Name	**:**	**CAD of Electrical Machines**
Course Code	**:**	**EEE1002**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives :

Students should be able to:

- Explore design process for electric motors, generators and transformers based upon fundamental theories.
- Design transformer and rotating machines.
- Analyze the performance of electrical machines
- Apply computer aided optimization techniques for design of electrical machines

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Introduction** Basic principles of electrical machine design, Materials used in electrical machines, Choice of specific electrical and magnetic loadings, Magnetic circuit calculations, Thermal considerations, Heat flow, Temperature rise, Rating of machines, Heating-Cooling, losses, temperature rise.	**6**
Unit 2	**Design of transformers** Sizing of a transformer, Main dimensions, kVA output for single- and three-phase transformers, Window space factor, Overall dimensions, Operating characteristics, Voltage regulation, No load current, Temperature rise in transformers, Design of cooling tank, Methods for cooling of transformers.	**14**
Unit 3	**Design of rotating machines** General concepts and constraints of design of rotating machines. Design of squirrel-cage and wound rotor type three Phase induction motors. Design of stator and its windings, slot and its insulation, squirrel – cage motor and slip-ring motor rotor design, Operating characteristics. Introduction to design concepts of synchronous machines vis a vis induction machine.	**12**
Unit 4	**Computer aided design of Transformer and Rotating Machines and Optimization techniques** Need for Computer aided design. selection of input data and design variables, flow chart for design of transformer and rotating machines, Application of software for design implementation of Transformer and rotating machines. Design optimization objectives and constraint functions, constrained and unconstrained minimization, flow chart development for design optimization of electrical machines.	**10**

List of Experiments:		**Number of Turns**
1	Winding design and drawing of DC machine.	02
2	Winding design and drawing of AC machine	02
3	Design and development of Electromagnet in Maxwell 2-D and 3-D and	02

	force calculation in coil and slug	
4.	Simulation of eddy current losses for both linear and non-linear magnetic materials by using eddy current solver.	01
5.	Computer aided design of a of single phase and three phase transformers	02
6.	Computer aided design of induction machine	02
7.	Computer aided design of dc machine	02
8.	Computer aided design of synchronous machine.	01

Course Outcomes: By the end this course the students will be able to	
CO1	Choose various parameters and Design transformers.\
CO 2	Choose various parameters and Design rotating machines.
CO 3	Evaluate the performance of transformer and rotating machines ..
CO 4	Implement design of Transformer and Induction Machine using any software

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	A.K.Sawhney, A course in Electrical Machine Design , DhanpatRai& Sons	2005

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1.	Say M.G, "The performance and design of AC machines", CBS publishers and distributors.	2002
2.	Veinott C.G, "Computer aided design of electrical machinery", MIT Press.	1987
3.	Sen S.K, "Principle of electrical machine design with computer programs", Oxford and IBH company Pvt Ltd.	2001

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Computer-Aided Design of Electrical Machines By Prof. Bhim Singh | IIT Delhi	Swayam
2	Transformer design - https://youtu.be/U8MzjXZt0tM	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	-	2	-	1	-	1	-	1	1	1	1	-
CO2	1	1	2	-	2	-	1	-	1	-	1	1	-	-	1
CO3	-	-	2	-	-	2	1	-	-	-	-	-	-	3	-
CO4	-	-	3	-	3	-	-	-	1	-	1	2	-	3	3

CourseName	**:**	**MedicalInstrumentation**
CourseCode	**:**	**EEE1003**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to

- Acquire the knowledge of human anatomy and physiology.
- Understand the operation of various medical instruments for monitoring and therapeutics.
- Measure and analyzethe various medical signals using transducers.
- Evaluate the performance of bio-medical telemetry and telemedicine devices.

TotalNo.ofLecture- 42

LectureWiseBreakup		**Number ofLecture**
Unit 1	**IntroductiontoBioInstrumentation** Problemsencounteredinmeasuringalivingsystem,electricshockhazards,safetycodesforelectro-medicalequipment.	03
Unit 2	**SourcesofBioelectricPotentials and electrodes** Restingandactionpotentials,propagationofactionpotential,thebioelectricpotentialwithspecialreferencetoECG,EEG andEMG.Recordingelectrodes,electrical conductivityofelectrodes,jelliesandcreams	08
Unit 3	**TransducersinMedicalEquipments** Displacement,pressure,bodytemperaturemeasurement,photoelectrictransducers,opticalfiber Sensors	04
Unit 4	**BiomedicalRecorders** Electrocardiograph,electroencephalograph,electro-myographbiofeedbackinstrumentation	04
Unit 5	**PatientMonitoringSystem** Systemconcepts,cardiacmonitor,bedsidepatientmonitoringsystem,measurementofheartrate,pulserate,bloodpressuremeasurement,temperature,respiratoryrate, catheterizationoflaboratoryinstrument. **MethodsofHeatingTissues** Physiological effect of heat, short wave biotherapy, Infra-redradiation,microwave diathermy,surgicaldiathermy. **BiomedicalTelemetryandTelemedicine** Introductionandapplicationtobiomedicalengineering.	10
Unit 6	**ModernImagingSystem** Computedtomography,magneticresonanceimagingsystem,thermalcamerabasedonIRsensors,imagereconstructiontechniques.	08
Unit 7	**TherapeuticEquipments** Pacemakers,cardiacdefibrillators,painreliefthroughelectricalstimulation,hemodialysismachine, electronicsinanaerheticmachine	05

ListofExperiments:		**Number ofTurns**
1	TostudytheECGmachine,pickupECGsignal,displayitonCROandtofindthedurationofP,R, andT Waves.	02
2	Toplotexperimentallytherelationshipbetweenthesurface EMGand muscularforce.	02
3	Topickup EEGsignalsand studytheir patterns.	02
4	TostudyanMRI systemavailable inthefield.	02
5	Tostudythefrequencyspectrumof EMGonadisplaydeviceusingamoveablebandpassfilter.	02
6	Visittoamedicalequipment manufacturingindustry	02
7	Visittoahospital/clinictostudyvariouspatientmonitoringequipmentanduseoftelemetryin Medicine	02

CourseOutcomes: By the end this course the students will be able to	
CO1	Understand anatomical and physiological system of body
CO2	Identify the various bio signal sources
CO3	Use the appropriate diagnostic and monitoring systems
CO4	Apply telemetry and telemedicine systems for patient monitoring

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	Bioinstrumentation,JohnG.Webster,JohnWiley&Sons	2004
2	BiomedicalInstrumentationandMeasurementsbyLeslieCromwell,FredJ.Weibell&ErichAPfeiffor,2nd edition, PHI	2015

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	HandbookofBiomedicalInstrumentationbyKhandpur, McGrawHillsEducation	2014

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	https://onlinecourses.nptel.ac.in/noc22_bt56/preview	NPTEL
2	https://onlinecourses.swayam2.ac.in/nou23_bt05/preview	Swayam

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**-**	**2**
CO2	**1**	**1**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**3**	**2**	**-**	**2**
CO3	**1**	**1**	**3**	**-**	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**3**	**2**	**2**	**2**
CO4	**1**	**1**	**3**	**2**	**2**	**2**	**-**	**2**	**3**	**3**	**2**	**3**	**2**	**3**	**2**

CourseName	**:**	**NeuralNetworksandFuzzySystems**
CourseCode	**:**	**EEE1004**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentsshouldbeableto:

- Acquiretheknowledgeofneuralnetworks and its different structure,development, implementationof different algorithm.
- Design ofneural networksfordifferentapplications.
- Acquiretheknowledgeoffuzzy systems and its differentstructure.
- Design offuzzy systemsfordifferentapplications.

TotalNo.of Lectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction and FundamentalModelsofANN** Biologicalneuron,modelsofArtificialNeuralNetworks(ANN),characteristicsof neuralnetworks,differenttypesoflearningofneural network. Mcculloch–Pitts,Hebbian,Perceptron,Delta,Adaline,Madaline:architecture,algorithmandapplications.	09
Unit 2	**FeedForward and FeedbackNetworks** Backpropagation,Radialbasisfunction:architecture,algorithmandapplications. Hopfieldnet:architecture,trainingalgorithmandapplicationfordiscreteandcontinuous net.	08
Unit 3	**Self-OrganizingFeatureMap and AssociativeMemoryNetworks** Kohonenself-organizingmaps,LearningVectorQuantization(LVQ),Maxnet,Hammingnet-architecture, algorithmandapplications. Hetero,autoandbi-directionalassociative networks:architecture,algorithmandapplications.	08
Unit 4	**IntroductionofFuzzySystems** Fuzzylogic,classicalsetsandfuzzysets,operationson fuzzysets,propertiesof fuzzysets,crispandfuzzyrelations,membershipfunctions,fuzzification,defuzzification.	09
Unit 5	**FuzzyRuleBasedSystem and ApplicationsofFuzzy Logic** Formationofrules,decompositionofrules,aggregationandpropertiesoffuzzyrules,fuzzyinference system. Fuzzylogic applications invarious areasincludingpowersystems,imageprocessing, control systems,industriesetc.	08

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Haveknowledgeofconcepts,differentstructure and implementationofalgorithm.
CO2	Design applicationsofneural networks.
CO3	Applytheconceptsandrulebasedfuzzylogicsystem.
CO4	Designandimplementationoffuzzylogiccontrollersin engineeringareas.

TextBooks:

Sr.No.	NameofBook/Authors/Publisher	Year ofPublication/ Reprint
1	FundamentalofNeuralNetworks-Architectures,Algorithm andApplicationsbyLaureneFausett, Pearson.	1993
2	NeuralNetworks- AcomprehensivefoundationbySimonHaykin,MacmillanPublishing Company,NewYork.	1994
3	FuzzyLogicwithEngineeringApplicationsbyTimothyJ RossWileyStudentsEdition.	2010

ReferenceBooks:

Sr.No.	NameofBook/Authors/Publisher	Year ofPublication /Reprint
1	NeuralNetworks-AclassroomapproachbySatishKumar,TheMcGraw-HillCompanies.	2005
2	IntroductiontoNeuralNetworksusing MATLABby S NSivanandam,S SumatiandSNDeepa, TataMcGrawHill.	2006
3	IntroductiontoFuzzyLogicusingMATLABbySNSivanandam,SSumatiandSNDeepa, Springer.	2007

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Fuzzy Logic and Neural Networks, Prof. Dilip Kumar Pratihar | IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_ge07/preview	NPTEL
2	Fuzzy Logic Prof. Nishchal K. Verma, IIT Kanpur http://www.iitk.ac.in/idea/ee658.html	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	-	-	1	-	-	1	-	-	1	3	2	2
CO2	2	3	3	-	2	3	3	-	1	2	2	1	3	3	3
CO3	2	1	-	-	-	1	-	-	1	-	-	1	3	2	2
CO4	3	3	3	-	2	3	3	-	1	2	2	1	3	3	3

Course Name	**:**	**Digital Signal Processing**
Course Code	**:**	**EEE1005**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

Course Objectives:

Students should be able to

- Understand the concept of digital signal processing for various process controls.
- Acquire the knowledge of signal and signal processing.
- Signal and its time domain representation and transformations.
- Understand the principles of digital filters and their design.

Total No. of Lectures-42

Lecture Wise Breakup		**Number of Lectures**
Unit 1	**Signal & Signal Processing** Introduction to basic principles signal processing operations and its applications, Signals and functions in signal processing	08
Unit 2	**System and their properties** Properties of the systems: Linearity, Casuality, Time – variance, Convolution, Stability , memory	10
Unit 3	**Transformations** Discrete-time Fourier transform, discrete Fourier transform, computation of the DFT of various functions, properties of DFT, FFT , Butterfly diagrams and introduction to different FFT algorithms, the z- transform, inverse z-transform, Region of convergence (ROC), Causality and Stability	12
Unit 4	**Design of digital filters** Design of Butterworth and Chebyshev filters,IIR and FIR filters structures , design using Bilinear transformation , Frequency transformation technique, design of FIR filters using window function	12

Course Outcomes: By the end of this course, the students will be able to	
CO1	Apply knowledge of digital signal processing for various process controls.
CO2	Understand signal and signal processing techniques.
CO3	Apply time domain representation, and transformation techniques
CO4	Design filters .for their projects and research application

Text Books:

Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	Sanjit K. Mitra, “Digital Signal Processing”, Tata McGraw Hil	2001
2	A. Antoniou, “Digital Filters: Analysis & Design”, McGraw Hill book company	2001

Reference Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	S.D. Stearns, “Digital Signal Analysis”, Prentice Hall Inc	1990

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Digital Signal Processing, ,Prof. S.C. Dutta Roy | IIT Delhi https://nptel.ac.in/courses/117102060	NPTEL
2	***Flipped learning through NPTEL*** *Z-transform: lecture 5* **http://surl.li/moboc**	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**3**	**2**	**2**	**-**	**2**	**-**	**-**	**-**	**3**	**1**	**3**	**-**	**2**	**2**
CO2	**2**	**3**	**2**	**-**	**-**	**1**	**-**	**2**	**-**	**2**	**1**	**3**	**-**	**2**	**2**
CO3	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**3**	**-**	**2**	**2**
CO4	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**3**	**-**	**2**	**2**

Course Name	**:**	**Signals and Systems**
Course Code	**:**	**EEE1006**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

Course Objectives:

Students should be able to

- Acquire the knowledge of classification of signals
- Understand LTI systems, impulse response, sampling, and its applications.
- Analysis of LTI system using convolution.
- Understand the concept of Fourier series, Fourier transforms, Laplace transforms, z-transforms.

Total No. of Lectures-42

Lecture Wise Breakup		**Number of Lectures**
Unit 1	**Types of Signals & Systems and Their Representation** Continuous-time and discrete-time signals, energy and power of signals, periodic-aperiodic signals, even-odd signals, standard signals: unit impulse, unit step, ramp, exponential and sinusoids. Transformations of the independent variable, continuous and discrete time systems, system properties.	08
Unit 2	**LTI Systems** Impulse response, convolution integral and convolution sum, LTI systems' properties, LTI system characterization by linear constant coefficient difference equation.	06
Unit 3	**Fourier Series and Fourier Transform of Signals** Fourier series representation of continuous and discrete time periodic signals, convergence, properties of Fourier series, Fourier series and LTI systems, application of Fourier series in filtering, Fourier transform representation of continuous and discrete time signals, Fourier transform properties, Hilbert transform and its properties, system characterization by linear constant coefficient difference equation.	12
Unit 4	**Laplace and Z-Transform** The Laplace transform, region of convergence, properties of Laplace transform, initial and final value theorems, inverse Laplace transform, system functions, poles and zeros of system functions, analysis and characterization of LTI systems using Laplace transform, z-transform, region of convergence and pole-zero plot for z-transform, properties of z-transform, inverse z-transform, analysis and Characterization of LTI systems using z-transform, stability criterion.	12
Unit 5	**Sampling and Reconstruction** Sampling theorem, classification of sampling, aliasing, anti-aliasing filter, analog to digital conversion, signal reconstruction	4

Course Outcomes: By the end of this course, the students will be able to	
CO1	Acquire knowledge of various signals and systems,.
CO2	Understand convolution, LTI systems
CO3	Analyze the spectral characteristics of signals using Fourier series
CO4	Apply the concept of Fourier transforms, Laplace transforms, z-transforms, and sampling for project implementation

Text Books:

Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication/ Reprint**
1	S. Haykin and B. Van Been, "Signals and Systems" , John Wiley & Sons, 2nd Edition	2003
2	B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2nd edition	2006

Reference Books:

Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication/ Reprint**
1.	Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, "Signals and Systems", Prentice Hall, 2nd Edition	1997

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	**Flipped learning through NPTEL** Z-transform definition and RoC (Lecture 20) **http://surl.li/mocdi**	NPTEL
2	Signals and Systems, Prof. Kushal K. Shah | IISER Bhopal https://onlinecourses.nptel.ac.in/noc21_ee28/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**2**	**2**	**-**	**2**	**-**	**-**	**-**	**3**	**1**	**3**	**-**	**2**	**2**
CO2	**2**	**3**	**2**	**-**	**-**	**1**	**-**	**2**	**-**	**2**	**1**	**3**	**-**	**2**	**2**
CO3	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**3**	**-**	**2**	**2**
CO4	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**3**	**-**	**2**	**2**

CourseName	**:**	**PLC&SCADA**
CourseCode	**:**	**EEE1007**
Credits	**:**	**4**
LTP	**:**	**4-0-0**

CourseObjective:

Studentsshouldbeableto

- Acquiretheknowledgeofvariousskillsnecessaryforindustrial applicationsofPLC
- Learn Programming of PLC
- Acquiretheknowledgeofdataacquisitionsystemandcommunicationnetworksusingstandarddevices,
- Acquire knowledge of SCADA

TotalNo.ofLecture-56

LectureWiseBreakup		**Number ofLecture**
Unit 1	**ComputerBasedControl** Implementingcontrolsystemusingcomputerormicroprocessor,computer-basedcontroller,hardwareconfigurationandsoftware requirements **DistributedControlSystem** Meaningandnecessityofdistributedcontrol,hardwarecomponentsofDCS,DCSsoftware	06
Unit 2	**IntroductiontoPLC** PLCvsmicroprocessor/microcontroller/computer,advantagesanddisadvantagesofPLC,architectureandphysicalformsofPLC **BasicPLCFunctions** Registers:holding,inputandoutputregisters,timersandtimerfunctions,countersandcounterfunctions	06
Unit 3	**IntermediatePLCFunctions** Arithmeticfunctions:addition,subtraction,multiplication,divisionandotherarithmeticfunctions,number comparisonandconversion **DataHandlingFunctionsofPLC** Skipfunctionandapplications,mastercontrolrelayfunctionandapplications,jumpwithnon-returnand return, datatable, registerand othermovefunctions	10
Unit 4	**BitFunctionsofPLC** Digitalbitfunctionsandapplications,sequence functionsandapplications **AdvancedFunctionsofPLC** Analoginputandoutputfunctions,analoginputandoutputmodules,analogsignal processinginPLC,PIDcontrolfunction, networkcommunication function	12
Unit 5	**PLCProgramming** PLCprogramminglanguages,ladderprogramming,mnemonicprogrammingandhighlevellanguageprogramming	10
Unit 6	**SCADA** Supervisorycontrolvsdistributedcontrol,layoutandpartsofSCADAsystem,detailedblockschematic of SCADA system; Functions of SCADA system: data acquisition, monitoring, control, datacollection and storage, data processing and calculation, report generation; MTU: functions, single anddualcomputerconfigurationsofMTU;RTU:functions,architecture/layout; MTU-RTU communicationandRTU-fielddevicecommunication;applicationsofSCADA	12

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Gainknowledgeofvariousskillsnecessaryforindustrialapplicationsof PLC
CO2	Understandthebasicprogrammingconceptsandvariouslogicalinstructionsusedin PLC

CO3	Solvetheproblemsrelatedto I/Omodule,dataacquisitionsystemandcommunicationnetworksusingstandard devices
CO4	Designandanalysisofgeneralstructureofanautomatedprocessforrealtimeapplicationusing PLCand SCADA

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	Digital Controland StateVariableMethodsbyM. Gopal,TataMcGrawHills,3rdEdition	2008
2	OptimalControlTheory: AnIntroductionbyD.E.Kirk,DoverPublications	2004

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	ProgrammableLogicControllersProgrammingMethodsandApplicationsbyJohnHackworth	2008
2	Mechatronics,Tilak Thakur, Oxford university press	2023

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Industrial Automation and Control Prof. S. Mukhopadhyay, **IIT Kharagpur** **https://nptel.ac.in/courses/108105088**	**NPTEL**
2	Industrial Automation with PLC & SCADA Arumugam J, Scientist 'D' **http://nielit.gov.in/calicut/calicut/calicut/content/online-course-industrial-automation-plc-scada**	**NIELIT**
3	NPTEL Mechatronics Lecture 33 : Program Logic Controllers Prof. Pushparaj Mani Pathak, **IIT Roorkee** **https://www.youtube.com/watch?v=MS3qJq2jvu0**	**NPTEL**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	-	-	1	1	1	-	-	2	2	3	2	3	3
CO2	1	1	-	-	3	-	-	-	2	2	2	3	2	3	3
CO3	1	1	-	-	3	-	-	-	2	2	2	3	2	3	3
CO4	-	-	-	-	3	-	-	-	2	3	3	3	2	3	3

CourseName	**:**	**EnergyManagementandEnergyAudit**
CourseCode	**:**	**EEE1008**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeableto

- To impart the knowledge regarding energy conservation opportunity in various system.
- To impart the knowledge of energy conservation, energy auditing
- Acquire concept of recycling for energy saving.
- To impart the knowledge of energy monitoring and targeting for industrial application.

TotalNo. ofLectures-42

LectureWiseBreakup		**Number ofLecture**
Unit1	**EnergyScenario** Commercial and non-commercial energy, primary energy resources, commercial energy production,final energy consumption, energy needs of growing economy, long term energy scenario, energypricing, energy sector reforms, energy and environment, energy security, energy conservation and itsimportance,restructuringoftheenergysupplysector,energystrategyforthefuture, airpollution,climatechange.EnergyConservationAct-2001and Electricity Act-2003 itsfeatures.	06
Unit 2	**BasicsofEnergy anditsVariousForms** Electricitytariff,loadmanagementandmaximumdemandcontrol.Thermalbasics:fuels,thermalenergycontentsof fuel,temperatureandpressure,heatcapacity,sensibleandlatentheat,evaporation,condensation,steam,moistairandhumidity,heattransfer,unitsandconversion.	07
Unit 3	**EnergyManagementandAudit** Definition,energyaudit,need,typesofenergyaudit.Energymanagement(audit)approachunderstanding energy costs, benchmarking, energy performance, matching energy use to requirement,maximizingsystemefficiencies,optimizingtheinputenergyrequirements,fuelandenergysubstitution,energyauditinstruments.Materialandenergybalance:facilityasanenergysystem, methodsforpreparingprocessflow, materialandenergybalancediagrams.	06
Unit 4	**EnergyEfficiencyinElectricalSystems** Electrical system: electricity billing, electrical load management and maximum demand side management control, powerfactor improvement and its benefit, selection and location of capacitors, performance assessment of PFcapacitors,distributionandtransformerlosses.Electricmotors:types,lossesinductionmotors,motorefficiency,factorsaffectingmotorperformance,rewindingand motorreplacementissues,energysavingopportunitieswithenergyefficientmotors.	07
Unit 5	**EnergyEfficiencyinIndustrialSystems** Compressedairsystem:typesofaircompressors,compressorefficiency,efficientcompressoroperation, compressed air system components, capacity assessment, leakage test, factors affecting theperformance and savings opportunities in HVAC. Fans and blowers: types, performance evaluation,efficient system operation, flow control strategies and energy conservation opportunities. Pumps andpumping system: types, performance evaluation, efficient system operation, flow control strategies andenergyconservationopportunities.Coolingtower:typesandperformanceevaluation,efficientsystemoperation,flowcontrolstrategiesand energysavingopportunities,assessmentofcoolingtowers.	08

Unit 6	**EnergyEfficientTechnologiesinElectricalSystems** Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starterswith energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancysensors,energyefficientlightingcontrols,energysavingpotentialofeachtechnology.	08

ListofExperiments(Any10to beperformed):		**Number ofTurns**
1	ToMeasurethebatterycharge-dischargecapacityofsecondarybatteries.	01
2	Tostudyand measuregroundresistance	01
3	Tostudyand measureinsulationresistanceofwire.	01
4	Tostudyand measureleakage currentinACcircuits	01
5	Tostudyandmeasurehighpower inACcircuits	01
6	Tostudyandmeasurewindvelocityatdifferentlocation	01
7	Tostudyandmeasurehumidityand temperatureofdifferentlocation	01
8	Tostudyandmeasureenergylossin ACcircuits	01
9	Tostudyandmeasuredipsand swellsin ACcircuits	01
10	TostudyandmeasurepowerandenergyinACcircuits	01
11	TostudyandmeasurepowerinverterefficiencyinACcircuits	01
12	TostudyandmeasureharmonicsinACcircuits	01
13	TomeasureinrushcurrentinACcircuits	01
14	Electricaltariffcalculation	01
15	TostudyandmeasureunbalanceinACcircuits	01
16	TostudyandmeasurepowerqualityinACcircuits	01
17	Tomeasurethevibration(frequency)intensityindifferentmachine.	01
18	Tomeasurethelightintensityindifferentplace.	01
19	Tomeasurethefluegasesindifferenttypesof fuels.	01

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Applythe fundamentalknowledgeofenergymanagement.
CO2	Applyconceptofstrategiesandplanningforenergyconservation
CO3	Apply concept of recycling for energy saving, monitoring and targeting.
CO4	Performenergyauditin theday-to-day activities involving industries,buildingsand any field oflifewhereenergy isinvolved.

Text Books:

Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	HandbookonEnergyAuditandEnvironmentManagementbyAbbi,Y.P.andJain,S,Teri Bookstore	2006
2	HandbookofEnergy Auditsby AlbertThumann,TerryNiehusand W.Younger,CRCPress	2008
3	EnergyEngineeringandManagementbyAmlanChakrabarti,2nd Edition,PHILearningPvt.Ltd.	2018
4	EnergyManagementPrinciples:Applications,Benefits,Savings,Elsevier	2016

Reference Books:

Sr.No.	NameofBook/Authors/Publisher	Yearof Publication/ Reprint
1	IndustrialEnergyManagement:PrinciplesandApplicationsbyGiovanniPetrecca,TheKluwer internationalseries-207	1999
2	EnergyManagementHandbookbyW.C.Turner,JohnWileyandsons.	2004
3	UtilizationofElectricalEnergyandConservationbyS.C.Tripathy,McGrawHill,	1991
4	GuidebooksforNationalCertificationExaminationforEnergyManagersandEnergyAuditors byBureauofEnergyEfficiency(BEE)(4books).Availableonlinefordownloadathttps://beeindia.gov.in/content/energy-auditors	

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://archive.nptel.ac.in/courses/108/106/108106022/	NPTEL
2	https://onlinecourses.swayam2.ac.in/nou23_es05/preview	SWAYAM
3	https://www.classcentral.com/course/swayam-basic-principles-of-energy-management-energy-audit-204235	
4	https://beeindia.gov.in/sites/default/files/1Ch3.pdf	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	-	1	-	2	3	2	3	2	3	1	1	2
CO2	1	1	1	-	1	-	2	3	2	3	3	3	1	2	3
CO3	1	1	1	-	2	-	2	3	2	3	3	3	1	2	3
CO4	2	2	1	2	2	-	3	3	3	3	3	3	2	3	3

Course Name	**:**	**Smart Grid Technologies**
Course Code	**:**	**EEE1009**
Credits	**:**	**4**
L T P	**:**	**4-0-0**

Course Objectives:

Students should be able to:

- Understand the importance and functionalities of smart grid in the modern power systems.
- Analyze the importance of emerging market of energy storage and explore the energy storage technologies for smart grids.
- Understand the need, operation, protection and control of microgrids.
- Understand the power quality issues with high penetration of renewable energy sources.
- Acquire the knowledge and implementation of smart grid communication technologies for various applications.

Total No. of Lectures – 56

Lecture wise breakup		**Number ofLectures**
Unit 1	**Introduction to Smart Grid** Evolution of electric grid, concept of smart grid, definitions, need of smart grid, functions of smart grid, opportunities & barriers of smart grid, difference between conventional & smart grid, concept of resilient & self-healing grid, present development & international policies in smart grid	**9**
Unit 2	**Smart Grid Technologies: Part 1** Introduction to smart meters, real time/dynamic pricing including ToD pricing, Automatic meter reading (AMR), advanced metering infrastructure (AMI), power management and management of peak load using smart grid technologies, plug in hybrid electric vehicles (PHEV), vehicle to grid, smart sensors, smart appliances and building management systems (BMS), energy management systems (EMS), demand response, outage management system (OMS), asset optimization using smart grid technologies, customer empowerment and engagement using technology and interactive applications and business analytics, work force management and field force automation.	**11**
Unit 3	**Smart Grid Technologies: Part 2** Smart substations, substation automation, feeder automation, SCADA, assessment management through condition based monitoring, geographic information system (GIS), intelligent electronic devices (IED) & their application for monitoring & protection, grid storage like battery, / SMES, /pumped hydro, / compressed air energy storage, thermal storage, wide area measurementsystem (WAMS), phase measurement unit(PMU).	**10**
Unit 4	**Distributed Energy Resources and Micro Grids** Introduction to Distribution Energy Sources, Concept of micro grid, need & applications of micro grid, formation of micro grid, issues of interconnection, protection & control of micro grid. Power quality & EMC in smart grid, power quality issues of grid connected renewable energy sources, power quality conditioners for smart grid.	**17**
Unit 5	**Information and Communication Technology for Smart Grid** Home Area Network (HAN), / Neighborhood Area Network (NAN), / Wide Area Network (WAN). Different Communication Technologies and Protocols	**9**

	like Bluetooth, /Zig-Bee, /GPRS, /Wi-Fi, /Wi-Max/RF/PLC based communication, mesh communication network etc., integrated communication infrastructure with integrated network monitoring system, basics of CLOUD computing & cyber security for smart grid Case study of Smart Grid	

Course Outcomes: By the end of this course, the students will be able to	
CO1	Understand the smart grid technologies and its field applications.
CO2	Analyze the role of automation in the transmission and distribution systems.
CO3	Evaluate the energy storage system for optimizing renewable energy in smart grid.
CO4	Analyze the need, operation and control of microgrids.
CO5	Understand and conceptualize the design of smart grid by selecting appropriate communication technologies.

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	James A. Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley-IEEE Press	2012

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.	2012
2	Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley.	2009
3	JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications", Wiley.	2012
4	Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell.	2012
5	Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7).	2006
6	Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities".	2010

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Smart Grid: Basics to Advanced Technologies, IIT Roorkee Prof. N. P. Padhy, Prof. Premalata Jena https://onlinecourses.nptel.ac.in/noc23_ee60/preview	NPTEL
2	Smart Grid Technologies by Jaydeep Shah https://www.udemy.com/course/smart-grid-technologies/?utm_source=adwords&utm_medium=udemyads&utm_campaign=DSA_Catchall_la.EN_cc.INDIA&utm_content=deal4584&utm_term=_._ag_82569850245_._ad_533220805577_._kw__._de_c_._dm__._pl__._ti_dsa-	Udemy

	52949608673_._li_9143984_._pd__._&matchtype=&gad_source=1&gclid=CjwKCAjwnOipBhBQEiwACyGLuuL6TQY57R0PyGnf3OEywAicd0TDUF91V6ZOZV9MqhF2VdG69aYJRBoCqikQAvD_BwE	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO	PSO3
CO1	**2**	**1**	**1**	**-**	**1**	**-**	**2**	**1**	**-**	**1**	**-**	**1**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**1**	**2**	**-**	**2**	**1**	**-**	**1**	**-**	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**-**	**2**	**-**	**2**	**1**	**-**	**1**	**-**	**2**	**3**	**2**	**2**
CO4	**3**	**3**	**2**	**1**	**2**	**-**	**2**	**1**	**-**	**1**	**-**	**2**	**3**	**2**	**2**
CO5	**3**	**1**	**2**	**-**	**3**	**-**	**2**	**1**	**-**	**1**	**-**	**2**	**3**	**3**	**2**

CourseName	**:**	**AdvancedControlSystems**
CourseCode	**:**	**EEE1010**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentsshouldbeableto

- Impart the knowledge regarding energy conservation opportunity in various system.
- Impart the knowledge of energy conservation, energy auditing
- Acquire concept of recycling for energy saving.
- Impart the knowledge of energy monitoring and targeting for industrial application.

TotalNo.ofLectures–42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**StateVariableAnalysisandDesign** Introduction,conceptsofstate,statevariablesandstatemodel,statemodelsforlinearcontinuous-timesystems,statevariables,diagonalization,solutionofstateequations,conceptsofcontrollabilityand observability,differenttypesofcanonicalforms.	13
Unit 2	**ControlSystemDesigninStateSpace** Poleplacementdesignusingfullstatefeedback-regulatorandtrackingsystems,observers,fullorderand reducedorderobservers,observer basedcompensator design.	06
Unit 3	**OptimalControlSystems** Introduction,Parameteroptimization:servomechanisms,optimalcontrolproblems:statevariableapproach,thestateregulatorproblem,theinfinite-timeregulatorproblem,theoutputregulatorandthe trackingproblems.	09
Unit 4	**IntroductionofDigitalControl** Digital control systems: advantages and disadvantages of digital control, representation of sampledprocess, z-transform, z-transfer function, inverse-transform and response of linear discrete systems, z-transformanalysisofsampled-data controlsystems,z-ands-domainrelationship.	06
Unit 5	**NeuralNetworksandFuzzySystems** Introductiontoneuralnetworksandfuzzysystems,intelligentcontrol,modelsofneuralnetworksand Fuzzy controllers.	08

Course Outcomes: By the end of this course, the students will be able to	
CO1	Apply statevariableanalysisanddesign for a given system
CO2	Perform stability analysis of a given system
CO3	Apply concept of digitalandoptimalcontrolsystems.
CO4	Apply neuralandfuzzycontrollers

TextBooks:

Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	ModernControlSystemTheorybyMGopal,NewAgeIntl.Pvt.Ltd.	1993
2	ModernControlEngineeringbyKOgata.	2010
3	DiscreteTimeControlSystemsbyKOgata.	1995

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	Automatic Control systems by B C Kuo.	2009
2	Digital Control State variable methods by M Gopal.	2003

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Introduction to Digital Control. Dr. IndraniKar, Prof. S. Majhi | IIT Guwahati https://nptel.ac.in/courses/108103008	NPTEL
2	Fuzzy Logic and Neural Networks, Prof. Dilip Kumar Pratihar | IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_ge07/preview	NPTEL
3	***Flipped learning through NPTEL*** *State-Variable Methods (1) (Lecture – 45)* **https://www.youtube.com/watch?v=d34nosv-_uc**	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**2**	**1**	**3**	**2**	**2**	**2**
CO2	**2**	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**2**	**1**	**3**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**-**	**1**	**-**	**-**	**-**	**2**	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**-**	**2**	**-**	**-**	**-**	**2**	**2**	**2**	**3**	**2**	**2**	**2**

CourseName	**:**	**DigitalControlSystems**
CourseCode	**:**	**EEE1011**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeableto

- Acquire knowledge of discrete time representation
- Acquiretheknowledgeofdigitalcontrolsystems
- Acquire knowledge of various stability analysis techniques
- Designand analyzetheperformanceofdigitalcontrolsystems.

TotalNo.ofLectures-42

Lecture Wise Breakup		**Number of Lectures**
Unit 1	**IntroductiontoDigitalControlSystems** Discretetimesystemrepresentation,mathematicalmodelingofsamplingprocess.	05
Unit 2	**ModelingDiscrete-TimeSystemsbyPulse TransferFunction** Z-transform,mappingofs-planetoz-plane,pulsetransferfunction,relatedexamples.	07
Unit 3	**StabilityAnalysis** Jurystabilitytest, stabilityanalysisusingbi-lineartransformation,relatedexamples.	07
Unit 4	**TimeResponseAnalysis** Transientandsteadystateresponses,timeresponseparametersofasecondordersystem,relatedexamples.	07
Unit 5	**DesignofSampledDataControlSystems** Rootlocusmethod,controllerdesignusingrootlocus,nyquiststabilitycriteria,bodeplot,leadcompensatordesign,lagcompensatordesign,lag-lead compensatordesigninfrequencydomain.	10
Unit 6	**DeadbeatResponseDesign** Designofdigitalcontrolsystemswithdeadbeatresponse,practicalissueswithdeadbeatresponsedesign,sampleddata controlsystemswithdeadbeatresponse.	06

ListofExperiments		**Number ofTurns**
1	DiscretetimestatespacemodelingforSISOsystem.	01
2	DiscretetimestatespacemodelingforMIMOsystem.	01
3	TimeresponseanalysisofSISOdiscretetimesystem.	01
4	TimeresponseanalysisofMIMOdiscretetimesystem.	01
5	StabilityanalysisofSISOdiscretetimesystem.	01
6	StabilityanalysisofMIMOdiscretetime system.	01
7	Designofleadcompensatorfordiscretetimesystem.	01
8	Designoflagcompensatorfordiscretetimesystem.	01
9	DesignofLag-leadcompensatorfordiscretetime system.	01
10	Designofdigitalcontrolsystemswithdeadbeatresponse.	01
11	DesignofRootlocus fordiscretetimesystem.	01
12	ImplementationofBodeplotfordiscretetime system.	01
13	ImplementationofNyquistcriteriaondiscretetimesystem.	01
14	Project	01

CourseOutcomes: Bytheendofthiscourse,thestudentswillbeableto	
CO1	Applytheconceptsofsignalprocessingand digitalcontrol.

CO2	Applyz-transformationfordigitalcontrolsystem.
CO3	Designandanalyzethedigitalcontrolsystems.
CO4	Apply the knowledge acquired on various physical system

Text Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublicatio n/Reprint**
1	DigitalControlandStatevariablemethodsbyMGopal,TataMcGraw-Hillpublishingcompany limited.	2008
2	Discrete-TimeLinearSystems: TheoryandDesignwithApplications byG Gu,SpringerScience &BusinessMedia.	2012

Reference Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublicatio n/Reprint**
1	DiscreteTimeControlSystemsbyKOgata.	1995
2	Discrete Control Systems by Y Okuyama, Springer London.	2014
3	Advanced Discrete-Time Control by K Abidi, J X Xu, Springer Singapore.	2015

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Introduction to Digital Control, Dr. IndraniKar& Prof. S. Majhi | IIT Guwahati https://nptel.ac.in/courses/108103008	NPTEL
2	***Flipped learning through NPTEL*** *Time response analysis (week 4,5)* *Design of control systems(week 8-10)* **https://onlinecourses.nptel.ac.in/noc20_ee90/preview**	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**2**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**2**	**-**	**3**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**2**	**-**	**3**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**3**	**1**	**-**	**-**	**-**	**2**	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**2**	**2**	**2**	**3**	**2**	**2**	**2**

CourseName	**:**	**PowerConditioning**
CourseCode	**:**	**EEE1012**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Students should be able to

- Understand the various power quality problems
- Explore the causes of poor power quality and the impact of poor power quality.
- Analyze the operation of various power quality conditioners.
- Design and simulate the custom power devices for power quality improvement.

TotalNo.ofLectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**PowerQuality: An Introduction** Overview and definition of power quality (PQ), classification of power quality problems, causes of power quality problems, international powerquality standards and regulations, power quality monitoring, loads whichcausespowerqualityproblems,powerqualitymeasuresandstandards-IEEEguides,standardsand recommended practices, IEC standards, harmonics: important harmonic introducing devices, effect ofpower systemharmonicsonpowersystemequipmentandloads.	07
Unit 2	**Harmonic Problem and Passive Compensation Techniques** Harmoniceffectswithinthepowersystem,interferencewithcommunicationlines,harmonicmeasurements and formulations,harmonicelimination techniques. Introduction of passive compensation, classification of series and shunt compensators, principle of operation and design of passive compensators, limitations of passive filters, modeling, simulation, and performance of passive power filters, parallel resonance of passive filters.	09
Unit 3	**Power Control Theories for Active Compensators** Concepts and evolution of electric power theory, electricpower definitions; instantaneous powertheory: basis of the p-q theory, Clarke transformation, p-q theory application to 3φ-3 wire and 3φ-4wiresystems;modifiedp-qtheory,instantaneousabctheory,comparisonofp-qtheoryand Instantaneousabctheory,synchronousreferenceframetheoryandapplications.	09
Unit 4	**Active Power Compensators** Power factor correction, harmonic mitigation, zero voltage regulation, reactive power compensation, load balancing usingload compensation techniques: shunt and series active power filters, DSTATCOM (DistributionStaticCompensators),DVR(DynamicVoltageRestorers),UPQC(UniversalPowerQualityConditioners),	10
Unit 5	**Modelling and Simulation of Custom Power Devices** Modelling, simulation, and performance analysis of custom power devices using MATLAB/Simulink under different non-linear loads, modeling and simulation of hybrid power filters	07

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	To understand the various terminologies of power quality
CO2	To explore the causes of poor power quality and the effect of power quality on the electrical grid
CO3	To analyze the operation of various active and passive power quality compensators
CO4	To design and develop the custom power devices for power quality enhancement.

TextBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	H.Akagi,E.H.WatanabeandM.Aredes,"InstantaneouspowerTheoryandapplications to PowerConditioning,"IEEEPress,JohnWileyandSons.	2007
2	BhimSingh,AmbrishChandra,KamalAl-Haddad,"PowerQuality:ProblemsandMitigation Techniques,"Wiley.	2015

Reference Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	J.ArrilagaandN.RWatson,"PowerSystemHarmonics,"JohnWileyandSons.	2003
2	A.E.Emanuel,"PowerDefinitionsandthePhysicalMechanismofPowerFlow,"IEEEPress, JohnWileyand Sons.	2010
3	TP.S.Revuelta,S.P.Litrán,J.P.Thomas,"ActivePower Line Conditioners:Design,Simulation andImplementation,"Elsevierpublications.	2016

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Power Quality**By Prof. Bhim Singh | IIT Delhi** https://onlinecourses.nptel.ac.in/noc21_ee103/preview	NPTEL
2	NOC:Power Quality, IIT Delhi, Prof. Bhim Singh https://nptel.ac.in/courses/108102179	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO**	**PSO3**
CO1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**-**
CO2	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**-**	**2**	**2**	**1**	**2**	**2**	**2**	**-**
CO3	**3**	**3**	**2**	**1**	**2**	**2**	**1**	**1**	**-**	**2**	**2**	**2**	**2**	**2**	**1**
CO4	**3**	**2**	**3**	**2**	**3**	**1**	**1**	**-**	**2**	**2**	**3**	**2**	**3**	**3**	**1**

Course Name	**:**	**AdvancePowerElectronics**
Course Code	**:**	**EEE1013**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives :

Students should be able to

- Explore the switched mode power electronics switches
- Analyze the operation of various switched mode power converters, multilevel inverters and resonant inverters and their performance analysis.
- Apply the switched mode converters for different applications such as motor drive, EV charging and renewable integration.
- Design and develop the new power electronic converters for various practical applications

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Design Aspects** Selection of power switches for converters, linear regulators, design of magnetic: magnetic concept, inductor design, current, and potential transformer design, thermal design aspects.	07
Unit 2	**DC-DC Switched Mode Converters** DC steady state principle, Isolated Converters: Forward converter, push-pull converter, half-bridge converter, full-bridge converter, and fly back converter, bidirectional power supplies, small-signal analysis of DC-DC converters and closed-loop control.	07
Unit 3	**Soft-SwitchedConverters** Soft switching DC-DC converters: resonant converters, ZCS and ZVS topologies, generalized analysis of ZCS, zero voltage and zero current transition converters; voltage and current mode control of PWMconverters.	07
Unit 4	**MultilevelInverters** Multilevel inverters: introduction and basic concept, types of multilevel inverters (diode clamp, flyingcapacitor, and cascaded),switchingdevicecurrents,DC-linkcapacitorvoltagebalancing,featuresofmultilevel converters, applications of multilevel inverters, and advanced multilevel inverter topologies.	07
Unit 5	**ResonantInverters** Operating principle, wave forms analysis, switching trajectory, losses and control ofseriesandparallelresonantinverters,ZVSandZCSresonant Converters, Frequency response of resonant series loaded, parallel loaded, and series parallel- loaded inverter.	07
Unit 6	**Multi-pulse and Phase-shift AC-DCRectifiers** Multipulsemethodsforharmonicsreduction:introduction, principle ofcancellationofharmonics. Determinationofphaseshiftandvectorrepresentation,analysisof12-pulseconverter(Wye-Wyeand Wye-Delta)configurationfor30-degreephaseshift,introductiontoPWMrectifiers:powerfactorcorrected rectifiers.	07

List of Experiments:		Number of Turns
1	Tostudytheoperationofisolated DC-DCconverters.	02
2	Tostudytheoperationofnon-isolated DC-DCconverters.	01
3	Tosimulatetheresonantconverters.	01
4	Tosimulatethe fullbridgeconverters.	01
5	Tostudytheoperationofvoltagesourceandcurrentsourceinverter.	02
6	OperationofvariableDClink inverter.	01
7	Tostudytheoperationof multilevelinverter.	01
8	Tosimulatepowerfactorcorrectedrectifier.	01
9	Tosimulatetheresonantinverters.	01
10	Tostudytheoperationof3-phaselinecommutated rectifier.	01
11	Tostudytheoperationofpower factorcorrectedrectifier.	01
12	DSPbasedcontrolofPFCrectifier.	01
13	Tosimulatepowerfactorcorrectedrectifier.	01
14	Tosimulatetheresonantinverters.	01

Course Outcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand the switched mode power converters
CO2	Analyzethe operation of power converters like soft switched, multilevel inverter and resonant inverters.
CO3	Apply the knowledge of ZVS and ZCS for various power converters
CO4	Design of new/modified soft switched converters for EV charging and drives applications.

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	R.W.EricksonandDraganMaksimovic,"FundamentalsofPowerElectronics", KLUWER AcademicPublishers.	2004
2	MHRashid,"PowerElectronics:Circuits,DevicesandApplications",PrenticeHallofIndia PvtLtd.	2013
3	NMohan,T.M.Undeland and W.P.Robbins,"Power Electronics: Convertersapplicationsand design",JohnWileyandsons.	2006

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	B.R.Pelly,"ThyristorPhaseControlledConvertersandCycloconverters",John Wileyand sons.	1971
2	LGyugyiandB.R.Pelly,"StaticPowerFrequencyChangers",JohnWileyandSons.	1976
3	GuySeguier,ChristianRombautandRobertBausiere"PowerelectronicConverters:Volume 2AC-ACConversion",NorthOxfordAcademicPublishers.	1987

4	R.S.Ramshaw,"PowerElectronicSemiconductorswitches",ChapmanandHall.	1994
5	R.W.EricksonandDraganMaksimovic,"FundamentalsofPowerElectronics", KLUWERnAcademicPublishers2.	2004
6	MarianKKazimierczuk,"Pulse-widthModulatedDC–DCPowerConverters",JohnWileynandSons.	2008

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	NOC:Advance power electronics and Control, IIT Roorkee Prof. Avik Bhattacharya https://nptel.ac.in/courses/108107128	NPTEL
2	Power Electronics, IIT Kharagpur Prof. D.Prasad, Prof. N.K. De, Dr. D.Kastha, Prof. SabyasachiSengupta https://nptel.ac.in/courses/108105066	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**1**
CO2	**2**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**1**
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**-**	**-**	**2**	**2**	**2**	**2**	**2**	**2**	**-**
CO4	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**-**	**3**	**2**	**3**	**3**	**3**	**3**	**1**

CourseName	**:**	**ModellingandControlofPowerElectronicConverters**
CourseCode	**:**	**EEE1014**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to

- Apply various modelling techniques for power electronic converters.
- Analyze the control techniques designed for power electronic converters.
- Design the mathematical model and control for various power converters.

TotalNo.ofLectures- 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction to Modelling and Control** Modelling and control introduction for power converters and systems, overview of basic and advanced power electronic converters, various applications, types of power converter models. DC transformer model, loss modelling, dynamic modelling of the power converters, AC modeling of converters, state-space averaging.	08
Unit 2	**Modelling of Power Converters** Averaged switch modelling of DC-DC converters, Dynamic modelling of the power converters, AC modelling of converters, state-space averaging, Transfer functions and frequency domain analysis, simulation-oriented modelling, bond graph for modelling of DC-DC converter, lagrange method for modelling of DC-DC converter.	10
Unit 3	**Modelling of DC-AC Convertors** Inverter concepts and inverter topologies, multilevel inverter topologies, mathematical modelling of two level inverter, Pulse Width Modulation (PWM), voltage source and current source inverters, multilevel inverter modelling.	08
Unit 4	**Control of Power Converters** Control loop design, Digital control design, Feedback control design, voltage mode and current mode control, control of inverters and rectifiers, control challenges, limitations of analog control techniques, need for digital control in DC-DC converter.	08
Unit 5	**Implementation of Controllers** Analog and digital implementation of the controllers, advanced analysis and control techniques applied to power electronics converters, simulation validation of converter modelling.	08

CourseOutcomes: Bytheend ofthiscourse, thestudents willbeableto	
CO1	Remember the basic operation and modelling feasibility of power electronics systems
CO2	Analyze the complexity of the system and effective approach to overcome the problem.
CO3	Apply the knowledge of mathematics to design and understand the operation of power electronics system.
CO4	Design and model the power electronic converter with high performance in terms of stability, reliability and performance.

List of Experiments:		Number of Turns
1	Simulate and experimentally validate state space averaged model based voltage mode control of DC-DC convertors.	2
2	Simulate and experimentally validate state space averaged model based current mode control of DC-DC convertors.	2
3	Experimentally compare differences between analog and digitally implemented control of DC-DC convertors.	2
4	Simulate and experimentally validate advanced nonlinear control approaches for the control of DC-DC convertors.	3
5	Simulate and experimentally compare various multilevel inverter topologies with different PWM techniques.	3
6	Simulate and experimentally validate various control techniques for the control of DC-AC convertors.	2

TextBooks		
Sr.No	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1.	Control of Power Electronic Converters and Systems, Volume 1-3, FredeBlaabjerg. ISBN: 9780128052457, 978-0128161364, 978-0128194324	2018
2.	N.Mohan,"PowerElectronics-Converters,ApplicationsandDesign",3rdEd.,JohnWiley& Sons.	2003
3.	P.T.Krein,"ElementsofPowerElectronics,"NewYork:OxfordUniv.Press.	1998

ReferenceBooks		
Sr.No	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1.	M.H.Rashid,"PowerElectronics-circuits,Devices&Applications,"3rded.,PHI.	2005
2.	R.W.Erickson,D.Maksimovic,"FundamentalsofPowerElectronics",KluwerAcademicPublishers.	2004
3.	I.Batarseh,"PowerElectronicCircuits,"Wiley.	2004
4.	J.Kassakian,M.F.Schlecht,andG.C.Verghese,"PrinciplesofPowerElectronics", Addison-WesleyPublishingCompany.	1991
5.	D.GrahameHolmes,ThomasA.Lipo,"PulseWidthModulationforPowerConverters: PrinciplesandPractice,"Wiley.	2003
6.	V.Bobal,J.Bohm,andJ.Fessl,"DigitalSelf-TuningControllers:Algorithms,Implementation andApplications"1stEd.,Springer.	2005
7.	FrancescoVasca,LuigiIannelli,Eds.,"DynamicsandControlofSwitchedElectronicSystems:AdvancedPerspectivesforModeling,SimulationandControlofPowerConverters",Springer, 1stEd.	2012

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Digital Control in Switched Mode Power Converters and FPGA-based Prototyping “By Prof. SantanuKapat | IIT Kharagpur” https://onlinecourses.nptel.ac.in/noc22_ee124/preview	NPTEL
2	Advance power electronics and Control By Prof. Avik Bhattacharya | IIT Roorkee https://onlinecourses.nptel.ac.in/noc20_ee28/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	1	1	-	2	2	2	2	2	2	1
CO2	2	2	3	3	2	1	-	-	2	2	2	2	2	2	1
CO3	2	2	3	3	3	2	-	-	2	2	2	2	3	3	1
CO4	3	3	3	3	3	2	-	-	3	3	3	3	3	3	1

CourseName	**:**	**GridIntegrationofRenewable Energy Systems**
CourseCode	**:**	**EEE1015**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Students should be able to

- Acquire the knowledge of basic grid integration requirement and grid codes
- Understand the operation of solar and wind energy systems.
- Apply the synchronization techniques for integration of different renewable energy resources.
- Simulate the grid connected solar, wind and BES based systems.

TotalNo.ofLectures- 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Basic Requirement of Integration and Grid Codes** Basics of power processing – AC-DC conversion, DC-DC conversion, DC-AC conversion, AC-ACconversion; grid integration – operation paradigms of power systems, requirements for grid integration, issues inrenewableenergyintegrationto grid, power qualityissues.Gridstandardsandcodes,IEEEstandards 1547-2003 and 519-2014, demandsidemanagement,low/high voltage ride through conditions.	06
Unit 2	**Integration of Solar PV Systems** Configurations of grid connected solar PV systems, design aspects of grid connected solar PV system, various control aspects, maximum power point tracking, Grid following inverter control: control structure in stationary reference (α-β) frame,*d-q* control, instantaneous power theory based control, conventional droop control, and limitations of conventional droop control, multifunctional inverter for PV systems, parallel operation of inverters, grid forming inverter controls.	10
Unit 3	**Integration of Wind Energy Systems** Overview of wind turbine systems and configurations, Detailed analysis of doubly fed induction generator and PMSM based wind generators, Dynamic modeling of wind generators, Field oriented control of rotor side and grid side power converters, Control methods for maximum power extraction, active and reactive power control.	10
Unit 4	**Grid Synchronization Techniques** Conventional synchronization techniques: zero-crossing method, phase locked loop (PLL), PLL inthe synchronously rotating reference frame (SRF-PLL), second-order generalized integrator-based(SOGI-PLL),sinusoidaltrackingalgorithm,sinusoidal-lockedloops:single-phasesynchronous machine (SSM) connected to the grid, structure of a sinusoidal-locked loop, tracking of frequencyand phase, trackingofvoltageamplitude,parameterstuning.	10
Unit 5	**Grid Connected Microgrid System** Introduction to BES, Fuel Cell System, Design of Solar PV, wind, and BES assisted AC mircgrid system, control for AC microgrid system.	06

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand the role of different grid codes for the integration purpose.
CO2	Analyze the operation of solar, wind, and BES based renewable energy systems.
CO3	Apply the synchronization techniques to integrate the renewable energy sources with the electrical grid.
CO4	Design and develop the grid connected microgrid system in MATLAB.

Textbooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublicatio n/Reprint**
1	VittalV,AyyanarR,"GridIntegrationandDynamicImpactofWindEnergy",S pringer.	2012
2	RemusTeodorescu,MarcoLiserre,PedroRodriguez,"GridConvertersforPho tovoltaicand WindPowerSystems"Wiley-IEEEPress.	2011

Referencebooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublicatio n/Reprint**
1	Qing-ChangZhong,TomasHornik.,"ControlofPowerInvertersinRenewableEnerg yandSmartGridIntegration",Wiley-IEEE Press.	2012
2	AmirnaserYazdani,RezaIravani.,"Voltage-SourcedConvertersinPowerSystems: Modeling,Control,andApplications",Wiley-IEEEPress.	2012

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Sustainable Power Generation Systems By Dr. Pankaj Kalita | IIT Guwahati https://onlinecourses.nptel.ac.in/noc23_ge47/preview	NPTEL
2	NOC:Smart Grid: Basics to Advanced Technologies, IIT Roorkee Prof. N.P. Padhy, Prof. Premalata Jena https://nptel.ac.in/courses/108107113	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**1**
CO2	**3**	**2**	**3**	**2**	**2**	**2**	**3**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**1**
CO3	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**-**
CO4	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**3**	**2**	**2**	**2**	**3**	**2**	**1**

CourseName	**:**	**AdvancedElectricDrives**
CourseCode	**:**	**EEE1016**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able –

- To understand the modeling of electrical machines.
- To get the knowledge of different control techniques required for electrical machine.
- To apply the various control techniques to induction motor, synchronous motor and special motors.
- To design the advanced electrical drive for industrial applications.

TotalNo.ofLectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Modeling ofMachines** Generalized theory and Kron's primitive machine model (two axis model), modeling of DCmachines,modeling of three phase symmetrical induction machines (IM), synchronous machine modeling, Reference frame theory and per unit system	10
Unit 2	**Controlof InductionMotor Drive** Scalar control of induction motor, principle of vector control and field orientation, sensor less control (speed sensor less) and flux observers, direct toque and flux control, multilevel converter-fed induction motor drive, utility friendly induction motor drive.	12
Unit 3	**Control of Synchronous Motor Drive** Self-controlled synchronous motor, vector control of synchronous motor, cycloconverter-fed synchronous motor drive, control of synchronous reluctance motor.	10
Unit 4	**ControlofSpecialMotor Drive** Control of permanent magnet synchronous motor, Control of brushless DC motor, Controlofswitchedreluctancemotor(SRM)drives:switchinganglecontrol,current control,direct torquecontrol;closedloopspeedcontrolofSRM,convertersforsteppermotors,openloopandclosedloop controlofsteppermotors.	10

ListofExperiments:		**Number ofTurns**
1	TostudytheoperationofDC series,shuntandseparatelyexcitedmachine.	02
2	TosimulatestatefeedbackcontrolDCdrive.	01
3	Tosimulatesliding modecontrolofseparatelyexcitedDCmachine.	01
4	ToobtaintheperformanceDTCinduction motordrive.	02
5	Tosimulatevectorcontrolinductionmotordrive.	02
6	Toobtaintheperformanceofvectorcontrolledsynchronousmotordrive.	01
7	Toobtaintheperformanceofvectorcontrolled PMSMdrive.	01
8	ToobtaintheperformanceofvectorcontrolledPMBLDC motordrive.	01
9	Toobtaintheperformanceofswitchedreluctance motor.	01
10	Tosimulateclosed loopcontrolSRM.	01

11	Tosimulateclosedloopcontrolsteppermotors.	01

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understandthefundamentals of advancedelectricdrives and machine modeling
CO2	Get the knowledge of different control mechanism of induction motor, synchronous motor and special motors.
CO3	Apply the different control mechanism to electrical machines.
CO4	Design and develop the modern control techniques for industrial drive.

Textbooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	P.C.Krause,O.Wasynezuk,D.S.Sudhoff,"AnalysisofElectricMachineryAndDriveSystems," McGraw-Hill Book Company	2013
2	WernerLeonard,"ControlofElectricDrives,"Springer.	2000

Referencebooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	P.S. Bhimbra , "Generalized Theory of Electric Machines", Khanna Publication.	2001
2	R.Krishnan,"ElectricMotorDrives:Modeling,Analysis,AndControl,"PrenticeHall.	2001
3	P.Vas,"VectorControlofACMachines," ClarendonPressOxford.	1990
4	PeterVas,"SensorlessVectorandDirectTorqueControl,"OxfordUniversityPress.	1998

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Advanced Electric Drives, IIT Kanpur, Dr. S.P. Das https://nptel.ac.in/courses/108104011	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**-**	**1**	**2**	**2**	**2**	**2**	**2**	**1**
CO2	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**-**	**1**	**2**	**2**	**2**	**3**	**2**	**1**
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**2**	**2**	**2**	**2**	**1**
CO4	**3**	**2**	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**1**

CourseName	**:**	**Special Machine Drives**
CourseCode	**:**	**EEE1017**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentsshouldbeableto

- Explorethefundamentalsofspecial electrical machines and drives.
- Acquire the knowledge of permanent magnet machines, switched reluctance motor, and stepper motor drives.
- Understand the operation and control of permanent magnet machines, switched reluctance motor, and steeper motor drives.
- Apply the knowledge of drive control for industrial drives and related applications.

TotalNo.ofLectures-42

LectureWiseBreakup		**Numberof Lectures**
Unit 1	**Permanent Magnet Machines and their Control** Permanent Magnet Motors: Permanent Magnet Materials, Principles of Permanent Magnet Synchronous Motor and Brushless DC Motors. Dynamic Modelling of BLDC Motors, Control of Brushless DC Motor. Dynamic Modelling of PMSM, Vector Control of PMSM in Park Reference Frame. Sensor less control of Permanent Magnet Machines, Application of modern control theory to the sensor-less control of Permanent Magnet Machines	18
Unit 2	**Switched Reluctance Machines and their Control** Switched Reluctance Motor (SRM): Principle of Operation, Torque Production, and Modes of Operation. Power Convertors for SRM. Closed Loop Speed Control of SRM: design of current and speed loop, design of current controllers, flux linkage controller, torque control. Modeling and simulation of the SRM drive system. Sensor less operation of SRM drives: current sensing, rotor position measurement and estimation methods, sensor less rotor position estimation methods. Control of acoustic noise in SRM. Applications of SRM in low medium and high power and high speed drives.	18
Unit 3	**Stepper Motors and their Control** Principle of Operation and Types, Torque Production, Converters for Stepper Motors, Control of Stepper Motors.	08

CourseOutcomes:	
CO1	Understand the basic operation of special machine drives.
CO2	Analysethe performance and characteristics of special machine drive.
CO3	Evaluate the performance of various industrial drives using their control.
CO5	Design the control structure for special drives used industrial applications.

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year of Publication/ Reprint**
1	R Krishnan, “Switched Reluctance Motor Drives”, CRC Press 2001, ISBN 0-8493-0838-0.	2001
2	Werner Leonhard, “Control of Electric Drives” Third Edition, Springer, ISBN 3-540-4120-2.	

Reference Books:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year of Publication/ Reprint**
1	SadeghVaez-Zadeh, “Control of Permanent Magnet Synchronous Motors”, Oxford University Press, ISBN: 9780198742968	2018
2	ZiQiang Zhu, Xi Meng Wu, “Sensorless Control of Permanent Magnet Synchronous Machine Drives”, John Wiley IEEE Press, ISBN: 978-1-394-19436-0	2023

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Special Electromechanical Systems, IIT Delhi, Prof.Sreenivasa Murthy https://nptel.ac.in/courses/108102156	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	1	2	-	-	1	-	1	2	3	1	-
CO2	2	3	1	1	1	2	-	-	1	-	1	2	3	2	-
CO3	3	3	2	1	1	2	-	-	1	-	1	2	3	2	1
CO4	3	1	2	1	-	1	-	-	1	-	1	2	3	2	1

Course Name	**:**	**Power System Operation and Control**
Course Code	**:**	**EEE1018**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Course Objectives:		
Student should be able to • Acquire the knowledge of the economic load dispatch, • Acquire the knowledge of unit commitment, • Acquire the knowledge of power system operational security. • Acquire the knowledge of energy management system		

Total Number of Lectures-42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Economic Dispatch** Economic dispatch of hydro, thermal, hydro-thermal generating units, dispatch problem solution methods (any two), economic dispatch with & without transmission line losses. Base point and participation factors, penalty factors.	6
Unit 2	**Frequency Control and AGC** Review of theory of frequency dynamics. Multi-area frequency dynamics. Load-frequency and tie-line power flow control. Theory of Automatic Generation control, AGC implementation methods.	9
Unit 3	**Unit Commitment** Introduction, constraints, Priority lists, Integer Programming, Dynamic Programming, Lagrangian Relaxation and Neural Net Methods.	6
Unit 4	**Interconnected Systems Operation** Need of system interconnection. Operating policies. Economic interchange. Optimal multi-area Operation.	5
Unit 5	**Reactive Power Control** Conceptof reactive power control, effect of reactive power control on power system operation (frequency and voltage), compensation techniques.	3
Unit 6	**Energy Management Systems and Real-Time Control** Energy management systems: control center – Various levels – National – Regional and state level, Software systems, Computer hardware resources and configurations. Data management. EMS, Expert systems for contingency and security evaluation, event analysis, system restoration and reactive control. Short range load forecasting, SCADA.	6
Unit 7	**Power Systems Operational Security and Dispatch** Review of security concept and state of operation, contingency analysis; generation dispatch; dynamic security; power system state estimation; maximum likelihood weighted least-squares estimation; and measurements; network observabilities and pseudo-measurements; applications in system control.	7

CourseOutcomes: At the end of this course, the student will be able to	
CO1	Perform the economic load dispatch
CO2	Do unit commitment,
CO3	Do power system operational security.
CO4	Do energy management system

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, "Power Generation Operation and Control", 3rd Edition John Wiley & Sons, Inc., Hoboken, New Jersey.	2014
2	S. Sivanagaraju , G Sreenivasan, "POWER SYSTEM OPERATION AND CONTROL ," Pearson Education India; 1st edition (1 January 2009)	2009

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	O. I. Elgerd "Electric Energy Systems, Theory", McGraw Hill	1983
2	Mahalanabis et al., "Computer-aided power system analysis" Tata McGraw.	1988
3	Anderson &Fouand "Power system control and stability" Lowa State University Press.	1977
4	"Fundamentals of supervisory systems" IEEE Tutorial Course Text, 91EH0337-6PWR.	1991
5	KundurP.andBaluN.J.,"PowerSystemStabilityandControl", EPRISeries,McGraw-Hill InternationalBookCompany.	1998
6	Abhijit Chakarabarti , SunitaHalder, Power System Operation and control," 3rd Edition, PHI Learning Private Limited, 2010	2010

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	https://www.engineeringonline.ncsu.edu/course/ece-550-power-system-operation-and-control/	

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**-**	**-**	**1**	**2**	**-**	**-**	**1**	**-**	**-**	**3**	**3**	**-**	**-**
CO2	**3**	**3**	**-**	**-**	**1**	**2**	**-**	**-**	**1**	**-**	**-**	**3**	**3**	**2**	**-**
CO3	**3**	**3**	**-**	**-**	**1**	**2**	**-**	**-**	**1**	**-**	**-**	**3**	**3**	**2**	**1**
CO4	**3**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**3**	**3**	**-**	**1**

CourseName	**:**	**RestructuredandDeregulatedPowerSystems**
CourseCode	**:**	**EEE1019**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentshouldbeableto

- Acquireknowledgeofeconomicissuesinpowersector, need of power systemde-regulation and restructuring of power system
- Explore different market models
- Understand transmission line congestion management
- Conceptualize the importance of different ancillary services and voltage control methods
- Understand and model transmission pricing and loss allocation in the restructured power system

TotalNo.ofLectures– 42

Lecturewisebreakup		**NumberofLectures**
Unit 1	**Restructure of Power Industry** Introduction, Need and structure of deregulated power system, Challenges of national and international deregulated power system, fundamentals of electricityact2003	**5**
Unit 2	**Fundamentals of Market Economics & Market Models** Supply demand behaviour, ElasticandInelasticdemand, market equilibrium, Market Clearing Price (MCP), Day-aheadandHour-AheadMarkets, Market Models based on energy trading, contractual agreement: Pool & Bilateral models,different independent models, role of ISO, market power, Bidding and auction mechanisms,marketmodelsinIndian marketcontextand powertradinginIndia.	**12**
Unit 3	**TransmissionCongestionManagement** Transmissioncongestion,impactoftransmissioncongestion,differentmethodsofcongestion management, financial transmission right, flow gate rights, market power andcongestionissues,numericalexamples,internationalexperiencesoftransmissioncongestion management,securitymanagement:spinningreserves,interruptibleloadoptions.	**9**
Unit 4	**Ancillary Service and Management** Introduction and types of ancillary services, Voltage control and reactivepowersupport, impactofFACTSdevicesontransmissionpricing.	**7**
Unit 5	**TransmissionPricing** Power wheeling, transmission open access, Introduction to LMP, Formulation and analysis,differentmethodsoftransmissionpricing, issues in national and internationaltransmissionpricing, Introduction to loss allocation methods, OPF in deregulated power system	**9**

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Describe importance of deregulated power system and role of power system entities in deregulated environment.
CO2	Explain the different market models and its implications.
CO3	Understand the methods of congestion management in deregulated power system
CO4	Explain the importance of different ancillary services and techniques of voltage control methods
CO5	Understand transmission open access pricing and loss allocation methods in the restructured power system

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	LaiLioLee,PowerSystemrestructuringandderegulation.JohnWileyandSons,UK	2012
2	BhattacharyaK,BollenMHTandDoolderJC,OperationofRestructuredPowerSystems, Kluwer AcademicPublishers,USA	2012
3	ShahidehpourMetal.,Market OperationsinElectricPowerSystems,JohnWileyandSons	2002

TextBooks:		
Sr. No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	IlicM,PowerSystemsRestructuring- EngineeringandEconomics,KluwerInt.Series	2008
2	PhilipsonLorrin,WillisHLee,Understandingelectricutilitiesandde-regulation,Marcel DekkerPub	2006

ReferenceBooks:		
Sr. No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	P V Ramakrihna, Power System Deregulation (Unit Commitment Problem), Namya Press	2020

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	https://archive.nptel.ac.in/courses/108/101/108101005/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**1**	**-**	**2**		**1**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**1**	**1**
CO2	**2**	**1**	**-**	**2**		**-**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**-**
CO3	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**1**
CO4	**1**	**-**	**-**	**-**		**1**	**-**	**1**	**-**	**-**	**1**	**1**	**1**	**-**	**1**
CO5	**1**	**1**	**-**	**1**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**1**

CourseName	**:**	**FACTS Devices and HVDC Transmission**
CourseCode	**:**	**EEE1020**
Credits	**:**	**4**
LTP	**:**	**3 10**

CourseObjectives:

Studentsshouldbeableto

- Understand the different FACTS devices
- Understand application of FACTS devices in power system
- Understand application of Power Electronic devices in HVDC transmission lines.
- Understand Enhance stability with FACTS devices

Total no. Lectures: 42

Lecturewisebreakup		**Numberof Lectures**
Unit 1	**FACTS**:Concept,powerflowandstability,basictheory ofline compensation.	**4**
Unit2	**PowerElectronicControllers:**ReviewofPWMvoltagesource invertersusedinFACTS,classificationsofFACTScontrollers.	**4**
Unit3	**StaticShuntCompensators:**SVCandSTATCOM-TCR,TSC,systemstability.	**6**
Unit4	**StaticSeriesCompensators:**GCSC,TSSC,TCSCandSSSC, controltechniques.	**6**
Unit5	**StaticVoltageandPhaseAngleRegulators**:Powerflowcontrol,TCVRand TCPAR.	**4**
Unit6	**UnifiedPowerFlowController(UPFC)**:Conceptofpowerflow control,operationandcontrolofUPFC,InterlinePowerFlowController.	**4**
Unit7	**StabilityAnalysis:**ModelingofFACTSdevices,optimizationof FACTS,transientanddynamicstabilityenhancement	**6**
Unit8	**Applications:**PrincipleofcontrolofFACTSinHVDClinks,co-ordinationofFACTSdeviceswithHVDClinks.	**3**
Unit9	**HVDC Transmission System:** Brief history of HVDC transmissionsystem,comparisonwithEHVACtransmission,analysisofconvertercircuitsforHVDCtransmission,HVDCcontrolsystem: CIA, CC and CEA control, analysis of faults in HVDC converters,basicconceptsofmulti-terminalHVDCsystem.	**5**

CourseObjectives: On the completion of this course, the students will be able to	
CO1	Acquire understanding of different FACTS devices
CO2	apply FACTS devices in power system
CO3	Understand the application of Power Electronic devices in HVDC transmission lines.
CO4	Enhance stability with FACTS devices

Text Books:		
S.No.	**NameofAuthors/Books/Publishers**	**Year ofPublication /Reprint**
1.	K R Padiyar, “HVDC Power transmission system,” Wiley Eastern Limited.	1992
2.	HingoraniN.G.andGyugyiL.,“UnderstandingFACTS”,IEEE Press,StandardPublishersDistributors.	2001
3.	PadiyarK.R.,“FACTSControllerinPowerTransmissionand Distribution”,NewAgeInternationalPrivateLimited	2008
4.	S. Kamakshaiah& V. Kamaraju, “HVDC Transmission, Tata McGraw hill education.	2011

Reference Books:		
S.No.	**NameofAuthors/Books/Publishers**	**Year ofPublication/Reprint**
1.	MillerT.J.E.,“ReactivePowerControlinElectricSystems,” Wiley India Pvt Ltd	2010
2.	Arrilaga J., “High Voltage Direct Current Transmission”, 2nd Ed., IET Publications.	1993
3.	SongY.H.andJohnsA.T.,“FlexibleACTransmissionSystems(FACTS)”,IEEPress.	2000
4.	GhoshA.andLedwichG.,“PowerQualityEnhancementUsingCustomPowerDevices,”KluwerAcademicPublishers.	2002
5.	MathurR.M.andVarma R.K.,“Thyristor–BasedFACTS ControllersforElectricalTransmissionSystems,”JohnWileyandSons.	2002

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://onlinecourses.nptel.ac.in/noc23_ee58/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	-	-	-	-	-	3	3	1	-
CO2	2	2	-	-	-	1	-	-	1	-	-	3	3	2	-
CO3	2	1	1	-	1	1	-	-	1	-	-	3	3	2	2
CO4	2	1	2	1	2	2	-	-	1	-	-	3	3	2	2

Course Name	**:**	**Utilization of Electrical Energy and Electric Traction**
Course Code	**:**	**EEE1021**
Credits	**:**	**04**
L T P	**:**	**3- 1-0**

Course Objectives:

Student should be able to

- understand different ways of electric energy utilization,
- design heating and illumination systems
- understand electric traction system
- Understand the electrical energy for chemical processes.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Electric Energy As Mechanical Power** Traction Railway electrification, speed-time curves, definition and analysis of traction effort, tractions motors-battery driven vehicles, energy efficient drives, advanced speed control measures.Starting and speed control of DC series motors, energy saving with series parallel starting, multiple unit control, braking of traction motors, recent trend in electric traction (Locomotive and trains).	09
Unit 2	**Electric Energy As Thermal Energy:** Electric Heating: Advantages of electrical heating, Heating methods: Resistance heating – direct and indirect resistance heating. Induction heating, Electric arc heating, direct and indirect arc heating, Dielectric heating, Infra-red heating, Microwave heating.Electric Welding: Advantages of electric welding, Welding method. Principles of resistance welding, types – spot, projection seam and butt welding. Principle of arc production, electric arc welding, characteristics of arc.	09
Unit 3	**Electric Energy As Chemical Energy** Electrolytic Processes: Need of electro-deposition, Laws of electrolysis, process of electro-deposition, Factors affecting electro-deposition, Principle of galvanizing and its applications. Principles of anodizing and its applications, Electroplating on non-conducting materials, Utilization of electric energy in manufacturing of chemicals. Energy consumption in online and off line UPS, Batteries, etc.	09
Unit 4	**Electric Energy As Light Energy** Nature of light, laws of illumination, luminous efficiency, photometry, energy consumption in different type of electric light sources. Calculation of number of light points for interior illumination, depreciation factor, room index and utilization factor, maintenance factor, space to height ratio, reflection factor, Design of general illumination schemes (i) Indoor Applications, (ii) Outdoor Area Application.	09

Unit 5	**Electric Energy For Refrigeration And Air Conditioning** Control of temperature-basic wiring diagram-simple heat load and motor calculations. Air –conditioning-function of complete air conditioning system-types of compressor motor and fan motor-wiring diagram for a typical air conditioning unit.	06

CourseObjectives: by the end of this course, the students will be able to	
CO1	Understand different ways of electric energy utilization,
CO2	Design heating and illumination systems
CO3	Understand electric traction system
CO4	Understand the electrical energy for chemical processes.

Text Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	H. Partap, " Art and Science of Utilization of electrical Energy," 13th Edition Dhanpat Rai and sons, Delhi.	2015
2	R. K. Rajput, "Utilization of Electrical Energy," 3rd Edition, Laxmi Publications (P) Ltd India	2023

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	W.J.M. VanBommel, "Road Lighting," Kluwer TechnischeBoeken, macmillan	1980
2	Utilization of Electical Energy by J.B. Gupta, Kataria Publications, Ludhiana.	1968
3	Open Shaw Taylor, " Utilization of electrical Energy," Pitman Publications.	1962
4	C.L. Wadhwa," Generation, Distribution, and Utilization of Electrical Power," Wiley Eastern Ltd, New Delhi.	2011
5	Prasad M ," Refrigeration and Air Conditioning," Wiley Eastern Ltd, New Delhi	2007

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	https://nptel.ac.in/courses/108105060	NPTEL
2	https://archive.nptel.ac.in/courses/108/106/108106170/	NPTEL
3	https://archive.nptel.ac.in/courses/108/102/108102121/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**2**	**3**	**-**	**-**
CO2	**3**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**2**	**3**	**1**	**-**
CO3	**3**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**2**	**3**	**-**	**1**
CO4	**3**	**2**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**2**	**3**	**-**	**1**

Course Name	**:**	**High Voltage Engineering**
Course Code	**:**	**EEE1022**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able to

- Acquire the knowledge of discharge phenomena in solid.
- Acquire the knowledge of discharge phenomena in liquids.
- Acquire the knowledge of discharge phenomena gases.
- Acquires the knowledge of high voltage testing and measurement.

Total No. of Lectures – 42

Lecture Wise Breakup		**Number of Lectures**
Unit 1	**Discharges in Solids, Liquids and Gases** Types of insulating materials, factors affecting dielectric strength, different mechanisms of breakdown of solids; different theories of breakdown in liquids; commonly used solid and liquid insulation materials and their properties; general characteristics of gaseous insulation, basic processes of ionization in a gas: Townsend mechanism, Paschen's law; vacuum breakdown mechanisms;commonly used gases for insulation and their properties, Corona discharge.	08
Unit 2	**Travelling Waves on Transmission Lines** Specifications of travelling waves, typical cases of line termination, junction of two dissimilar lines,forked line, Bewley lattice diagram, attenuation and distortion.	05
Unit 3	**HVDC and EHVAC Transmission** Standard high voltage transmission voltage, kinds of DC links, comparison of HVAC and HVDC Transmission, power handling capacity and line losses in HVAC.	04
Unit 4	**Lightning Phenomenon** Change accumulation in clouds: formation of lightning stroke; characteristics of lightning stroke; instruments for measuring lightening surges.	05
Unit 5	**Generation of AC/DC/Impulses** Definition of impulse wave, generation of high DC/AC impulses; single stage and multi stage impulse generators and equivalent circuits.	05
Unit 6	**High Voltage Measurements** Measurements of AC, DC and impulse voltage; sphere gap, resistance and capacitance potential dividers, standard capacitors: high voltage measurements by measuring rectified current of standard capacitors: crest voltmeter, Electrostatic voltmeter. Impulse voltage measurement by cathode ray oscillograph.	06
Unit 7	**High Voltage Testing Equipments** Power frequency high voltage testing transformer, cascade connection of transformers; generation of high direct voltage by voltage doubler circuit and Cockcroft Walton Circuit; introduction to nanomaterials for high voltage engineering, introduction to modern tools in high voltage	04
Unit 8	**Non-Destructive High Voltage Testing and Insulators** H.V. testing of cables and transformers, testing of transformer oil for electric strength. General idea about dielectric constant and loss factor; application of H.V Schering bridge for tests.	05

List of Experiments		Number of Turns
1	To study flashover characteristic of a needle sheet gap for power frequency volt	02
2	Testing of transformer oil	01
3	To find flashover voltage of pin insulator	02
4	To calibrate the control desk voltmeter using a standard 2.5 cm sphere gap.	02
5	To study flashover characteristic of rod gap for power frequency voltage	02
6	To draw the breakdown characteristics for sphere gap if applied voltage is at power frequency	02
7	To find flashover voltage of suspension insulator	02
8	To find flashover voltage of post insulator	01

Course Outcomes: By the end of this course, the students will be able to	
CO1	Acquire knowledge of the fundamentals of discharge phenomena in solid and liquids
CO2	Acquire knowledge of the fundamentals of discharge phenomena in gases.
CO2	Acquire basics of HVDC and EHVAC transmission and lightning
CO3	Acquire knowledge of high voltage testing and measurement.

Text Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	C.L. Wadhwa, 'High Voltage Engineering', 2nd edition, New Age International Ltd.	2006
2	M.S.Naidu and V.Kamaraju,' High Voltage Engineering', McGraw-Hill, 5th edition.	2013

Reference Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Die Dieter Kind, Kurt Feser, 2nd edition, 'High Voltage Test Technique'	2001
2	E.Kuffel and W.S.Zaengl, 'High Voltage Engineering Fundamentals', Newness, 2nd edition,	2000
3	Chaurasia M P, 'High Voltage Engineering', Khanna Publishers, 2nd Edition.	1989

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://archive.nptel.ac.in/courses/108/104/108104048/	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	1	-	-	-	-	1	-	-	1
CO2	2	-	-	-	-	-	1	-	-	-	-	1	-	-	1
CO3	1	-	1	-	1	-	1	-	1	1	-	1	1	-	-
CO4	2	2	2	1	2	-	-	-	2	1	-	1	-	-	-

Course Name	**:**	**Numerical Protection & Protection Audit**
Course Code	**:**	**EEE1023**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Student shall be able to:

- Analyze the requirement of protection for various power utilities.
- Understand the functioning and new development in digital relaying.
- Apply the digital relaying techniques in power system protection.
- Plan & design, review the protection schemes of major power components.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**General Philosophy of Protection** Power system operation, instrument transformers, and general terms of protection, fundamental requirement of protection at generation, transmission & distribution. Industrial protection requirement, challenges in Protection with invertor based resources integration	**06**
Unit 2	**Basic Elements of Digital Protection** Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing, error, sample and hold circuits, multiplexers, analog to digital conversion, digital filtering concepts, the digital relay as a unit consisting of hardware and software	**08**
Unit 3	**Relay Units** Sequence networks-fault sensing data processing units- FFT and wavelet based algorithms and differential equation-based algorithms: phasor estimation techniques-DFT and least square estimation, travelling wave protection schemes, fault location techniques.	**07**
Unit 4	**Protection of Power System Apparatus** Major electrical protection of generators with class of tripping, transformer protection– magnetizing inrush current, transformer differential relays, back over current protection. Bus bar protection, distance protection schemes with zones setting, power line carrier protection.	**09**
Unit 5	**RecentAdvancesinDigitalPowerSystemProtection** DigitalprotectiontechniquesbasedonwideareameasurementswithPMUsorFDRs,digitalprotectiontechniquesbasedon wirelesstechnology(Wi-Fi-Wi-Max-TokenRing,etc.), Fault location techniques.	**06**
Unit 6	**Protection Audit** Requirement of Protection audit, scope of audit, Audit guidelines/standards audit procedure/format, key elements of equipment and systems protection, auxiliary protection infra-structure, disturbance recorder/event logger analysis.	**06**

List of Experiments:		Number of Turns
1	Todevelopcodeforestimatingvoltageandcurrentphasorsandtheirsequencecomponentsusing DFT	2
2	Todevelopcodetocompareth eresponseofhalfcycleDFT,quartercycleDFTand recursiveDFT phasor estimationalgorithmsduringfaults.	3
3	Todevelopcodeforestimatingvoltageandcurrentphasorsandsequencecomponentsusingleastsquare errorphasorestimationalgorithm	2
4	Todevelopcodefordistancerelayschemefortransmissionlines.	2
5	Todevelopcodefordirectionalrelayschemefortransmissionlines.	2
6	Todevelopcodefordifferentialprotectionschemefortransformers	2

Course Outcomes: By the end of this course, the students will be able to	
CO1	Understand the function of numerical protection schemes for protection of power utilities network.
CO2	Analysis the functioning of numerical relays.
CO3	Evaluate & review the industrial protection schemes the functioning of performance of modern perfection schemes.
CO4	Review the industrial protection schemes as per prevailing relaying Audit guidelines/standards

Text Books:		
Sr. No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	ATJohnandAKSalman-Digitalprotectionforpowersystems-IEEpowerseries-15,Peter PeregrinesLtd,UK, 1997.	1994
2	TS. MadhavRao, Power systemprotectionstatic relayswithmicroprocessorapplications, Tata McGrawHillPublication,1994.	1994
3	BadriRam,D.N.Vishwakarma,Powersystemprotectionandswitchgear,TataMcGrawHill,	2001

Reference Books		
Sr. No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	A.R.Warrington,ProtectiveRelays,Vol.1&2,ChapmanandHall,1973.	1973
2	GerhardZiegler-Numericaldistanceprotection,Siemens,2nded,2006.	2013
3	S.R.Bhide"DigitalPowerSystemProtection"PHILearningPvt.Ltd.2014.	2003
4	A.T.JohnsandS.K.Salman,"DigitalProtectionofPower Systems",IEEEPress,1999.	2006
5	A.G.PhadkeandJ.S.Thorp,"ComputerRelayingforPowerSystems",Wiley/Research StudiesPress,2009.	1998
6	L.P.Singh,"Digitalprotection",Newagepublishers,2nd Edition	2017
7	Stanley H Howowitz, Arun G Padke, " Power systems Relaying" , First edition wily press	2014
8	S G Patki, V K Kanjila& P PWahi, "Manual on Power systems protection," Central Board of Irrigation & Power	2020

Equivalent MOOCs courses

S. No.	Course Links	Offered by
1	A Couse on Power System Protection, coordinated by IIT Kharagpur, https://archive.nptel.ac.in/courses/108/105/108105167.	NPTEL
2	Power System Protection, coordinated by IIT Bombay, https://nptel.ac.in/courses/108101039.	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	--	1	1	--	--	1	1	1	1
CO2	3	3	1	2	1	--	--	--	1	--	1	1	1	1	1
CO3	3	2	3	1	1	1	--	--	1	--	--	1	1	1	1
CO4	3	2	3	1	1	1	--	--	1	--	--	1	1	1	1

Course Name	**:**	**Power System Dynamics modelling and Stability**
Course Code	**:**	**EEE1024**
Credits	**:**	**04**
L T P	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeable to

- Learn the basic concepts of power system components, modelling for stability studies.
- Learn the methods of system analysis in steady state and transient state,
- Investigate the power system stabilities.
- Understand effect of RES on Power System.

TotalNo.ofLectures– 42

Lecturewisebreakup		**NumberofLectures**
Unit 1	**Introduction to Power System Stability**: Types of disturbances, Definition of stability, classification of stability, Rotor angle stability, frequency stability, voltage stability, mid-term and long-term stability.	03
Unit 2	**Synchronous Machine Modelling**: Synchronous machine modeling: sub-transient model, two axis model, one axis (flux decay) model, classical model, Steady state analysis of synchronous machine, Modeling of Synchronous Machine connected to Infinite Bus (SMIB) system.	06
Unit 3	**Modeling of Exciter, Turbine and Load**: Types of excitation system-AC, DC, Static, Modeling of DC excitation system, introduction to AVR, development of Hydraulic turbine transfer function and steam turbine transfer function, power system loads: static, dynamic (synchronous motor, induction motor, etc.).	06
Unit 4	**Small Signal Stability Analysis**: Physically interpretation, State Space representation, Eigen properties of state matrix, linearizing a nonlinear power system model, Small-Signal stability analysis of single machine connected to infinite bus, Power system stabilizer, effects of excitation system, small signal stability of multi-machine systems.	07
Unit 5	**Large Signal Stability**: Physical Interpretation, disturbances (causes and effects), equal area criterion, representation of power system for transient stability studies, numerical integration methods: modified Euler and 4^{th} order Runge-Kutta methods, numerical stability. Sub Synchronous resonance causes and effects. Methods to enhance transient stability.	08
Unit 6	**Voltage Stability**: Difficulties with reactive power transmission, Voltage stability, voltage collapse, Relation of Voltage Stability to Rotor Angle Stability, P-V curves, V-Q curves, Graphical Explanation of Long-term Voltage stability. Characteristics of reactive power compensating devices. Mitigation of voltage collapse	07
Unit 7	**Power System Stability with RES**: Review of wind power generation, principle of operation of various types of wing generators, effect of level of RES injection, interface to grid (power System), small signal and transient stability with synchronous and wing generators connected to power system (SMIB approach). Mitigation of frequency stability issues in low inertia power systems	05

ListofExperiments:		NumberofTurns
1	Modeling of synchronous machines, exciter, and turbines	05
2	Simulation studies of Small Signal Stability of Power system	05
3	Control of active and reactive power simulation studies	04

CourseOutcomes:	
CO1	Learn the basic concepts of power system components, modelling for stability studies.
CO2	learn the methods of system analysis in steady state and transient state,
CO3	Investigate the power system stabilities.
CO4	Understand effect of RES on Power System.

TextBooks:		
Sr.No.	NameofBook/Authors/Publisher	YearofPublication/Reprint
1	K.R. Padiyar, "Power System Dynamics Stability and Control," B.S. Publisher.	2002
2	P. Kundur, "Power system stability and control", edited by Neal J. Balu, Mark G. Lauby, McGraw-Hill.	1994
3	C W Taylor, "Power System Voltage Stability," McGraw Hill	1994

References books:		
Sr.No.	NameofBook/Authors/Publisher	YearofPublication/Reprint
1	V.A. Venikov, "Transient Phenomena in power system" Mir Publications. 1964	1964
2	A.A. Fouad and P.M. Anderson, "Power system stability and control" Iowa University Press Ames Iowa. 1977	1977
3	E.W. Kimbark, "Power system Stability," John Wiley and Sons Vol.I and IIIInc. New York. 1948	1948

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://onlinecourses.nptel.ac.in/noc21_ee16/preview	NPTEL
2	Power System Stability and Control, coordinated by IIT Madras, NPTEL, "http://nptel.ac.in/courses/108106026/	NPTEL
3	Power System Dynamics and Control, coordinated by IIT Bombay, NPTEL, "http://nptel.ac.in/downloads/108101004/#,"	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**-**
CO2	**2**	**3**	**-**	**-**	**2**	**-**	**-**	**-**	**1**	**-**	**-**	**3**	**3**	**3**	**-**
CO3	**1**	**3**	**-**	**-**	**2**	**1**	**1**	**-**	**1**	**-**	**-**	**3**	**3**	**3**	**2**
CO4	**1`**	**2**	**-**	**-**	**2**	**1**	**1**	**-**	**1**	**-**	**-**	**3**	**3**	**3**	**2**

CourseName	**:**	**EnergyStorageSystems**
CourseCode	**:**	**EEE1025**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

The students should be able to:

- Understand the need of energy storage and familiarize with different types of energy storage systems.
- Analyze emerging needs for energy storage systems pertaining to renewable energy
- Develop understanding of the fundamental principles and concepts of energy storage systems including their benefits and fundamental limitations.
- Analyze the application of energy storage systems in various sectors including renewable energy integration, smart grids, electric vehicles, and off-grid systems.

TotalNo.of Lectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction** Storage Needs, variations in energy demand, variations in energy supply, interruptions in energy supply,transmission congestion, demand for portable energy, energy storage for power systems, role of energystoragesystems,overviewofenergystoragetechnologies:thermal,mechanical,chemical, electrochemical,electrical, efficiencyofenergystoragesystems.	04
Unit 2	**ElectricalandChemicalEnergy Storage** Batteriestypes,supercapacitors,superconductingmagneticenergystorage(SMES),chargingmethodologies,stateofcharge (SoC),stateofhealth(SoH)estimationtechniques,batterymodelling. **MechanicalandThermalEnergyStorage** Flywheel,pumpedhydrostorage,aquiferouscoldstorageandcryogenicstorage,high-temperaturestorage(PCM).	08
Unit 3	**HydrogenProductionandStorage,FuelCells** Electrolyzertechnologies,hydrogenstoragetechnologies,fuelcelltechnologies.	05
Unit 4	**MobileStorageSystem** Storagerequirementforelectricvehicle,grid-to-vehicle(G2V),vehicletogrid(V2G).	05
Unit 5	**HybridEnergyStorageSystems** Hybridenergystoragerequirement,highfrequencyandlowfrequencyenergystoragemediums,configurationsandapplications.	05
Unit 6	**ApplicationsofEnergyStorageSystems** Storage for - solar energy, wind energy, fuel cells; energy storage in microgrid and smart grid, energymanagement with storage systems, increase of energy conversion efficiencies by introducing energystorage.	10
Unit 7	**SystemIntegrationofEnergy StorageSolutions** Powergenerationunitsandgridmanagement.	05

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Acquire knowledge on various types of energy storage systems
CO2	Analyse feature of energy storage systems
CO3	Apply energy storage systems to various applications such as smart grid, micro grid, energy management and grid management etc.

CO4	Demonstrate proficiency in selecting appropriate energy storage system based on project requirements and constraints as a member working cooperatively in a small multidisciplinary team.

Text/ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	A.G.Ter-Gazarian,"EnergyStorageforPowerSystems",SecondEdition,TheInstitutionof EngineeringandTechnology(IET)Publication,UK.	2011
2	FranciscoDíaz-González,AndreasSumper,OriolGomis-Bellmunt,"EnergyStorageinPower Systems"WileyPublication.	2016
3	A.R.Pendse,"EnergyStorageScienceandTechnology",SBSPublishers & DistributorsPvt.Ltd., NewDelhi.	2011

Text/ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	ElectricPowerResearchInstitute(USA),"ElectricityEnergyStorageTechnology Options:A WhitePaperPrimeron Applications,Costs,and Benefits"(1020676).	2010
2	PaulDenholm,ErikEla,BrendanKirbyandMichaelMilligan,"TheRoleofEnergyStoragewith RenewableElectricityGeneration",NationalRenewableEnergyLaboratory(NREL)-ANationalLaboratoryoftheU.S. DepartmentofEnergy-TechnicalReportNREL/TP6A2-47187.	2010
3	DetlefStolten,"HydrogenandFuelCells:Fundamentals,TechnologiesandApplications",Wiley.	2010

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Electrochemical Energy Storage, IIT Kharagpur https://nptel.ac.in/courses/113105102	NPTEL
2	Fuel Cell Technology, IIT Delhi https://archive.nptel.ac.in/courses/103/102/103102015	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	2	1	2	1	2	2	1	1	2	2	1
CO2	2	2	1	1	1	1	1	1	2	2	1	2	2	1	1
CO3	2	2	2	2	1	2	2	1	2	2	1	2	2	2	1
CO4	2	2	2	2	1	2	2	2	2	2	1	3	2	2	1

Department of Electrical Engineering
Course Curriculum
B.Tech (Electrical Engineering)

Detailed Syllabus of Open Elective Courses

Course Code	OE-I, II, III, IV	L	T	P	Credits
EEO1001	Renewable Energy Sources	3	0	2	4
EEO1002	Electric Vehicles Technology	3	0	2	4
EEO1003	Fuzzy Logic and Neural Networks	3	1	0	4
EEO1004	EnergyStorageSystems	3	1	0	4
EEO1005	Signals and Systems	3	1	0	4

Course Name	**:**	**Renewable Energy Sources**
Course Code	**:**	**EEO1001**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives :

Students should be able –

- To explore the energy generation scenario and related policies for renewable energy generation.
- To analyze the operation of various renewable energy technologies.
- To apply the renewable energy generation technologies for existing electric grid.
- To design of renewable energy systems for domestic, commercial and industrial applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Introduction** Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits.	08
Unit 2	**SolarPhotovoltaic Energy Technology** Introduction: Need and prospects of photovoltaics, solar PV cells basics, single junction, multi-junction. Introduction of PV cells, panels and their working. Performance of PV plants in different scenarios. Maximum power point methods, Grid-connected single-phase PV inverter schemes and control, types of grid interface. Standalone PV system: Stand alone PV system components and design, solar water pumping system, solar street light system, and solar lanterns.	12
Unit 3	**WindEnergy Technology** Introduction of wind energy, panels and their working. Power estimation in wind, Wind energy conversion principles, Components of wind energy Conversion Systems. Working principle of different types of wind turbines and their operations. Wind power Conversion Technologies and applications.	10
Unit 4	**Recent Developments in Renewable Energy Systems** Solar Thermal Energy: Absorption, radiations and thermal collectors Biomass energy conversion technologies, biomass co-generation, ethanolfrom biomass. Small hydropower systems: overview of micro, mini and small hydro systems. Energy generation from ocean waves: ocean thermal energy conversion and tidal energy conversion, introductionto geothermalenergyconversion.	12

List of Experiments:		**Number of Turns**
1	Measure the solar irradiation at a given location and	1
2	Obtain I-V and P-V characteristics of solar PV module for different irradiation and temperature.	1

3	Obtain I-V and P-V characteristics solar PV modules when connected in (i) series and (ii) parallel.	1
4	Evaluate the effect of variation in tilt angle on PV module power output.	1
5	Simulate a standalone solar PV system for residential load applications using MPPT control.	2
6	Obtain the operational characteristics of wind energy system at different wind speed.	1
7	Study effect of load on wind turbine output.	1
8	To simulate and study hydro power system.	1
9	Evaluate the performance of wind energy conversion system using laboratory set	2
10	design a hybrid micro-grid system assisted with solar PV, wind and battery energy storage system. -up.	3

Course Outcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understandthe requirement of sustainable energy resources in the present scenario.
CO2	Analyze the operations of various renewable energy technologies and their performance analysis.
CO3	Apply the knowledge of renewable energy technologies for energy generation and grid integration.
CO4	Develop the standalone and grid connected renewable energy systems.

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	C.S. Solanki, "Renewable Energy Technologies: A practical guide for beginner," PHI.	2009
2	WagnerH.andMathurJ,"IntroductiontoHydroEnergySystems:Basics,Technologyand Operation",Springer.	2011
3	Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", Wiley Interscience, John Willey and Sons.	2004

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	C.S.Solanki, "SolarPhotovoltaics-Fundamentals,TechnologiesandApplications,"PHI.	2015
2	JennyNelson,"ThePhysicsofSolarCells,"(ImperialCollege,UK).	2003
3	VaughnC.NelsonandKennethL.Starcher,"IntroductiontoRenewableEnergy,(Energyandthe Environment)2ndEdition,".	2015

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	**Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems, IIT Guwahati** Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi https://nptel.ac.in/courses/103103206	NPTEL
2	https://onlinecourses.nptel.ac.in/noc24_ch26/preview	SWYAM

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**1**	**2**	**2**	**2**	**2**	**1**	**-**
CO2	**2**	**2**	**1**	**2**	**1**	**-**	**-**	**-**	**1**	**2**	**2**	**2**	**2**	**2**	**-**
CO3	**3**	**2**	**2**	**1**	**1**	**1**	**-**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**1**
CO4	**3**	**3**	**3**	**2**	**1**	**2**	**-**	**1**	**1**	**2**	**2**	**2**	**3**	**2**	**1**

CourseName	**:**	**ElectricVehicle Technology**
CourseCode	**:**	**EEO1002**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to :

- Acquire the knowledge on hybrid and electric vehicle operation and architectures.
- Select appropriate motor, converter and energy storage system for the electric vehicles.
- Acquire the knowledge of energy management and control strategies used in hybridandelectricvehicles.
- Design a battery electric vehicle and hybrid electric vehicle.

TotalNo.ofLectures- 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**IntroductiontoElectricVehicles** Comparisonof BEV, HEV, FCEV and ICengine drivevehicles; social and environmental importance of hybrid and electric vehicles, impact of modern drive-trainsonenergysupplies,basicsofvehicleperformance,vehiclepowersourcecharacterization,transmission characteristics, Mathematical models to describe vehicle performance, basic concept ofhybridtraction,introductiontovarioushybriddrive-traintopologies,powerflowcontrolinhybrid drive-traintopologies,fuelefficiencyanalysis. Standards and government policies related to EVs and HEVs.	08
Unit 2	**ElectricPropulsionUnit** Introduction to electric components used in hybrid and electric vehicles, different types of motors usedinEVandtheirtorque-speedcharacteristics,configurationandcontrol: DCmotordrives,inductionmotor,permanentmagnetmotor,and switchreluctancemotordrives; drivesystemefficiency.	09
Unit 3	**EnergyStorageinVehicles and Power Converters** Introduction toenergy storagerequirements inhybridandelectricvehicles,storagetypes: battery,supercapacitor/ultra-capacitors,flywheel,andfuelcellbasedenergy storageanditsanalysis,hybridizationofdifferent energystoragedevices, bidirectionalDC-DCconverters.	08
Unit 4	**BatteryChargers** FundamentalsofEVbatterypackdesign,ACandDCChargers,Alternatecharging sources–wireless&solar,*batterymanagement system*.	03
Unit 5	**EnergyManagementandControlStrategies** Introductiontoenergymanagementstrategiesusedinhybridandelectricvehicles, classificationofdifferentenergymanagementstrategies,comparisonofdifferentenergymanagementstrategies, implementationissuesofenergymanagementstrategies.	06
Unit 6	**ElectricVehicleCaseStudies** Designofabatteryelectric vehicle(BEV), design offuel cell electricvehicle,designofhybridelectricvehicle,designofmore electric aircraft,	04

	Electric metro.	

ListofExperiments:		**Number ofTurns**
1	Toobtaintheperformance oflead-acid andli-ionbatteryenergystorage.	02
2	Toobtaintheperformanceofsupercapacitor.	01
3	Tosimulatelead-acid/li-ionbatteryandsupercapacitorhybridenergystoragesystem.	02
4	TosimulatetheI-Vcharacteristicsoffuelcell.	01
5	Toobtainthedifferenceinperformanceof ACand DCchargers.	01
6	TosimulatetheDCfastchargersforelectricvehicles(EV).	01
7	ToobtaintheperformanceofbidirectionalDC-DCconverter.	01
8	Toobtaintheperformanceofresonantconverter.	01
9	TosimulatesinePWMinverter.	01
10	Toobtaintheperformanceof – permanentmagnet,inductionandswitchedreluctancemotors.	02
11	TosimulatethebatterybasedEV.	02

CourseOutcomes: By the end this course the students will be able to	
CO1	Interpretworkingofdifferentconfigurationsofelectricvehiclesanditscomponents,hybridvehicle configuration,performanceanalysis.
CO2	Developtheelectricpropulsionunitanditscontrolforapplicationofelectricvehicles.
CO3	Apply the knowledge of energy management strategies in electric vehicles.
CO4	Design a battery electric vehicle and hybrid electric vehicle.

TextBook

Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication / Reprint**
1	MehrdadEhsani,YiminGao,StefanoLongo,KambizM.Ebrahimi,“ModernElectric,Hybrid Electric,andFuelCellVehicles”,Taylor&FrancisGroup,LLC.	2018

ReferenceBooks:

Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication / Reprint**
1	IqbalHusain, “ElectricandHybridVehicles:DesignFundamentals”,3rdeditionCRCPress.	2021
2	TomDenton,“ElectricandHybridVehicles”,Taylor&Francis.	2018
3	JohnMiller,“PropulsionSystemsforHybridVehicles,”InstituteofElectricalEngineers,UK.	2004
4	ChrisMi,MAMasrur,DWGao,“HybridElectricVehicles– Principlesandapplicationswith practicalperspectives,”Wiley.	2011
5	JamesLarminie,JohnLowry,“Electric VehicleTechnologyExplained”,Wiley.	2003

6	C.M.Jefferson&R.H.Barnard,"HybridVehiclePropulsion,"WITPress.	2002
7	L. Ashok Kumar, S Albert Alexander," Power converters for Electric Vehicles," CRCPress.	2021
8	H. J. Bergveld, "Battery management systems : design by modelling" University Press Facilities, Eindhoven	2001

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1	Electric vehicles and Renewable energy, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, and Prof. L Kannan https://archive.nptel.ac.in/courses/108/106/108106182/	NPTEL
2	Electric Vehicles - Part 1, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, and Prof. L Kannan https://archive.nptel.ac.in/courses/108/102/108102121/	NPTEL
3	Introduction to Hybrid and Electric Vehicles, IIT Guwahati Dr. Praveen Kumar, Prof. S. Majh NPTEL :: Electrical Engineering - Introduction to Hybrid and Electric Vehicles	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	2	3	1	1	1	-	3	3	3	2
CO2	3	3	3	2	2	2	3	1	1	1	-	3	3	3	2
CO3	3	3	2	3	2	2	3	1	1	1	-	3	3	3	2
CO4	3	3	3	3	2	2	3	1	1	1	-	3	3	3	2

CourseName	**:**	**Fuzzy Logic and Neural Networks**
CourseCode	**:**	**EEO1003**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

Studentsshouldbeableto:

- Acquiretheknowledgeofneuralnetworks and its different structure,development, implementationof different algorithm.
- Design ofneural networksfordifferentapplications.
- Acquiretheknowledgeoffuzzy systems and its differentstructure.
- Design offuzzy systemsfordifferentapplications.

TotalNo.of Lectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction and FundamentalModelsofANN** Biologicalneuron,modelsofArtificialNeuralNetworks(ANN),characteristicsof neuralnetworks,differenttypesoflearningofneural network. Mcculloch–Pitts,Hebbian,Perceptron,Delta,Adaline,Madaline:architecture,algorithmandapplications.	09
Unit 2	**FeedForward and FeedbackNetworks** Backpropagation,Radialbasisfunction:architecture,algorithmandapplications. Hopfieldnet:architecture,trainingalgorithmandapplicationfordiscreteandcontinuous net.	08
Unit 3	**Self-OrganizingFeatureMap and AssociativeMemoryNetworks** Kohonenself-organizingmaps,LearningVectorQuantization(LVQ),Maxnet,Hammingnet-architecture, algorithmandapplications. Hetero,autoandbi-directionalassociative networks:architecture,algorithmandapplications.	08
Unit 4	**IntroductionofFuzzySystems** Fuzzylogic,classicalsetsandfuzzysets,operationson fuzzysets,propertiesof fuzzysets,crispandfuzzyrelations,membershipfunctions,fuzzification,defuzzification.	09
Unit 5	**FuzzyRuleBasedSystem and ApplicationsofFuzzy Logic** Formationofrules,decompositionofrules,aggregationandpropertiesoffuzzyrules,fuzzyinference system. Fuzzylogic applications invarious areasincludingpowersystems,imageprocessing, control systems,industriesetc.	08

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Haveknowledgeofconcepts,differentstructure and implementationofalgorithm.
CO2	Design applicationsofneural networks.
CO3	Applytheconceptsandrulebasedfuzzylogicsystem.
CO4	Designandimplementationoffuzzylogiccontrollersin engineeringareas.

TextBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication / Reprint**
1	FundamentalofNeuralNetworks-Architectures,Algorithm andApplicationsbyLaureneFausett, Pearson.	1993
2	NeuralNetworks-AcomprehensivefoundationbySimonHaykin,MacmillanPublishing Company,NewYork.	1994
3	FuzzyLogicwithEngineeringApplicationsbyTimothyJ RossWileyStudentsEdition.	2010

ReferenceBooks:		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/Reprint**
1	NeuralNetworks-AclassroomapproachbySatishKumar,TheMcGraw-HillCompanies.	2005
2	IntroductiontoNeuralNetworksusing MATLABby S NSivanandam,S SumatiandSNDeepa, TataMcGrawHill.	2006
3	IntroductiontoFuzzyLogicusingMATLABbySNSivanandam,SSumatiandSNDeepa, Springer.	2007

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Fuzzy Logic and Neural Networks, Prof. Dilip Kumar Pratihar | IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_ge07/preview	NPTEL
2	Fuzzy Logic Prof. Nishchal K. Verma, IIT Kanpur http://www.iitk.ac.in/idea/ee658.html	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**1**	**3**	**2**	**2**
CO2	**2**	**3**	**3**	**-**	**2**	**3**	**3**	**-**	**1**	**2**	**2**	**1**	**3**	**3**	**3**
CO3	**2**	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**	**1**	**3**	**2**	**2**
CO4	**3**	**3**	**3**	**-**	**2**	**3**	**3**	**-**	**1**	**2**	**2**	**1**	**3**	**3**	**3**

CourseName	**:**	**EnergyStorageSystems**
CourseCode	**:**	**EEO1004**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

CourseObjectives:

The students should be able to:

- Understand the need of energy storage and familiarize with different types of energy storage systems.
- Analyze emerging needs for energy storage systems pertaining to renewable energy
- Develop understanding of the fundamental principles and concepts of energy storage systems including their benefits and fundamental limitations.
- Analyze the application of energy storage systems in various sectors including renewable energy integration, smart grids, electric vehicles, and off-grid systems.

TotalNo.of Lectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction** Storage Needs, variations in energy demand, variations in energy supply, interruptions in energy supply,transmission congestion, demand for portable energy, energy storage for power systems, role of energystoragesystems,overviewofenergystoragetechnologies:thermal,mechanical,chemical, electrochemical,electrical, efficiencyofenergystoragesystems.	04
Unit 2	**ElectricalandChemicalEnergy Storage** Batteriestypes,supercapacitors,superconductingmagneticenergystorage(SMES),chargingmethodologies,stateofcharge (SoC),stateofhealth(SoH)estimationtechniques,batterymodelling. **MechanicalandThermalEnergyStorage** Flywheel,pumpedhydrostorage,aquiferouscoldstorageandcryogenicstorage,high-temperaturestorage(PCM).	08
Unit 3	**HydrogenProductionandStorage,FuelCells** Electrolyzertechnologies,hydrogenstoragetechnologies,fuelcelltechnologies.	05
Unit 4	**MobileStorageSystem** Storagerequirementforelectricvehicle,grid-to-vehicle(G2V),vehicletogrid(V2G).	05
Unit 5	**HybridEnergyStorageSystems** Hybridenergystoragerequirement,highfrequencyandlowfrequencyenergystoragemediums,configurationsandapplications.	05
Unit 6	**ApplicationsofEnergyStorageSystems** Storage for - solar energy, wind energy, fuel cells; energy storage in microgrid and smart grid, energymanagement with storage systems, increase of energy conversion efficiencies by introducing energystorage.	10
Unit 7	**SystemIntegrationofEnergy StorageSolutions** Powergenerationunitsandgridmanagement.	05

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Acquire knowledge on various types of energy storage systems
CO2	Analyse feature of energy storage systems
CO3	Apply energy storage systems to various applications such as smart grid, micro grid, energy management and grid management etc.
CO4	Demonstrate proficiency in selecting appropriate energy storage system based on project requirements and constraints as a member working cooperatively in a small multidisciplinary

	team.

TextBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	A.G.Ter-Gazarian,"EnergyStorageforPowerSystems",SecondEdition,TheInstitutionof EngineeringandTechnology(IET)Publication,UK.	2011
2	FranciscoDíaz-González,AndreasSumper,OriolGomis-Bellmunt,"EnergyStorageinPower Systems"WileyPublication.	2016
3	A.R.Pendse,"EnergyStorageScienceandTechnology",SBSPublishers & DistributorsPvt.Ltd., NewDelhi.	2011

ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Yearof Publication/ Reprint**
1	ElectricPowerResearchInstitute(USA),"ElectricityEnergyStorageTechnologyOptions:A WhitePaperPrimeron Applications,Costs,and Benefits"(1020676).	2010
2	PaulDenholm,ErikEla,BrendanKirbyandMichaelMilligan,"TheRoleofEnergyStoragewith RenewableElectricityGeneration",NationalRenewableEnergyLaboratory(NREL)-ANationalLaboratoryoftheU.S. DepartmentofEnergy-TechnicalReportNREL/TP6A2-47187.	2010
3	DetlefStolten,"HydrogenandFuelCells:Fundamentals,TechnologiesandApplications",Wiley.	2010

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Electrochemical Energy Storage, IIT Kharagpur https://nptel.ac.in/courses/113105102	NPTEL
2	Fuel Cell Technology, IIT Delhi https://archive.nptel.ac.in/courses/103/102/103102015	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	2	1	2	1	2	2	1	1	2	2	1
CO2	2	2	1	1	1	1	1	1	2	2	1	2	2	1	1
CO3	2	2	2	2	1	2	2	1	2	2	1	2	2	2	1
CO4	2	2	2	2	1	2	2	2	2	2	1	3	2	2	1

Course Name	**:**	**Signals and Systems**
Course Code	**:**	**EEO1005**
Credits	**:**	**4**
LTP	**:**	**3-1-0**

Course Objectives:

Students should be able to

- Acquire the knowledge of classification of signals.
- Understand LTI systems, impulse response, sampling, and its applications.
- Analysis of LTI system using convolution.
- Understand the concept of Fourier series, Fourier transforms, Laplace transforms, z-transforms.

Total No. of Lectures-42

Lecture Wise Breakup		**Number of Lectures**
Unit 1	**Types of Signals & Systems and Their Representation** Continuous-time and discrete-time signals, energy and power of signals, periodic-aperiodic signals, even-odd signals, standard signals: unit impulse, unit step, ramp, exponential and sinusoids. Transformations of the independent variable, continuous and discrete time systems, system properties.	08
Unit 2	**LTI Systems** Impulse response, convolution integral and convolution sum, LTI systems' properties, LTI system characterization by linear constant coefficient difference equation.	08
Unit 3	**Fourier Series and Fourier Transform of Signals** Fourier series representation of continuous and discrete time periodic signals, properties of Fourier series, Fourier series and LTI systems, Fourier transform representation of continuous and discrete time signals, Fourier transform properties.	10
Unit 4	**Laplace and Z-Transform** The Laplace transform, region of convergence, properties of Laplace transform, initial and final value theorems, inverse Laplace transform, analysis and characterization of LTI systems using Laplace transform, z-transform, Characterization of LTI systems using z-transform, stability criterion.	10
Unit 5	**Sampling and Reconstruction** Sampling theorem, classification of sampling, analog to digital conversion, signal reconstruction.	06

Course Outcomes:	
CO1	Acquire knowledge of various signals and systems.
CO2	Understand the convolution of LTI systems
CO3	Analyze the spectral characteristics of signals using Fourier series
CO4	Apply the concept of Fourier transforms, Laplace transforms, z-transforms, and sampling for project implementation

Text Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication/ Reprint**
1	S. Haykin and B. Van Been, “Signals and Systems” , John Wiley & Sons, 2nd Edition	2003
2	B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2nd edition	2006

Text Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication/ Reprint**
1	Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, “Signals and Systems”, Prentice Hall, 2nd Edition	1997

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	***Flipped learning through NPTEL*** *Z-transform definition and RoC (Lecture 20)* **http://surl.li/mocdi**	NPTEL
2	Signals and Systems, Prof. Kushal K. Shah | IISER Bhopal https://onlinecourses.nptel.ac.in/noc21_ee28/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**2**	**2**	**2**	**-**	**2**	**-**	**-**	**-**	**3**	**1**	**2**	**-**	**2**	**2**
CO2	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**2**	**-**	**2**	**1**	**2**	**-**	**2**	**2**
CO3	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**2**	**-**	**2**	**2**
CO4	**2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**	**1**	**2**	**-**	**2**	**2**

Department of Electrical Engineering
Course Curriculum
B.Tech (Electrical Engineering)

Detailed Syllabus of Minor Specialization Coursein Electrical Engineering

Minor Specialization in Power Apparatus and Power Electronics

Semester	Course Code	Course Name	L	T	P	Credits
III	EEM1001	Industrial Electrical Machines	3	0	2	4
IV	EEM1002	Electrical PowerSystem	3	0	2	4
V	EEM1003	PowerElectronics	3	0	2	4

Course Name	**:**	**Industrial Electrical Machines (Minor Specialization)**
Course Code	**:**	**EEM1001**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives :

Students will be able to:

- Acquire knowledge of constructional features, and operating principle of various types of DC machines.
- Acquire knowledge of constructional features, and operating principle of various types of AC machines.
- Evaluate electrical machine performance
- Identify the machines applications in the industry.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Three-Phase Induction Machines** General construction features, rotating field theory, per phase and approximate equivalent circuit, production of torque, torque speed characteristics, no load and blocked rotor test, Starting: rotor rheostat starter, reduced voltage starting, star delta starting. Speed control, Braking: regenerative, plugging, dynamic braking. Physical phenomenon, cogging, crawling, locking, induction generator, Introduction to DFIG Application of induction machines.	10
Unit 2	**Synchronous Machines** Constructional features, armature windings, pitch and distribution factor, winding connections, induced emf equation, Efficiency, losses in synchronous machines, power angle,paralleloperationofsynchronousgenerators,synchronizingpower. V-curves and inverted V-curves of synchronous motors, hunting, damping, methods of starting of synchronous motor.	10
Unit 3	**DC Machines** Operating principle and construction, armature winding, armature reaction, compensating winding, commutation, emf and torque equation. **DC Generator**: Methods of excitation, different types of DC generators, **DC Motors:** Types and operating characteristics of DC motor, different types of DC motors, starting, speed control and braking of DC motors, efficiency, applications of DC motors, universal motor. Applications of various DC machines	15
Unit 4	**Single Phase Induction Motors** Double revolving field theory, torque-speed characteristics, types of single-phase induction machines and their applications. **Special Motors** Principle of operation and applications of BLDC, Reluctance, Stepper, Servo and PMSM motors	7

List of Experiments:		Number of Turns
1	To perform open circuit test and block rotor test on a three-phase induction motor to draw equivalent circuit.	01
2	Determination of the performance characteristics of a three-phase induction motor by load test.	01
3	To synchronize an alternator to an infinite bus.	01
4	To Plot V and inverted -V curves of synchronous motor.	01
5	To study various components of DC machine and plot Open Circuit Characteristics	02
6	To obtain performance characteristics of a D.C. Shunt motor.	01
7	To obtain external characteristics of a D.C. shunt generator	01
8	To obtain external characteristics of a D.C. series generator.	01
9	To obtain external characteristics of DC compound generator.	01
10	Speed control of a dc shunt motor by varying armature circuit and field circuit method	01

Course Outcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand the basic operation and performance of various induction machines
CO2	Understand basic operation and performance of various synchronous machines
CO3	Understand the basic operation and performance of various DC machines
CO4	Apply suitable machines for different industrial applications

Text Book:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Electric Machinery by A.E. Fitzgerald, Charles Kingsley, Jr. and Stephen D. Umans, Tata McGraw-Hill	2013

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Alternating Current Machines by M.G Say, Pitman publishing Ltd	1976
2	Electric Machinery and Transformers by Bhag S Guru &Huseyin R Hiziroglu, Oxford University Press	2001
3	Principles of Electric Machines And Power Electronics by P C Sen, Wiley India	2013
4	Electric Machines by D P Kothari and I J Nagrath, 5th Edition, Tata Mcgraw Hill Education Private Limited	2017
5	Electrical Machines by P S Bhimbhra, Khanna Publishers	2021

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Electrical Machines – II by Prof. Tapas Kumar Bhattacharya, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc22_ee06/preview	Swayam
2	Electrical Machines By Prof. G. Bhuvaneshwari | IIT Delhi https://onlinecourses.nptel.ac.in/noc21_ee24/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	-	-	-	1	-	-	1	3	1	2
CO2	3	2	2	-	1	-	-	-	1	-	-	1	3	1	2
CO3	3	2	2	-	1	-	-	-	1	-	-	1	3	1	2
CO4	1	1	1	-	2	3	2	-	1	-	2	1	-	3	3

CourseName	**:**	**Electrical PowerSystem (Minor Specialization)**
CourseCode	**:**	**EEM1002**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshouldbeable to

- Understand the concept of Power generation, transmission and distribution.
- Understand the performance of transmission & distribution systems.
- Understand the frequency control, grounding requirement and new evolution in power systems.
- Understand, the requirement of grounding, safety and Modern Power Systems Structure

TotalNo.ofLectures– 42

WWWWWWWWWWQLecturewisebreakup		**NumberofLectures**
Unit 1	**GenerationSystems & Economics** Principles of hydro, thermal, nuclear and renewable generation. connected load, maximumdemand,demandfactor,diversityfactor,chronologicalloadcurve,loaddurationcurve,masscurve,loadfactor,capacityfactor,plantutilizationfactor;base,peak andstandbystations, typesofload, different types of tariffs.	10
Unit 2	**Insulators** Insulatingmaterials,Types ofinsulators,voltagedistributionoveraninsulatorstring.String-efficiency, Equalizingvoltagedropsacrossinsulatorsofastring. New types of insulators.	05
Unit 3	**Transmission and Distribution** Overhead and underground transmission, transmission voltages. Introduction to EHV and HVDC transmission. Conductor: solid stranded, ACSR, hollow and bundle conductors. Different types of supporting structure. Corona and its effect. Modern trends in Transmission system. Distribution voltage levels, selection of conductor size for distributors. Type and location of distribution substations. Main equipment in distribution sub-station, supporting structures. Distribution system voltage regulation and power factor improvement.	9
Unit 4	**Basic Protection and Switchgears:** Symmetrical component, symmetrical and unsymmetrical shunt faults. Protection of electrical apparatus, basic concepts of relaying, and fuse, isolator, circuit breakers. Different types of relays and circuit breakers.	06
Unit 5	**Frequency & Voltage Control:** Load frequency model of Turbine, generator and load, automatic frequency control for single area with primary & secondly frequency control. Introduction to voltage- reactive power control with compensating devices.	05
Unit 6	**Grounding and Safety** Earthing requirement and arrangements,differenttypesof neutralearthing,calculationof neutralvoltage, earthingresistanceof different rods/arrangements, earthingofsubstationequipment.	04
Unit 7	**Modern Power Systems Structure:** Need and importance of restructuring, Components of deregulated power system, difference between integrated and restructured power system,	03

	different entities of deregulated power system, advantages and limitation of competitive system,	

ListofExperiments:		**Numberof Turns**
1	TomeasurePotentialdistributionacrossdifferentunitsofastringofinsulatorswit hand withoutguardring.	1
2	Tostudyofdifferentpartsofapowercableandmeasurementofinsulationresistan ceofa cable.	2
3	Toplotequi-potentialcurveandvoltagegradientin • Two/three-corecable • Single-corecable.	2
4	ToobtainVoltageRegulationofalongtransmissionlinewithresistiveinductivea nd capacitiveloads.	2
5	ToobtainVoltageProfileofalongtransmissionlinewhen: • Opencircuited • Usingshunt/seriescapacitive compensation • Usingshuntinductivecompensation.	2
6	Tomeasurecoretocore&coreto sheathcapacitanceofathreephasecable.	2
7	ToplotVoltage/Currentcharacteristicsofasolar celland determinationofitsparameters.	1
8	TostudydifferenttypesofLineinsulatorsandobtainbreakdowncharacteristicso fanyone typeofinsulator	2

Course Outcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand power generation & its economics
CO2	Understand major power transmission & distribution systems components
CO3	Evaluate the performance of transmission & distribution systems.
CO4	Understand requirement of grounding, voltage and frequency control and protection.

Text Books:		
Sr. No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	C. L. Wadhwa, "ElectricalPowerSystems" NewAgeInternationalLtd	2010
2	I.J. Nagrath, D.P. Kothari, "ModernPower Systemanalysis"TataMcGrawHill	2003

ReferenceBooks:		
Sr. No.	**NameofBook/Authors/Publisher**	**YearofPublication/Reprint**
1	B. R. Gupta, "PowerSystemAnalysis&Design" SChand&Co	2001
2	S.N. Singh, "ElectricalPowerGeneration, Transmissionanddistribution"PHIPublication	2008
3	Understanding Electric Utilities and De-Regulation by H. Lee Willis , Lorrin Phillipson, CRC Press; 2nd edition	2005
4	J. Duncan Glover, Mulukutla S. Sarna, " Power System Analysis and Design" 3rd edition, Thomson Asia Pte Ltd., ISBN 981-243-125-X, 2003	2003

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://www.coursera.org/learn/electrical-power-generation-an-industrial-outlook?specialization=power-system-generation-transmission-and-protection	Coursera

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	1	--	1	1	--	--	1	1	1	1
CO2	3	1	1	1	1	--	--	--	1	--	1	1	1	1	1
CO3	3	1	1	1	1	1	--	--	1	--	--	1	1	1	1
CO4	3	1	1	1	1	1	--	--	1	--	--	1	1	1	1

CourseName	**:**	**PowerElectronics(Minor Specialization)**
CourseCode	**:**	**EEM1003**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Studentsshould beableto:

- Acquire the knowledge of power semiconductor devices, selectionof suitablepowerconverter
- Understand the operating and switching characteristics of power electronic devices
- Impartknowledgeontheapplicationofdifferentpowerconvertertopologies.
- Apply the knowledge of protection circuits to the power devices.

TotalNo.ofLectures -42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**OverviewofPowerSemiconductorDevices** Powerelectronicsversuslinearelectronics,scopeand applications,interdisciplinarynatureofpower electronics,powersemiconductordevices-MOSFET,IGBT,TRIAC,SCR:construction,operationand switchingcharacteristics.	04
Unit 2	**GateDriveandProtectionCircuitsforPowerDevices** GatedrivecircuitsforpowerMOSFET/IGBT,gatedrivecircuitsforSCR/TRIAC :isolationofgateand base drives using pulse transformers and opto-coupler, UJT triggering for SCR, protection circuitsfor power devices: snubber circuits, current protections – fusing, fault current with AC source, faultcurrentwithDCsource.	06
Unit 3	**AC-DCConverters** Phase controlled rectifier, single-phase half-wave and full-wave controlled rectifier, single-phase semi-converter,three-phase half-waveandfull-wavecontrolledrectifier,three-phasedualconverter.	06
Unit 4	**DC-DCConverters** DC-DCconverters:workingprincipleofbuck,boostandbuck-boostconverters,controlstrategies,controlcircuitdesign, synchronousconverters.	09
Unit 5	**DC-ACConverters&ACVoltageController** DC-AC converters: single phase full bridge inverter, three phase voltage source inverter for balancedload, need of sine PWM inverters, control circuit design of single and three phase inverters, singlephaseACvoltage controller.	10
Unit6	**PowerElectronicsApplications** HVDCtransmissionsystem,On-lineandOff-lineUPS,powerelectronicsinbatterychargingapplications, power electronics in induction heating, electronic lamp ballast, power electronics forelectricdriveapplications,power electronicsconverter forrenewableenergyapplications.	07

ListofExperiments:		**Number ofTurns**
1	AnexperimentalstudyonMOSFETandIGBT gatedrivercircuit.	02
2	Astudyonoverload protectionofMOSFETand IGBT.	01
3	Toobtaintheperformanceofsingle-phasecontrolled rectifier.	01
4	Toobtaintheperformanceofthree-phasecontrolled rectifier.	01

5	Toobtaintheperformanceofbuck,boost,buck-boostDC-DCconverters.	02
6	Tosimulatesynchronousconverters.	01
7	Toobtaintheperformanceofsingle-phasefullbridgeinverter.	01
8	Toobtaintheperformanceofthreephase fullbridgeinverter.	01
9	TosimulatetheAC voltagecontroller.	01
10	Tosimulatetheon-lineandoff-lineUPS.	01
11	Tosimulatethepowerconverterforelectricdriveapplication.	01
12	Toobtaintheperformanceofpowerelectronicconverterforbatterycharging.	01

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand the basic operation of power electronics switches.
CO2	Impart the knowledge of operating principle of power electronics converters.
CO3	Analyzethe performance of power electronics converters.
CO4	Apply the knowledge of power converter to the commercial applications.

Text Books		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	VinodKumar,RanjanKumarBehera,DheerajJoshi,RameshBansal,"PowerElectronics, Drives,andAdvanced Applications.CRCpress.	2020
2	FredeBlaabjerg,TomislavDragičević,PooyaDavari,"ApplicationsofPowerElectronics"Volume1, MDPI.	2019

ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	MuhammadH.Rashid."Powerelectronics:devices,circuitsandapplications."Pearson.	2017

Equivalent MOOCs courses:

Sr. No.	**Course Links**	**Offered by**
1	**Fundamental of Power Electronics** By Prof. L Umanand | IISc Bangalore https://onlinecourses.nptel.ac.in/noc21_ee01/preview	NPTEL
2	**Power Electronics, IIT Delhi** **Prof. G.Bhuvaneshwari, IIT Delhi** https://archive.nptel.ac.in/courses/108/102/108102145/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	-	1	-	-	-	1	-	-	1	2	1	1
CO2	2	2	2	-	1	-	-	-	1	-	-	1	2	1	1
CO3	2	2	2	-	1	-	-	-	1	-	-	1	2	1	1
CO4	1	1	1	-	2	2	2	-	1	-	2	1	-	2	1

Department of Electrical Engineering
Course Curriculum
B.Tech (Electrical Engineering)

Detailed Syllabus of Minor Specialization Course in Renewable Energy and E-Mobility

Minor Specialization in Renewable Energy and EV Management

Semester	Course Code	Course Name	L	T	P	Credits
III	EEM2001	Photovoltaics- Photon to Solar Farms	3	0	2	4
IV	EEM2002	Renewable Energy Technologies	3	0	2	4
V	EEM2003	ElectricVehicles and Battery Management System	3	0	2	4

Course Name	**:**	**Photovoltaics- Photon to Solar Farms**
Course Code	**:**	**EEM2001**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives :

Students should be able to

- Explore the basic principle of solar cells and modules.
- Understand the solar equivalent circuits and of different operating parameters
- Analyze the energy conversion mechanism and related issues for solar PV systems.
- Develop the standalone and grid connected PV systems using software.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**Solar Resource** The solar spectrum, altitude angle of sun, solar position, sun path diagrams, clear sky direct beam radiations, total clear sky insolation on a collecting surface, monthly clear sky insolation, solar radiation measurements, need and prospects of photovoltaics.	08
Unit 2	**Photovoltaic Materials and Electrical Characteristics** Introduction, basic semiconductor physics, A generic photovoltaic cell, equivalent circuit, from cells to modules to arrays, the *PV* and *I-V* curves under standard conditions, shading impacts, crystalline silicon technology, thin film photovoltaics.	10
Unit 3	**Photovoltaic Systems** Introduction to major photovoltaic systems. Stand alone PV systems: sizing and design of PV system, PV powered water pumping system. Grid connected systems: Basic components, sizing, design, utility interfacing requirements, and grid connected PV system economics.	10
Unit 4	**Control Structure for Photovoltaic System** System level concerns for grid connected and standalone PV systems, algorithms for grid connected single-phase and three-phase PV systems, synchronizing technique.	07
Unit 5	**Modelling and Simulation** Modeling and simulation of grid connected and standalone PV systems using software tools such as MATLAB, PSIM, PSpice etc.	07

List of Experiments:		**Number of Turns**
1	measure the solar irradiation at a given location and	1
2	obtain I-V and P-V characteristics of solar PV module for different irradiation and temperature.	1
3	obtain I-V and P-V characteristics solar PV modules when connected in (i) series and (ii) parallel.	1

4	evaluate the effect of variation in tilt angle on PV module power output.	1
5	simulate a standalone solar PV system for residential load applications using MPPT control.	2
6	study and simulate a transformer-less single-phase grid connected roof-top photovoltaic (PV) system connected to the electrical utility grid.	2
7	study and simulate three-phase grid-connected solar photovoltaic (PV) system using MATLAB.	3
8	carry out a techno-economic analysis of grid connected solar PV system.	1
9	evaluate the performance of solar photovoltaic system using laboratory set-up.	2

Course Outcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Understand the basics principle of solar photovoltaic cells, modules, and arrays.
CO2	Understand the operation of various photovoltaic systems and their applications.
CO3	Analyze the energy conversion from solar photovoltaic modules and their utilization.
CO4	Analyze the control structure of grid connected and standalone solar PV systems.

Text Book:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	C.S. Solanki, "Renewable Energy Technologies: A practical guide for beginner," PHI.	2009
2	Solar Cells: Operating Principles, Technology and System Applications, Martin A. Green, Prentice-Hall, 1986, ISBN No. 13: 978-0138222703	1986
3	Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", Wiley Interscience, John Willey and Sons.	2004
4	Solar Energy Fundamentals, Technology, and Systems, Smets Arno et al., UIT Cambridge, ISBN: 9781906860325, 9781906860325	2005

Reference Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Weidong Xiao, "Photovoltaic Power System: Modeling, Design, and Control",Wiley.	2017
2	JennyNelson,"ThePhysicsofSolarCells,"(ImperialCollege,UK).	2003
3	VaughnC.NelsonandKennethL.Starcher,"IntroductiontoRenewableEnergy,(Energyandthe Environment)2ndEdition,.	2015

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	**Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems, IIT Guwahati** Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi https://nptel.ac.in/courses/103103206	NPTEL
2	https://onlinecourses.nptel.ac.in/noc24_ch26/preview	SWYAM

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	-	-	-	1	1	1	2	2	1	-
CO2	2	2	1	1	1	-	-	-	1	1	1	2	2	2	-
CO3	2	2	1	1	1		-	1	1	1	1	2	2	2	1
CO4	2	2	2	2	1	1	-	1	1	2	2	2	2	2	1

CourseName	**:**	**RenewableEnergy Technologies**
CourseCode	**:**	**EEM2002**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to :

- Toprovide theknowledgeofwind energy, fuel cell, and other renewable sources.
- To present the construction and working various renewable energy sources.
- To understand the control aspect of various renewable energy sources.
- To design and simulate the control of wind energy conversion system and other renewable energy sources.

TotalNo.ofLectures-42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**Introduction** Indian energy scenario, available renewable energy potential, government schemes and policies for renewable energy generation, sustainable energy resources: national and international scenario.	05
Unit 2	**Basics of WindEnergy** Operating principle, wind energy generation basics, power, torque-speed characteristics, maximum power coefficient, wind velocity measuring instrument, factors effecting the wind energy output, wind turbine architecture, fixed speed and variable speed wind turbines,	08
Unit 3	**Wind Energy Conversion System** Wind energy conversion: DFIG and PMSG based wind turbines, types and classification of WECS, wind turbine controller, design of controller for grid side and rotor side converter.	08
Unit 4	**Hydrogen and Fuel Cell Technology** Introduction to hydrogen energy, various hydrogen production methods, types of electrolyzer, type of fuel cells, component of fuel cells, fuel cell calculations, design of integrated hydrogen energy systems, fuel-cell electric vehicle and applications.	08
Unit 5	**Other Renewable Energy Resources** Biomass energy conversion technologies, biomass co-generation, ethanolfrom biomass. Small hydropower systems: overview of micro, mini and small hydro systems. Energy generation from ocean waves: ocean thermal energy conversion and tidal energy conversion, introductionto geothermalenergyconversion.	09
Unit 6	**Battery Energy Storage System** Battery energy storage system: Introduction to electrochemical techniques, electrochemical energy storage systems, advanced rechargeable batteries.	04

List of Experiments:		Number of Turns
1	obtain the operational characteristics of wind energy system at different wind speed.	1
2	study effect of load on wind turbine output.	1
3	study and simulate aDFIG based wind energy conversion system.	2
4	evaluate the performance of wind energy conversion system using laboratory set-up.	2
5	study and simulate the characteristics of fuel cell with the help of a resistive load.	2
6	design a hybrid micro-grid system assisted with solar PV, wind and battery energy storage system.	3
7	To evaluate fuel cell system performance with only DC load connected to the charge controller with battery bank.	2
8	To simulate and study hydro power system.	1

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto;	
CO1	Understandthe energy scenario and requirement of renewable energy sources.
CO2	Understand the operations of wind, fuel cell, hydrogen, biomass and small hydro based renewable energy sources.
CO3	Apply the knowledge of renewable energy technologies for small scale applications.
CO4	Analyze the control aspects of various renewable energy sources.

TextBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	C.S.Solanki, "SolarPhotovoltaics-FundamentalsTechnologiesandApplications,"PHI.	2015
2	Kothari, D.P., Ranjan, R. and Singal, K.C., 2021. Renewable energy sources and emerging technologies.	2021

ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication /Reprint**
1	VaughnC.NelsonandKennethL.Starcher,"IntroductiontoRenewableEnergy, (Energyandthe Environment)2ndEdition,".	2015
2	WagnerH.andMathurJ,"IntroductiontoHydroEnergySystems:Basics,Techn	2011

	ologyand Operation",Springer.	
3	Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", Wiley Interscience, John Willey and Sons.	2004

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	**Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems, IIT Guwahati** Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi https://nptel.ac.in/courses/103103206	NPTEL
2	https://onlinecourses.nptel.ac.in/noc24_ch26/preview	SWYAM

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**2**	**3**	**1**	**-**
CO2	**2**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**2**	**2**	**2**	**-**
CO3	**2**	**3**	**2**	**2**	**1**		**-**	**1**	**1**	**1**	**1**	**2**	**3**	**2**	**1**
CO4	**2**	**3**	**3**	**2**	**1**	**1**	**-**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**1**

CourseName	**:**	**ElectricVehicles and Battery Management System**
CourseCode	**:**	**EEM2003**
Credits	**:**	**4**
LTP	**:**	**3-0-2**

CourseObjectives:

Students should be able to:

- Acquire the knowledge on hybrid and electric vehicle operation and architectures.
- Select appropriate motor, converter and energy storage system for the electric vehicles.
- Acquire the knowledge of Battery management system used in electricvehicles.
- Design a battery electric vehicle and battery management system.

TotalNo.ofLectures- 42

LectureWiseBreakup		**Number ofLectures**
Unit 1	**IntroductiontoElectricVehicles** Comparisonof Battery Electric Vehicle (BEV) and Internal Combustion (IC)engine drivevehicles; social and environmental importance of hybrid and electric vehicles, basicsofvehicleperformance,powersourcecharacterization,transmission characteristics, Mathematical models for vehicle performance, basic concept ofhybridtraction, drive-traintopologies,powerflowcontrolinhybrid drive-traintopologies,fuelefficiencyanalysis. Standards and government policies related to EVs and HEVs.	08
Unit 2	**ElectricDrive System** Introduction to electric components used in hybrid and electric vehicles. Types of motors usedinEVandtorque-speedcharacteristics,configurationandcontrol of motors used in EV. DCmotordrives,inductionmotor,permanentmagnetmotor,switchreluctancemotordrives; drivesystemefficiency.	08
Unit 3	**EnergyStorage** Introduction toenergy storagerequirements inhybridandelectricvehicles,storagetypes: battery,super capacitor/ultra capacitors,flywheel,andfuelcellbasedenergy storageanditsanalysis.	06
Unit 4	**BatteryChargers** ACandDCChargers,Alternatechargingsources–wireless&solar Bidirectional DC-DC converters for electric vehicle storage system	03
Unit 5	**EnergyManagementandControlStrategies** Introductiontoenergymanagementstrategiesusedinhybridandelectricvehicles, classificationofdifferentenergymanagementstrategies,comparisonofdifferent energymanagementstrategies, implementationissuesofenergymanagementstrategies.	06
Unit 6	**Battery Management System** FundamentalsofEVbatterypackdesign, Electrical , Mechanical and Thermal Design of Battery Pack, BMS function, Cell balancing, BMS Architecture, Layout and connection, Battery pack sensing and protection,	07
Unit 7	**ElectricVehicleCaseStudies** Designofabatteryelectric vehicle(BEV), Design ofBattery Management System.	04

ListofExperiments:		**Number ofTurns**
1	Toobtaintheperformance oflead-acid andli-ionbatteryenergystorage.	02
2	Toobtaintheperformanceofsupercapacitor.	01
3	Tosimulatelead-acid/li-ionbatteryandsupercapacitorhybridenergystoragesystem.	02
4	TosimulatetheI-Vcharacteristicsoffuelcell.	01
5	Toobtainthedifferenceinperformanceof ACand DCchargers.	01
6	TosimulatetheDCfastchargersforelectricvehicles(EV).	01
7	ToobtaintheperformanceofbidirectionalDC-DCconverter.	01
8	Toobtaintheperformanceofresonantconverter.	01
9	TosimulatesinePWMinverter.	01
10	Toobtaintheperformanceof – permanentmagnet,inductionandswitchedreluctancemotors.	02
11	TosimulatethebatterybasedEV.	02

CourseOutcomes: Bytheendofthiscourse, thestudents willbeableto	
CO1	Interpretworkingofelectricpropulsionunitanditscontrolforapplicationofelectricvehicles.
CO2	Evaluate various motors, converters, and energy storage systems employed in electric vehicle applications.
CO3	Explore the function of Battery Management Systems (BMS) in EVs.
CO4	Design a battery electric vehicle and battery management system.

TextBook		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication / Reprint**
1	MehrdadEhsani,YiminGao,StefanoLongo,KambizM.Ebrahimi,"ModernElectric,Hybrid Electric,andFuelCellVehicles",Taylor&FrancisGroup,LLC.	2018
2	H. J. Bergveld, "Battery management systems : design by modelling" University Press Facilities, Eindhoven	2001

ReferenceBooks		
Sr.No.	**NameofBook/Authors/Publisher**	**Year ofPublication/ Reprint**
1	IqbalHusain, "ElectricandHybridVehicles:DesignFundamentals",3rdeditionCRCPress.	2021
2	TomDenton,"ElectricandHybridVehicles",Taylor&Francis.	2018
3	JohnMiller,"PropulsionSystemsforHybridVehicles,"InstituteofElectricalEngineers,UK.	2004
4	ChrisMi,MAMasrur,DWGao,"HybridElectricVehicles– Principlesandapplicationswith practicalperspectives,"Wiley.	2011
5	JamesLarminie,JohnLowry,"Electric VehicleTechnologyExplained",Wiley.	2003
6	C.M.Jefferson&R.H.Barnard,"HybridVehiclePropulsion,"WITPress.	2002
7	L. Ashok Kumar, S Albert Alexander," Power converters for Electric Vehicles," CRCPress.	2021

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Electric vehicles and Renewable energy, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, Prof. L Kannan https://archive.nptel.ac.in/courses/108/106/108106182/	NPTEL
2	Electric Vehicles - Part 1, IIT Madras Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha, Prof. L Kannan https://archive.nptel.ac.in/courses/108/102/108102121/	NPTEL
3	Introduction to Hybrid and Electric Vehicles, IIT Guwahati Dr. Praveen Kumar, Prof. S. Majh NPTEL :: Electrical Engineering - Introduction to Hybrid and Electric Vehicles	NPTEL
4	***BatteryManagement System*** Learning through flipped classroom : https://archive.nptel.ac.in/courses/108/106/108106182/ (Week 4 to 7, BMS Design and Embedded system Part 1 to 5)	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	2	3	1	1	1	1	3	3	2	3
CO2	3	2	1	2	2	2	3	1	1	1	1	3	3	2	3
CO3	3	2	1	2	2	2	3	1	1	1	1	3	3	2	3
CO4	3	3	3	3	2	2	3	1	1	1	1	3	3	2	3