UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Electrical Engineering

Second Year with Effect from AY 2020-21

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, Faculty of Science and Technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

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Program Structure for Second Year Electrical Engineering
(Semester III & IV)
UNIVERSITY OF MUMBAI
(With Effect from 2020-2021)

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
EEC301	Engineering Mathematics-III	3	--	1	3	--	1	4
EEC302	Electrical Circuit Analysis	3		--	3		--	3
EEC303	Fundamentals of Electrical Machines & Measurements	4	--	--	4	--	--	4
EEC304	Electrical Power System I	3	--	--	3	--	--	3
EEC305	Analog Electronics	3	--	--	3	--	--	3
EEL301	Electrical Machines & Measurements Lab	--	2	--	--	1	--	1
EEL302	Electronics Lab-I	--	2	--	--	1	--	1
EEL303	Simulation Lab-I	--	2	--	--	1	--	1
EEL304	Applied Electrical Engineering Lab (SBL)	--	4	--	--	2	--	2
EEM301	Mini Project – 1A	--	4$	--	--	2	--	2
Total		**16**	**14**	**1**	**16**	**07**	**1**	**24**

Examination Scheme

Course Code	Course Name	Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test I	Test II	Avg					
EEC301	Engineering Mathematics-III	20	20	20	80	3	25	--	125
EEC302	Electrical Circuit Analysis	20	20	20	80	3	--	--	100
EEC303	Fundamentals of Electrical Machines & Measurements	20	20	20	80	3	--	--	100
EEC304	Electrical Power System-I	20	20	20	80	3	--	--	100
EEC305	Analog Electronics	20	20	20	80	3	--	--	100
EEL301	Electrical Machines & Measurements Lab	--	--	--	--	--	25	25	50
EEL302	Electronics Lab-I	--	--	--	--	--	25	25	50
EEL303	Simulation Lab-I	--	--	--	--	--	25	25	50
EEL304	Applied Electrical Engineering Lab (SBL)	--	--	--	--	--	50	--	50
EEM301	Mini Project – 1A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**175**	**75**	**775**

$ indicates work load of Learner (Not Faculty), for Mini Project

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
EEC401	Engineering Mathematics-IV	3	--	1	3	--	1	4
EEC402	Electrical AC Machines-I	3	--	--	3	--	--	3
EEC403	Digital Electronics	3	--	--	3	--	--	3
EEC404	Power Electronic Devices and Circuits	3	--	--	3	--	--	3
EEC405	Electric and Hybrid Electric Vehicles	3	--	--	3	--	--	3
EEL401	Electrical AC Machines Lab I	--	2	--	--	1	--	1
EEL402	Python Programming Lab	--	2	--	--	1	--	1
EEL403	Electronics Lab II	--	2	--	--	1	--	1
EEL404	PCB Design and Fabrication Lab (SBL)	--	4	--	--	2	--	2
EEM401	Mini Project – 1B	--	4$	--	--	2	--	2
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Examination Scheme

Course Code	Course Name	Theory					Term Work	Pract/ oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test I	Test II	Avg.					
EEC401	Engineering Mathematics-IV	20	20	20	80	3	25	--	125
EEC402	Electrical AC Machines-I	20	20	20	80	3	--	--	100
EEC403	Digital Electronics	20	20	20	80	3	--	--	100
EEC404	Power Electronic Devices and Circuits	20	20	20	80	3	--	--	100
EEC405	Electric and Hybrid Electric Vehicles	20	20	20	80	3	--	--	100
EEL401	Electrical AC Machines Lab-I	--	--	--	--	--	25	25	50
EEL402	Python Programming Lab	--	--	--	--	--	25	25	50
EEL403	Electronics Lab-II	--	--	--	--	--	25	25	50
EEL404	PCB Design and Fabrication Lab (SBL)	--	--	--	--	--	50	--	50
EEM401	Mini Project -1B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**100**	**775**

$ indicates work load of Learner (Not Faculty), for Mini Project

Students group and load of faculty per week.

Mini Project 1A / 1B: Students can form groups with minimum 2 (Two) and not more than 4 (Four)
Faculty Load: 1 hour per week per four groups

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC301	**Engineering Mathematics-III**	**03**	**-**	**01**	**03**	**-**	**01**	**04**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**25**	**-**	**-**	**125**

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II, Scalar and Vector Product: Scalar and vector product of three and four vectors.

Course Objectives	1. To learn the Laplace Transform, Inverse Laplace Transform of various functions and its applications. 2. To understand the concept of Fourier Series, its complex form and enhance the problem solving skill. 3. To understand the concept of complex variables, C-R equations, harmonic functions and its conjugate and mapping in complex plane. 4. To understand the basics of Linear Algebra. 5. To use concepts of vector calculus to analyze and model engineering problems.
Course Outcomes	**On successful completion of course learner/student will be able to:** 1. Understand the concept of Laplace transform and its application to solve the real integrals in engineering problems. 2. Understand the concept of inverse Laplace transform of various functions and its applications in engineering problems. 3. Expand the periodic function by using Fourier series for real life problems and complex engineering problems. 4. Understand complex variable theory, application of harmonic conjugate to get orthogonal trajectories and analytic function. 5. Use matrix algebra to solve the engineering problems. 6. Apply the concepts of vector calculus in real life problems.

Module	Detailed Contents	Hours
1.	**Module: Laplace Transform** 1.1 Definition of Laplace transform, Condition of Existence of Laplace transform. 1.2 Laplace Transform (L) of Standard Functions like e^{at}, $sin(at)$, $cos(at)$, $sinh(at)$, $cosh(at)$ and $t^n, n \geq 0$. 1.3 Properties of Laplace Transform: Linearity, First Shifting theorem, Second Shifting Theorem, change of scale Property, multiplication by *t*, Division by *t,* Laplace Transform of derivatives and integrals (Properties without proof). 1.4 Evaluation of integrals by using Laplace Transformation. **Self-learning Topics:** Heaviside's Unit Step function, Laplace Transform of Periodic functions, Dirac Delta Function.	**06**

2.	**Module: Inverse Laplace Transform** 2.1 Inverse Laplace Transform, Linearity property, use of standard formulae to find inverse Laplace Transform, finding Inverse Laplace transform using derivatives. 2.2 Partial fractions method to find inverse Laplace transform. 2.3 Inverse Laplace transform using Convolution theorem (without proof). **Self-learning Topics:** Applications to solve initial and boundary value problems involving ordinary differential equations.	**06**
3.	**Module: Fourier Series:** 3.1 Dirichlet's conditions, Definition of Fourier series and Parseval's Identity (without proof). 3.2 Fourier series of periodic function with period 2π and $2l$. 3.3 Fourier series of even and odd functions. 3.4 Half range Sine and Cosine Series. **Self-learning Topics:** Complex form of Fourier Series, Orthogonal and orthonormal set of functions. Fourier Transform.	**06**
4.	**Module: Complex Variables:** 4.1 Function $f(z)$ of complex variable, limit, continuity and differentiability of $f(z)$Analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof). 4.2 Cauchy-Riemann equations in cartesian coordinates (without proof). 4.3 Milne-Thomson method to determine analytic function $f(z)$when real part (u) or Imaginary part (v) or its combination (u+v or u-v) is given. 4.4 Harmonic function, Harmonic conjugate and orthogonal trajectories **Self-learning Topics:** Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations.	**06**
5.	**Module: Linear Algebra: Matrix Theory** 5.1 Characteristic equation, Eigen values and Eigen vectors, Example based on properties of Eigen values and Eigen vectors. (Without Proof). 5.2 Cayley-Hamilton theorem (Without proof), Examples based on verification of Cayley- Hamilton theorem and compute inverse of Matrix. 5.3 Similarity of matrices, Diagonalization of matrices. Functions of square matrix **Self-learning Topics:** Application of Matrix Theory in machine learning and google page rank algorithms, derogatory and non-derogatory matrices**.**	**06**
6.	**Module: Vector Differentiation and Integral** 6.1 **Vector differentiation**: Basics of Gradient, Divergence and Curl (Without Proof) 6.2 **Properties of vector field:** Solenoidal and irrotational (conservative) vector fields 6.3 **Vector integral:** Line Integral, Green's theorem in a plane (Without Proof), Stokes' theorem (Without Proof) only evaluation. **Self-learning Topics:** Gauss' divergence Theorem and applications of Vector calculus.	**06**

Term Work:

General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practicals.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus.

3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering Mathematics. This project should be graded for 10 marks depending on the performance of the students.

   The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment-I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment-II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

References Books:

1. Advanced engineering mathematics, H.K. Das, S. Chand, Publications
2. Higher Engineering Mathematics, B. V. Ramana, Tata Mc-Graw Hill Publication
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication
4. Advanced Engineering Mathematics, Wylie and Barret, Tata Mc-Graw Hill.
5. Theory and Problems of Fourier Analysis with applications to BVP, Murray Spiegel, Schaum's Outline Series
6. Vector Analysis Murry R. Spiegel, Schaum's outline series, Mc-Graw Hill Publication
7. Beginning Linear Algebra, Seymour Lipschutz, Schaum's outline series, Mc-Graw Hill Publication
8. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC302	**Electrical Circuit Analysis**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To impart the knowledge of various fundamental electrical theorems for analysis of electrical circuits from application point of view. 2. To inculcate the problem solving and analysis skills in students.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Apply network theorems for the analysis of electrical circuits. 2. Obtain the transient and steady-state response of electrical circuits. 3. Develop and analyse transfer function model of system using two port network parameters. 4. Analyse time domain behaviour from pole zero plot. 5. Analyse electrical network using graph theory. 6. Analyse the effect of switching conditions on electrical networks using differential equations and Laplace Theorem.

Module	Detailed Contents	Hours
1.	**Electrical Circuit Analysis** **With DC Dependent Sources:** Mesh analysis, Super mesh analysis, Nodal analysis, Super node analysis, Source transformation and Source shifting. Superposition theorem, Thevenin's theorems and Norton's theorem and Maximum power transfer theorem; **With AC Sources:** Magnetic coupling, Mesh analysis, Nodal analysis, Superposition theorem, Thevenin's theorems, Norton's theorem, Maximum power transfer theorem and Reciprocity theorem.	**08**
2.	**First and Second Order Circuits:** Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.	**06**
3.	**Graph Theory and Network Topology:** Introduction, Graph of network, Tree, Co-tree, Loop incidence matrix, Cut set matrix, Tie set matrix and Loop current matrix, Number of possible tree of a graph, Analysis of network equilibrium equation and Principle of duality.	**05**
4.	**Electrical Circuit Analysis Using Laplace Transforms:** The Laplace transform and its application in electrical circuit analysis, transient and steady state response to step, ramp and impulse signals.	**05**

5.	**Two port parameters:** Open circuit, short circuit, transmission and hybrid Parameters, relationships between parameter sets, reciprocity and symmetry conditions, parallel connection of two port networks, cascade connection of two-port networks.	**06**
6.	**Network Functions- Poles and Zeros:** Network functions for one port and two port networks, Driving point and transfer functions, ladder network, General network, poles and zeros of network functions, restrictions on Pole and zero locations for driving point functions and Transfer functions, time domain behavior from pole - zero plot.	**06**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment-TEST-I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment Test-II) when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. W H Hayt, S M Durbin, J E Kemmerly, *Engineering Circuit Analysis,* Tata McGraw-Hill Education, 2013.
2. M. E. Van Valkenburg, *Network Analysis,* 3rd Edition, PHI Learning.
3. D. Roy Choudhury, *Networks and System,* 2nd Edition, New Age International.
4. M. E. Van Valkenburg, *Linear Circuits*, Prentice Hall.
5. C. K. Alexander and M. N. O. Sadiku, *Electric Circuits*, McGraw Hill Education, 2004.
6. K. V. V. Murthy and M. S. Kamath, *Basic Circuit Analysis*, Jaico Publishers, 1999

Reference Books:

1. F. F. Kuo, *Network Analysis and Synthesis*, John Wiley and sons.
2. N Balabanian and T.A. Bickart, *Linear Network Theory: Analysis, Properties, Design and Synthesis*, Matrix Publishers.
3. C. L.Wadhwa, *Network Analysis and Synthesis*, New Age International.
4. B. Somanathan Nair, *Network Analysis and Synthesis*, Elsevier Publications.

NPTEL/ Swayam Course:

1. **Course: Basic Electric Circuits By Prof. Ankush Sharma (IIT Kanpur); https://swayam.gov.in/nd1_noc19_ee36/preview**
2. **Course: Basic Electrical Circuits by Prof. Nagendra Krishnapura (IIT Madras) https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee64/**

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC303	**Fundamentals of Electrical Machines & Measurements**	**04**	**-**	**-**	**04**	**-**	**-**	**04**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	**To impart the knowledge on the following:** 1. Concepts of magnetism and energy conversion. 2. Concepts of DC machines and their applications. 3. Working principles of various analog and digital instruments & devices used for measurement of the various electrical and electronic parameters.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate the principle of energy conversion in single and double excited machines. 2. Understand the performance parameters of DC machines. 3. Analyze the effect of performance parameters and application of DC machines. 4. Analyze the working of various analog and digital instruments in electrical and electronic measurements. 5. Analyze the performance of bridges used in electrical and electronic measurements. 6. Illustrate the need for extension of range of meters and calibration in instruments.

Module	Detailed Contents	Hours
1	**Basics of Magnetism:** Magnetic field and circuit, Numerical based on series parallel magnetic circuit, Flux linkage, Inductance and energy, Faraday's laws, Hysteresis and eddy current losses.	**04**
2	**Electromechanical Energy Conversion:** Principle, Energy stored in magnetic field, Field and co energy, Force and torque equations, Torque in singly and doubly excited systems, MMF in distributed windings Winding inductance, Magnetic field in rotating machines, Rotating MMF wave Leakage flux and magnetic saturation.	**08**
3	**DC Machines:** Armature reaction, Characteristics of DC generators (OCC and SCC) and motors (speed – torque and performance), Necessity of starter and types, Speed control and braking methods, Losses and efficiency, Swinburne's, Hopkinson's and Retardation tests, PMDC motor.	**12**
4	**Analog Measurement:** Fundamental element of an instrument, Static and dynamic characteristics, Errors in Measurement, Standards and calibrations, Difference between indicating and integrating instruments, Moving coil and moving iron instruments, Ammeters shunts & voltmeter multiplier, Dynamometer type wattmeter, Power factor meter, Instrument transformer. Measurements of R, L and C.	**07**

5	**Potentiometers, Bridges and Transducers:** **Potentiometers:** Basic potentiometer circuit, calibration of ammeter, voltmeter and wattmeter. **Bridges:** Wheatstone, Kelvin's double bridge, Maxwell's bridge, Schering Bridge, Q meter. **Transducers:** Classification of transducers, Selection of transducers, Resistive, capacitive & inductive transducers, Piezoelectric, Hall effect, Optical and digital transducers. **Measurement of non-electrical quantities:** Basic principles of: temperature (Thermistor and Thermo couple), pressure (strain-gauge, capacitive and inductive type) and speed (Inductive and Hall Effect). Basic requirements of signal conditioning circuits. Amplifier, Filter, and linearization circuit. **Self-study**: Hay's bridge, Anderson's bridge, velocity, force and torque measurement.	**10**
6	**Digital Measurements:** Advantages of digital meters over analog meters, Resolution & sensitivity of digital meters, Working principles of digital Voltmeter, Ammeter, Multi-meter. Working principles and features of Digital Tachometer, Digital Megger, and Digital Storage Oscilloscope. Introduction to MEMS (micro-electromechanical systems) technology and their applications in electrical and automotive domain.	**07**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment-I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment-II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. Bimbhra P. S., *Electric Machinery*, Khanna Publisher,
2. Bimbhra P. S., *Generalized Machine Theory*, Khanna Publisher,
3. S. K. Pillai, *A first course on Electrical Drives,* New Age Publication
4. V. K. Mehta, *Principles of Electrical Machines,* S Chand Publications
5. AK Sawhney, *Electrical & Electronic Measurements and Instrumentation*, Dhanpat Rai & Sons
6. Helfric and Cooper, *Modern Electronic Instrumentation and Measurement Techniques*, PHI
7. H.S.Kalsi, *Electronic Instrumentation*, Third Edition, Tata McGraw Hill
8. Ramon Pallaá S-Areny and J. G. Webster, *Sensors And Signal Conditioning*, Second Edition, John Wiley & Sons, Inc.

Reference Books:

1. M. G. Say and E. O. Taylor, *Direct current machines*, Pitman publication
2. Ashfaq Husain, *Electric Machines*, Dhanpat Rai and Co. Publications
3. Alan.S.Moris, *Principle of Measurement & Instrumentation*, Prentice Hall of India

4. RS Sirohi & Radhakrisnan, *Electrical Measurement & Instrumentation*, New Age International
5. M. V. Deshpande, *Electric Machines*, PHI
6. Vedam Subramanyam, *Electrical Drive-concept and applications*, TMH Publication
7. Sabrie Soloman, *Sensors Handbook*, Second Edition, McGraw Hill

NPTEL/ Swayam Course:

Course: Electrical Machines – I By Prof. Tapas Kumar Bhattacharya (IIT Kharagpur)
https://swayam.gov.in/nd1_noc20_ee60/preview

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC304	**Electrical Power System-I**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To learn basics of electrical power systems and its different components. 2. To get knowledge of transmission / distribution line and its parameters. 3. To learn representation and performance evaluation of power systems. 4. To understand electric cable and earthing
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Understand the power system and its components. 2. Categorize the ac transmission / distribution lines and understand the insulators. 3. Evaluate the parameters of different types of ac transmission / distribution lines. 4. Draw the PU reactance diagram of a power system for analysis. 5. Analyse the performance of transmission lines. 6. Understand the performance parameters of electric cable and earthing.

Module	Detailed Contents	Hours
1	**Introduction:** Basic structure of power system: generation, transmission and distribution, single line diagram of typical AC supply system, different types of conventional and non-conventional energy sources, their working principle and operation with block diagram.	**05**
2	**Types of AC Transmission / Distribution Lines and Insulators:** **Types of AC Transmission / Distribution Lines:** single phase two wire, three phase three wire (symmetrical and unsymmetrical spacing), three phase double circuit, three phase four wire, concept of composite and bundle conductor. **Insulators:** Type of insulators, potential distribution across insulator string, string efficiency, methods for improving string efficiency (Numerical).	**05**
3	**Transmission / Distribution Line Parameters:** Resistance of transmission line, skin effect, proximity effect, definition of inductance, internal and external flux linkage of single conductor, inductance of single phase two wire line, inductance of three phase three wire line with symmetrical and unsymmetrical spacing, concept of GMR and GMD, inductance of three phase double circuit line, inductance of bundled conductor lines, Capacitance of transmission line, capacitance of single phase line, capacitance of three phase line with symmetrical and unsymmetrical spacing, effect of earth on transmission line capacitance (single phase only) (Numerical)	**10**

4	**Representation of Power System Components:** Introduction, single phase solution of balanced three phase networks, one-line diagram and impedance or reactance diagram, Per Unit (PU) system, advantage of PU system, PU impedance diagram, representation of load (Numerical).	**04**
5	**Performance of Transmission Line:** Classification and modelling of short, medium and long lines, regulation and efficiency of short and medium lines, Ferranti effect, evaluation and estimation of generalized circuit constant (ABCD) for short and medium lines, surge impedance loading, tuned power line, (Numerical).	**06**
6	**Electric Cable and Earthing:** **Electric Cable:** Classification and construction of cable, insulation resistance of cable, capacitance of single core and three core cable, grading of cable, inter-sheath grading, capacitance grading **Earthing:** Earthing definition, soil resistivity, step and touch potentials; measurement of earth resistance, soil resistivity, neutral grounding and its methods.	**06**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment-I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment-II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. Fredrick T Morse, *Power Plant Engineering,* East-West Press Pvt Ltd
2. Mahesh Verma, *Power Plant Engineering,* Metrolitan Book Co Pvt Ltd
3. RK Rajput, *A Text Book of Power System engineering,* Laxmi Publication
4. George W Sutton-(Editor), *Direct Energy Conversion,* Lathur University, Electronic Series Vol-3 McGraw Hill
5. D. P. Kothari, I. J. Nagrath, *Power System Engineering*, 3 Edition, Mc Graw Hill
6. B.R. Gupta, *Power System Analysis And Design*, S.Chand
7. J B. Gupta, *A Course in Power System*, S. K. Kataria & Sons
8. Mehta V.K., *Principles of Power System*, S Chand

Reference Books:-

1. Stevenson and Grainger, *Modern Power System Analysis*, 1 Edition, TMH publication
2. W. D. Stevenson, *Elements of Power System*, 4 Edition TMH

NPTEL/ Swayam Course:

Course: **Power System Analysis, By Prof. Debapriya Das (IIT Kharagpur)**
https://swayam.gov.in/nd1_noc19_ee62/preview

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC305	**Analog Electronics**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To understand the characteristics of diode, transistors and FETs. 2. To understand design of different biasing circuits of BJT and MOSFET. 3. To understand the functioning of Op-Amplifier and design of Op- amp based circuits. 4. To understand the functioning of linear voltage regulators and IC 555.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Design and analyse various rectifiers and amplifier circuits. 2. Analyse DC and AC parameters of BJT. 3. Analyse DC and AC parameters of MOSFET. 4. Understand the functioning of OP-AMP and design OP-AMP based circuits. 5. Practical design aspect of regulated power supply circuits using linear regulators. 6. Understand applications of commonly used special semiconductor devices.

Module	Detailed Contents	Hours
1	**Diode:** Basic construction, Operation and characteristics of diode, Application of diode as clipper, Full Wave Bridge Rectifier with and without Filter; analysis and selection of the components required for C and LC filter (Numerical).	**04**
2	**Bipolar Junction Transistor:** Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier *DC Circuit Analysis:* Types of biasing circuits, load line (Numerical); thermal runaway, stability factor analysis, thermal stabilization. *AC Circuit Analysis:* Small signal analysis of CE configurations with different biasing network using hybrid-pi model. Amplification derivation of expression for voltage gain, current gain, input impedance and output impedance of CC, CE amplifiers (Numerical); Study of frequency response of BJT amplifier.	**08**
3	**Field Effect Transistor:** Types of FETs, basics of construction and working principle; MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier *DC Circuit Analysis*: Types of biasing circuits of MOSFET (Numerical), dc load line and region of operation. *AC Circuit Analysis*: Small signal model of MOSFET CS amplifier, derivation of expressions for voltage gain and output impedance of MOSFET CS amplifier (Numerical).	**06**

4	**Operational Amplifiers:** Differential amplifier, direct coupled multi-stage amplifier, Block diagram of Op-amp, ideal op-amp, non-idealities in an op-amp, Frequency response; Idealized analysis and design of Inverting and Non-inverting amplifier, voltage follower; Design of different Op-amp circuits (adder, subtractor, integrator and differentiator, Schmitt trigger)(with Numerical); Comparator (ZCD, window comparator); introduction to Instrumentation amplifier (using 3 Op-amp); First order Low Pass Filter using op-amp; Oscillator (Wein bridge), Square-wave generator.	**10**
5	**Linear Voltage Regulators and Timer:** IC-78xx, 79xx, LM 317, Design of voltage supply using IC-78xx and LM317 (Numerical). IC-555- Functional block diagram, study of Mono-stable and Astable Multivibrator using IC555 (Numerical)	**04**
6	**Special Purpose Semiconductor Devices:** Principle of operation and applications of special diodes– Zener diode, LED, Schottky diode and Photodiode; Basics of Opto-isolator.	**04**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment-I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment-II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:-

1. Neamen D.A., *Electronic Circuit Analysis and Design*, McGraw Hill International.
2. Robert Boylestad and Louis Nashelsky, *Electronic Devices and Circuits*, PHI
3. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, PHI, 2000
4. Millman and Halkias, *Electronic Devices and Circuits*, Tata McGraw-Hill.
5. A. S. Sedra and K. C. Smith, *Micro-electronic Circuits*, Oxford University Press, 1998.

Reference Books:-

1. David Bell, *Electronic Devices and Circuits*, Oxford University Press
2. Thomas Floyd, *Electronic Devices*, PHI
3. S. Salivahanan and N. Suresh Kumar, "*Electronic Devices and Circuits, TMH*
4. P. Horowitz and W. Hill, *The Art of Electronics,* Cambridge University Press, 3rd Edition

NPTEL/ Swayam Course:

1. **Course**: **Analog Electronic Circuits By Prof. Pradip Mandal (IIT Kharagpur)**
   https://swayam.gov.in/nd1_noc20_ee45/preview
2. **Course: Analog Electronic Circuit By Prof. Shouribrata Chatterjee (IIT Madras)**
   https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee89/

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL301	**Electrical Machines and Measurements Lab**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**

Course Objectives	**To impart the knowledge on the following :** 1. Practical understanding of DC machines and their applications. 2. Working principles of various sensors, transducers and instruments used for measurement of the various physical parameters.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Illustrate and analyze the performance of DC machines. 2. Demonstrate different speed control methods of DC motors. 3. Illustrate and analyze the working of various sensors, transducers and instruments used for measurement of the various physical parameters. 4. Demonstrate the use of bridges for measurements of passive electrical components. 5. Understand and analyse the working signal processing circuits used in measurements and instruments

Syllabus: Same as **EEC303: Fundamentals of Electrical Machines and Measurements**

Suggested List of Laboratory Experiments: Minimum four from 1 – 9 and four from 10 – 16, in all minimum eight experiments need to be performed.

1. Open circuit and load characteristics of DC shunt generator.
2. Load characteristics of DC compound generator with differential and cumulative connections.
3. Load test on DC shunt motor.
4. Load test on DC compound motor.
5. Load test on DC series motor.
6. Speed control of DC shunt motor.
7. Retardation test of DC motor.
8. Swinburne's test on DC motor.
9. Hopkinson's test on DC motor.
10. Measurement of the medium resistance using Wheatstone bridge.
11. Measurement of the low resistance using Kelvin’s double bridge.
12. Measurement of inductance using Maxwell’s bridge.
13. Measurement of capacitance using Schering’s bridge.
14. Measurement of R/L/C using a bridge technique as well as LCR meter.
15. Current Measurement using Shunt, CT, and Hall Sensor.
16. Measurement of temperature using RTD/ Thermistor
17. Measurement of Pressure using Pressure transducer.
18. Study of Signal Processing circuits used for sensors/ transducers.
19. Range Extension of meters used in electrical and electronic measurements.

Any other experiments based on syllabus which will help students to understand topic/concept.

Note:

Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum 08 experiments. The distribution of marks for term work shall be as follows:

Laboratory Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term Work.

Oral Examination:

Oral examination will be based on entire syllabus of **EEC303: Fundamentals of Electrical Machines & Measurements**

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL302	**Electronics Lab-I**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**25**	**-**	**50**

Course Objectives	1. To understand the basic concept of various electronic devices, circuits and their application. 2. To develop ability among students to design and implement electronic circuits.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Identify the different types of semiconductor devices and demonstrate their applications in electronic circuits. 2. Analyse the performance of different types of rectifier with and without filter. 3. Determine the dc and ac parameters of various semiconductor devices. 4. Illustrate the frequency response of BJT/ MOSFET amplifier. 5. Understand the practical use of Op-amps in signal processing and waveform generators.

Syllabus: Same as that of Course **EEC305 Analog Electronics**

Suggested List of Laboratory Experiments: Minimum eight experiments need to be performed.

1. Study of V-I characteristics of standard PN junction diode.
2. Use of diode as clipper.
3. Rectifier- Filter performance analysis
4. BJT biasing network and stability analysis
5. BJT Input and Output Characteristics for CE configuration
6. Frequency response of BJT CE amplifier
7. Study of MOSFET characteristics and calculation of parameters
8. Frequency response of MOSFET CS amplifier
9. Study of differential BJT amplifier
10. Design of OP-AMP based Inverting amplifier and Non-inverting Amplifier
11. Study of OP-AMP as Adder and Subtractor
12. Study of OP-AMP as comparator
13. Study of a OP-AMP based Wien Bridge oscillator
14. Design of adjustable Voltage regulator based on IC 78XX
15. Design of adjustable Voltage regulator based on LM317
16. Study of V-I characteristics of zener diode.
17. Study of V-I characteristics of Schottkey diode.
18. Study of photo devices applications
19. Study of opto-isolators

Any other experiment based on syllabus which will help students to understand topic/concept.

Note:

Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum 08 experiments. The distribution of marks for term work shall be as follows:

Laboratory Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term Work.

Practical & Oral Examination:

Practical exam will be based on the experiments carried out & Oral examination will be based on entire syllabus of **EEC305 Analog Electronics.**

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL303	**Simulation Lab-I**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**

Course Objectives	1. To understand basic block sets of different simulation platform used in electrical /electronic circuit design. 2. To understand use and coding in different software tools used in electrical/ electronic circuit design
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Develop knowledge of software packages to model and program electrical and electronics systems 2. Model different electrical and electronic systems and analyze the results 3. Articulate importance of software packages used for simulation in laboratory experimentation /research by analyzing the simulation results. 4. Simulate electric machines/circuits for performance analysis.

Suggested Software Tools to be Used for Simulation Lab-I:

1. Students should be encouraged to use open source softwares such as **SCILAB, LTSPICE**, Texas Instrument's '**Webbench**', **Ngspice,** ***Solve Elec*** etc. for carrying out the lab simulation listed below.
2. Use of Professional Licensed versions of softwares like **MATLAB**, **Proteus**, **LabVIEW**, **NI Multisim, PSpice, PowerSim, TINA** etc. is also allowed**.**
3. Use of 'Python' platform for simulating components/ circuit behaviour.

Suggested List of Laboratory Experiment: Minimum eight experiments need to be performed from various subjects domain

1. Introduction to basic block sets of simulation platform.
2. Simulation of single phase bridge rectifier with and without filter
3. Algorithm on matrix operations
4. Simulation of transmission line model
5. Algorithms to determine transmission line performance and parameters
6. Simulation of differential equations
7. Simulation to verify different network theorems with dependent and independent sources
8. Algorithm for generation of standard test signals
9. Simulation / Algorithms to draw the response of electrical network for standard test signals.
10. Simulation / Algorithms to draw the pole zero plot of electrical networks
11. Simulation of DC motor performance characteristics
12. Simulation of various measurement bridges l Maxwell's bridge, Hay's bridge etc.
13. Design of OP-AMP based Inverting amplifier and Non-inverting Amplifier
14. Study of OP-AMP as Adder and Subtractor
15. Study of OP-AMP as comparator

16. Study of a OP-AMP based RC phase shift oscillator
17. Study of a OP-AMP based Wien Bridge oscillator

Any other simulations / algorithms based on third semester syllabus, which will help students to understand topic / concept.

Note:

Students and teachers are also encouraged to use the virtual labs whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:
Term work consists of minimum 08 simulation / algorithms from various subject domains. The distribution of the term work shall be as follows:

Simulation / Algorithm	: 20 marks
Attendance	: 05 marks

The final certification and acceptance of term-work ensures the minimum passing in the term-work.

Oral Examination:
Oral examination will be based on laboratory experiments carried out in **Simulation Lab-I**

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL304	**Skill Based Lab (SBL) Applied Electrical Engineering Lab**	-	**04**	-	-	**02**	-	**02**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	**50**	-	-	**50**

Course Objectives	1. To provide hands on experience to use laboratory instruments for testing and measurement. 2. To develop the ability to repair and maintain electrical equipment/ appliances 3. To impart the knowledge of electrical installation on institute campus. 4. To impart the knowledge of Electrical fire and shock hazards safety.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Demonstrate the effective use of various electrical and electronic measuring lab equipments. 2. Identify various electrical LV/HV substation, supply equipments and their network connection 3. Identify and use different low voltage protective switchgears along with residential / industrial wiring practices. 4. Repair and maintain common house-hold appliances. 5. Handle Electrical fire and shock hazards safety challenges in real practice.

Module	Detailed Contents	Hours
1	**Use of Lab Equipments:** *Standard Lab Equipments*: Multi-meter, Power Supply, Function Generator, Tachometer, thermometer, clamp-on meter, DSO etc. (**Study all the equipments**) *Special Measuring Equipments*: True RMS multi-meter, Lux meter, Megger, LCRQ meter, Power Meter, Thermal Analyser, Anemometer, Humidity Meter, Earthing Resistance meter, Insulation Resistance meter etc. (**Study at least 3 such equipments**) *Special Lab Equipments:* High Power DC Supply, Isolated DSO, Power Analyser, Emulators etc. (**Study at least one of such equipments**) **Lab Activities**: Students should be trained to use these classes of lab equipments with good expertise achieved. Students should clearly understand and differentiate the situations in which use of each of these equipments is best suitable.	**12**
2	**Electrical LV/HV Substation and Supply Equipments:** Electrical LV/HV Substation: RMU, Transformer, HV switchgear and panels, LV switchgears and panels, HT metering, LT metering APFC panel, Backup DG sets, UPS, Changeover switchgears, Feeder Pillar, Solar PV Installation. Single line diagram (SLD), Supply Utility service: Electricity bills and details. **Students should study the actual electrical supply system on institute campus, prepare SLD for the network and detailed report on actual ratings of the complete system.**	**04**

3	**Residential/ Industrial Wiring and switch-gears** Wiring materials, selection of wire, conductor sizing, Cables and cable management Estimation and costing of residential wiring (**Simple numerical on wiring of single room**); Fire retardant wires. Different switching and protection devices (MCBs/ Fuses/Relays), selection and sizing connection of energy meter and distribution board, wiring standards (IS-732, section 4). (**Students should be given demonstration of real life devices and DBs in use**). **Students should perform following experiments (Any three)** 1. Identify different types of cables/wires, switches and their uses. 2. Identify different types of fuses & fuse carriers, MCB and ELCB, MCCB with ratings and usage. 5. Wiring of simple light circuit for controlling light/fan point (PVC conduit wiring and wiring accessories) 6. Wiring of fluorescent lamps and light sockets (6 A). 7. Wiring of Power circuit for controlling power device (16A socket) 8. Design of Staircase wiring / Go-down wiring / Tunnel wiring 9. Demonstration and measurement of power/energy consumption and repair maintenance of electric iron/mixer grinder/ washing machine/refrigerator/ air conditioner/water heater/geyser/single phase pump/exhaust fan.	**12**
4	**Repair and Maintenance of House-hold Appliances and Machines:** Testing, fault finding, Dismantling, assembling and testing after repairs of house hold appliances like standard fan and regulator, BLDC fan, heater, geyser, mixer, washing machine, microwave oven, LED lamps/tubes, Induction Cooker, Air cooler etc. (**Minimum three such appliances must be studied**) Troubleshooting of 1 ph and 3ph transformers and motors (**Minimum one transformer and one motor**)	**12**
5	**Electrical Fire Prevention and Safety in Buildings:** Guidelines and charts for electrical fire prevention, role of electrical switchgear and protection devices, Earth leakage and Earth Resistance measurements, Preventive maintenance, Thermal analysis of electrical installations, Electrical Fire mitigation ; Electrical Shock safety, symptoms and emergency first aid; Indian Electricity Act and National Electrical Code; (**Complete training of Electrical Fire Prevention and Safety must be provided to all the students)**	**08**

Term Work:

Term work shall consist of minimum requirement as given in the syllabus. The distribution of marks for term work shall be as follows:

Laboratory Performance : 30 marks
Journal : 10 marks
Attendance : 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Books Recommended:

1. J. B. Gupta, *Electrical Installation Estimating & Costing,* S. K. Kataria & Sons, 2009
2. Raina Bhattachraya, *Electrical Design Estimating And Costing,* New Age International,
3. K B. Bhatia, *Electrical Appliances and Devices,* Khanna Publications
4. K B. Bhatia, *Fundamentals of Maintenance of Electrical Equipments,* Khanna Publications
5. BIS SP 30:National Electrical Code
6. Electricity Act 2003

Semester-III								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEM301	**Mini Project – 1A**	-	**04$**	**-**	**-**	**02**	**-**	**02**

$ indicates work load of Learner (Not Faculty)

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**

Course Objectives	1. To acquaint with the process of identifying the needs and converting it into the problem. 2. To familiarize the process of solving the problem in a group. 3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. 4. To inculcate the process of self-learning and research.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Identify problems based on societal /research needs. 2. Apply Knowledge and skill to solve societal problems in a group. 3. Develop interpersonal skills to work as member of a group or leader. 4. Draw the proper inferences from available results through theoretical/ experimental/simulations. 5. Analyse the impact of solutions in societal and environmental context for sustainable development. 6. Use standard norms of engineering practices 7. Excel in written and oral communication. 8. Demonstrate capabilities of self-learning in a group, which leads to life long learning. 9. Demonstrate project management principles during project work.

General Guidelines for Mini Project 1A/ 1B

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.

- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project-1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Mini Project 1A/1B–General Guidelines for Execution

Design and Fabrication

a. Initial fabrication of the project by students can be done using standard devices/material/software tools to verify the circuit functionalities Initial project fabrication and testing is expected to be done by soldering/assembling on general purpose PCB/ Bakelite boards or suitable platforms required for the electrical/electronic/digital components. Avoid the use of breadboards.
b. If essential, use of a simulation/ emulation software tools to test and verify the performance of the circuit should be encouraged.
c. Students should prepare the proper drawings (electrical/ mechanical), schematics/ layouts of the project.
d. For final implementation of the circuit, preparation of PCB (if any required) using suitable CAD tools and fabricating the same in the lab is expected.

Devices/ Components/ Systems to be Used:

Students are encouraged to use passive components like resistors, capacitors, inductors etc. If any specialize inductor is not readily available, the fabrication of the same in the lab should be encouraged. Other components like: Transistors, diodes, voltage regulators, logic gates, Op-amps, general purpose microcontroller, DC motors/ AC motors, sensors, actuators, relays etc. (Students may add more components as per the requirement of project).

Testing and analysis of the Project

Students should test the circuit using suitable laboratory equipments like power supply, multi-meter, CRO, DSO etc. In case of any debugging requirement, students should record the problems faced during the testing and solutions sought after for the fault in the circuit.

All the testing results must be well documented in the final project report verifying the functionalities of the propose project.

Use of Reference Material/Literature :

Students are advised to refer Application Notes, research publications & data sheets of various electrical/electronic/digital devices from Texas Instruments, Microchips, International Rectifiers, ST Microelectronics, Philips, NXP and many other manufacturers.

Self-learning and Skill Set Development

Students should be encouraged to develop/ improve their understanding and skill sets by attending various online/offline expert lectures / video lectures/ courses/ webinars/ workshops etc. to facilitate the smooth execution of mini project

1. Understanding passive components viz. resistors, capacitors and inductors from practical point of view: types/ varieties, device packages, applications and cost.
2. Understanding semiconductor components viz. diodes, BJT and JFET/MOSFETs from practical point of view: types/ varieties, device packages, applications and cost.
3. Design principles of simple electrical / electronic circuits with some examples.
4. Selection of switches and circuit protection components.
5. Selection and sizing of wires and conductors.
6. Soldering Practice.

7. Heat-sinking and Enclosure design concepts
8. Overall workmanship while working on the project fabrication.
9. Use of different software tools for design and development of circuits
10. Use of standard as well as advanced laboratory equipments needed for testing of such projects

Suggested Application Domains for Mini Projects:

List of key application domains from where students are encouraged to derive Mini Projects topics:

1. Home/Office automation
2. Renewable Energy
3. Energy Conservation
4. Energy Storage
5. Battery Charging and Protection
6. Fire Safety
7. Electrical System Protection
8. Lighting Control
9. Wireless Power Transfer
10. Electrical Components Testing
11. Electrical Parameters Measurement
12. Non-conventional Electricity Generation
13. Laboratory Equipments
14. E-Mobility
15. Video Surveillance Systems
16. Robotics for Hazardous applications
17. Waste Management System 2.
18. Smart City Solutions
19. Smart Classrooms and learning Solutions
20. Smart Agriculture solutions etc.
21. Health/ Biomedical

Students can identify the mini project topics either from above suggested domains or **any other relevant engineering domains**.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year Mini Project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.

- First shall be for finalization of problem
- Second shall be on finalization of proposed solution of problem.

- In second semester expected work shall be procurement of components /systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year Mini Project:

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalization of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Oral Examination:

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions

3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

Reference Books:

1. P. Horowitz and W. Hill, "The Art of Electronics", 3rd Edition, Cambridge University Press, 2015
2. R. S. Khandpur, "Printed Circuit Board", McGraw-Hill Education; 1st edition, 2005.
3. Simon Monk, "Hacking Electronic: Learning Arduino and Raspberry Pi", McGraw-Hill Education TAB; 2 edition (September 28, 2017).

Suggested Software Tools:

1. LTspice:https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html#
2. Eagle : https://www.autodesk.in/products/eagle/overview
3. OrCAD: https://www.orcad.com/
4. Multisim : https://www.multisim.com/
5. Webbench:http://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html
6. Tinkercad : https://www.tinkercad.com/
7. Raspbian OS: https://www.raspberrypi.org/downloads
8. Arduino IDE: https://www.arduino.cc/en/main/software

Online Repository:

1. https://www.electronicsforu.com
2. https://circuitdigest.com
3. https://www.electronicshub.org
4. Github

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC401	**Engineering Mathematics-IV**	**03**	**-**	**01**	**03**	**-**	**01**	**04**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**25**	**-**	**-**	**125**

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III, Binomial Distribution.

Course Objectives	**The course is aimed:** 1. To understand line and contour integrals and expansion of complex valued function in a power series. 2. To understand the basic techniques of statistics for data analysis, Machine learning and AI. 3. To understand probability distributions and expectations. 4. To understand the concepts of vector spaces used in the field of machine learning and engineering problems. 5. To understand the concepts of Quadratic forms and Singular value decomposition. 6. To understand the concepts of Calculus of Variations.
Course Outcomes	**On successful completion of course learner/student will be able to:** 1. Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals. 2. Apply the concept of Correlation and Regression to the engineering problems in data science, machine learning and AI. 3. Apply the concepts of probability and expectation for getting the spread of the data and distribution of probabilities. 4. Apply the concept of vector spaces and orthogonalization process in Engineering Problems. 5. Use the concept of Quadratic forms and Singular value decomposition which are very useful tools in various Engineering applications. 6. Find the extremals of the functional using the concept of Calculus of variation.

Module	Detailed Contents	Hours.
1	**Module: Complex Integration:** 1.1 Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions (without proof), Cauchy's Integral formula (without proof). 1.2 Taylor's and Laurent's series (without proof). 1.3 Definition of Singularity, Zeroes, poles of *f(z)*, Residues, Cauchy's Residue Theorem (without proof). **Self-learning Topics:** Application of Residue Theorem to evaluate real integrations, Z-Transform.	**06**

2	**Module: Statistical Techniques:** 2.1 Karl Pearson's Coefficient of correlation (r) 2.2 Spearman's Rank correlation coefficient (R) (repeated and non-repeated ranks) 2.3 Lines of regression. 2.4 Fitting of first and second degree curves. **Self-learning Topics:** Covariance, fitting of exponential curve.	**06**
3	**Module: Probability Distributions:** 3.1 Baye's Theorem, Random variable: Probability distribution for discrete and continuous random variables, Density function and distribution function. 3.2 Expectation, mean and variance. 3.3 Probability distribution: Poisson & normal distribution. **Self-learning Topics:** Moments, Moment Generating Function, Applications of Probability Distributions in Engineering.	**06**
4	**Module: Linear Algebra: Vector Spaces:** 4.1 Vectors in n-dimensional vector space, norm, dot product, The Cauchy-Schwarz inequality (with proof), Unit vector. 4.2 Orthogonal projection, Orthonormal basis, Gram-Schmidt process for vectors. 4.3 Vector spaces over real field, subspaces. **Self-Learning Topics**: Linear combinations, linear Dependence and Independence, QR decomposition.	**06**
5	**Module: Linear Algebra: Quadratic Forms:** 5.1 Quadratic forms over real field, Linear Transformation of Quadratic form, Reduction of Quadratic form to diagonal form using congruent transformation. 5.2 Rank, Index and Signature of quadratic form, Sylvester's law of inertia, Value- class of a quadratic form-Definite, Semidefinite and Indefinite. 5.3 Reduction of Quadratic form to a canonical form using congruent transformations. 5.4 Singular Value Decomposition. **Self-learning Topics:** Orthogonal Transformations**,** Applications of Quadratic forms and SVD in Engineering.	**06**
6	**Module: Calculus of Variations:** 6.1 Euler-Lagrange equation (Without Proof), When F does not contain y, When F does not contain x, When F contains x, y, y'. 6.2 Isoperimetric problems- Lagrange Method. 6.3 Functions involving higher order derivatives: Rayleigh-Ritz Method. **Self-Learning Topics:-** Brachistochrone Problem, Variational Problem, Hamilton Principle, Principle of Least action, Several dependent variables.	**06**

Term Work:

General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practicals.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 40% (approx.)syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. Complex Variables and Applications, Brown and Churchill, McGraw-Hill education.
2. Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill education.
3. Advanced engineering mathematics, H.K. Das, S . Chand, Publications.
4. Higher Engineering Mathematics, B. V. Ramana, Tata Mc-Graw Hill Publication
5. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication
6. Advanced Engineering Mathematics, Wylie and Barret, Tata Mc-Graw Hill.
7. Beginning Linear Algebra, Seymour Lipschutz Schaum's outline series, McGraw Hill Publication
8. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC402	**Electrical AC Machines - I**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To impart knowledge of performance and operation of an induction motor. 2. To impart the knowledge of working principle, operations, performance and applications of single phase and three phase Transformers.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate working principle and performance of single phase transformer under different operating conditions 2. Understand working principle of autotransformer. 3. Analyze various types of connections and performance of three phase transformer under various conditions. 4. Demonstrate working principle and evaluate performance of three phase induction motor under various operating conditions. 5. Exemplify various starting methods and speed control of three phase induction motor.

Module	Detailed Contents	Hours
1	**Single phase Transformer:** Review of working principle, EMF equation and Equivalent Circuit, Phasor diagram (Resistive, Inductive and capacitive load), voltage regulation, Losses and Efficiency, Condition for Maximum Efficiency, Parallel Operation: No load Operation, On load Operation: - Equal Voltage Operation and Unequal Voltage Operation, Testing of Transformer: OC and SC test, Sumpner's Test	**06**
2	**Autotransformer:** Working, Advantages of Autotransformer over two winding Transformer, Disadvantages, Isolation Transformer working and its applications.	**02**
3	**Three Phase Transformer:** Constructional details, Principle of operation, Connections and Phasor groups, Parallel operation, Excitation Phenomenon in transformers, Harmonics in three phase transformers, Suppression of harmonics, Oscillating neutral phenomenon, Switching intransient phenomenon, Open delta or V - connection, Three phases to two phase conversion (Scott connection).	**08**
4	**Three Phase Induction Motor:** Review of Constructional details and Principle of operation, Slip, Rotor emf and frequency, current and power, Power stages, Phasor diagram, Equivalent circuit, Torque-speed characteristics in braking ,motoring and generating regions, Losses and efficiency, No load and blocked rotor test, Circle diagram, Applications.	**10**

5	**Starting and Speed control of Three Phase Induction Motor:** Need of starter, Types of starters: Direct On Line (DOL) starter, Rotor resistance starter, Autotransformer and Star delta starters, Speed control: Voltage control, Frequency control, Pole changing method, V/f control.	**05**
6	**Single phase Induction Motor**: Principle of operation (Review), Double field revolving theory, Equivalent circuit of single phase induction motor, Determination of equivalent circuit parameters from no load and block rotor test, Staring methods, Split phase starting- Resistance spilt phase, capacitor split phase, capacitor start and run, shaded pole starting, Applications of 1ϕ IM	**05**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 40% (approx..) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. Bimbhra P.S., *Electric Machinery* , Khanna Publisher
2. Bimbhra P.S., *Generalized Machine Theory*, Khanna Publisher
3. V. K. Mehta, *Principles of Electrical Machines*, S Chand Publication

Reference Books:

1. M.G. Say, Performance and Design of Alternating Current Machines, CBS Pub.
2. Ashfaq Husain, *Electric Machines***,** Dhanpat Rai and Co.
3. A.E. Fitzgerald, Kingsly, Stephen., *Electric Machinery*, Tata McGraw Hill

NPTEL/ Swayam Course:

1. **Course: Electrical Machines – II By Prof. Tapas Kumar Bhattacharya (IIT Kharagpur)**
   https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee01/
2. **Course: Electrical Machines By Prof. Bhuvaneshwari (IIT Delhi)**
   https://swayam.gov.in/nd1_noc19_ee69/preview

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC403	**Digital Electronics**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To understand working of logic families and logic gates. 2. To understand combinational and sequential logic circuits. 3. To understand Analog to Digital and Digital to Analog conversions. 4. To introduce ROM as Programmable Logic Device.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Perform various conversion of number systems 2. Understand working of logic families and logic gates. 3. Design and implement combinational circuits. 4. Design and implement sequential circuits. 5. Understand the process of Analog to Digital conversion and Digital to Analog conversion. 6. Use PLDs to implement the given logical problem.

Module	Detailed Contents	Hours
1	**Fundamentals of Digital Systems and Logic families:** Review of Number formats: Binary, signed binary, Octal, hexadecimal, BCD and their basic math operations (addition and subtraction) Logic gates: Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean Algebra, Specifications of Digital IC Logic Families: TTL, CMOS logic families, Comparison of TTL and CMOS, Interfacing of TTL and CMOS, Tri-state logic	**06**
2	**Combinational Digital Circuits:** Design & Simplification of logic functions: K-map representation, simplification of logic functions using K-map (upto 4 variables), Minterm, maxterm, SOP and POS implementation, realization of logic function using universal gates Binary Arithmetic circuits: Adder and Subtractor (Half and Full), Multiplier, 2 bit comparators, Multiplexer, de-multiplexer, decoder Designing code converter circuit: binary to gray, Gray to Binary, Multiplexer (ULM), De-multiplexers, BCD to 7 segment	**08**
3	**Sequential Digital Circuits** Comparison of combinational & sequential circuit, Flip-flops -SR, JK,T, D, Master Slave JK, Counters-Modulus of counter, Design of Synchronous, Asynchronous counters, Ripple Up/Down Counter, Ring counter, Shift Registers –Right and left shift registers, Serial to parallel converter, parallel to serial converter, applications of counters.	**06**
4	**A/D and D/A Converters:** Digital to Analog converter: Weighted resistor converter, R-2R ladder D/A converter, examples of D/A converter ICs.	**06**

	Analog to Digital converter: sample and hold circuit, Quantization and encoding, successive approximation A/D converter, dual slope A/D converter, voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs	
5	**Semiconductor Memories:** Classification and characteristics of memories, Memory organization and operation, expanding memory size- Memory mapping and address decoding , sequential memory, read only memory (ROM), read and write memory (RAM), content addressable memory (CAM), commonly used memory chips	**06**
6	**Programmable Logic Devices:** ROM as a programmable logic device, programmable logic array, programmable array logic, Complex Programmable Logic Devices (CPLDs), Field Programmable Gate Array (FPGA)	**04**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. Anand Kumar, “Fundamentals of Digital Circuits”, Prentice Hall India, 2016
2. R. P. Jain, “Modern Digital Electronics” Tata McGraw Hill Education, 2009
3. Morris. M. Mano, “Digital Logic and Computer design”, Pearson Education India, 2016
4. Alan b. Marcovitz, “Introduction to logic Design”, McGraw Hill International 2002.
5. Malvino & Leach, Digital principal and Application”, Tata McGraw Hill, 1991

NPTEL/ Swayam Course:

1. **Course: Electrical Machines – II By Prof. Tapas Kumar Bhattacharya (IIT Kharagpur)**
   https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee01/
2. **Course: Electrical Machines By Prof. Bhuvaneshwari (IIT Delhi)**
   https://swayam.gov.in/nd1_noc19_ee69/preview

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC404	**Power Electronic Devices and Circuits**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. To impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and facilitate selection of semiconductor devices for various applications. 2. To introduce different power conversion topologies such as ac to dc, dc to dc, dc to ac and the underlying principles of converter operation aiding to analyse their performance. 3. To keep abreast with the latest technologies and research going on in different domains related to power electronics.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Understand the basic operation and characteristics of various semi controllable and fully controllable devices 2. Analyse various single phase and three phase power converter circuits and understand their applications. 3. Analyse dc to dc converter circuits and their applications. 4. Identify and describe various auxiliary circuits and requirements in power electronics applications such as gate driver circuit, snubber circuits and heat sinks. 5. Apply the basic concepts to select devices and converters for various applications

Module	Detailed Content	Hours
1	**Thyristors:** Basic operation of silicon controlled rectifier, Static characteristics, two transistor analogy, Dynamic characteristics, Firing circuits (R,RC, Ramp triggering using UJT), Commutation circuits, Protection circuit of SCR. **Self study topic**: Other devices of Thyristor family	**06**
2	**Power semiconductor devices:** Basic operation and characteristics of power diodes, power BJTs, power MOSFETs, IGBTs, Safe Operation Area (SOA) for each devices, Silicon Carbide (SiC) and GaN devices, Comparison of devices, selection of devices for various applications, Conduction and switching losses.	**06**
3	**Controlled Rectifiers:** Single phase half wave rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load, freewheel diode, Rectification and inversion mode of single phase fully controlled rectifier, single phase dual converter, Three phase semi converter and full converter with R load, Applications, calculation of output voltage, single phase PWM rectifier, basic working principle and applications.	**08**
4	**Inverter:** Classification based on source and power level, Single phase bridge Inverters (VSI), Performance parameters, Three phase VSI (120° and 180° conduction mode), Voltage	**05**

	control of single phase inverters- PWM techniques-Single PWM, Multiple PWM, Sinusoidal PWM, Basics of Space vector modulation, Single phase current source inverters (CSI), comparison of VSI and CSI.	
5	**DC to DC Converter**: Introduction, Switching mode regulators – Buck, Boost, Buck-Boost, bidirectional dc to dc converters, all with resistive load and only CCM mode, Applications: Power Factor Correction Circuits, LED lamp driver, Numerical included.	**07**
6	**Auxiliary Circuits**: Types of drivers-level shifters, bootstrap drivers, isolated drivers, Gate Drive circuitry for Power Converters, methods of current and voltage measurement, snubber circuits and heat sinks.	**04**

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, Pearson Education, 2009.
2. N. Mohan and T. M. Undeland, *Power Electronics: Converters, Applications and Design*, John Wiley & Sons, 2007.
3. R.W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, Springer Science & Business Media, 2007.
4. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley India, 2009.
5. P.C Sen., *Modern Power Electronics*, Wheeler publishing Company, 1st Edition, 2005
6. Alok Jain, *Power Electronics: Devices, Circuits and Matlab Simulations*, Penram Int. 2010
7. B. Jayant Baliga, *Silicon Carbide Power Devices*, World Scientific, 2005.

Reference Books:

1. C.W. Landers, *Power Electronics*, McGraw Hill, 1993
2. Ashfaq Ahmed, *Power Electronics for Technology*, Pearson, 1998
3. Joseph Vithayathil, *Power Electronics*, Tata McGraw hill, 1995.
4. P. Friedrichs, T. Kimoto, L. Ley and G. Pensl, *Silicon Carbide, Volume 2: Power Devices and Sensors*, Wiley Publications, 2011.
5. Dokić, Branko L. and Blanuša, Branko, *Power Electronics Converters and Regulators* Springer International Publishing, 2015

NPTEL/ Swayam Course:

1. **Course: Advance Power Electronics And Control – Prof. Avik Bhattacharya (IIT Roorkee) https://nptel.ac.in/courses/108/107/108107128/**
2. **Course: Power Electronics By Prof. G. Bhuvaneshwari (IIT Delhi) https://swayam.gov.in/nd1_noc20_ee97/preview**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEC405	**Electric and Hybrid Electric Vehicle**	**03**	**-**	**-**	**03**	**-**	**-**	**03**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	1. Know the history of electric hybrid electric vehicles (EV & HEV) and emphasize the need and importance of EV-HEV for sustainable future. 2. Introduce the fundamental concepts and principles of electric and hybrid electric vehicles drive train topologies 3. Develop a thorough understanding of the key elements of EV/HEV: Electric Machines for Propulsion Applications and Energy Sources 4. Model, analyze and design electric and hybrid electric vehicles drive train and to understand energy management strategies
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. Identify and describe the history and evolvement of electric & hybrid electric vehicles. 2. Identify and describe the principles of various EV/HEVs drive train topologies. 3. Select electric propulsion system components for EV/HEV drives for the desirable performance and control**.** 4. Compare and evaluate various energy sources and energy storage components for EV/HEV. 5. Model, analyze and design EV/HEV drive train with energy management strategies**.** 6. Recognize the need to adapt and engage in operations EV/HEV for sustainable transportation system.

Module	Detailed Contents	Hours
1	**Introduction:** Basics of vehicles mechanisms**,** history of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, Power/Energy supplies requirements for EV/HEV applications. State of the art and Indian and global scenario in EV/HEV	**04**
2	**Drive-train Topologies:** Various electric drive-train topologies, basics of hybrid traction system, various hybrid drive-train topologies, power flow control in drive-train topologies, fuel efficiency analysis.	**06**
3	**DC and AC Machines for Propulsion Applications:** Electric system components for EV/HEV, suitability of DC and AC machines for EV/HEV applications, AC and DC Motor drives.	**06**
4	**Energy Sources for EV/HEV:** Requirements of energy storage in EV/HEV: batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV, characteristics and comparison of	**08**

	energy sources for EV/HEV, hybridization of different energy sources. EV battery chargers and standards	
5	**Drive-train Modelling and Design Considerations :** Modeling and analysis of EV/HEV drive train: Total tractive force calculation, sizing of motor, and design considerations for power electronics drive.	**07**
6	**Energy Management Strategies and Energy Efficiency:** EV/HEV energy management strategies, classification and comparison of various energy management strategies. Basic EV AC and DC Chargers, G2V and V2G concept.	**05**

Self-study: Testing and Evaluation Standards for EV & HEV available on Automotive Research Association of India (ARAI) website: https://emobility.araiindia.com/standards/

Assessment:

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first-class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 40% (approx.) syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Books Recommended:

Text Books:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. Sheldon Williamsom, *Energy Management Strategies for Electric and Plug-in Hybrid Vehicles*, Springer 2013
4. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
5. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives,* Wiley 2011

Reference Books:

1. N.Mohan, T.M.Undeland, and W.P Robbins, *Power Electronics, Converters, Applications & Design,* Wiley India Pvt. Ltd., 2003
2. B. K Bose*, Modern Power Electronics and AC Drives*, Pearson Education 2002
3. Robert A. Huggins, *Energy Storage*, Springer 2010

NPTEL/ Swayam Course:

1. **Course: Intro. to Hybrid and Electric Vehicles - Prof. Praveen Kumar & Prof. S. Majhi (IIT Guwahati): https://nptel.ac.in/courses/108/103/108103009/**
2. **Course: Electric Vehicles - Part 1 By Prof. Amit Kumar Jain (IIT Delhi) https://nptel.ac.in/courses/108/102/108102121/**

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL401	**Electrical AC Machines Lab-I**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**25**	**-**	**50**

Course Objectives	**To impart the knowledge on :** 1. Construction, principle of operation, design, performance and applications of single and three phase Transformers 2. Construction, principle of operation, design, performance and applications of single and three phase Induction Motors.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Demonstrate the working principles and types of connections of 1φ and 3φ transformers. 2. Analyze the performance of 3φ transformer under various operating conditions. 3. Evaluate the performance of 3φ induction motor by carrying no load test , blocked rotor test and load test 4. Illustrate the operation of various type of 3φ induction motor starters. 5. Illustrate different methods of speed control and braking of 3φ induction motors.

Syllabus: Same as **EEC402- Electrical AC Machines-I**

Suggested List of Laboratory Experiments: Minimum eight experiments need to be performed.

1. Study of transformer connections**.**
2. Sumpner's test on single phase transformer
3. Open circuit & short circuit test on three phase transformer.
4. Parallel operation of transformers.
5. Scott connection of transformer.
6. Open Delta (V) connection of transformer
7. Load Test on three phase squirrel cage induction motor.
8. Load test on three phase slip ring induction motor.
9. No load and Blocked rotor test on three phase induction motor. (Determination of equivalent circuit parameters)
10. Separation of no load losses of three phase induction motor.
11. Performance analysis of three phase induction motor using circle diagram.
12. Study of different types of induction motor starters.
13. Speed control by v/f method.
14. Study of induction motor braking methods
15. Open circuit and short circuit test on single phase transformer and find equivalent circuit parameters.
16. No load and block rotor test on single phase induction motor.
17. Load test on single phase induction motor.

Any other experiments based on syllabus which will help students to understand topic/concept.

Note:

Students and teachers are encouraged to use the 'Virtual Labs' (an MHRD Govt. of India Initiative) whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum 8 experiments. The distribution of marks for term work shall be as follows:

Laboratory performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term-work.

Practical and Oral Examination:

Practical exam will be based on the laboratory experiments carried out and Oral examination will be based on entire syllabus of **EEC402-Electrical AC Machines-I**

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL402	**Python Programming Lab**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**

Course Objectives	**Students to get familiar with** 1. To introduce core programming basics and program design with functions using Python programming language. 2. Interpret the use of procedural statements like assignments, conditional statements, loops and function calls. 3. Infer the supported data structures like lists, dictionaries and tuples in Python. 4. Describe the need for Object-oriented programming concepts in Python.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Describe the Numbers, Math functions, Strings, List, Tuples and Dictionaries in Python 2. Express different Decision Making statements and Functions 3. Object oriented programming in Python 4. Understand and summarize different File handling operations 5. Explain how to design GUI Applications in Python and evaluate different database operations

Prerequisite: Basic Programming syntax of Java/C.

Module	Detailed Contents	Hours
1	**Basics of Python** **Theory:** Numbers in Python, Basic & Built-in Math functions, Number Formats, Strings, Quotes, print () Function, Assigning Values to Names & Changing Data Through Names, Copying Data, Tuples-Unchanging Sequences of Data, Lists-Changeable Sequences of Data; Dictionaries - Groupings of Data Indexed by Name, Special String Substitution Using Dictionaries, Arrays, Treating a String Like a List, Special Types, Ranges of Sequences, Working with Sets, Arrays. **Lab Experiment:** Write python programs to understand Expressions, Variables, Quotes, Basic Math operations, Strings: Basic String Operations & String Methods, List, Tuples, Dictionaries, Arrays (**Minimum Two Programs** based on math operations, Strings and List/Tuples/ Dictionaries)	**05**
2	**Decision Making and Functions:** **Theory:** If statement, if-elif-else, Repetition using while loop, for loop, break statement, Handling Errors- try: statement, except: statement, Functions-Grouping Code under a Name, defining a Function, function in the function, Checking & Setting Your Parameters, Calling Functions from within Other Functions, Functions Inside of Functions, Layers of Functions	**05**

	Lab Experiment: Write python programs to understand different decision making statements and Functions. (**Minimum Two Programs** based on Decision making, Looping Statements and Functions)	
3	**Object Oriented Programming using Python programming:** **Theory**: Creating a Class, Self Variables, Constructors, Types of Methods, Inner Classes, Constructors in Inheritance, Polymorphism, Interfaces in Python. Exceptions Handling: Errors in a Python Program, Exceptions, Exception Handling, Types of Exceptions. **Lab Experiment:** Write python programs to understand different Object oriented features in Python (**Minimum Two programs** based on a) Classes & objects, b) Constructors, c) Inheritance & Polymorphism, d) Exception handling.	**05**
4	**Advanced Python Libraries:** **Introduction to Objects and Functions** of a. Numpy - core library for scientific computing b. Pandas - fast, powerful, flexible and easy to use open source data analysis and manipulation tool c. MatplotLib - comprehensive library for creating static, animated, and interactive visualizations d. SciPy - ecosystem of open-source software for mathematics, science, and engineering **Lab Experiment:** Write **Minimum Two programs** python programs to understand different functionalities exposed by each of the above libraries.	**07**
5	**GUI Programming and Databases Theory**: **GUI Programming** - Writing a GUI with Python: GUI Programming Toolkits, Creating GUI Widgets with Tkinter, Creating Layouts, Radio Buttons and Checkboxes, Dialog Boxes. Database Access - Python's Database Connectivity, Types of Databases Used with Python, Mysql database Connectivity with Python, Performing Insert, Deleting & Update operations on database **Lab Experiment:** Students should be given demonstration of GUI designing and database operations.	**02**

Term work:

Term work shall consist of minimum 08 experiments. The distribution of marks for term work shall be as follows:

Laboratory Performance : 20 marks
Attendance : 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term-work.

Oral Examination:

Oral examination will be based on the lab experiments carried out

Reference Books:

1. Mark Lutz, *Learning Python*, O Reily, 4thEdition, 2009,
2. Mark Lutz, *Programming Python*, O Reily, 4thEdition, 2010
3. Tim Hall and J-P Stacey, *Python 3 for Absolute Beginners*, 2009.
4. Magnus Lie Hetland, *Beginning Python: From Novice to Professional*, 2nd Edition, 2009.
5. Wesley J. Chun, *Core Python Programming*, Second Edition, Pearson
6. Jeeva Jose, *Taming Python by Programming*, Khanna Publishing House
7. J. Jose, *Introduction to Computing and Problem Solving with Python*, Khanna Publications
8. Seema Thareja, *Python Programming*, Pearson

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL403	**Electronics Lab II**	-	**02**	**-**	**-**	**01**	**-**	**01**

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**25**	**-**	**25**

Course Objectives	1. To introduce the basic building blocks and applications Digital logic devices. 2. To illustrate the students to practical circuits based on the power electronics devices used in various applications.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Use various digital logic Gates, flip-flops and counters for various applications 2. Build, design and analyse sequential / combinational circuits. 3. Understand the operation various power electronics devices and circuits 4. Use power converters for various real life applications

Syllabus: Same as that of Course **EEC403- Digital Electronics** and **EEC404-Power Electronics Devices and Circuits.**

Suggested List of Laboratory Experiments: Minimum four experiments from each Group A and Group B (total minimum eight) need to be performed.

Group A: EEC405- Digital Electronics

1. SOP and POS Minimization (different problem statement for each student)
2. Characteristics of TTL and MOS logic family
3. Implementation of counters with flip-flops.
4. Constructing flip-flops using all NAND gates.
5. Designing a mod N counter where N <14 using J K flip-flops and D flip-flops.
6. Design of a ripple counter
7. Design two bit comparator using gate ICs.
8. Study of Analog to Digital Converter
9. Study of Digital to Analog Converter
10. Any one of the following
    (i) Full Adder using Gates and using Decoder or a Multiplexer.
    (ii)Using a shift register as a sequence generator.

Group B: EEC403-Power Electronics Devices and Circuits:

1. Study of I-V characteristics of Thyristors (SCR/Triac)
2. Study of switching characteristics of Power BJT/ Power MOSFET/ IGBT
3. Implementation of Single phase Half wave and Full wave rectifiers
4. Study of single phase PWM rectifier
5. Implementation and testing of SPWM VSI.
6. Design of IGBT gate drivers circuit
7. Design and Implementation of DC-DC Buck converter

8. Design and Implementation of DC-DC Boost converter
9. Implementation and testing of LED driver circuit
10. Study of current and voltage measurement circuits in switching converters
11. Study of Analog to Digital Converter

Any other experiments based on syllabus which will help students to understand topic/concept.

Note:

Students and teachers are encouraged to use the 'Virtual Labs' (an MHRD Govt. of India Initiative) whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum 08 experiments. The distribution of marks for term work shall be as follows:

Laboratory Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical and Oral Examination:

Practical will be based on the laboratory experiments carried out and Oral examination will be based on entire syllabus of **EEC403 - Digital Electronics** and **EEC404 - Power Electronics Devices and Circuits.**

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEL404	**Skill Based Lab- II PCB Design and Fabrication Lab**	-	**04**	**-**	**-**	**02**	**-**	**02**

Examination Scheme								
Theory					Term Work/Practical/Oral			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**50**	**-**	**-**	**50**

Course Objectives	1. To develop the skill set to work on real-life projects and its design. 2. To develop the required skill set to design, develop and assemble the PCB using the CAD tools
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Understand types of PCBs and various tools used for PCB design. 2. Identify various electrical/electronic components and their packages/ footprints. 3. Illustrate the use of PCB CAD tools and their features for the practical designs. 4. Design the schematic, board layout for simple, moderately complex and complex circuits. 5. Fabricate and assemble the PCBs for simple and moderately complex circuits.

Module	Detailed Contents	Hours
1	**Basics of PCB Designing:** Types of PCBs, Single Layer, Multi-Layer, PCB Materials, PCB designing using different PCB-CAD tools; Schematic Editor, Component libraries with model and footprint, Circuit Emulation, Artwork with auto / manual routing and 3-D Visualization.	**04**
2	**Electrical/ Electronic Components and Packages:** Semiconductor devices and footprints: Diodes: rectifier/ ultrafast/ schottky/ power/ zener diodes, LED, transistors(BJT), SCRs, GTOs, MOSFETs, IGBTs, DIACs, TRIACs etc; Integrated circuits (ICs) and Opto-isolators Different PCB connectors, Terminals, Terminal Blocks; Inductor and Transformers: pulse, low and high frequency); Capacitors and resistors; High voltage devices, Protection elements Component package types: Through Hole Packages: Axial lead, Radial Lead, Single Inline Package(SIP), Dual Inline Package(DIP), Transistor Outline(TO), Through Hole Packages, surface mounted devices (SMD) components.	**06**
3	**PCB Development Tools:** Introduction to open source and commercial softwares like: Proteus, Altium, Eagle, OrCAD, KiCAD etc. Schematic preparation, Selection of Components from standard and special libraries, Components Footprints, net-list, creating new component footprints / library. Updating libraries	**06**

4	**PCB Artwork Designing:** PCB Layout Designing: Placement and layout of components, Design Rule Check (DRC), Electronic rule checking (ERC); PCB Layers: electrical Layers: top Layer, bottom Layer, board outlines and cut-outs, drilling details, components outlines, text; pads, vias, Tracks, colour of layers; Multilayer PCBs. PCB materials: Standard FR-4 Epoxy Glass, Multi-functional FR-4, Tetra Functional FR-4, Polyimide Glass, Teflon etc. Rules for track: PCB conducting layer thickness selection, PCB track width calculation, track length, track angle, track joints, track size; manual routing, auto-routing: Setting up Rules, Defining Constraints; Gerber Generation; PCB Fabrication PCB Making, Printing, Etching, Drilling. EMI and EMC issues in PCB designing.	**08**
5	**PCB Designing in Lab:** **Students should prepare PCBs for at least three projects:** • First project should be a simple circuit: Complete schematic, board layout (single-sided), PCB fabrication, component mounting and testing to be completed. • Second project should be a moderately complex circuit: Complete schematic, board layout (Single layer), PCB fabrication, component mounting and testing to be completed • Third project should be a complex circuit: Complete schematic and board layout (multi-layer) design, gerber files generation to be completed. All three projects are required to be carried out by each individual student (not in a group). For each project a detailed report inclusive of all the schematic, artwork layouts, PCB photos, assembled PCB photos, details of the circuit design and test result etc. must be prepared. Each Project can be carried out based on the following steps: **PCB project:** Selection of circuit, components, components packages, manufacturer (make), generic components, symbols. (i) Selection of circuit: PCB design practice can be carried out for following circuits: 1. Analog Electrical / Electronic Circuits 2. Linear DC Power Supply 3. Op-amp based Signal Processing circuits 4. Different measurement based on transducers /sensors. 5. Mini Project based on Electrical / Electronic domain 6. Microcontroller circuits etc. (ii) Components selection: Students can design/ select the components from datasheets/ manufacturer catalogues / data-book, online supplier's inventory etc. (iii) Selection of PCB type: PCB material, number of layers, thickness of copper etc. (iv) Prepare the schematic and board layout using the open source CAD tools or Licensed CAD tool available in the lab. (v) Fabricate PCB in the lab using printing, etching and drilling process.(Only two projects) (vi) Post PCB fabrication process: component mounting, soldering and Hardware Testing. (vii) Prepare the report on overall lab work carried out with schematics, PCB artwork final PCB fabrication and assembled PCBs photographs.	**24**

Term Work:

Term work shall consist of minimum three PCB designing projects and the reports based on that. The distribution of marks for term work shall be as follows:

Laboratory Performance : 30 marks (PCB design and fabrication- 10 each for three PCBs based on workmanship and quality of work)

Journal : 10 marks

Attendance : 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Books Recommended:

1. Simon Monk, *Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards,* 1st Edition, McGraw-Hill Education
2. P. Horowitz and W. Hill*, The Art of Electronics,* 3 Edition, Cambridge University Press.
3. Matthew Scarpino, *Designing Circuit Boards with EAGLE: Make High-Quality PCBs at Low Cost*, 1st Edition Prentice Hall.
4. Archambeault and Drewniak James, *PCB Design for Real-World EMI Control, Springer Publications*

Note: Online demonstrative videos provided by various PCB CAD tools developers can be used to train the students to enable them to gain required skill sets in PCB designing and fabrication essential in engineering career.

Semester-IV								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	TW/Pract.	Tut.	Total
EEM401	**Mini Project – 1B**	-	**04$**	**-**	**-**	**02**	**-**	**02**

$ indicates work load of Learner (Not Faculty)

Examination Scheme								
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**

Course Objectives	1. To acquaint with the process of identifying the needs and converting it into the problem. 2. To familiarize the process of solving the problem in a group. 3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. 4. To inculcate the process of self-learning and research.
Course Outcomes	**Upon successful completion of this course, the learner will be able to** 1. Identify problems based on societal /research needs. 2. Apply Knowledge and skill to solve societal problems in a group. 3. Develop interpersonal skills to work as member of a group or leader. 4. Draw the proper inferences from available results through theoretical/ experimental/simulations. 5. Analyse the impact of solutions in societal and environmental context for sustainable development. 6. Use standard norms of engineering practices 7. Excel in written and oral communication. 8. Demonstrate capabilities of self-learning in a group, which leads to life long learning. 9. Demonstrate project management principles during project work.

(A) General Guidelines for Mini Project 1A/ 1B

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project

of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project-1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.

- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

(B) Mini Project 1A/1B–General Guidelines for Execution

Design and Fabrication

e. Initial fabrication of the project by students can be done using standard devices/material/software tools to verify the circuit functionalities Initial project fabrication and testing is expected to be done by soldering/assembling on general purpose PCB/ Bakelite boards or suitable platforms required for the electrical/electronic/digital components. Avoid the use of breadboards.

f. If essential, use of a simulation/ emulation software tools to test and verify the performance of the circuit should be encouraged.

g. Students should prepare the proper drawings (electrical/ mechanical), schematics/ layouts of the project.

h. For final implementation of the circuit, preparation of PCB (if any required) using suitable CAD tools and fabricating the same in the lab is expected.

Devices/ Components/ Systems to be Used:

Students are encouraged to use passive components like resistors, capacitors, inductors etc. If any specialize inductor is not readily available, the fabrication of the same in the lab should be encouraged. Other components like: Transistors, diodes, voltage regulators, logic gates, Op-amps, general purpose microcontroller, DC motors/ AC motors, sensors, actuators, relays etc. (Students may add more components as per the requirement of project).

Testing and analysis of the Project

Students should test the circuit using suitable laboratory equipments like power supply, multi-meter, CRO, DSO etc. In case of any debugging requirement, students should record the problems faced during the testing and solutions sought after for the fault in the circuit.

All the testing results must be well documented in the final project report verifying the functionalities of the propose project.

Use of Reference Material/Literature :

Students are advised to refer Application Notes, research publications & data sheets of various electrical/electronic/digital devices from Texas Instruments, Microchips, International Rectifiers, ST Microelectronics, Philips, NXP and many other manufacturers.

(C) Self-learning and Skill Set Development

Students should be encouraged to develop/ improve their understanding and skill sets by attending various online/offline expert lectures / video lectures/ courses/ webinars/ workshops etc. to facilitate the smooth execution of mini project

1. Understanding passive components viz. resistors, capacitors and inductors from practical point of view: types/ varieties, device packages, applications and cost.
2. Understanding semiconductor components viz. diodes, BJT and JFET/MOSFETs from practical point of view: types/ varieties, device packages, applications and cost.
3. Design principles of simple electrical / electronic circuits with some examples.
4. Selection of switches and circuit protection components.
5. Selection and sizing of wires and conductors.
6. Soldering Practice.
7. Heat-sinking and Enclosure design concepts
8. Overall workmanship while working on the project fabrication.
9. Use of different software tools for design and development of circuits
10. Use of standard as well as advanced laboratory equipments needed for testing of such projects

(D) Suggested List of Application Domains/ Software tools/ Online Repository for Mini Projects

List of key application domains from where students are encouraged to derive Mini Projects topics:

1. Home/Office automation
2. Renewable Energy
3. Energy Conservation
4. Energy Storage
5. Battery Charging and Protection
6. Fire Safety
7. Electrical System Protection
8. Lighting Control
9. Wireless Power Transfer
10. Electrical Components Testing
11. Electrical Parameters Measurement
12. Non-conventional Electricity Generation
13. Laboratory Equipments
14. E-Mobility
15. Video Surveillance Systems
16. Robotics for Hazardous applications
17. Waste Management System 2.
18. Smart City Solutions
19. Smart Classrooms and learning Solutions
20. Smart Agriculture solutions etc.
21. Health/ Biomedical

Students can identify the mini project topics either from above suggested domains or **any other relevant engineering domains**.

Reference Books:

1. P. Horowitz and W. Hill, "The Art of Electronics", 3rd Edition, Cambridge University Press, 2015
2. R. S. Khandpur, "Printed Circuit Board", McGraw-Hill Education; 1st edition, 2005.
3. Simon Monk, "Hacking Electronic: Learning Arduino and Raspberry Pi", McGraw-Hill Education TAB; 2 edition (September 28, 2017).

Suggested Software Tools:

1. LTspice:https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html#
2. Eagle : https://www.autodesk.in/products/eagle/overview
3. OrCAD: https://www.orcad.com/
4. Multisim : https://www.multisim.com/
5. Webbench:http://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html
6. Tinkercad : https://www.tinkercad.com/
7. Raspbian OS: https://www.raspberrypi.org/downloads
8. Arduino IDE: https://www.arduino.cc/en/main/software

Online Repository:

1. https://www.electronicsforu.com
2. https://circuitdigest.com
3. https://www.electronicshub.org
4. Github

(E) Guidelines for Assessment of Mini Project

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

<u>One-year Mini Project:</u>

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
  - First shall be for finalization of problem
  - Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components /systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

<u>Half-year Mini Project:</u>

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalization of problem and proposed solution
  - Second shall be for implementation and testing of solution.

(F) Assessment criteria of Mini Project

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.

- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Oral Examination:

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

****

Item No. -
AC-

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Electrical Engineering

Second Year with Effect from AY 2020-21

Third Year with Effect from AY 2021-22

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Item No.-
AC-

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year in Bachelor of Electrical Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	**Under Graduation**
7	Pattern	**Semester**
8	Status	**Revised**
9	To be implemented from Academic Year	**With effect from Academic Year: 2021-2022**

Date

Dr. S. K. Ukarande
Associate Dean, Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean, Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Third Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Final Year Engineering in the academic year 2022-23.

Dr. S. K. Ukarande
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Dr Anuradha Muzumdar
Dean
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Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface By BoS

The outcome based course curriculum for the undergraduate degree in Electrical Engineering in Rev.2019 'C' scheme has been chalked out through the thoughtful discussions and deliberations of academic and industry experts. While devising the syllabus content framework, the correct balance between the fundamental / core topics with appropriate mix of topics from the state of the art technologies in electrical and allied domains is attempted. With the increased Industry-Institute interaction and internship programs, students are encouraged to explore the opportunity to improve communication skills, problem solving skill and good team management. These skills shall surely help them to meet the future challenges in their career.

The new course curriculum will also give ample opportunity to the students to work in cross discipline domains to gain the hands on experience through the project based learning facilitated through the various skill based labs, Mini projects, Course projects , Major projects etc. The increased number of department and institute level electives shall facilitate students with the truly choice based learning and skilling in a particular domains.

On behalf of the Board of Studies (BoS) in Electrical Engineering of the University of Mumbai, we seek the active participation from all the stake holders of the engineering education to meet the set outcomes and objectives for the Undergraduate Program in Electrical Engineering.

Board of Studies in Electrical Engineering

Dr. Sushil S. Thale : Chairman
Dr. B. R. Patil : Member
Dr. S. R. Deore : Member
Dr. B. B. Pimple : Member
Dr. Nandkishor Kinhekar : Member

Program Structure for Third Year Electrical Engineering
(Semester V & VI)
University Of Mumbai
(With Effect from 2021-2022)
Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
EEC501	Electrical AC Machines II	3	--	3	--	3
EEC502	Electrical Power System II	3	--	3		3
EEC503	Control System	3	--	3	--	3
EEC504	Electromagnetic Field and Wave	3	--	3	--	3
EEDO501X	Department Optional Course – 1	3	--	3	--	3
EEL501	Electrical AC Machines Lab II	--	2	--	1	1
EEL502	Simulation Lab II	--	2	--	1	1
EEL503	Control System Lab	--	2	--	1	1
EEL504	Professional Communication and Ethics-II	--	2*+2	--	2	2
EEM501	Mini Project – 2 A	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac / Oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
EEC501	Electrical AC Machines-II	20	20	20	80	3	--	--	100
EEC502	Electrical Power System-II	20	20	20	80	3	--	--	100
EEC503	Control System	20	20	20	80	3	--	--	100
EEC504	Electromagnetic Field and Wave	20	20	20	80	3	--	--	100
EEDO501X	Department Optional Course – 1	20	20	20	80	3	--	--	100
EEL501	Electrical AC Machines Lab-II	--	--	--	--	--	25	25	50
EEL502	Simulation Lab-II	--	--	--	--	--	25	25	50
EEL503	Control System Lab	--	--	--	--	--	25	25	50
EEL504	Professional Communication and Ethics-II	--	--	--	--	--	25	25	50
EEM501	Mini Project – 2A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**125**	**125**	**750**

* Theory class to be conducted for full class

$ indicates work load of Learner (Not Faculty), for Mini Project; **Faculty Load**: 1 hour per week per four groups

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./ Tut.	Theory	Pract.	Total
EEC601	Power System Protection & Switchgear	3	--	3	--	3
EEC602	Microcontroller Applications	3	--	3		3
EEC603	Control System Design	3	--	3	--	3
EEC604	Signals and Systems	3	--	3	--	3
EEDO601X	Department Optional Course – 2	3	--	3	--	3
EEL601	Power System Protection & Switchgear Lab	--	2	--	1	1
EEL602	Microcontroller Applications Lab	--	2	--	1	1
EEL603	Control System Design Lab	--	2	--	1	1
EEL604	SBL-III: Industrial Automation Lab	--	4	--	2	2
EEM601	Mini Project – 2 B	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac / Oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
EEC601	Power System Protection & Switchgear	20	20	20	80	3	--	--	100
EEC602	Microcontroller Applications	20	20	20	80	3	--	--	100
EEC603	Control System Design	20	20	20	80	3	--	--	100
EEC604	Signals and Systems	20	20	20	80	3	--	--	100
EEDO601X	Department Optional Course – 2	20	20	20	80	3	--	--	100
EEL601	Power System Protection & Switchgear Lab	--	--	--	--	--	25	25	50
EEL602	Microcontroller Applications Lab	--	--	--	--	--	25	25	50
EEL603	Control System Design Lab	--	--	--	--	--	25	--	25
EEL604	SBL-III: Industrial Automation Lab	--	--	--	--	--	25	25	50
EEM601	Mini Project – 2 B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**125**	**100**	**725**

$ indicates work load of Learner (Not Faculty), for Mini Project; **Faculty Load**: 1 hour per week per four groups

Department Optional Courses

Sem. V: Department Optional Course – 1

EEDO5011: Renewable Energy Sources
EEDO5012: Advanced Power Electronics
EEDO5013: Advanced Measurements and Instrumentation
EEDO5014: Analog and Digital Communication

Sem. VI: Department Optional Course – 2

EEDO6011: Special Electrical Machine
EEDO6012: Electric Traction
EEDO6013: High Voltage Engineering
EEDO6014: Energy Storage

SBL: Skill Based Lab

Students group and load of faculty per week.
Mini Project 1A / 1B: Students can form groups with minimum 3 (Three) and not more than 4 (Four)
Faculty Load: 1 hour per week per four groups

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract /Tut.	Total
EEC501	Electrical AC Machines -II	3	--	3	--	3

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC501	Electrical AC Machines -II	20	20	20	80	03	-	-	100

Course Objectives	• To impart knowledge of operation and performance of synchronous machine
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To illustrate the working of synchronous generator 2. To determine the voltage regulation of synchronous generator by different methods 3. To analyze the parallel operation of synchronous generators. 4. To apply Blondel's two reaction theory and solve simple problems on salient pole synchronous machines. 5. To analyze the operation of synchronous motor. 6. To derive the basic machine relations in dq0 variables for a synchronous machine without considering damper winding.

Module	Contents	Hours
1	Synchronous Generator-Introduction: Construction, Operation, E.M.F. equation, Winding factors, Armature reaction	03
2	Analysis of Synchronous Generator: Phasor diagrams of cylindrical rotor synchronous generator, Voltage regulation, No load (OC) and SC test, Voltage regulation methods: EMF, MMF, ZPF, ASA.	06
3	Performance of Synchronous Generator: Power flow equations and maximum power conditions, Need for parallel operation and conditions, Effect of variation of field current and prime mover input on parallel operation, Concept of infinite bus, Effect of variation of field current on alternator connected to infinite bus, Numerical problems on parallel operation.	10
4	Salient pole synchronous generator: Concept of direct and quadrature reactance, Blondel's two reaction theory, Phasor diagram of salient pole machine, Power angle characteristics, Synchronizing power and torque.	06
5	Synchronous Motor: Principle of operation, Self-starting methods, Phasor diagram, Load angle (δ), Power flow equations and maximum power conditions, Effect of change in excitation and mechanical power on performance of motor, V and Inverted V curves, Power factor control, Hunting,	09

	Excitation and power circles, Measurement of X_d and X_q by slip test, Starting against high torques.	
6	**Theory of Synchronous Machines:** Ideal synchronous machine, Transformation to direct and quadrature axis variables, basic machine relations in dq0 variables (Primitive model of synchronous machine without considering damper winding), steady state analysis.	05

Text Books:

1. Bimbhra P.S., Electric Machinery, Khanna Publisher
2. Bimbhra P.S., Generalized Machine Theory, Khanna Publisher
3. V. K. Mehta, Principles of Electrical Machines, S Chand Publication

Reference Books:

1. M.G. Say, Performance and Design of Alternating Current Machines, CBS Pub.
2. Ashfaq Husain, Electric Machines, Dhanpat Rai and co. publications
3. A.E. Fitzgerald, Kingsly, Stephen, Electric Machinery, Tata McGraw Hill

Web Reference /Video Courses

1. **NPTEL Course**: **Electrical Machines-II** By Prof. Krishna Vasudevan, Prof. G. Sridhara Rao, Prof. P. Sasidhara Rao, IIT-Madras. Weblink- https://nptel.ac.in/courses/108/106/108106072/
2. **NPTEL Course**: **Electrical Machines** By Prof. G. Bhuvaneshwari, Dept. of Electrical Engineering , IIT-Delhi. Weblink:- https://nptel.ac.in/courses/108/102/108102146/
3. **NPTEL Course**: **Electrical Machines-II** By Prof. Tapas Kumar Bhattacharya, Dept. of Electrical Engg. ,IIT-Kharagpur. Weblink:- https://nptel.ac.in/courses/108/105/108105131/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEC502	**Electrical Power System II**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC502	**Electrical Power System II**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To understand different types of faults and their analysis. 2. To understand power system transients and insulation coordination. 3. To understand concept of corona.
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. Understand and analyse unsymmetrical faults on transmission line 2. Analyse symmetrical component and construct sequence network 3. Analyse symmetrical faults on transmission lines. 4. Understand power system transients 5. Understand phenomenon of lightning and insulation coordination. 6. Understand concept of corona.

Module	Contents	Hours
1.	**Symmetrical Fault Analysis:** Introduction to synchronous machine, basic construction, operation and equivalent circuit diagram, short circuit of synchronous machine: no load and loaded machine, transient on a transmission line, selection of Circuit breaker, short circuit MVA. Algorithm for SC studies, Z Bus formulation, symmetrical fault analysis using Z bus. **(Numerical)**	10
2.	**Symmetrical Components:** Introduction, Symmetrical component transformation, phase shift in star-delta transformers, sequence impedances and sequence network of transmission line, synchronous machine and transformer, power invariance, construction of sequence network of a power system. **(Numerical)**	08
3.	**Unsymmetrical Fault Analysis:** Types of unsymmetrical faults, Analysis of shunt type unsymmetrical faults: single line to ground (SLG) fault, line to line (L-L) fault, double line to ground (LLG) fault. **(Numerical)**	05
4.	**Power System Transients:** Review of transients in simple circuits, recovery transient due to removal of short circuit, arcing grounds, capacitance switching, current chopping phenomenon. Travelling waves on transmission lines, wave equation, reflection and refraction of waves, typical cases of line terminations, attenuation, Bewely lattice diagram. **(Numerical)**	06
5.	**Lightning and Insulation Coordination:** Lightning phenomenon, mechanism of Lightning stroke, shape of Lightning voltage wave, over voltages due to Lightning, Lightning protection problem, significance of tower footing resistance in relation to Lightning, insulator flashover and withstand voltages, protection against surges, surge arresters, surge capacitor, surge reactor and surge	06

	absorber, Lightning arrestors and protective characteristics, dynamic voltage rise and arrester rating. **Insulation Coordination:-** Volt time curve, basic approach to insulation co-ordination in power system, over voltage protection, ground wires, insulation coordination based on lightning, surge protection of rotating machines and transformers.	
6.	**Corona:** Phenomenon of corona, Disruptive critical voltage, Visual critical voltage, corona loss, factors affecting corona loss, Radio interference due to corona, practical considerations of corona loss, corona in bundled conductor lines, corona ring. **(Numerical)**	04

Text Books:-

1. B.R. Gupta, Power System Analysis and Design, S. Chand, 4e
2. D. P. Kothari, I. J. Nagrath, "Power System Engineering", 3e, Mc Graw Hill
3. Wadhwa C.L. Electrical power system, New Age International, 4e
4. Mehta V.K., Principles of Power System, S. Chand

Reference Books:-

1. Hadi Saadat, Power System Analysis, TMH publications
2. Turan Gonen, Modern power system analysis, Wiley
3. Stevenson and Grainger, Modern power system analysis, TMH publication, 1ed

Website Reference/ Video Courses:

1. NPTEL Course: **Power Systems Analysis** By Prof. Arindam Ghosh, Department of Electrical Engineering IIT Kanpur :-Web link- https://nptel.ac.in/courses/108/106/108106098/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEC503	Control Systems	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC503	Control Systems	20	20	20	80	3	-	-	100

Course Objectives	1. Modeling of electric, mechanical and electromechanical systems, using differential equations, transfer functions, block diagrams, and state variables. 2. To analyze and design system parameters to meet transient and steady state error performance specifications. 3. To learn time response analysis and demonstrate their knowledge to frequency response 4. To learn stability analysis of system using Root locus, bode plot, polar plot, and Nyquist plot.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Demonstrate an understanding of the fundamentals of (feedback) control systems. 2. Determine and use models of physical systems in forms suitable for use in the analysis and design of control systems. 3. Express and solve system equations in state-variable form (state variable models). 4. Determine the time and frequency-domain responses of first and second-order systems to step and sinusoidal (and to some extent, ramp) inputs. 5. Determine the (absolute) stability of a closed-loop control system

Module	Contents	Hours
1.	Introduction to Control System: Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems. Concept of feedback and Automatic control, Effects of feedback	03
2.	Mathematical Model of Physical System Transfer function of electrical, mechanical (translational and rotational) System. Force Voltage and Force Current analogies. Transfer function model of AC & DC servomotor, potentiometer & tacho-generator. Block diagram reduction technique and signal flow graph, Mason's rule, Signal flow graph of electrical network. Conversion of BDR to SFG and vice versa.	08
3.	Time Domain Analysis: Time domain analysis of a standard second order closed loop system. Concept of un-damped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.	09
4.	State Variable Analysis Introduction to state variable, General state space representation, State space representation of Electrical and Mechanical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade).	07

	Similarity transformations, diagonalizing a system matrix. Laplace Transform solution of state equation, stability in state space	
5.	Root locus Techniques: Definition and properties of root locus, rules for plotting root locus, stability analysis using root locus.	04
6.	Frequency Domain Analysis: Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Gain margin and phase margin via Nyquist diagram and Bode plots.	08

Text Books:-

1. Control System Engineering by Norman Nise
2. Control System Engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern
3. Modern Control System Engineering by K. Ogata, Prentice Hall
4. Modern Control Systems, Twelfth edition, by Richard C Dorf, Robert H Bishop, Pearson.
5. Gopal, M., Digital Control System, Wiley Eastern (1986).

Reference Books:-

1. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis S.N. Sheldon, Marcel Dekkar
2. Feedback control of Dynamic System, G.F. Franklin, Pearson higher education,
3. Control System Engineering, Shivanagraju s. Devi L., New Age International
4. Control Systems Technology, Curtis Johnson, Heidar Malki, Pearson
5. Control Systems Engineering, S. K. Bhattacharya, Pearson.
6. Control Systems, Theory and applications, Smarajit Ghosh, Pearson

Web Reference /Video Courses

1. NPTEL Course: Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/
2. NPTEL Course: Control Systems By Prof. C.S. Shankar Ram, Department of Design Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/107/106/107106081/
3. NPTEL Course: Control Engineering By Prof. S.D. Agashe, Department of Electrical Engineering, IIT Bombay :-Web link- https://nptel.ac.in/courses/108/101/108101037/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
EEC504	Electromagnetic Field and Wave	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	--	3	--	3

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC504	Electromagnetic Field and Wave	20	20	20	80	03	--	-	100

Course Objectives	1. Implement the knowledge of mathematics and physics. 2. Visualize Electric field. 3. Visualize magnetic field 4. Understand their application in electrical engineering 5. Analyse time varying electric and magnetic fields 6. Formulate electromagnetic wave equation
Course outcomes	Upon successful completion of this course, the learner will be able to: 1. Apply knowledge of mathematics and physics in electrical engineering field. 2. Analyze electrostatic fields 3. Apply and analyse magneto-static fields. 4. Analyze the effect of material medium on electric and magnetic fields. 5. Analyze and formulate time varying electric and magnetic fields. 6. Formulate wave equations for Electromagnetic wave propagation in different media.

Module	Contents	Hours
1.	Vector Basics: Introduction to Vectors Calculus, Rectangular, Cylindrical and Spherical Co-ordinate System, Co-ordinate and vector transformation; Numericals on line, Surface and Volume Integrals.	05
2.	Static Electric Fields: Coulomb's Law in Vector Form, Electric Field Intensity, Definition, Principle of Superposition, Electric Field due to point charges, Electric Field due to line charge (one and two conductor transmission lines), Electric Field due to an infinite uniformly charged sheet, Definition and physical interpretation of gradient, Electric scalar potential, Relationship between potential and electric field and its application on Surface voltage gradient on conductor. Numericals	12
3.	Static Magnetic Fields: The Biot-Savart's Law in vector form, Magnetic Field intensity due to a finite and infinite wire carrying a current I, Magnetic field intensity on the axis of a circular loop carrying a current I, Ampere's circuital law and its application on A solid cylindrical conductor and Infinitely long coaxial transmission line, Magnetic flux density, Definition and physical Interpretation of Curl, The Lorentz force equation for a moving charge and its applications on Force on a wire carrying a current I placed in a magnetic field, Magnetic Vector Potential. Numericals	08
4.	Electric and Magnetic Fields in Materials: Poisson's and Laplace's equation , Electric Polarization, Electric current, Current density, Point form of ohm's law, Continuity equation for current Numericals	06

5.	Time varying Electric and Magnetic Fields: Faraday's law, Maxwell's Second Equation in integral form from Faraday's Law, Equation expressed in point form, Displacement current, Ampere's circuital law in integral form, Modified form of Ampere's circuital law as Maxwell's first equation in integral form, Equation expressed in point form, Maxwell's four equations in integral form and differential form. Numericals	05
6.	Electromagnetic Wave theory: Derivation of Wave Equation, Uniform Plane Waves, Maxwell‟s equation in phasor form, Wave equation in phasor form. (No numericals)	03

Self Study Topics- Potential due to electrical dipole and flux lines, Electric Flux Density, Gauss Law Definition and physical Significance of Divergence, Divergence theorem. Application on Estimation and control of electric stress, control of stress at an electrode edge.

Note: Students should be encouraged to study the self-study topics through text books, reference books , online courses /contents etc. The students' performance on self-study contents be verified through MCQs and/or presentations or any other suitable methodology.

Text/Reference Books:-

1. W. Hayt, "Engineering electromagnetic", McGraw Hill, 4th edition, 1987.
2. Edminister, "Schaum‟s series in electromagnetic" McGraw Hill publications, 3rd edition, 1986.
3. M.N.O.Sadiku, "Elements of Engineering Electromagnetics" Oxford University Press, 3rd Ed.
4. N. Narayan Rao, "Elements of Electromagnetic", PHI publication, 4th edition, 2001.
5. David K.Cherp, "Field and Wave Electromagnetics - Second Edition-Pearson Edition

Website Reference/ Video Courses:

1. NPTEL Course: **Electromagnetic Fields** By Prof. Harishankar Ramachandran, Department of Electrical Engineering IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO5011	**Renewable Energy Sources**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO5011	**Renewable Energy Sources**	20	20	20	80	3	-	-	100

Course Objectives	1. To review of conventional and non-conventional energy sources. 2. To give the students basic knowledge of solar thermal energy applications 3. To give the students basic knowledge solar photovoltaic system 4. To give the students basic knowledge of wind energy system 5. To give the students basic knowledge of fuel cell system operation 6. To give the students basic knowledge about other renewable energy sources.
Course outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand different types conventional energy sources and their reserves 2. Identify and analyse the process of power generation through solar thermal energy utilization 3. Identify and analyse the process of power generation through solar photovoltaic energy utilization 4. Identify and describe the various components and types of Wind Energy system 5. Identify and describe the basic operation and types of Fuel cell system 6. Understand different types of other non-conventional energy sources

Module	Contents	Hours
1.	Introduction-: World's and India's production and reserves of commercial energy sources, energy alternatives, review of conventional and non-conventional energy sources. Statistic of net potential and current generation status of different energy alternatives.	04
2.	Solar Energy (Thermal Energy applications) : Solar thermal energy storage, Liquid flat plate collector, Solar air heater, concentrating collectors, thermal energy storage, solar pond	04
3.	Solar Energy (Direct Electricity Applications): Solar Photovoltaic- solar cell: characteristics, losses, model of a solar cell, emerging solar cell technologies; Solar PV modules, mismatch in module, hot spots, bypass diode; PV module: I-V and power curve, effect of variation in temperature and solar radiations; MPPT, types, different algorithms for electrical MPPT. Distributed MPPT, MPPT converters. Types of PV systems: standalone, grid connected systems; BOS of PV system, Battery charge controllers, Power Conditioning Unit, Solar PV Micro-inverters Solar Plant design: mounting of PV panels supporting structures, Calculation and Design methodology of standalone PV system and grid connected system.	12
4.	Wind Energy: Review of wind energy system and its components, types of wind turbines, characteristics; general concepts of aerofoils and aerodynamics, Wind data, Energy content of the wind, Power generation and control in wind energy systems, performance calculations of wind	08

	energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	
5.	**Fuel Cell:** Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications.	05
6.	**Other Sources:** Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean, Thermal Electric Conversion, geothermal, Micro-hydro, Wave energy	06

Text / Reference Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Green M.A " Solar Cells": Operating Principles, Technology and System Applications, Prentice Hall Inc, Englewood Cliffs N.J, U.S.A, 1982
3. James Larminie, Andrew Dicles "Fuel Cell Systems Explained," Wiley publication
4. Chetan Singh Solanki , Solar Photo Voltaics , PHI Learning Pvt Ltd., New Delhi,2009
5. Hashem Nehrir and Caisheng Wang, Modeling and control of Fuel Cells: Distributed Generation Applications, IEEE Press, 2009
6. J.F. Manwell and J.G. McGowan, Wind Energy Explained, Theory Design and Applications, Wiley publication
7. Leo J.M.J. Blomen and Michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993.
8. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
9. Felix A. Farret and M. Godoy Simoes, Integration of Alternative Sources of Energy, 2006, John Wiley and Sons.
10. S. Chakraborty, M. G. Simões and W. E. Kramer, Power Electronics for Renewable and Distributed Energy System, Springer 2013
11. N. Femia • G. Petrone, G. Spagnuolo and M. Vitelli, Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems, CRC Press, 2013.

Website Reference/ Video Courses:

1. **NPTEL Course: Energy Resources & Technology** By Prof. S. Banerjee, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105058/
2. **NPTEL Course: Non-Conventional Energy Systems** By Prof. L. Umanand, IISC Bangalore:- Web link- https://nptel.ac.in/courses/108/108/108108078/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO5012	Advanced Power Electronics	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO5012	Advanced Power Electronics	20	20	20	80	3	-	-	100

Course Objectives	1. To understand and analyse dc to dc conversion with isolation and hence to analyze different converter circuits for power conversion. 2. To understand the principles of design of magnetics such as high frequency transformers and inductors. 3. To keep abreast with the latest technologies and research going on in different areas related to power electronics. 4. To enhance the capability of problem solving skills. 5. To model the converter and design the controller for deeper understanding and detailed analysis.
Course outcomes	Upon successful completion of this course, the learner will be able to: 1. Analyze and select dc to dc power electronic converter topology for energy conversion applications. 2. Apply the basic concepts of magnetics to design high frequency transformers and Inductors for dc to dc converter topologies. 3. Analyze resonant power electronic converter topologies for high frequency applications 4. Model and design controllers for the closed loop operation of dc to dc converters. 5. Apply the basic concepts of power electronics in the fields of AC and DC drives, power generation and energy conversion, industrial applications, extraction of energy from renewable sources.

Module	Contents	Hours
1.	**Switching Voltage Regulators:** Comparison of Linear voltage regulators and switching voltage regulators, Buck, Boost, Buck-Boost converters in Boundary and Discontinuous Conduction Mode (DCM), Isolated converters-unidirectional and bidirectional core excitation, Flyback converter, Forward converter, Full bridge converter **(Numericals).**	11
2.	**Design of DC to DC converters (Boost, Buck, BDC, Flyback only):** Review of magnetic concepts, area product, design of inductor, design of high frequency transformer, numerical on design of inductor and transformer. Selection of capacitor, switching device and diode.	07
3.	**Resonant converters:** Drawbacks of switch-mode converters, basic resonant circuit concepts, Resonant switch converters - ZVS, ZCS, comparison, Basic concept of resonant dc link inverter and Applications of resonant converters.	04
4.	**Modeling and control (Boost, Buck and Flyback only):** State space model of various dc to dc converters, effect of ESR of capacitor and inductor resistance on the state space models, state space averaging technique, small signal analysis, transfer function, feedback control, compensator design, voltage mode control and current mode control, advantages of digital control.	08

5.	**Multi-Level Inverter:** Need for multilevel inverters, Diode clamped, flying capacitor and cascaded MLI, Phase shifted and level shifted PWM techniques, introduction to SVM for three level inverter.	04
6.	**Applications of power electronic converters:** Solar PV power conditioning unit, Bidirectional converter in battery charging, Resonant converters in induction heating, converters in residential applications, Application of Multi level inverter and three port DC to Dc converters.	05

Self study Topics: series and parallel load resonant converter.

Note: Students should be encouraged to study the self-study topics through text books, reference books, online courses /contents etc. The students' performance on self-study contents be verified through MCQs and/or presentations or any other suitable methodology.

Books Recommended:

Text Books:

1. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
2. L. Umanand, Bhatt, "Design Of Magnetic Components for Switched Mode Power Converters", John Wiley & Sons.
3. Simon Ang, Alejandro Oliva, "Power-Switching Converters", Taylor and Francis group
4. Bin Wu, "High Power Converters and AC drives", IEEE press, John Wiley & Sons.
5. M.H. Rashid, Hand book of Power Electronics", Third edition Butterworth-Heinemann, 2011.

Reference Books:

1. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
2. R.W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
3. Joseph Vithayathil, "Power Electronics", Tata McGraw hill, 1995.
4. P. T. Krein, Elements of Power Electronics, Oxford University Press.
5. V. Ramanarayanan, "Course Material on Switched Mode Power Conversion", 2007.
6. Simone Buso and Paolo Mattavelli "Digital Control in Power Electronics", Morgan & Claypool Publishers.

Website Reference/ Video Courses:

1. NPTEL Course: **Advance Power Electronics And Control** By Prof. Avik Bhattacharya, Dept. of Electrical Engineering, IIT Roorkee :-Web link- https://nptel.ac.in/courses/108/107/108107128/
2. NPTEL Course: **Switched Mode Power Conversion** By Prof. L. Umanand and Prof. V. Ramanarayanan, IISC Bangalore :-Web link- https://nptel.ac.in/courses/108/108/108108036/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO5013	Advanced Measurements and Instrumentation	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	--	3	--	3

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO5013	Advanced Measurements and Instrumentation	20	20	20	80	03	--	-	100

Course Objectives	1. To impart knowledge of architecture of the analog and digital measurement systems 2. To illustrate the working principle of electrical and non-electrical parameters measurements 3. To emphasize the principles and application of MEMS 4. To acquaint with digital data acquisition and virtual instrumentation system
Course outcomes	Upon successful completion of this course, the learner will be able to: 1. Classify, select and use various types of measurement sensors/ transducers and instrumentation system suitable for the given application 2. Classify and select proper measuring instrument for various electrical and non-electrical parameters measurements 3. Illustrate the principles and application of MEMS in various fields of engineering. 4. Understand the working of digital data acquisition system 5. Understand the role of virtual instrumentation in various application domains

Module	Contents	Hours
1	Measurement and Instrumentation: Basics of measurement and instrumentation system: Measurement System Architecture: analog and digital systems; Measuring Instruments: Classification, Absolute and secondary instruments, indicating instruments, constructional details, characteristics; Errors in measurements, Sensor Dynamics, Overview of Signal Conditioning: Analog and Digital Signal Conditioning	04
2	Sensors and Transducers: • **Electrical Parameters measurement:** Voltage and current, Instrument Transformers: Potential and current transformers. • **Displacement Measurement:** Transducers for displacement, displacement measurement, potentiometer, LVDT. • **Strain Measurement:** Theory of Strain Gauges, Bridge circuit, Strain gauge based load cells and torque sensors, • **Velocity, Speed, Vibration and Acceleration Measurement:** *Velocity and Speed*: Electromagnetic tachometer, Photoelectric tachometer, variable reluctance tachometer, Digital Encoders. *Vibration and acceleration*: Eddy current type, piezoelectric type; Accelerometer: Principle of working, practical accelerometers, strain gauge based and piezoelectric accelerometers. • **Pressure Measurement:** Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors. • **Flow Measurement:** Bernoulli flowmeter, Ultrasonic flowmeter, Magnetic flow meter, Rotameter.	10

	• **Miscellaneous Sensors:** Leak detector, Flame detector, Smoke detector, pH sensors, Conductivity sensors, Humidity sensors, Potentiometric Biosensors and Proximity sensors **(Only basic principle of working)**	
3	**MEMS Technology:** Introduction Nanotechnology and MEMS, MEMS design, and fabrication technology – Lithography, Etching, MEMS material, Bulk micromachining, Surface micromachining, Micro-actuator, electrostatic actuation, Micro-fluidics. *MEMS types and their applications:* Mechanical MEMS – Strain and pressure sensors, Accelerometers etc., Electromagnetic MEMS – Micro-motors, Wireless and GPS MEMS, Magnetic MEMS – all effect sensors, SQUID magnetometers, Optical MEMS – Micro-machined fiber optic component, Optical sensors, Thermal MEMS – thermo-mechanical and thermo-electrical actuators, Peltier heat pumps	10
4	**Digital Data Acquisition System:** Interfacing transducers to Electronics Control and Measuring System. Instrumentation and Isolation Amplifier; Review of Computer-Controlled Test Systems. IEEE-488 GPIB Bus; Microcontroller based data acquisition	04
5	**Virtual Instrumentation:** Historical perspective, Block diagram and Architecture of Virtual Instruments Data-flow Techniques: Graphical programming in data flow, Comparison with conventional programming. VI Programming Techniques: VIs and sub-VIs, Loops and Charts, Arrays, Clusters and graphs, Case and sequence structures, Formula nodes, Use of Analysis Tools: Advanced analysis tools such as Fourier transforms, Power spectrum, Correlation methods, Windowing and filtering and their applications in signal and image processing, Motion Control.	06
6	**Process Control System:** Electrical, Pneumatic, Hydraulic and Thermal systems, Process Control, Selection of Control: On-Off control, P, Pi, PID control. Sensitivity analysis of sensor-influence of component variation, Signal conditioning: Amplifier, Conversion, Filtering, Impedance Buffering, Modulation / Demodulation, Linearization, Grounding and Isolation.	05

Books Recommended:

Text Books and Reference Books:

1. Introduction To Instrumentation And Measurements by Robert B. Northrop, CRC Press, 2014
2. Instrumentation for Process Measurements and Control, by Norman Andrson, Chilton Company
3. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
4. Mechanical Engineering Measurements, A K Sawhney, Dhanpat Rai & Sons, New Delhi
5. Instrumentation & Mechanical Measurements, A K Thayal
6. Control System Engineering by Nagrath IJ and Gopal M, Wiley Eastern Ltd.
7. Control systems by Dhanesh Manik, Cengage Learning
8. Engineering Metrology and Measurements by N V Raghavendra and L Krishnamurthy, Oxford University Press
9. Instrumentation and Control System, W. Bolton, Elsevier
10. Smart Sensors and MEMS, by Stoyan Nihtianov and Antonio Luque, Woodhead Publishing, 2018.
11. Fundamentals of Micro-fabrications and Nanotechnology- From MEMS to Bio-Mems and Bio-NEMS, by Marc J. Madou, CRC Press, 2011
12. Handbook of Silicon Based MEMS Materials and Technologies, by Markku Tilli et al. William Andrew, Elsevier, 2015

Website Reference / Video Courses:

1. **NPTEL Course: Electrical Measurement And Electronic Instruments** By Prof. Avishek Chatterjee, Dept. of Electrical Engineering, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105153/

2. **NPTEL Course: Industrial Instrumentation** By Prof. Alok Barua, IIT Kharagpur:-Web link- https://nptel.ac.in/courses/108/105/108105064/
3. **NPTEL Course: Industrial Instrumentation** By Prof. **Prof. S. Mukhopadhyay and Prof. S.Sen**, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105062/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO5014	Analog and Digital Communication	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO5014	Analog and Digital Communication	20	20	20	80	3	-	-	100

Course Objectives	1. To introduce the elements of communication systems, describe the generalized block diagram and the types of communication systems. 2. To make students understand analog and digital communication techniques 3. To teach data and pulse communication techniques 4. To introduce source and Error control coding
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand theory of noise and the various methods involved in modulation techniques 2. Interpret the concepts in analog communication and differentiate various analog modulation techniques. 3. Develop the concepts in digital communication and various digital modulation techniques 4. Apply and integrate various pulsed modulation in digital communication systems. 5. Conversant in proposing suitable error controlling and correction algorithms. 6. Understand and incorporate the basic knowledge of optical fiber communication and Satellite communication.

Module	Contents	Hours
1.	Introduction to Communication Systems : Need and Importance of Communication, Elements of a Communication System, Types of communication systems (block diagram approach), Electromagnetic Spectrum used in communication, concept of bandwidth and power, Receiver characteristics, Need for modulation; Noise: Source of Noise - Types of noise, External Noise- Internal Noise – Noise Calculation, signal to noise ratio	05
2.	Analog Communication: Theory of Amplitude Modulation(DSBFC, DSBSC) - Evolution and Description of SSB Techniques, Independent sideband (ISB) and Vestigial Side Band (VSB) principles and transmitters; Theory of Frequency and Phase Modulation ; Comparison of various Analog Communication System (AM, FM, PM)	08
3.	Digital Communication: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), BPSK,QPSK, Quadrature Amplitude Modulation (QAM); Bandwidth, Efficiency Comparison of various Digital Communication System (ASK – FSK – PSK – QAM).	07

4.	**Sampling Techniques:** Sampling theorem, Nyquist criteria; Types of Sampling. Pulse modulation schemes – PAM, PPM and PWM generation and detection-Pulse code modulation. Conversion of PWM to PPM. Multiplexing Techniques - FDM and TDM; Delta modulation, adaptive delta modulation, principle, generation and detection; TDM and FDM basic concepts and block diagram; Applications of pulse communication	07
5.	**Source and Error Control Coding:** Entropy -Source encoding theorem - Shannon fano coding - Huffman coding - mutual information – Channel capacity - Channel coding theorem; Error Control Coding - Linear block codes - Cyclic codes –Convolution codes - Viterbi decoding algorithm.	08
6.	**Overview of other Types of Communication:** Optical fiber communication; Satellite Communication; Bluetooth.	04

Text Books:-

1. G. Kennedy and B. Davis, "Electronic Communication Systems", Tata McGraw Hill, 2011
2. Roddy and Coolen, "Electronic Communication", 4th Edition, Pearson Education 2008
3. Simon Haykin, "Digital Communications", 2014, 1st edition, John Wiley, India.
4. T.L.Singal, "Analog and Digital Communication", 2012, 1st edition, Tata McGraw Hill Education Private Ltd, New York.

Reference Books:

1. Taub and Schilling, "Principles of Communication Systems", McGraw Hill, Fourth reprint 2009.
2. Wayne Tomasi, "Electronic Communications Systems – Fundamentals Through advanced", 5th Ed., Pearson Education, 2009.
3. Hwei Ksu and Debjani Mitra, "Analog and Digital Communication: Schaum's Outline Series",
4. McGraw Hill Education (India) Pvt Ltd., 3rd Edition 2009.
5. John. G. Proakis, "Digital Communication", 2014, 5th edition, Pearson Education, Noida, India.
6. Herbert Taub and Donald L Schilling," Principles of Communication Systems", Tata McGraw Hill, New Delhi, 2012
7. Bernard Sklar, "Digital Communications: Fundamentals and Applications", 2016, 2nd edition, Prentice Hall, New Jersey, US.

Website Reference / Video Courses:

1. NPTEL Course: **Principles of Digital Communications** By Prof. S N Merchant, Dept. of Electrical Engineering, IIT Bombay:- Web link- https://nptel.ac.in/courses/108/101/108101113/
2. NPTEL Course: **Principles of Communication Systems-I** By Prof. Aditya K. Jagannatham, IIT Kanpur:-Web link- https://nptel.ac.in/courses/108/104/108104091/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL501	Electrical AC Machines Lab-II	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	2		1	1

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL501	Electrical AC Machines Lab-II	---	---	---	---	--	25	25	50

Course Objectives	**To impart the knowledge on the following :** 1. Practical understanding of Synchronous machines and their characteristics 2. Voltage regulation and Parallel operation of Synchronous generators
Course outcomes	Upon successful completion of this course, the learner will be able : 1. To analyze the operation of synchronous machines 2. To determine the voltage regulation of synchronous machines 3. To analyze the synchronization (or parallel operation) of synchronous machines 4. To determine the parameters of synchronous machines

Syllabus: Same as EEC501: Electrical AC Machines-II

Suggested List of Laboratory Experiments: Minimum six experiments need to be performed.

1. Constructional details of Synchronous machine
2. Voltage regulation of Alternator by Direct loading method
3. Voltage regulation of Alternator by EMF and MMF method
4. Voltage regulation of Alternator by ZPF and ASA method
5. Synchronization / Parallel operation of Alternator
6. Starting methods of Synchronous motor
7. Load test on Synchronous motor
8. 'V' and 'inverted V' curves of Synchronous machine
9. Determination of X_d and X_q of Synchronous machine by Slip test
10. Use of Synchronous motor as a Synchronous condenser
11. To determine positive sequence, negative sequence and zero sequence reactance of an alternator

Any other experiment based on syllabus which will help students to understand topic / concept.

Industry Visit: Students' visit to be arranged to the nearby industry involved in design/ manufacturing/ processing in the following electrical engineering domains: Electrical Machines / Electrical Power / Renewable energy / Power Electronics / Instrumentation / Communication Systems. All students shall submit visit report in appropriate format as a part of the submission for EEL501.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 05 marks
Industrial Visit report	: 05 marks
Attendance (Theory and Practical)	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical and Oral Examination:

Practical and Oral examination will be based on entire syllabus of **EEC501: Electrical AC Machines-II**

ELECTRICAL ENGINEERING - SEMESTER-V						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL502	Simulation Lab-II	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	2		1	1

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL502	Simulation Lab-II	---	---	---	---	--	25	25	50

Course Objectives	The course is aimed: 1. To understand basic block sets of different simulation platform used in electrical /electronic circuit design. 2. To understand use and coding in different software tools used in electrical/ electronic circuit design
Course outcomes	Upon successful completion of this course, the learner will be able to 1. Develop the skill to use the software packages to model and program electrical and electronics systems 2. Model different electrical and electronic systems and analyze the results 3. Articulate importance of software packages used for simulation in laboratory experimentation /research/industry by analyzing the simulation results. 4. Simulate circuits for performance analysis.

Suggested Software Tools to be Used for Simulation Lab-II:

Note:

1. Students should be encouraged to use open source softwares such as SCILAB, LTSPICE, Texas Instrument's 'Webbench', Ngspice, Solve Elec etc. for carrying out the lab simulation listed below.
2. Use of Professional Licensed versions of softwares like MATLAB, Proteus, LabVIEW, NI Multisim, PSpice, PSim, PSCAD, TINA etc. is also allowed.
3. Use of 'Python' platform for simulating components/ circuit behaviour should also be emphasized
4. Many of the following suggested experimentation can be carried out on Virtual lab platform

Suggested List of Laboratory Experiment: Minimum eight experiments need to be performed from various subjects domain. Some of the simulation experiments can also be selected based on the department elective offered

1. Study of sampling theorem, effect of under-sampling.
2. Study of Quantization of continuous-amplitude, discrete-time analog signals.
3. Study of properties of Linear time-invariant system.
4. Simulation of Signal processing circuit (amplifier/ filter /linearizing circuits) used for sensors / transducers
5. Virtual Instrumentation based Simulations of measurement and processing of Non-electrical parameters like temperature, pressure, force, speed etc.
6. Virtual Instrumentation based Simulation of any suitable industrial Process
7. Simulate the performance of a chemical sensor
8. Characterize the strain gauge sensor
9. Characterize the temperature sensor (Thermocouple)
10. Characterize the temperature sensor (RTD)
11. Simulate the performance of a bio-sensor
12. Measurement of level in a tank using capacitive type level probe

13. Simulation of Solar PV MPPT (P&O or Incremental conductance) based characterization under different operating conditions
14. Simulation of Solar PV and Battery hybrid energy source
15. Simulation of Fuel cell based Two stage (DC-DC converter and VSI) power supply for AC loads
16. Simulation of Back to back converter for Wind Energy Application
17. Simulation of closed loop control of Buck/Boost/Buck-Boost DC-DC converters
18. Simulation of a Resonant converter (Series/ parallel; ZVS/ZCS)
19. Simulation of Multilevel Inverter
20. Simulation of Solar PV MPPT converter with VSI
21. Simulation of Battery based Bidirectional Converter
22. Simulation of Flyback converter based SMPS
23. Simulating a Local Area Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)
24. Simulating a Wi-Fi Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)
25. Simulating a Wi-Fi Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)
26. Setting up a Bluetooth Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)
27. Setting up a ZigBee Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)
28. Simulating a Wireless Sensor Network (Using Vlab platform: Advanced Network Technologies Virtual Lab)

Any other simulations / algorithms based on fifth semester syllabus, which will help students to understand topic / concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference
1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance : 10 marks
Journal : 10 marks
Attendance (Theory and Practical) : 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on all the laboratory experiments carried out in **EEL-502- Simulation Lab-II**

ELECTRICAL ENGINEERING - SEMESTER-V						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL503	Control Systems Lab	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	2		1	1

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL503	Control Systems Lab	---	---	---	---	--	25	25	50

Course Objectives	1. To study basic concepts of control system 2. To familiarize with the modelling of dynamical systems and the characteristics of control components like AC servo motor, DC servo motor, DC position control system and synchro 3. To employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions to ascertain the required dynamic response from the system
Course outcomes	Upon successful completion of this course, the learner will be able to 1. Illustrate the functioning of various components of control system. 2. Analyse the response of physical system for various inputs. 3. Analyze and interpret stability of the system through Root Locus, Bode plot and Nyquist plots 4. Execute time response analysis of a second order control system using MATLAB

Syllabus: Same as EEC503: Control Systems

Suggested List of Laboratory Experiments: Minimum four from Group (A) and four from Group (B), in all minimum eight experiments need to be performed.

(A) Laboratory Experiments

1. Study of AC Servomotor
2. Study of DC Servomotor
3. Study of potentiometer as an error detector
4. Study of Synchros as an error detector
5. Study of AC position control system
6. Study of DC position control system
7. Obtain time response of first order to step ramp and parabolic input
8. Obtain time response of second order system to step input.

(B) Simulation Based Experiments (on Simulation Platform like MATLAB/SCILAB or Python Programming tool)

1. a) Simulation of a typical second order system and determination of step response and evaluation of time domain specifications
   b) Evaluation of the effect of additional poles and zeroes on time response of second order system
   c) Evaluation of effect of pole location on stability
   d) Effect of loop gain of a negative feedback system on stability
2. Draw the Root loci for a given transfer function and verification of breakaway point and imaginary axis crossover point.
3. Obtain the phase margin and gain margin for a given transfer function by drawing bode plots and verify the same.

4. Draw the Nyquist plot for a given transfer function.
5. Obtain State model from Poles and zero and also from transfer function
6. Determination of step, ramp & impulse response of a state model

Any other experiment based on syllabus which will help students to understand topic / concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance	:10 marks
Journal	:10 marks
Attendance (Theory and Practical)	:05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire syllabus of **EEC503: Control Systems**

ELECTRICAL ENGINEERING - SEMESTER-V								
Course Code	Course Name	Teaching scheme			Credit assigned			
EEL504	Professional Communication & Ethics-II	Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
		--	2*+ 2 Hours (Batch-wise)	--	--	2	--	02

*Theory class to be conducted for full class.

Course Code	Course Name	Examination Scheme									
		Theory					Term work	Pract	Oral	Internal Oral	Total
		Internal Assessment			End sem	Duration (hrs)					
		Test 1	Test 2	Avg.							
EEL504	Professional Communication & Ethics-II	--	--	--	--	--	25	--	--	25	50

Course Rationale	This curriculum is designed to build up a professional and ethical approach, effective oral and written communication with enhanced soft skills. Through practical sessions, it augments student's interactive competence and confidence to respond appropriately and creatively to the implied challenges of the global Industrial and Corporate requirements. It further inculcates the social responsibility of engineers as technical citizens.
Course Objectives	• To discern and develop an effective style of writing important technical/business documents. • To investigate possible resources and plan a successful job campaign. • To understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement. • To develop creative and impactful presentation skills. • To analyze personal traits, interests, values, aptitudes and skills. • To understand the importance of integrity and develop a personal code of ethics.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles. 2. strategize their personal and professional skills to build a professional image and meet the demands of the industry. 3. emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations. 4. deliver persuasive and professional presentations. 5. develop creative thinking and interpersonal skills required for effective professional communication. 6. apply codes of ethical conduct, personal integrity and norms of organizational behaviour.

Module	Contents	Hours
1	ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL) 1.1 Purpose and Classification of Reports: Classification on the basis of: • Subject Matter (Technology, Accounting, Finance, Marketing, etc.) • Time Interval (Periodic, One-time, Special) • Function (Informational, Analytical, etc.)	06

	• Physical Factors (Memorandum, Letter, Short & Long) **1.2. Parts of a Long Formal Report:** • Prefatory Parts (Front Matter) • Report Proper (Main Body) • Appended Parts (Back Matter) **1.3. Language and Style of Reports** • Tense, Person & Voice of Reports • Numbering Style of Chapters, Sections, Figures, Tables and Equations • Referencing Styles in APA & MLA Format • Proofreading through Plagiarism Checkers **1.4. Definition, Purpose & Types of Proposals** • Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals) **1.5. Parts of a Proposal** • Elements • Scope and Limitations • Conclusion **1.6. Technical Paper Writing** • Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	
2	EMPLOYMENT SKILLS **2.1. Cover Letter & Resume** • Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination) **2.2 Statement of Purpose** • Importance of SOP • Tips for Writing an Effective SOP **2.3 Verbal Aptitude Test** • Modelled on CAT, GRE, GMAT exams **2.4. Group Discussions** • Purpose of a GD • Parameters of Evaluating a GD • Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes **2.5. Personal Interviews** • Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	06
3	BUSINESS MEETINGS **3.1 Conducting Business Meetings** • Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette **3.2. Documentation** • Notice • Agenda • Minutes	02

4	TECHNICAL/ BUSINESS PRESENTATIONS 4.1 Effective Presentation Strategies • Defining Purpose • Analyzing Audience, Location and Event • Gathering, Selecting &Arranging Material • Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform skills 4.2 Group Presentations • Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	02
5	INTERPERSONAL SKILLS 5.1 Interpersonal Skills • Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making 5.2 Start-up Skills • Financial Literacy • Risk Assessment • Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	08
6	CORPORATE ETHICS 6.1 Intellectual Property Rights • Copyrights • Trademarks • Patents • Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information) 6.2 Case Studies • Cases related to Business/ Corporate Ethics	02

List of assignments:

(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analyzing a Published Technical Paper
5. Writing a SOP
6. IPR
7. Interpersonal Skills
8. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).

2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end–semester presentation based on the book report.

Assessment:

Term Work:
Term work shall consist of minimum 8 experiments.
The distribution of marks for term work shall be as follows:
Assignment : 10 Marks
Attendance : 5 Marks
Presentation slides : 5 Marks
Book Report (hard copy) : 5 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal oral:

Oral Examination will be based on a GD & the Project/Book Report presentation.

Group Discussion : 10 marks
Project Presentation : 10 Marks
Group Dynamics : 5 Marks

Books Recommended:
Textbooks and Reference books:

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). *Business communication today*. Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).*Personal development for life and work*. Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEM501	Mini Project – 2A	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	4$	--	2	2

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEM501	Mini Project – 2A	--	--	--	--	--	25	25	25

$ indicates work load of Learner (Not Faculty)

Course Objectives	1. To design and develop a moderately complex electrical/electronic/digital circuit with practical applications. 2. To understand basic concepts of circuit design while developing the project. 3. To enable the students to gain hands-on experience independently proposing and implementing the project and thus acquire the necessary confidence to deal with complex electrical/electronic/digital systems.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Identify problems based on societal /research needs. 2. Apply Knowledge and skill to solve societal problems in a group. 3. Develop interpersonal skills to work as member of a group or leader. 4. Draw the proper inferences from available results through theoretical/ experimental/ simulations. 5. Analyse the impact of solutions in societal and environmental context for sustainable development. 6. Use standard norms of engineering practices 7. Excel in written and oral communication. 8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning. 9. Demonstrate project management principles during project work

A. <u>Mini Project -Topic Selection and Approval</u>

1. The group may be of maximum **FOUR (04)** students.
2. Students should propose project ideas & finalize the project idea in consultation with guide/ HOD. Students should select a problem which addresses some basic home, office or other real life applications. The mini project must have hardware part. The software part is optional.
3. Students should identify different components/ devices, instruments, simulation/emulations software tools required for the project.
4. Students should submit implementation plan in the form of Gantt/ PERT/ CPM chart, which will cover weekly activity of project.
5. A Log Book to be prepared by each group to record the work progress in terms of milestones per week by students. Weekly comment, remarks to be put by guiding faculty.

B. Mini Project –Execution

i. Design and Fabrication

a. Initial fabrication of the project by students can be done using standard devices/material/software tools to verify the circuit functionalities Initial project fabrication and testing is expected to be done by soldering/assembling on general purpose PCB/ Bakelite boards or suitable platforms required for the electrical/electronic/digital components. Discourage the use of breadboards.
b. If essential, use of a simulation/ emulation software tools to test and verify the performance of the circuit should be encouraged.
c. Students should prepare the proper drawings (electrical/ mechanical), schematics/ layouts of the project.
d. For final implementation of the circuit, preparation of PCB (if any required) using suitable CAD tools and fabricating the same in the lab is expected.

ii. Devices/ Components/ Systems to be Used:

Students are encouraged to use passive components like resistors, capacitors, inductors etc. If any specialize inductor is not readily available, the fabrication of the same in the lab should be encouraged. Other components like: Transistors, diodes, voltage regulators, logic gates, Op-amps, general purpose microcontroller, DC motors/ AC motors, sensors, actuators, relays etc. (Students may add more components as per the requirement of project).

iii. Testing and analysis of the Project

Students should test the circuit using suitable laboratory equipments like power supply, multi-meter, CRO, DSO etc. In case of any debugging requirement, students should record the problems faced during the testing and solutions sought after for the fault in the circuit.

All the testing results must be well documented in the final project report verifying the functionalities of the propose project.

iv. Use of Reference Material/Literature :

Students are advised to refer Application Notes, research publications & data sheets of various electrical/electronic/digital devices from Texas Instruments, Microchips, International Rectifiers, ST Microelectronics, Philips, NXP and many other manufacturers.

C. Project Report Format:

Mini Project report should include circuit diagram, operation, application, design details, testing, waveforms (if applicable) references, simulation results and final prepared PCB image, conclusion, etc. Project report should include report of all above steps listed in (2) and the conclusion.

Note:-

It is expected that the department should organise some of the guidance expert lectures / video lectures/ courses/ webinars/ workshops etc. for the students at the appropriate timing during the Mini Project practical slots on following topics:

1) Understanding passive components viz. resistors, capacitors and inductors from practical point of view: types/ varieties, device packages, applications and cost.
2) Understanding semiconductor components viz. diodes, BJT and JFET/MOSFETs from practical point of view: types/ varieties, device packages, applications and cost.
3) Design principles of simple electrical / electronic circuits with some examples.
4) Selection of switches and circuit protection components.
5) Selection and sizing of wires and conductors.
6) Soldering Practice.
7) Heat-sinking and Enclosure design concepts
8) Overall workmanship while working on the project fabrication.
9) Use of different software tools for design and development of circuits

10) Use of standard as well as some of the advanced laboratory equipments needed for testing of such projects

Application Domains:

List of key application domains from where students are encouraged to derive Mini Projects topics:

1) Smart Agriculture solutions
2) Power converter applications in various Applications
3) IoT based applications in power systems
4) AI/ML applications in disaster management
5) Renewable Energy
6) Energy Conservation
7) Energy Storage
8) Battery Charging and Protection
9) Fire Safety
10) Electrical System Protection
11) Lighting Control
12) Wireless Power Transfer
13) Electrical Components Testing
14) Electrical Parameters Measurement
15) Non-conventional Electricity Generation
16) Laboratory Equipments
17) E-Mobility / Electric Vehicles
18) Video Surveillance Systems
19) Robotics for Hazardous applications
20) Waste Management System
21) Smart City Solutions
22) Smart Classrooms and learning Solutions
23) Design of Electrical Equipment
24) PLC based automation system
25) Power system Monitoring System (EMS)

It is every much expected that the complexity of the Mini Project 2A/ 2B should be increased compared to the selection of projects during Mini Project 1A/1B. Also based on the subjects learned in Sem. III and Sem. IV the broader area inclusive of the concepts learned must be selected. Students can identify the mini project topics either from above suggested domains or any other relevant electrical engineering domains. The inter-disciplinary nature of the project is also desirable.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year Mini Project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
  - First shall be for finalization of problem
  - Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components /systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year Mini Project:

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalization of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In one year, project, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of half year project all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Oral Examination:

Mini Project shall be assessed based on following points:

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact

4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

Reference Books:

1. P. Horowitz and W. Hill, "The Art of Electronics", 3rd Edition, Cambridge University Press, 2015
2. R. S. Khandpur, "Printed Circuit Board", McGraw-Hill Education; 1st edition, 2005.
3. Simon Monk, "Hacking Electronic: Learning Arduino and Raspberry Pi", McGraw-Hill Education TAB; 2 edition (September 28, 2017).

Suggested Software tools:

1. LTspice:https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html#
2. Eagle : https://www.autodesk.in/products/eagle/overview
3. OrCAD: https://www.orcad.com/
4. Multisim : https://www.multisim.com/
5. Webbench: http://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html
6. Tinkercad : https://www.tinkercad.com/
7. Raspbian OS: https://www.raspberrypi.org/downloads
8. Arduino IDE: https://www.arduino.cc/en/main/software

Online Repository:

1. https://www.electronicsforu.com
2. https://circuitdigest.com
3. https://www.electronicshub.org
4. Github

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
EEC601	Power System Protection and Switchgear	3	-	3	-	3

Course Code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC601	Power System Protection and Switchgear	20	20	20	80	03	-	100

Course Objectives	• To impart basic knowledge of power system protection, substation equipment and protection schemes.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To select the appropriate switching/protecting device for substations. 2. To discriminate between the application of circuit breaker and fuses as a protective device. 3. To understand the basic concept of relay, types of relay and their applications in power system. 4. To select the specific protection required for different components of power system according to the type of fault. 5. To apply the specific protection provided for different types of transmission lines.

Module	Contents	Hours
1	**Substation Equipment and switching devices** **Substation Equipment:** Instrument Transformers: Role of instrument transformers in measuring and protection, difference between measuring and protection CTs, selection of technically suitable instrument transformers; **Switchgear**-Definition, Types, Location of switchgear in typical power system, single line diagram to show the measuring and protection scheme **Switching Devices**- Isolator & Earthing switch (Requirements & definitions, types and construction, Pantograph Isolators, Ratings), Load break switches- Ratings and applications; Contactors- Basic working principle, Terms & Definitions, applications.	03
2	**Circuit Breakers and Fuses:** **Circuit Breaker:** Arc initiation, arc quenching principles, Re-striking voltage, RRRV, Recovery voltage, Types of Circuit Breakers: For LV application- MCB, MCCB, ELCB, air circuit breakers. For HV application- SF6 circuit breakers, vacuum circuit breakers (working principle, Construction, operating mechanisms, ratings & applications), Mechanical life, Electrical life and testing of circuit breakers. Principle and applications of LV and HV DC circuit breakers **Fuses & their applications**-Introduction, classification, working principle and applications of re-wirable and HRC fuses, Expulsion and drop out fuses, Fusing factor, selection of fuse link and cut off characteristics	10
3	**Introduction to Protective relaying:** Shunt & Series Faults, causes and Effects of faults, Importance of protective relaying, Protective zones, primary & Back-up protection, Different types of backup protection, desirable qualities of protective relaying, PSM & TSM(Importance, Different types of Time-current characteristics and application), working principle of **Electromagnetic Induction**	09

	disc Relays, Thermal, bimetal relays, Frequency relays, under/over voltage relays, DC relays, **Different Principles of protection** - Over current & earth fault (non- directional & directional types), differential protection(current and voltage type), distance protection (Working Principle and application of Impedance relay, Causes and remedies of Over reach-under reach, Reactance and Mho relay, Power swing blocking relay).	
4	**Protection Schemes Provided for major Apparatus:** **Generators** - Stator side (Differential, Restricted Earth fault, protection for 100% winding, Negative phase sequence, Reverse power, turn-turn fault), Rotor side (Field suppression, field failure, Earth fault, turn to turn fault) **Transformers**-Differential protection for star delta Transformer, Harmonic restraint relay, REF protection, Protection provided for incipient faults (Gas actuated relay). **Induction motors** - Protection of motor against over load, short circuit, earth fault, single phasing, unbalance, locked rotor, phase reversal, under voltage, winding temperature, Protection co-ordination	06
5	**Protection of Transmission Lines:** Feeder protection - Time grading, current grading, combined time & current grading protection provided for Radial, Ring Main, Parallel, T- Feeder. Bus Zone Protection - Differential protection provided for different types of bus zones. LV, MV, HV Transmission Lines - Protection provided by over current, earth fault, Differential and Stepped distance protection. EHV & UHV Transmission lines - Type and nature of faults, Need for auto-reclosure schemes, Carrier aided distance protection (Directional comparison method), Power Line Carrier Current protection (Phase comparison method). Introduction to the concept of Islanding	06
6	**Introduction to Static & Numerical Relays:** **Static Relays**- Introduction, Definition, Advantages and Disadvantages, Application of op-amps, logic gates, DSP, in static/ digital Relays. Relays as comparators (Amplitude & phase), **Numerical Relays**- Introduction, Block diagram of numerical relay, Signal sampling, Anti –Aliasing Filter, Introduction to the concept of Phase Measurement Unit	05

Books Recommended:

Text Books:

1. Switchgear & Protection by Sunil.S.Rao, Khanna Publications
2. Power system Protection & Switchgear by Badriram Vishwakarma, TMH
3. Power System Protection And Switchgear by Bhuvanesh A O, Nirmal CN, Rashesh PM, Vijay HM, Mc Graw Hill

Reference Books:

1. Fundamentals of protection by Paithanker & Bhide.S.R, P.H.I
2. Static Relays by Madhava Rao, TMH
3. A text book on Power System Engineering by Soni, Gupta, Bhatnagar & Chakraborthi, Dhanpat Rai & Co
4. Protective Relaying by Lewis Blackburn, Thomas.J.Domin
5. Power System Protection by P.M. Anderson, Wiley Interscience
6. Modern Power System Protection – Divyesh Oza, TMH Publication

Website Reference / Video Courses:

1. **NPTEL Course: Power System Protection** By Prof. S.A. Soman, Dept. of Electrical Engineering, IIT Bombay:- Web link- https://nptel.ac.in/courses/108/101/108101039/

2. NPTEL Course: Power System Protection and Switchgear By Prof. Bhaveshkumar Bhalja, Dept. of Electrical Engg, IIT Roorkee:- Web link- https://nptel.ac.in/courses/108/107/108107167/
3. NPTEL Course: Power System Protection By Prof. Ashok Kumar Pradhan, Dept. of Electrical Engineering, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105167/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
EEC602	Microcontroller Applications	3	-	3	-	3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
EEC602	Microcontroller Applications	20	20	20	80	03	-	-	100

Course Objectives	1. To understand the features and architecture of PIC 18 microcontroller. 2. To introduce assembly programming knowledge for PIC 18 microcontroller. 3. To impart embedded programming knowledge for PIC 18 microcontroller using C. 4. To introduce various applications using microcontroller based system
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To analyse the difference between microprocessor and microcontroller based systems. 2. To write, debug and execute the software programs for internal peripheral devices of microcontroller. 3. To write, debug and execute the software programs for external peripheral devices for microcontroller based systems. 4. To design and implement the peripheral devices interfacing with microcontroller

Module	Contents	Hours
1.	Introduction to Microcontroller Block diagram of generic microcontroller, Microcontroller versus Microprocessor, A brief history of PIC microcontroller, Overview of PIC 18 family and features, Internal Bus structure of PIC microcontroller, Clock frequency, machine cycle and instruction cycle.	05
2.	PIC18F Programming Model and Instruction Set PIC18 microcontroller programming model, Bus architecture, program memory and data memory organization, Special Function Registers (SFRs), General Purpose Registers (GPRs) *CPU registers:* Working Register (Wreg), Status Register, Bank Select Register (BSR), Instruction Decoder *Memory Pointers:* Program ROM and Program Counter (PC), Data ROM and Table Pointer (TBLPTR), File memory and File Select Register (FSR), Stack and Stack Pointer (STKPTR) *PIC 18 internal Architecture:* ALU, EEPROM, RAM, IO Ports, Timer, ADC, Serial port, CCP, Pipelining. (conceptual overview only) *Instructions and Assembly Programs:* Instruction Set, Instruction formats, Addressing modes, Assembler Directives, Assembly programs. (Assembly programs are restricted to basic arithmetic, logical and data transfer operations only)	08

3.	PIC 18 Support Devices *Timer Module:* Basic Concept of Timers and counters, Timer Registers, Control Registers, 8 bit and 16 bit operation (only for Timer 0), CCP module (Capture, Compare and PWM), Watch dog Timer. *ADC module:* ADC Features, Block diagram of ADC module, ADC Registers, ADCON0, ADCON1 and ADCON2. *Interrupt Module:* Basic concept of Interrupt, PIC 18 Interrupts, Interrupt versus polling, Interrupt sources, Interrupt vector, Interrupt service routine, Interrupt process, RCON, INTCON, IPR1 and PIE1.	06
4.	Parallel Ports and Serial Communication IO PORT Module: Basic concept of I/O interfacing, PORT Registers, TRIS Registers, LAT Registers, Simple input /output peripheral interfacing (switches & LEDs). Serial communication: Basics of serial communication, Data framing, USART module, SPBRG, TXREG, RCREG, TXSTA, RCSTA, PIR1	06
5.	PIC Programming in C *IO programming:* Byte size IO, Bit addressable IO. *Timer programming:* Generating delay, generating square wave. (for Timer0 using Interrupt based programming only) *Serial port programming:* Transmit data serially, Receive data serially. (Interrupt based programming only)	06
6.	Microcontroller Applications Interfacing matrix keyboard and Seven segments LED display, LCD Interfacing, ADC Interfacing, Traffic signal controller, DC motor interfacing, Stepper motor interfacing, PWM signal generation.	08

Text/Reference Books:-

1. Ramesh Gaonkar, "Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family)", Penram International publications (Ind) Pvt. Ltd.
2. Ali Mazidi, Rolind D Mckinlay and Danny Causey , "PIC Microcontroller and Embedded Systems", Pearson Education ltd., 2015
3. Robert B. Reese, "Microcontroller from Assembly Language to C using PIC18FXX2", Davinici Engineering press.
4. Han Way Huang, "PIC Microcontroller: An Introduction to Software and Hardware Interfacing", Cengage Learning, 2005.

Website Reference / Video Courses:

1. NPTEL Course: **Microprocessors And Microcontrollers** By Prof. Santanu Chattopadhyay, Dept. of Electrical Engineering, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105102/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

ELECTRICAL ENGINEERING SEM-VI						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEC603	Control System Design	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC603	Control System Design	20	20	20	80	3	-	-	100

Course Objectives	1. To establish a quantitative foundation to the design and analysis of Control systems. 2. To impart knowledge and skill on compensator design. 3. To study basics of digital control system and design of digital compensator. 4. To understand the concept of state –space analysis, to design the compensator in time and frequency domain, to design the PID compensator.
Course Outcomes	Upon successful completion of this course, the learner will be able to 1. Define fundamental control system design specifications and basic principles of controller design 2. Understand the basic design of various compensators. 3. Design compensators using root locus techniques. 4. Design modern controllers based on the state space techniques, 5. Recognize the importance of observability and controllability for system design.

Module	Contents	Hours
1.	Introduction to the Compensator: Basic concept of compensator design, its requirement, cascade compensator, feedback compensator, gain compensation, lag, lead and lag-lead compensator, proportional, derivative, integral Compensation, physical realization of compensator with passive and active components, basic block diagrams of a compensated closed loop control system.	03
2.	Design of Compensators using Root Locus Technique: Introduction, improving steady state error by gain compensation, transient response improvement by cascade compensation, improving steady state and transient response.	08
3.	Design of Compensators using Frequency Response Technique (Bode Plot): Introduction, Relation between closed-loop time response parameters of peak time, settling time, and percent overshoot with the open-loop frequency response parameters, transient response improvement by gain adjustment, Lag compensation, Lead compensation, Lag-lead compensation	08
4.	Design of Compensators using State variable approach: Introduction, pole placement topology, controller design by pole placement topology in phase variable form, controllability, controllability matrix, controllability by inspection, alternative approach to controller design, controller design by transformation. Introduction to Observer / estimator, observability, , observability matrix, observability by inspection, observer design by pole placement, alternative approach to Observer design. Steady state error design using integral control	07
5.	Digital control System: Introduction, advantage of digital control, components of digital control system, derivation of digital/ pulse transfer function, block diagram reduction, stability of digital system on Z-plane, bilinear transformation, steady state error and error constants	06

6.	**Design of Digital Compensators:** Transient response on the Z-plane, gain design on Z plane for transient response using root locus, stability design by root locus, cascade compensation (design of digital lead, lag and lag-lead compensator)of digital system using s-plane, implementing the digital compensator.	07

Text Books:-

1. Control system engineering by Norman Nise 2nd edition
2. Digital Control Systems by Benjamin C. Kuo,Oxford series 2nd Edition
3. Control Engineering: An Introductory Course by Wilkie J., Johnson M., Katebi R., Palgrave MacMillan.
4. Industrial Control Electronics: Devices, Systems and Applications by Bartelt, Delmar Thomson Learning, 1st edition

Reference Books:-

1. Modern control Engineering by Richard C Dorf, SH Bishop, & Wesley edition, Eighth Edition
2. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis, S.N. Sheldon, Marcel Dekkar, ISBN 0824740386
3. Control System Engineering, Shivanagraju s. Devi L., New age International latest edition
4. Control System engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern
5. Modern control system engineering by K. Ogata, printice Hall.
6. Automatic control systems, Basic analysis and Design, William A. Wolovich, Oxford
7. Process Control principles and applications, Surekha Bharot, Oxford Higher education

Website Reference / Video Courses:

1. NPTEL Course: **Advanced Linear Continuous Control Systems** By Prof. Yogesh Hote, Dept. of Electrical Engineering, IIT Roorkee:- Web link- https://nptel.ac.in/courses/108/107/108107115/
2. NPTEL Course: Industrial Instrumentation By Prof. Prof. S. Mukhopadhyay and Prof. S.Sen, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105062/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEC604	Signals and Systems	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC604	Signals and Systems	20	20	20	80	3	-	-	100

Course Objectives	1. To impart knowledge on continuous and discrete time signals. 2. To understand the basic properties of signals & systems 3. To know the methods of characterization of LTI systems in time domain 4. To analyze discrete time signals and system in the Fourier and Z transform domain 5. Understand the design of various types of digital filters and implement them using various implementation structures
Course Outcomes	Upon successful completion of this course, the learner will be able to 1. Discriminate continuous and discrete time signals and systems. 2. Understand the transformation of discrete time signal to Z domain. 3. Analyse frequency response of systems using Z domain. 4. Design, implementation, analysis and comparison of digital filters for processing of discrete time signals

Module	Contents	Hours
1.	Introduction- Classification of Signals and Systems: Definitions of signal and system. Standard signals- Step, Ramp, Pulse, impulse, Real and complex exponentials and Sinusoids, Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Even and odd, Energy & Power signals, Classification of systems- Linear/ Non-Linear, Time-Variant/Invariant , Causal /Anti causal, stable/unstable, Memory/ Memory less System (static and dynamic), Sampling Theorem (Derivation is not Required). Basic operations on signals-Folding, Scaling and Time shifting). Convolution in DT domain (Matrix Method only)	07
2.	Z-Transform Z-Transform of bilateral signal, Definition of ROC, Properties of ROC, Properties of Z-transform, Inverse Z-Transform (only partial fraction).	05
3.	Frequency Response & Fourier Series Pole-zero plot in DT domain, Minimum phase, Maximum phase, Mixed phase and Linear, Phase System based on location of zeros, Low pass, high pass, Band pass and band reject system based on pass band frequency, Formation of Difference Equation, Solution of difference Equation (with & without initial Conditions), Zero input, zero state and Total Response of the system, Magnitude and phase response (only Analytical Method). , Introduction to Fourier Series: Representation of continuous time Periodic Signals, convergence of the Fourier Series, Properties of continuous time Fourier Series, Fourier Series representation of discrete time periodic signals, Properties of discrete time Fourier Series	10
4.	Discrete and Fast Fourier Transform DTFT, DFT & IDFT (Only Matrix Method), Properties of DFT, DIT FFT Algorithm (Radix-2)	06
5.	Design of FIR System	06

	Introduction to FIR System, Group Delay, phase Delay, Condition for Linear phase FIR system, Window Technique (only Rectangular window function, Hamming Window function)	
6.	Design of IIR System Introduction to IIR System & Bilinear Transformation, Digital Butterworth Filter design using Bilinear Transformation	05

Text Books:-

1. Salivahan S.," Digital Signal Processing", TMH Publication,2012
2. Oppenhein & Schafer," Discrete Time Signal Processing," PHI Publication 1989.
3. Haykin S and Van Veen B," Signal and System", Wiley Publication, 2nd Ed.
4. Linder D.K.," Introduction to Signal & System," McGraw Hill International, 1999.

Reference Books:-.

1. Proakis & Manolakis," Digital Signal Processing", PHI Publication, 1995.
2. Mitra S.K.," Digital Signal Processing," TMH Publication, 2001.
3. Digital Signal Processing: A Practitioner's Approach, Kaluri V. Rangarao, Ranjan K. Malli November 2006, John Wiley.
4. Li Tan,"Digital Signal Processing, Fundamental & Application", Elsevier Publisher, Academic Press
5. DSP – A Practical Approach – Emmanuel C. Ifeacher, Barrie. W. Jervis, 2 ed., Pearson Education

Website Reference / Video Courses:

1. NPTEL Course: Principles of Signals And Systems By Prof. Ravindra Arora, Dept. of Electrical Engineering, IIT Kanpur:- Web link- https://nptel.ac.in/courses/108/104/108104100/
2. NPTEL Course: Signals And Systems By Prof. Kushal K. Shah, Dept. of Electrical Engineering, IISER Bhopal :- Web link- https://nptel.ac.in/courses/108/106/108106163/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING SEM-VI						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO6011	Special Electrical Machines	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO6011	Special Electrical Machines	20	20	20	80	3	-	-	100

Course Objectives	• To impart knowledge on special electrical machines and its control
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To exemplify the working of Stepper motor and its control 2. To demonstrate the functioning of SRM motor and its control 3. To illustrate the working of BLDC motor and its control 4. To illustrate the operational features of PMSM motor and its control 5. To illustrate the operational features of Synchronous reluctance motor and its control 6. To illustrate the working of Linear motors

Module	Contents	Hours
1	**Stepper motor and its Control:** Features, construction, application and working of Stepper motor Characteristics – Open Loop and Closed Loop Control – Control Strategies -Power Converter Circuit –DSP/ Microcontroller based Control	07
2	**Switched reluctance Motor and its Control:** Features, construction, application and working of Switched Reluctance motor; Open Loop and Closed Loop Control- Control Strategies - Power Converter Circuit –DSP/ Microcontroller based Control – Sensor less control	07
3	**Brushless DC Machines and its control:** Brushless DC Machines Construction and working principle, Equivalent magnetic circuit, Type of converter and speed control, Comparison between the axial and radial permanent magnet motors, Applications. Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit –DSP/ Microcontroller based Control	07
4	**Permanent Magnet Synchronous Machine and its control:** Features, construction , application and working of PMSM, Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit –DSP/ Microcontroller based Control	07
5.	**Synchronous Reluctance Motor and its control** Construction, Working, Phasor Diagram, Torque Equation, Control - Direct Axis Current Control, Fast Torque Response Control, Advantages	06
6.	**Linear Induction Machine** Construction, Types, Working, Feature, Thrust Equation, Equivalent circuit, Characteristics, Control, Application	05

Books Recommended:

Text Books:

1. E. G. Janardanan — Special Electrical Machine PHI, publication
2. G. K. Dubey- Fundamentals of Electrical Drives, CRC press 2002 - Technology & Engineering
3. K. Venkataratnam- Special Electric Machines, Universities Press, Apr-2009 - Technology & Engineering

Reference Books:

1. D. C. Hanselman — Brushless Permanent-Magnet Motor Design—Eman Press LLC
2. R. Krishnan, SWITCHED RELUCTANCE MOTOR DRIVES Modeling, Simulation, Analysis, Design, and Applications, CRC Press.
3. M. Ramamoorty, O. Chandra Sekhar—Electrical Machines - PHI publication
4. R Krishnan — Permanent Magnet Synchronous and Brushless DC Motor Drives—CRC press

Website Reference / Video Courses:

1. NPTEL Course: **Advanced Electric Drives** By Dr. S.P. Das, Department of Electrical Engineering, IIT Kanpur:- Web link- https://nptel.ac.in/courses/108/104/108104011/
2. NPTEL Course: **Fundamentals of Electric Drives** By Dr. S.P. Das, Department of Electrical Engineering, IIT Kanpur:- Web link- https://nptel.ac.in/courses/108/104/108104140/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO6012	Electric Traction	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO6012	Electric Traction	20	20	20	80	3	-	-	100

Course Objectives	• To impart knowledge of principles of electrical traction • To explore various electrical subsystems of traction • To increase the awareness of latest developments in electric traction systems
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To illustrate the basics as well as the state of the art of electrical traction systems and subsystems. 2. To understand traction mechanics and different factors contributing to the traction. 3. To illustrate and analyse the performance of various traction motors and drives 4. To explain the traction power Supply arrangement and its protection aspects. 5. To understand the design requirements of the overhead equipments 6. To demonstrate the functioning of railway signaling system

Module	Contents	Hours
1	Introduction to Electric Traction: Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.	04
2.	Traction Mechanics: Types of services, Speed-Time Curve, Trapezoidal, Quadrilateral Speed-Time Curve, Mechanics of train movement, Different Speed - time characteristics for train movement, Requirement of tractive effort and tractive effort produced, Train resistance, Power output and energy output from driving axles, Specific energy consumption & Factors affecting SEC, Adhesion & Coefficient of adhesion, Concept of Weight Transfer and weight transfer due to torque exerted by Traction motor, Influence of Electrical parts on Co-efficient of adhesion, wheel slip detection device (Numericals)	08
3.	Traction motor and Drives: Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, speed control methods, Braking methods, special Emphasis and techniques of regenerative braking, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor/IGBT based Converter Controlled Drives, DC Traction using Chopper Controlled Drives, AC Traction employing Poly-phase motors, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM	10

	control of induction motors, Power & Auxiliary circuit equipment (Other than traction motors), Linear Induction motors, introduction to Maglev Technology.	
4.	**Power Supply Arrangement and Protection:** Traction substation, spacing and location of Traction substations, Major equipment at traction substation, selection and sizing of major equipment like transformer and Switchgear, Types of protection provided for Transformer and overhead lines, surge protection, maximum demand and load sharing between substations, sectionalizing paralleling post and feeder posts, Booster transformers, Return Conductor, 2X25KV AC system, controlling/monitoring, Railway SCADA systems, Train lighting and Air-conditioning	07
5.	**Overhead Equipment and Track circuits:** Design requirement of catenary wire, contact wire, Dropper, Height, span length, Automatic weight tensioning, section insulator, overlap, Different techniques of current collection (overhead and underground systems), neutral section, overhead crossing of power lines, Protection.	05
6.	**Railway Signaling:** Block Section Concept, AC/DC Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing. Permissible limit of EMI and EMC, Permissible capacitively-coupled current, Coupling between circuits, conductive coupling, Electrostatic induction.	05

Textbook and Reference Books

1. Modern Electric traction by H.Partab:
2. Electric Traction – Motive Power and Energie Supply by Andreas Steimel, Oldenbourg Industrieverlag GmbH, 2008
3. Electrical Railway Transportation Systems by Morris Brenna, Federica Foiadelli and Dario Zaninelli, IEEE Press and Wiley, 2018
4. Power Electronics and Electric Drives for Traction Applications Edited by Gonzalo Abad, Wiley, 2017

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credit Assigned		
		Theory	Practical	Theory	Practical	Total
EEDO6013	High Voltage Engineering	3	-	3		3

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term work	Pract. & Oral	Oral	
		Test 1	Test 2	Avg					
EEDO6013	High Voltage Engineering	20	20	20	80	-	-	-	100

Course Objectives	1. To understand various breakdown processes in solid, liquid and gaseous insulating materials. 2. To impart the knowledge of Generation of high voltage DC, AC and Impulse voltages and currents. 3. To impart the knowledge of Testing and Measurement of high voltage DC, AC and Impulse voltages and currents. 4. To understand the design and layout of H V Laboratories
Course outcomes	Upon successful completion of this course, the learner will be able: 1. To know the fundamentals properties of the materials and their failure mechanisms to get appropriate and optimal design. 2. To explain and calculate the generation and measurement of High DC, AC and Impulse voltages and currents. 3. To understand testing of High voltage power apparatus. 4. To illustrate the major requirements in design of HV Laboratories.

Module	Contents	Hours
1	Electrostatic Fields, Their Control and Estimation: • Electric field Stress, its control and Estimation, Numerical methods – Finite difference, Finite Element and Charge simulation method for estimation of Electric Field. Surge voltage, their distribution and control	04
2	Conduction and Breakdown in Air and Other Gaseous Dielectrics: • Gases as insulating media, Collision Processes, Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's criterion for breakdown in electronegative gases, Limitation of Townsend's theory, Panchen's law, Breakdown in non-uniform fields and corona discharges. • Streamer mechanism of breakdown, Post-breakdown phenomenon and application. • Practical considerations in using gas for insulation purposes. (Numerical on Townsend's theory and Paschen's law)	07
3	Breakdown in Liquid and Solid Dielectrics: • Liquid Dielectrics, Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids: Suspended Particle Theory, Cavitations and bubble Theory. • Solid dielectrics used in practice, Intrinsic, Electro-mechanical and Thermal breakdown, Breakdown of solid dielectrics in practice, due to chemical, electrochemical deterioration, treeing, tracking, Internal discharges.	06

	• Breakdown of composite insulation, Application of insulating materials in electrical power apparatus, electronic equipment's.	
4	Generation & Measurement of High Voltage and Currents: • Generation of high voltage and currents: Generation of high DC voltages by rectifier, Voltage doublers and multiplier circuits. • Electrostatic machines, Generation of high AC voltage – Cascading of transformers, series and parallel Resonance transformer (system), Tesla coil. • Generation of impulse voltages and currents-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of conventional impulse generators, Introduction to Generation of high impulse current, (Design of Marx Generators circuits- numerical can be taken). • Generation of switching surges. (Numerical based on impulse generation, high DC voltage generation, optimum number of stages)	08
5	Measurement of High Voltages and Currents: • High ohmic series resistance with micro-ammeter., HVAC and impulse voltage-Resistance and capacitance voltage dividers, Sphere gap for measurement of High DC, AC and impulse voltages, Capacitance Voltage Transformer • Measurement of High DC, AC and impulse currents	06
6	High Voltage Testing of Electrical Power Apparatus and H V Laboratories Layouts: • Non-destructive testing of dielectric materials, DC resistivity measurement, Dielectric and loss factor measurement, Partial discharge measurement. • Testing of insulators and bushing, Power capacitors and cables testing, testing of surge diverters. • High Voltage laboratory–design, planning and layout. - Size and dimensions of the equipment and their layout, Classification of HV laboratory, Earthing and Shielding of H.V. laboratories, its importance.	08

Textbooks:

1. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.
2. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publication Co. Ltd. New Delhi

Reference books:

1. E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi
3. Ravindra Arora, Wolf Gang Mosch, "High Voltage Insulation Engineering", New Age International Publishers Ltd. Wiley Estern Ltd.
4. High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel.
5. Subir Ray, "An Introduction to High Voltage Engineering" PHI Pvt. Ltd. New Delhi

Website Reference / Video Courses:

1. NPTEL Course: High Voltage Engineering By Prof. Aditya K. Jagannatham, Dept. of Electrical Engineering, IIT Kanpur:- Web link- https://nptel.ac.in/courses/108/104/108104048/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO6014	Energy Storage	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	--	3		3

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO6014	Energy Storage	20	20	20	80	3	-	-	100

Course Objectives	• To explore the various energy storage technologies and their major applications • To increase awareness of ES suitability and capacity calculation for any given applications
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To illustrate the importance of energy storage systems in Power systems and other application domains 2. To illustrate the operational features of various energy storage technologies 3. To understand the principles and types of thermal, mechanical, electrochemical and electrical energy storage systems. 4. To compare and contrast different types of Energy storage systems 5. To illustrate the hybridization of various ES technology to improve the performance 6. To calculate the capacity of ES system for various application requirements,

Module	Contents	Hours
1.	Introduction to Energy Storage systems and components: Historical Perspective, Storage Needs, Variations in Energy Demand, Interruptions in Energy Supply, Demand for Portable Energy, Environmental and sustainability issues; Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies;	07
2.	Thermal Energy Storage: Principles and applications, Latent heat, sensible heat storage. Molten salt, Solar pond, seasonal thermal energy storage, Ice storage; Energy and exergy analysis of thermal energy storage.	05
3.	Mechanical Energy Storage: Potential Energy Storage, Energy Storage in Pressurized Gas, Compressed air energy storage (CAES), Flywheel, Applications	04
4.	Electrochemical Energy Storage: Parameters to be considered, Cyclic behaviour, equivalent circuit of electrochemical cell, self-discharge, Battery technologies: Flow battery, Rechargeable battery, Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, parameters; emerging trends in batteries. Fuel Cell: types, comparison and applications.	07
5.	Electrical Energy Storage: Pumped hydro storage system, Energy Storage in Capacitors, Comparative Magnitudes of Energy Storage, Transient behaviour of a Capacitor, Super-capacitor, series connection of super capacitors, charge balancing of super capacitors; Superconducting magnetic energy storage (SMES), Applications	06

6.	**Design, Sizing and Applications of Energy Storage**: Design considerations for sizing of different types of energy storage systems for various applications, case studies; Renewable energy storage- Battery sizing for stand-alone applications; Small scale application-Portable storage systems; (Numerical) E-mobility storage applications- Electric vehicles (EVs), batteries, super-capacitors and fuel cells, future technologies. Electric vehicle: V2X, G2V and V2G modes of operation. Hybrid Energy storage systems: configurations and applications. Energy Storage - Charging methodologies, SoC, SoH, SoS estimation techniques.	10

Textbook:

1. Robert Huggins, Fundamentals, Materials and Applications Second Edition, Springer, 2016
2. Dincer I., and Rosen M. A. (2011); Thermal Energy Storage: Systems and Applications,Wiley
3. Leo J.M.J. Blomen and Michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993.
4. Ahmed Faheem Zobaa, Energy storage – Technologies and Applications, InTech Publication 2013.
5. Jiuchun Jiang and Caiping Zhang, Fundamentals and Applications of Lithium-Ion Batteries In Electric Drive Vehicles, Wiley, 2015
6. K.T. Chau, Energy Systems for Electric and Hybrid Vehicles, IET, UK, 2016
7. M. Broussely and G. Pistoia, Industrial Applications of Batteries From Cars to Aerospace and Energy Storage, Elsevier, 2007.

Reference books

1. S. Kalaiselvam and R. Parameshwaran , Thermal Energy Storage Technologies for Sustainability Systems Design, Academic Press, 2014
2. Trevor M. Letcher, Storing Energy with Special Reference to Renewable Energy Source, Elsevier, 2016.
3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook, CRC Press, 2011
4. Aiping Yu, Victor Chabot, and Jiujun Zhang, Electrochemical Super-capacitors For Energy Storage And Delivery Fundamentals And Applications, CRC Press, 2013.
5. Younghyun Kim and Naehyuck Chang, Design and Management of Energy-Efficient Hybrid Electrical Energy Storage Systems, Springer, 2014

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credit Assigned		
		Theory	Practical	Theory	Practical	Total
EEL601	Power System Protection And Switchgear Lab	-	2	-	1	1

Course Code	Course Name	Examination Scheme							Total
		Theory				TW/Practical/Oral			
		Internal Assessment			End Sem. Exam	Term work	Pract. & Oral	Oral	
		Test 1	Test 2	Avg					
EEL601	Power System Protection And Switchgear Lab	-	-	-	-	25	--	25	50

Course Objectives	• To introduce the concept of different protection schemes
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To understand the working principle of various protective devices like Circuit breakers, fuses, switches and contactors. 2. To understand the concept of various over current protection scheme and its applications in power system. 3. To understand different protection schemes of transformer and Induction motor. 4. To understand protection schemes of transmission line.

Syllabus: Same as that of Course EEC601-Power System Protection and Switchgear

Suggested List of Laboratory Experiments: Minimum six experiments need to be performed.

1. Demonstration of working parts of different Fuses and Contactor.
2. Demonstration of working parts of MCB, MCCB, RCCB & Circuit breakers.
3. To perform overcurrent protection using Induction Disc relay by setting different TSM and plot time vs current characteristics.
4. To perform overvoltage protection using Induction Disc relay by setting different TSM and plot time vs current characteristics.
5. Demonstration of different protection schemes like protection against overload, locked rotor, single phasing of 3 phase Induction motor.
6. Demonstration of differential protection of 3 phase transformer.
7. Demonstration of Directional Over-current protection relay.
8. To perform simulation of Numerical Based relay.
9. To perform simulation of distance protection in transmission line.

- Any other experiment based on syllabus, which will help students to understand topics/concept.
- It is desirable to arrange the Visit to a substation and a report preparation.

Industry Visit: Students' visit to be arranged to the nearby industry involved in design/ manufacturing/ processing in the following electrical engineering domains: Electrical Switchgears / Electrical Substation / Electrical Machines / Traction Locomotives / HV Equipments / Energy Storage . All students shall submit visit report in appropriate format as a part of the submission for EEL601.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum six experiments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 05 marks
Industrial Visit Report	: 05 Marks
Attendance (Theory and Practical)	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire syllabus of EEC601-Power System Protection and Switchgear

ELECTRICAL ENGINEERING SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credit Assigned		
		Theory	Practical	Theory	Practical	Total
EEL602	**Microcontroller Applications Lab**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term work	Pract. & Oral	Oral	
		Test 1	Test 2	Avg					
EEL602	**Microcontroller Applications Lab**	-	-	-	-	**25**	**25**	**-**	**50**

Course Objectives	1. To impart the Assembly language programming knowledge of PIC 18 microcontroller. 2. To impart the Embedded C programming knowledge of PIC 18 microcontroller
Course Outcomes	Upon successful completion of this course, the learner will be able to 1. To write, debug and execute Assembly language based programs. 2. To write, debug and execute embedded language based programs. 3. To design and implement the interfacing of internal peripheral devices. 4. To design and implement the interfacing of external peripheral devices.

Syllabus: Same as that of Course EEC602 Microcontroller Applications

Suggested List of Laboratory Experiments: Minimum four from Group (A) and four from Group (B), in all minimum eight experiments need to be performed.

(A) Assembly Language Programming:

1. To perform Addition, subtraction
2. To perform Multiplication and Division
3. To perform Logical operations (AND, OR, X-OR, NOT)
4. To sort Even and Odd numbers
5. To sort Negative and Positive numbers
6. To Find Largest Number
7. To Find Largest Number
8. To copy source array to destination array (Table related process)
9. To Toggle the bits of Port.

(B) Embedded C Language Programming:

1. Timer programming to Generate square wave
2. Timer programming to Generate time delay
3. Timer programming to Generate the PWM pattern
4. ADC programming to perform Analog to digital conversion
5. Serial communication programming for serial data transfer
6. IO port programming to interface simple switches and 7-segment LED Display
7. IO port programming to interface Liquid Crystal Display (LCD)
8. Stepper Motor interfacing
9. DC Motor interfacing
10. Traffic Signal programming

Any other experiment based on syllabus, which will help students to understand topics/concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

The term work shall consist of minimum 08 experiments based on PIC 18F microcontroller using assembly and embedded C language and minimum 02 assignments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal (Experiment and Assignments)	: 10 marks
Attendance (Theory and Practical)	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical & Oral Examination:

Practical & Oral examination will be based on entire syllabus of EEC602-Microcontroller Applications

ELECTRICAL ENGINEERING - SEMESTER-VI						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL603	Control System Design Lab	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	2		1	1

Subject code	Subject Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL603	Control Systems Design Lab	---	---	---	---	--	25	-	25

Course Objectives	1. To enable the students to strengthen their understanding of the design and analysis of control systems through practical exercises 2. Use of modern software tools to analyze and simulate the performance of realistic system models and to design control systems to satisfy various performance specifications.
Course Outcomes	Upon successful completion of this course, the learner will be able to 1. Implement various types of compensators and control algorithms using simulation platforms 2. Apply root-locus & Bode Plot techniques to analyze and design control systems. 3. Able to design digital controllers, assess their design through the constraint specifications

Syllabus: Same as EEC603: Control System Design

Suggested List of Laboratory Experiments: Minimum eight experiments need to be performed.

1. To draw the frequency response characteristic of a given lag- lead compensating network.
2. To study the effect of P, PI, PD and PID controller on step response of a feedback control system (Using control engineering trainer/process control simulator). Verify the same by simulation.
3. Design of a Lead compensator using Root-locus method
4. Design of a lag compensator using Root-locus method
5. Design of a lead-lag compensator using Root-locus method
6. Design of a lead compensator using bode plot method
7. Design of a lag compensator using bode plot method
8. Design of a lead-lag compensator using bode plot method
9. Obtain transfer function of a given system from state variable model and vice versa. State variable analysis of a physical system - obtain step response for the system by simulation
10. State variable analysis using simulation tools. To obtain step response and initial condition response for a single input, two output system in state variable form by simulation.
11. Familiarization with digital control system toolbox
12. Determination of z-transform, inverse z-transform & pole zero map of discrete systems to study step response of a discrete time system and effect of sampling time on system response
13. To explore the Properties of Digital Control Systems. Convert continuous time system to discrete system and vice versa. Root Locus of Digital control system on z-plane

Any other experiment based on syllabus which will help students to understand topic/ concept is also suggested.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance : 10 marks
Journal : 10 marks
Attendance (Theory and Practical) : 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

ELECTRICAL ENGINEERING- SEM-VI						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL604	SBL-III: Industrial Automation Lab	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		-	4		2	2

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL604	SBL-III: Industrial Automation Lab	--	--	--	--	--	25	25	50

Course Objectives	1. Develop necessary acquaintance with components and subsystems used in industrial automation 2. Develop the necessary skillset to integrate, monitor, maintain such systems
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To comprehend with various components and subsystems used in industrial automation 2. To understand the integration of components and sub-systems. 3. To interface the microcontroller / PLC with external devices/ sensors/ actuators. 4. To interface the microcontroller / PLC with control circuits. 5. To design /implement / integrate such systems for any given applications

Section A:

Lab contents shall be covered through some of the following ways:

1) Class room discussions / Expert Lectures
2) Visiting various industries involving such facilities to illustrate industrial automation
3) Multiple day webinar specifically organized to cover such contents
4) In-house facility for demonstration of Industrial automation
5) Hands-on Workshop
6) Exhibitions showcasing these technologies
7) Using virtual Instrumentation platform
8) Using Virtual Lab platform (Virtual Labs (vlab.co.in)

Contents:

1) **Components and subsystems used in Industrial automation:**

Controllers: Computers, Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), Embedded Controllers.

Operator Interfaces (HMI)-Text based, Graphical, Touchscreens.

Sensors-Analog & Digital; Encoders, Proximity sensor, Ultrasonic Sensors, Photoelectric Sensors; Limit Switches

Actuators-Pneumatic, Hydraulic, Electric; Motors- AC, DC, Linear, Servo and Stepper motor.

Mechanisms and Machine Elements- Cam Driven Systems, ratchets and pawl, gears; Linkages and coupling; Conveyors- Belt, Roller, Chain, Vibrating, Pneumatic.

Motion Profile- trapezoidal velocity motion, S-curve velocity motion, Multi-axis motion

hardware and software platforms for Distributed Control System, DCS Functional Block Diagram, and Sequential Flow Charts

Software- Design and Analysis software, PLC programming, SCADA

2) Industry 4.0:

Conceptual Framework- Main Concepts and Components of Industry 4.0; Technology Roadmap for Industry 4.0; Technologies and Applications: Data Analytics in Manufacturing, Role of IoT, Robotics in the era of Industry 4.0, Additive Manufacturing, 3D printing; Augmented Reality

3) Real life Applications:

a) Agriculture/ farm produce-sorting and grading system
b) Automated / Robotic Assembly line
c) Temperature Control in Process Industries
d) Cyclic Operation of Traffic Lights
e) Conveyor System for an Assortment of Objects
f) Automatically filling of two tanks with liquid
g) Automated warehouse management system
h) Automated bottle filling plant
i) Automated packaging system

4) Industrial Safety Practices:

General Workplace Safety rules and procedures, recommended safety practices, Personal Protective Equipments (PPE), Industrial safety Acts and regulations

Section B:

Based on the insights received with the coverage of syllabus contents specified in section A, the students should carry out detailed study of at least six different applications listed below (maximum two from any group is desirable). They should have hands-on experience with each of these applications. Wherever possible software development / coding should be done by students.

Group 1: Pneumatic and Hydraulic based Industrial Automation systems:

a) Electro-Pneumatic System for Pickup and Lay Down of Plastic Containers
b) Design and assembly of Pneumatic / Hydraulic circuit and wiring of control interface for a particular application
c) Application with different types of Pneumatic / Hydraulic valves and actuators

(Any other application which incorporates Pneumatic and Hydraulic components)

Group 2: Drives and Control- Industrial Automation systems

a) Linear Motion Control System
b) PLC based Motion Control System
c) VFD control of Motor
d) HMI interface based Control
e) Conveyor belt system
f) Sorting and grading System for Agriculture Applications
g) Home automation system with Web Server
h) Lift control System (Demo)

(Any other application which incorporates (Drives / Control)

Group 3: Use of IoT in following Applications

a) Smart Agriculture,
b) Smart City,
c) Smart Life—Wearable Technologies,
d) Smart Health
e) Smart Grid

(Any other application which incorporates IoT)

Group 4: Other Applications: Based on PLC/ Embedded micro-controller

a) To wire up hardware, write and implement ladder programs for the following controls.
   i. Lamp control for various situations.
      a. Staircase control, hospital etc.

b. Traffic light control.

ii. Water level control using level sensors

iiii. Logic implementation for Bottle Filling Application

b) Tune PID controller for heat exchanger using DCS
(Any other suitable application)

Note: For each of the experiment carried out, students should prepare a detailed report, clearly specifying following:

[1] Technical description and specification of the system
[2] Drawing/ schematic/ block diagram for system visualization
[3] Components used and their specs
[4] Interconnectivity between the components
[5] Working principle
[6] Software tools used
[7] Program code (if any) developed
[8] Observations
[9] Photographs of the system

Books Recommended:

1. Industrial Automation Hands-On, by Frank Lamb, McGraw-Hill, 2013
2. Industrial Motion Control- Motor Selection, Drives, Controller Tuning, Applications, by Hakan Gürocak Wiley, 2016
3. Industry 4.0: Managing The Digital Transformation, by Alp Ustundag and Emre Cevikcan, Springer, 2018
4. Introduction to Industrial Automation, by Stamatios Manesis and George Nikolakopoulos, CRC Press, 2018

Term Work:

Term work shall consist of minimum requirement as given in the syllabus. The distribution of marks for term work shall be as follows:

Laboratory Performance : 15 marks
Journal : 05 marks
Attendance : 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on experiments carried out in EEL604-SBL-III- Industrial Automation Lab

ELECTRICAL ENGINEERING - SEMESTER-V						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEM601	Mini Project – 2B	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	4$	--	2	2

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEM601	Mini Project – 2B	--	--	--	--	--	25	25	25

$ indicates work load of Learner (Not Faculty)

Course Objectives	1. To design and develop a moderately complex electrical/electronic/digital circuit with practical applications. 2. To understand basic concepts of circuit design while developing the project. 3. To enable the students to gain hands-on experience independently proposing and implementing the project and thus acquire the necessary confidence to deal with complex electrical/electronic/digital systems.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Identify problems based on societal /research needs. 2. Apply Knowledge and skill to solve societal problems in a group. 3. Develop interpersonal skills to work as member of a group or leader. 4. Draw the proper inferences from available results through theoretical/ experimental/ simulations. 5. Analyse the impact of solutions in societal and environmental context for sustainable development. 6. Use standard norms of engineering practices 7. Excel in written and oral communication. 8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning. 9. Demonstrate project management principles during project work

A. Mini Project -Topic Selection and Approval

1. The group may be of maximum FOUR (04) students.
2. Students should propose project ideas & finalize the project idea in consultation with guide/ HOD. Students should select a problem which addresses some basic home, office or other real life applications. The mini project must have hardware part. The software part is optional.
3. Students should identify different components/ devices, instruments, simulation/emulations software tools required for the project.
4. Students should submit implementation plan in the form of Gantt/ PERT/ CPM chart, which will cover weekly activity of project.
5. A Log Book to be prepared by each group to record the work progress in terms of milestones per week by students. Weekly comment, remarks to be put by guiding faculty.

B. Mini Project –Execution

i. Design and Fabrication

a. Initial fabrication of the project by students can be done using standard devices/material/software tools to verify the circuit functionalities Initial project fabrication and testing is expected to be done by soldering/assembling on general purpose PCB/ Bakelite boards or suitable platforms required for the electrical/electronic/digital components. Discourage the use of breadboards.
b. If essential, use of a simulation/ emulation software tools to test and verify the performance of the circuit should be encouraged.
c. Students should prepare the proper drawings (electrical/ mechanical), schematics/ layouts of the project.
d. For final implementation of the circuit, preparation of PCB (if any required) using suitable CAD tools and fabricating the same in the lab is expected.

ii. Devices/ Components/ Systems to be Used:

Students are encouraged to use passive components like resistors, capacitors, inductors etc. If any specialize inductor is not readily available, the fabrication of the same in the lab should be encouraged. Other components like: Transistors, diodes, voltage regulators, logic gates, Op-amps, general purpose microcontroller, DC motors/ AC motors, sensors, actuators, relays etc. (Students may add more components as per the requirement of project).

iii. Testing and analysis of the Project

Students should test the circuit using suitable laboratory equipments like power supply, multi-meter, CRO, DSO etc. In case of any debugging requirement, students should record the problems faced during the testing and solutions sought after for the fault in the circuit.

All the testing results must be well documented in the final project report verifying the functionalities of the propose project.

iv. Use of Reference Material/Literature :

Students are advised to refer Application Notes, research publications & data sheets of various electrical/electronic/digital devices from Texas Instruments, Microchips, International Rectifiers, ST Microelectronics, Philips, NXP and many other manufacturers.

C. Project Report Format:

Mini Project report should include circuit diagram, operation, application, design details, testing, waveforms (if applicable) references, simulation results and final prepared PCB image, conclusion, etc. Project report should include report of all above steps listed in (2) and the conclusion.

Note:-

It is expected that the department should organise some of the guidance expert lectures / video lectures/ courses/ webinars/ workshops etc. for the students at the appropriate timing during the Mini Project practical slots on following topics:

1) Understanding passive components viz. resistors, capacitors and inductors from practical point of view: types/ varieties, device packages, applications and cost.
2) Understanding semiconductor components viz. diodes, BJT and JFET/MOSFETs from practical point of view: types/ varieties, device packages, applications and cost.
3) Design principles of simple electrical / electronic circuits with some examples.
4) Selection of switches and circuit protection components.
5) Selection and sizing of wires and conductors.
6) Soldering Practice.
7) Heat-sinking and Enclosure design concepts
8) Overall workmanship while working on the project fabrication.
9) Use of different software tools for design and development of circuits

11) Use of standard as well as some of the advanced laboratory equipments needed for testing of such projects

Application Domains:

List of key application domains from where students are encouraged to derive Mini Projects topics:

1) Smart Agriculture solutions
2) Power converter applications in various Applications
3) IoT based applications in power systems
4) AI/ML applications in disaster management
5) Renewable Energy
6) Energy Conservation
7) Energy Storage
8) Battery Charging and Protection
9) Fire Safety
10) Electrical System Protection
11) Lighting Control
12) Wireless Power Transfer
13) Electrical Components Testing
14) Electrical Parameters Measurement
15) Non-conventional Electricity Generation
16) Laboratory Equipments
17) E-Mobility / Electric Vehicles
18) Video Surveillance Systems
19) Robotics for Hazardous applications
20) Waste Management System
21) Smart City Solutions
22) Smart Classrooms and learning Solutions
23) Design of Electrical Equipment
24) PLC based automation system
25) Power system Monitoring System (EMS)

It is every much expected that the complexity of the Mini Project 2A/ 2B should be increased compared to the selection of projects during Mini Project 1A/1B. Also based on the subjects learned in Sem. III and Sem. IV the broader area inclusive of the concepts learned must be selected. Students can identify the mini project topics either from above suggested domains or any other relevant electrical engineering domains. The inter-disciplinary nature of the project is also desirable.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year Mini Project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
  - First shall be for finalization of problem
  - Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components /systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year Mini Project:

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalization of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In one year, project, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of half year project all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Oral Examination: Mini Project shall be assessed during oral examination based on following points:

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

Reference Books:

1. P. Horowitz and W. Hill, "The Art of Electronics", 3rd Edition, Cambridge University Press, 2015
2. R. S. Khandpur, "Printed Circuit Board", McGraw-Hill Education; 1st edition, 2005.
3. Simon Monk, "Hacking Electronic: Learning Arduino and Raspberry Pi", McGraw-Hill Education TAB; 2 edition (September 28, 2017).

Suggested Software tools:

1. LTspice:https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html#
2. Eagle : https://www.autodesk.in/products/eagle/overview
3. OrCAD: https://www.orcad.com/
4. Multisim : https://www.multisim.com/
5. Webbench: http://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html
6. Tinkercad : https://www.tinkercad.com/
7. Raspbian OS: https://www.raspberrypi.org/downloads
8. Arduino IDE: https://www.arduino.cc/en/main/software

Online Repository:

1. https://www.electronicsforu.com
2. https://circuitdigest.com
3. https://www.electronicshub.org
4. Github

AC-
Item No.

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Electrical Engineering

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC:
Item No.

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Final Year of B.E in Electrical Engineering**
2	Eligibility for Admission	**After Passing Third Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	**Under Graduation**
7	Pattern	**Semester**
8	Status	**Revised**
9	To be implemented from Academic Year	**With effect from Academic Year: 2022-2023**

Date:

Dr. S. K. Ukarande
Associate Dean, Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean, Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore, in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Fourth Year of Engineering from the academic year 2022-23.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface by BoS

The outcome based course curriculum for the undergraduate degree in Electrical Engineering in Rev.2019 'C' scheme has been chalked out through the thoughtful discussions and deliberations of academic and industry experts. While devising the syllabus content framework, the correct balance between the fundamental / core topics with appropriate mix of topics from the state of the art technologies in electrical and allied domains is attempted. With the increased Industry-Institute interaction and internship programs, students are encouraged to explore the opportunity to improve communication skills, problem solving skill and good team management. These skills shall surely help them to meet the future challenges in their career.

The new course curriculum will also give ample opportunity to the students to work in cross discipline domains to gain the hands on experience through the project based learning facilitated through the various skill based labs, Mini projects, Course projects , Major projects etc. The increased number of department and institute level electives shall facilitate students with the truly choice based learning and skilling in a particular domains.

On behalf of the Board of Studies (BoS) in Electrical Engineering of the University of Mumbai, we seek the active participation from all the stake holders of the engineering education to meet the set outcomes and objectives for the Undergraduate Program in Electrical Engineering.

Board of Studies in Electrical Engineering

Dr. Sushil Thale	**: Chairman**
Dr. B. R. Patil	**: Member**
Dr. S. R. Deore	**: Member**
Dr. B. B. Pimple	**: Member**
Dr. Nandkishor Kinhekar	**: Member**

Program Structure for Final Year B.E. in Electrical Engineering
(Semester VII & VIII)
University of Mumbai
(With Effect from 2022-2023)
Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
EEC701	Electrical Drives & Control	3	--	3	--	3
EEC702	Electrical Power System III	3	--	3		3
EEDO701X	Department Optional Course – 3	3	--	3	--	3
EEDO702X	Department Optional Course – 4	3	--	3	--	3
EEIO701X	Institute Optional Course – 1	3	--	3	--	3
EEL701	Electrical Drives & Control Lab	--	2	--	1	1
EEL702	Simulation Lab III	--	2	--	1	1
EEL703	Power Electronics Design Lab	--	2	--	1	1
EEP701	Major Project I	--	6#	--	3	3
Total		**15**	**12**	**15**	**6**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac /oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
EEC701	Electrical Drives & Control	20	20	20	80	3	--	--	100
EEC702	Electrical Power System III	20	20	20	80	3	--	--	100
EEDO701X	Department Optional Course – 3	20	20	20	80	3	--	--	100
EEDO702X	Department Optional Course – 4	20	20	20	80	3	--	--	100
EEIO701X	Institute Optional Course - 1	20	20	20	80	3	--	--	100
EEL701	Electrical Drives & Control Lab	--	--	--	--	--	25	25	50
EEL702	Simulation Lab III	--	--	--	--	--	25	25	50
EEL703	Power Electronics Design Lab	--	--	--	--	--	25	25	50
EEP701	Major Project I	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**125**	**75**	**700**

# indicates work load of Learner (Not Faculty), for Major Project

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./ Tut.	Theory	Pract.	Total
EEC801	Electrical System Design, Management and Auditing	4	--	4	--	4
EEDO801X	Department Optional Course – 5	3	--	3	--	3
EEDO802X	Department Optional Course – 6	3	--	3	--	3
EEIO801X	Institute Optional Course - 2	3	--	3	--	3
EEL801	Electrical System Design and Audit Lab	--	2	--	1	1
EEL802	Measurement and Instrumentation Lab	--	2	--	1	1
EEP801	Major Project II	--	12#	--	6	6
Total		**13**	**16**	**13**	**8**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/ oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
EEC801	Electrical System Design, Management and Auditing	20	20	20	80	3	--	--	100
EEDO801X	Department Optional Course – 5	20	20	20	80	3	--	--	100
EEDO802X	Department Optional Course – 6	20	20	20	80	3	--	--	100
EEIO801X	Institute Optional Course - 2	20	20	20	80	3	--	--	100
EEL801	Electrical System Design and Audit Lab	--	--	--	--	--	25	25	50
EEL802	Measurement and Instrumentation Lab	--	--	--	--	--	25	25	50
EEP801	Major Project II	--	--	--	--	--	100	50	150
Total		**--**	**--**	**80**	**320**	**--**	**150**	**100**	**650**

Students group and load of faculty per week.

Major Project I and II:

Students can form groups with minimum 3 (Three) and not more than 4 (Four)

Faculty Load: In Semester VII – ½ hour per week per project group
In Semester VIII – 1 hour per week per project group

Department Optional Courses

Course Code	Sem. VII: Department Optional Course- 3	Course Code	Sem. VII: Department Optional Course - 4
EEDO7011:	Digital Control System	EEDO7021:	Microgrid and Smart-grid
EEDO7012:	HVDC Transmission Systems	EEDO7022:	Power System Dynamics and Control
EEDO7013:	Internet of Things	EEDO7023:	Artificial Intelligence and Machine Learning
EEDO7014:	Digital Signal Processors and Applications	EEDO7024:	Electrical Machine Design

Course Code	Sem. VIII: Department Optional Course- 5	Course Code	Sem. VIII: Department Optional Course - 6
EEDO8011:	Power Quality and FACTs	EEDO8021:	Power System Planning and Reliability
EEDO8012:	Automation and Control	EEDO8022:	Lighting System Design
EEDO8013:	Advanced Electric Drives	EEDO8023:	Cyber Physical Systems
EEDO8014:	High Power Switching Converters	EEDO8024:	Electric Vehicle System Design

Institute Optional Courses

Course Code	Institute Optional Course-I #	Course Code	Institute Elective Course-II #
EEIO7011	Product Lifecycle Management	EEIO8021	Project Management
EEIO7012	Reliability Engineering	EEIO8022	Finance Management
EEIO7013	Management Information System	EEIO8023	Entrepreneurship Development and Management
EEIO7014	Design of Experiments	EEIO8024	Human Resource Management
EEIO7015	Operation Research	EEIO8025	Professional Ethics and CSR
EEIO7016	Cyber Security and Laws	EEIO8026	Research Methodology
EEIO7017	Disaster Management and Mitigation Measures	EEIO8027	IPR and Patenting
EEIO7018	Energy Audit and Management	EEIO8028	Digital Business Management
EEIO7019	Development Engineering	EEIO8029	Environmental Management

 # Common with all branches

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEC701	**Electrical Drives & Control**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC701	**Electrical Drives & Control**	**20**	**20**	**20**	**80**	**03**	**-**	**-**	**100**

Course Objectives	To impart knowledge on 1. the basic concepts of electrical drives 2. the speed and torque control techniques of both DC and AC drives
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To apply the knowledge of dynamics to solve problems on electrical drives. 2. To select the power rating of a motor based on duty cycle. 3. To illustrate the modes of operation and control schemes (both open and closed loop) of electrical drive. 4. To analyze the speed control of DC drives with waveforms. 5. To analyze various methods of speed control and braking methods used in induction motor drives. 6. To describe the advanced control techniques used in induction motor drives.

Module	Contents	Hours
1	Electrical Drives - Introduction & Dynamics: Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives, Fundamental Torque equations, Speed-Torque conventions and Multi-quadrant Operation, Equivalent values of Drive Parameters, Measurement of Moment of Inertia, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability, Load Equalization	10
2	Selection of Motor Power Rating: Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating: Continuous duty; Equivalent current, Torque and Power Methods for Fluctuating and Intermittent Loads; Short Time Duty; Intermittent Duty.	05
3	Control of Electrical Drives: Modes of Operation, Speed Transitions during Acceleration and Deceleration, Static and Dynamic Performance Requirement of a Drive. Review of Hysteresis Band Current Control Technique and pulse width modulation (PWM) voltage control techniques. Closed loop control of drives – Torque control, Speed control loop with inner current control loop.	05
4	DC Drives: Review of Basic multi-quadrant speed torque characteristics and equations of DC motors, Three Phase Fully Controlled Converter based Separately Excited DC Motor Drive. Chopper based Separately Excited DC Motor Drive (No Numerical on this Module)	04
5	AC Drives:	08

	Induction Motor Drives: Review of Basic Multi-Quadrant Speed-Torque Characteristics and Equations, Regenerative Braking, Plugging, Speed Transitions during Acceleration and Deceleration, Speed Control: Stator Voltage Control, V/f Control, Soft starting with V/f control. Synchronous Motor Drives: Introduction to Synchronous Motor Variable Speed Drives – V/f Control, Self Control.	
6	**Advanced Control Techniques in Induction Motor Drives** Review of d-q Model of Induction Motor, Principle of Vector Control (also called as Field Oriented Control (FOC)), DC Motor Analogy, Block diagram and Phasor Diagram of Direct Vector Control Scheme, Comparison of Scalar and Vector control, Direct Torque and Flux Control using the Switching Table of Inverter Voltage Vectors (DTFC or DTC).	07

Text Books:

1. Fundamentals of Electrical Drives by G. K. Dubey, Narosa Publication
2. First Course on Electrical Drives by S. K. Pillai, New Age International
3. Modern Power Electronics and AC Drives by B. K. Bose, Prentice Hall PTR
4. Electrical Drives: Concepts and Applications by Vedam Subramanyam, T.M.H

Reference Books:

1. Electric Motor Drives: Modeling, Analysis and Control by Krishnan.R, PHI.
2. Power Electronics by Joseph Vithayathil, Tata McGraw Hill
3. Power Electronics by Muhammad H. Rashid, Pearson

Web Reference /Video Courses

1. **NPTEL Course**: **Fundamentals of Electric Drives** By Prof. Shyama Prasad Das, IIT Kanpur
2. **NPTEL Course**: **Advanced Electric Drives** By Prof. Shyama Prasad Das, IIT Kanpur
3. **NPTEL Course**: **Industrial Drives - Power Electronics**, Prof. K. Gopakumar, IISC Bangalore

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEC702	**Electrical Power System III**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC702	**Electrical Power System III**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	Student shall be able 1. to understand concept of Generator operating cost, input-output, Heat rate and IFC curve, Constraints in operation, solve Load scheduling and unit commitment problem 2. to understand concept of out of step falling of synchronous generator, system stability and analysis 3. to apply different numerical techniques to study power system stability 4. to understand concept of load flow studies and solve it by using different numerical techniques 5. to understand concept of load frequency control and voltage control 6. to understand concept of interchange of power and energy
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. Solve Load scheduling and unit commitment problem 2. Define and classify power system stability 3. Determine critical clearing angle using techniques like equal area criterion 4. Formulate load flow problem and solve it by using different techniques 5. Model single area load frequency control and analyse its steady state and dynamic behavior 6. Understand concept of interchange of power and energy

Module	Contents	Hours
1.	Economic Operation of Power System Optimal operation of generators in thermal power station, heat rate curve, input-output curve, IFC curves, optimum generation scheduling neglecting Transmission losses (coordinate equation), optimum generation scheduling considering transmission losses (Exact coordinate equation), Transmission loss formula, Bmn coefficient, Inherent procedure of solving co-ordination equation, optimal unit commitment (Numerical)	10
2.	Power System Stability I Introduction to stability, types of stability, Power angle curve, dynamics of synchronous machine, power angle equation, steady state stability (Numerical)	05
3.	Power System Stability II Swing equation, transient stability, equal area criterion, application of equal area criterion, some techniques for improving transient stability (Numerical)	05
4.	Load Flow Studies Introduction, formation of Y bus using step by step method, Load flow problem, Load flow Equation and methods of solution, Gauss-Seidel method, Newton- Raphson method, Decoupled load flow method, Fast decoupled load flow method, comparison of load flow method (Numerical)	08
5.	Automatic Generation and Voltage control Introduction, Basic control loops in generator, AVR loop, Thermal control, speed governing system and transfer function, steam turbine, and power system transfer	06

	function, Load frequency control (single area), steady state and dynamic response.	
6.	**Power system security and Interchange of power** Power system security: Introduction, System state classification, security analysis, contingency analysis. Interchange of power: Interchange of power between interconnected utilities, types of interchange, capacity and diversity interchange, energy banking, power pools	05

Text Books:-

1. Kothari D.P., Nagrath I.J., Modern power system Analysis, TMH publication, 4e, 2019.
2. Chakrabarti A, Halder S., Power System Analysis-Operation and Control, PHI
3. Allen Wood, Bruce F. Wollenberg, Power Generation operation and control, Willey India
4. B.R. Gupta, Power System Analysis and Design, S. Chand

Reference Books:-

1. Hadi Saadat, Power System Analysis, TMH publications, 2e
2. Soman S.A., Kharpade S.A., and Subha Pandit - Computer Methods for Large Power System Analysis, an object Oriented Approach, Kluwer Academic Publisher New York 2001.

Website Reference/ Video Courses:

1. NPTEL Course: Power System Analysis, Prof. A.K. Sinha, IIT Kharagpur
2. NPTEL Course: Power System Engineering, By Prof. Debapriya Das, IIT Kharagpur
3. NPTEL Course: Power System Protection, By Prof. Ashok Kumar Pradhan, IIT Kharagpur
4. NPTEL Course: Operation and Planning of Power Distribution Systems, By Prof. Sanjib Ganguly, IIT Guwahati
5. NPTEL Course: Power System Dynamics, Dr. M.L. Kothari, IIT Delhi

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7011	**Digital Control System**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7011	**Digital Control System**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To familiarize the student with the concept of discretization 2. Introduction to discrete-time system representations and digital control 3. Learn to design controller for digital systems
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Obtain discrete representation of LTI systems. 2. Analyze stability of open loop and closed loop discrete-time systems. 3. Design and analyze digital controllers. 4. Design state feedback and output feedback controllers.

Module	Contents	Hours
1.	Discrete Representation of Continuous Systems: Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent	05
2.	Discrete System Analysis: Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.	06
3.	Stability of Discrete Time System: Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.	04
4.	State Space Approach for discrete time systems: State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Re-constructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability.	10
5.	Design of Digital Control System: Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.	07
6.	Discrete output feedback control: Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.	07

Text Books:-

1. K. Ogata, Discrete-time Control Systems, Ed. 2, Prentice-Hall, 1995
2. G. F. Franklin, J. D. Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison-Wesley, 1998.
3. B. C.Kuo, Digital Control Systems, Oxford University Press, 2/e, Indian Edition, 2007.
4. M. Gopal, Digital Control and State Variable Methods, Tata Mcgraw Hill, 2/e, 2003.

5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web Reference /Video Courses

1. NPTEL Course: Digital Control System by Dr. Indrani Kar and Prof. S. Majhi IIT Guwahati
2. NPTEL Course: Control Systems By Prof. C.S. Shankar Ram, IIT Madras

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7012	**HVDC Transmission Systems**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7012	**HVDC Transmission Systems**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	To impart knowledge on HVDC system, its control, protection along with brief analysis of HVDC converters
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Identify significance of dc over ac transmission systems, types of HVDC link, Components of HVDC system and applications. 2. Analyze multi-pulse converters. 3. Illustrate the basic control of HVDC system and its limitation, features and implementation. 4. Describe the converter firing control schemes for starting and stopping of HVDC link. 5. Understand and analyze faults and protection of HVDC system. 6. Illustrate the harmonics, their causes, effects and use of different filters.

Module	Contents	Hours
1	**Introduction to HVDC transmission:** Early discoveries and applications, Limitation and advantages of AC and DC transmission, Classification of HVDC links, Components HVDC Transmission system, Ground Return Advantages and Problems, Advances in HVDC transmission. HVDC system application in wind power generation	05
2	**Analysis of the Bridge rectifier:** Analysis of six pulse converter with grid control but no overlap, Current and phase relations, Analysis of six pulse converter with grid control and overlap less than 60°, Relation between AC and DC quantities, Analysis with overlap greater than 60°, Rectifier operation output voltage, thyristor voltage waveforms with and without overlap, Inverter operation output voltage waveforms. Equivalent circuit of rectifier and inverter, Multi bridge converter, Numerical from converter circuits and multiple bridge converters.	12
3	**HVDC System Control:** Basic means of control, Limitation of manual control, Constant current verses constant voltage control, Desired features of control, Actual control characteristics, Significance of current margin, Power reversal, Control implementation	06
4	**Converter Control:** Converter Firing Control Schemes (EPC and IPC. Starting and shutting down the HVDC link	04
5	**Faults and protection:** By pass valve, Causes and analysis of arc back, arc through, misfire, current extinction, single commutation failure, double commutation failure, short circuits in converter station Protection against over current, over voltage	08

6	**Harmonics & Filters:** Characteristics Harmonics and Un-Characteristics Harmonics, Causes, Consequences, Trouble Caused by Harmonics, Means of Reducing Harmonics, Filters, AC & DC Filters.	04

Text Books:-

1. Edward Wilson Kimbark, Direct Current Transmission, Wiley publication Interscience
2. K R Padiyar, HVDC power transmission systems, second edition, New Age International Ltd
3. S. Kamkshaiah and V Kamraju, HVDC transmission, Tata McGraw Hill, New Delhi
4. S.N. Singh, Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd edition, 2008

Reference Books:-

1. S. Rao, EHVAC and HVDC Transmission Engineering and Practice, Khanna publication, 1990
2. J. Arrillaga, HVDC Transmission, Wiley publication Inter science
3. C.L. Wadhwa, Electrical Power System (2nd Edition)

Web Reference /Video Courses

1. **NPTEL Course:** High Voltage DC Transmission, by Dr. S.N. Singh, IIT Kanpur

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7013	**Internet of Things**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7013	**Internet of Things**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	To provide overview of internet-of-things technologies, hardware, operating systems, networking, security and databases aspects.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Understand the concept of IOT 2. Illustrate IOT architecture and applications in various fields 3. Demonstrate use Devices, Gateways and Data Management in IoT. 4. Describe the security and privacy issues in IOT. 5. Understand emerging technological options, platforms and case studies of IoT implementation in home & city automation.

Module	Contents	Hours
1	**Introduction to IoT:** Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Sources of IoT; Sensing, Actuation, Basics of Networking; Software Architectures and Software Interoperability, Privacy and Security	06
2	**IoT Architecture:** Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints, Data representation and visualization, Interaction and remote control.	06
3	**Hardware Platforms:** Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases. IOT Physical Devices & Endpoints:	06
4	**Networking and Communication Protocols:** Cloud based IoT platforms, Zigbee and Zwave, advantage of low power mesh networking. Long distance Zigbee; Bluetooth/BLE: Low power vs high power, speed of detection, class of BLE. Wireless protocols such as Piconet and packet structure for BLE and Zigbee. Web Communication Protocols for connected devices, Web connectivity using Gateway, SOAP, REST, HTTP, RESTful and WebSockets (Publish –Subscribe),MQTT, AMQP, CoAP Protocols	10
5	**Introduction to Mobile App platform for IoT:** Protocol stack of Mobile app for IoT, Mobile to server integration.	04
6	**IoT Applications:** Fog Computing, eHealth, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid; Industrial IoT: Case Study: Agriculture, Healthcare, Activity Monitoring.	07

	Introduction to Programming and Integration of Sensors / Actuators with IoT platform using Arduino, Raspberry Pi.	

Text /Reference Books:-

1. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
2. S. Misra, A. Mukherjee, and A. Roy, Introduction to IoT. Cambridge University Press, 2020.
3. S. Misra, C. Roy, and A. Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0. CRC Press. 2020.
4. Adrian McEwen, Hakim Cassimally Designing the Internet of Things , John Wiley, 2014
5. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013.
6. CunoPfister, "Getting Started with the Internet of Things", OReilly Media, 2011
7. A. McEwen, H. Cassimally, "Designing the Internet of Things", Wiley, 2013.
8. Samuel Greenguard, "Internet of Things", MIT Press, 2015.
9. Mandler, B., Barja, J., Mitre Campista, M.E., Cagáová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing
10. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley-Blackwell.
11. Internet of things (IoT): Technologies, Applications, Challenges, and Solutions Edited by B.K. Tripathy J. Anuradha, CRC Press, 2018

Web Reference /Video Courses

1. **NPTEL Course:** Introduction to Internet of Things By Prof. Sudip Misra, IIT Kharagpur

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7014	**Digital Signal Processors and Applications**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7014	**Digital Signal Processors and Applications**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To introduce digital signal processors (DSP) architecture, its specifications, functionalities and programming for simple applications. 2. To introduce the numerical integration techniques and its use in implementation of digital compensator 3. To introduce various applications of DSPs in power system and power electronics and their practical design aspects.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. To identify and describe DSP/DSC architecture and its features along with number representation used. 2. To write a program code for DSP for simple applications 3. To compare and evaluate various numerical integration methods used for digital control implementation. 4. To model, analyze and design various compensators for converter/ inverter control 5. To understand various applications of DSP in power electronics and power systems 6. To design solar PV systems for various modes of operation.

Module	Contents	Hours
1	Introduction Digital signal processors (DSP) and digital signal controller (DSC) architectures; Fixed and floating-point processors, Fixed point and floating point number representations. Review of commonly used DSPs/DSCs in power and control applications, Introductions to TMS320C2000 processors	05
2	DSP/DSC Architecture, Peripherals and Programming: DSP/DSC Architecture, peripherals Overview of TMS320C2000 DSC family – Features, Architecture, Memory map, Clock system- Digital I/O -CPU Timers, Analog to Digital Converter (ADC), Pulse Width Modulator (PWM) Capture Module, Quadrature Encoder Pulse Module and communication ports. Programming: assembler, linker processes, code structure, Code Composer Studio (CCS), Programming for: generation of PWM, Sine PWM, measurement of AC/ DC voltage/ currents, use of CPU timers and Digital I/Os	08
3	Mathematical tools for Real Time DSP implementation: Review of numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method. Implementation of digital filters and transformations	05
4	Digital Controller Design: Modeling buck, boost converter and 3 phase inverter with LC filter, Design of compensators voltage and current mode, control for their closed loop applications. Design of PI, Type II and Type III controllers.	07

5	**Applications in Power Systems and Power Electronics:** Implementation of Active filters in DSP/DSC under balanced and unbalanced condition, harmonic oscillator and 3 phase lock loop, Static VAR Compensator, Speed control of Induction motor.	10
6	**DSP based System Design:** Design of a DSP controlled Solar PV based Converter/Inverter system for standalone and grid connected modes.	04

Reference Books:-

1. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
2. Digital Signal Processing in Power System Protection and Control By Waldemar Rebizant, Janusz Szafran, and Andrzej Wiszniewski, Springer.
3. Digital Power Electronics and Applications By Fang Lin Luo, Hong Ye and Muhammad Rashid, Elsevier Academic Press.
4. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
5. Power Electronics, Converters, Applications & Design by N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt. Ltd.
6. Modern Power Electronics and AC Drives by B. K Bose, Pearson Education
7. DSP Based Electromechanical Motion Control by Hamid Toliyat and Steven Campbell, CRC Press

Web Reference /Video Courses

Texas Instruments Website:

1. https://www.ti.com/microcontrollers-mcus-processors/microcontrollers/c2000-real-time-control-mcus/overview.html
2. https://training.ti.com/c2000-workshops

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7021	**Microgrid and Smart-grid**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7021	**Microgrid and Smart-grid**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To introduce the fundamental concept, various power architectures and control of distributed generation and microgrids. 2. To review various regulatory standards and state of the art of microgrids 3. To understand the microgrid and Smart Grid deployments for large scale integration of clean energy sources, various technologies, automation and ICT infrastructure requirements.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. To identify and describe the impact of renewable energy integration for mitigating energy crises and sustainable future. 2. To identify and describe the concept of Microgrid and its various topologies, modes of operation control and communication architecture. 3. To identify and describe the concept of Smart Grid, its features and the state of the art. 4. To understand various Smart Grid technologies, automation, resiliency and its adoption in current power system**.**

Module	Contents	Hours
1	**Introduction:** Energy crises and sustainable alternatives, review of conventional and non-conventional energy sources and power generation; Comparison of renewable technologies: Solar Photovoltaics, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources. Impact of grid integration of renewable energy resources on existing power system: reliability, stability and power quality issues	05
2	**Distributed Generations (DG) and Microgrids:** . DG topologies, regulatory standards/ framework: IEEE 1547 series, Limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues; Concept of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC Microgrids; Control architectures of microgrids: Centralised, decentralised and hierarchical control. Local and system level control functionalities; basics of Power sharing and coordinated control of microgrids	08
3	**Power Conditioning Units (PCUs) for Microgrid Sources:** PCUs in DC and AC microgrids, modes of operation and control of PCUs: Voltage mode control, current mode control. Microgrid functions: black-start and grid synchronisation.	05
4	**Microgrid operations and islanding:** Grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques. Role of energy Storage in Microgrid operations and stability	07
5	**Introduction to Smart-Grid:** Concept of Smart-Grid, Definitions, Need of Smart-Grid, Functions of Smart-Grid, Opportunities & Barriers of Smart Grid, Concept of Resilient & Self-Healing Grid, Microgrids role in smart-grid scenario.	07

	Review of Smart Grid Technologies: Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), EV (Vehicle to Grid).	
6	**Smart Grid Operations and Automation:** Smart Substations, Substation Automation, Feeder Automation. Intelligent Electronic Devices(IED) & their application for monitoring & protection, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU) *Communication Network for Microgrids & Smart Grid:* Home Area Network (HAN), Wide Area Network (WAN), Bluetooth, ZigBee, , Wireless Mesh Network, Cyber Security for Smart Grid.	07

Text Books :

1. Microgrids architectures and control Edited by Nikos Hatziargyriou, Wiley, IEEE Press, 2014
2. A. Keyhani, M. N. Marwali, M. Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley, 2009
3. Antonio Carlos Zambroni de Souza, Miguel Castilla, Microgrids Design and Implementation, Springer 2019

Reference Books:-

1. Yezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, John Wiley Publications, 2010
2. Dorin Neacsu, Power Switching Converters: Medium and High Power, CRC Press, 2006
3. B. M. Buchholz and Z. Styczynski, Smart Grids – Fundamentals and Technologies in Electricity Networks, Springer, 2014
4. C. W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, 2009
5. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, Smart Grid: Technology and Applications, Wiley, 2012
6. J. C. Sabonnadière and N. Hadjsaïd, Smart Grids, John Wiley & Sons and ISTE, 2012
7. IEEE standards —IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems IEEE standards 2003
8. IEEE standards —IEEE 1547-4-2011: IEEE Guide for Design Operation & Integration of Distributed Resources Island System with Electric Power System,
9. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration of Distributed Energy Resources: The CERTS Microgrid Concept' 2002

Web Reference /Video Courses

1. **NPTEL Course:** DC Microgrid and Control System, Prof. Avik Bhattacharya, IIT Roorkee
2. **NPTEL Course:** Introduction to Smart Grid, By Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name6	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7022	**Power System Dynamics and Control**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7022	**Power System Dynamics and Control**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To understand fundamental concepts & classification of power system stability. 2. To analyze theory and practice of modelling main power system components, such as synchronous machines, excitation systems. 3. Analyze the performance of the system with small signal analysis. 4. To explore voltage stability concepts in power stability studies.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Explain the dynamic models of power system components. 2. Analyze the performance of the system with small signal analysis. 3. Choose the fundamental dynamic behavior and controls of power systems to perform basic stability analysis. 4. Select the appropriate model depending on the analysis to be done.

Module	Contents	Hours
1	**Introduction to Power System Stability Problem:** Rotor angle stability, voltage stability, voltage collapse, Mid- term and Long- term stability, classification of stability	03
2	**Synchronous Machine Modeling and Representation:** Basic equations of synchronous machine, dqo transformation, Per unit- voltage- flux- torque- power equations and reactance, Equivalent circuit d-q axis, Voltage current flux linkage relation- phasor representation- rotor angle-steady state equivalent circuit. Three phase short circuit, Magnetic saturation and representation Simplifications for large scale studies, Constant flux linkage model.	12
3	**Excitation System:** Excitation system requirement, Elements of excitation system, Types of excitation system, Dynamic performance measures, Control and protective functions in modern excitation control system.	04
4	**Small Signal Stability:** Fundamental concept of stability of dynamic system, Eigen properties of state matrix, SSS of single machine infinite bus system, Effect of AVR on synchronizing and damping torque, Power system stabilizer.	12
5	**Voltage Stability:** Basic concepts, Voltage collapse, Voltage stability analysis, Prevention of voltage collapse.	04
6	**Method of Improving Stability:** Transient system enhancement methods, Small signal stability enhancement method	04

Text Books/ Reference Books:-

1. Prabha Kundur , Power System Stability and Control , TMH Publication,2008
2. K. R. PADIYAR," Power system dynamics "- B.S. Publications
3. P.M. Anderson and A. A. Fouad, "Power system control and stability", IEEE Press
4. Kimbark E W, Power System Stability, Volume I, III, Wiley publication.
5. Anderson P.M, Fouad A.A, Power System Control and Stability, Wiley Inter-Science, 2008 Edition

Web Reference /Video Courses

1. **NPTEL Course:** Power System Dynamics and Control, Dr. A.M. Kulkarni, IIT Bombay
2. **NPTEL Course:** Power System Dynamics, Control and Monitoring, By Prof. Debapriya Das, IIT Kharagpur
3. **NPTEL Course:** Power System Dynamics, Dr. M.L. Kothari, IIT Delhi

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7023	**Artificial Intelligence and Machine Learning**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7023	**Artificial Intelligence and Machine Learning**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To learn the ability of selecting suitable artificial intelligence and machine learning techniques for data handling and to gain knowledge from it. 2. To evaluate the performance of algorithms and to provide solutions for various real-world applications.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. To develop a basic understanding of artificial intelligence building blocks and analyze whether a problem can be solved using artificial intelligence techniques 2. To understand the fundamental concepts of neural networks, different neural network architectures, algorithms, applications and their limitations. 3. To formulate and identify machine learning techniques suitable for a given problem 4. To develop and apply regression algorithms for finding relationships between data variables. 5. To develop and apply pattern classification algorithms to classify multivariate data and demonstrate the usefulness of reinforcement learning and deep learning for controlling complex systems. 6. To create solutions to real-world electrical engineering problems using artificial intelligence and machine learning.

Module	Contents	Hours
1	Introduction to Artificial Intelligence: Introduction to artificial intelligence; Application areas of artificial intelligence; State space search: Depth first search, Breadth first search; Heuristic search: Best first search, Hill Climbing, Beam Search.	4
2	Artificial Neural Networks: Biological Neurons and Biological Neural Networks, Artificial Neural Networks Models, Activation Functions, Perceptrons, Representation Power, Training Rule, Gradient Descent, and the Delta Rule, Multilayer networks and the Back Propagation algorithm, Convergence and Local Minima, Feedforward networks, Inductive Bias, Hidden Layer, Generalization, Overfitting, and Stopping Criterion	8
3	Introduction to Machine Learning: Towards Intelligent Machines, Machine Learning Problems, Data Representation, Diversity of Data: Structured/Unstructured, Forms of Learning, Machine Learning and Data Mining, Basic Linear Algebra in Machine Learning Techniques	3
4	Supervised and Statistical Learning: Bias and Variance, Metrics for Assessing Regression (Numeric Prediction) Accuracy, Metrics for Assessing Classification (Pattern Recognition) Accuracy, Descriptive Statistics in Learning Techniques, Bayesian Reasoning: A Probabilistic Approach to Inference, k-Nearest Neighbor	10

	(k-NN) Classifier, Discriminant Functions and Regression Functions, Linear Regression with Least Square Error Criterion, Logistic Regression for Classification Tasks, Regression by Support Vector Machines, Decision Trees, Overfitting and Regularization	
5	**Data Clustering and Data Transformations:** Unsupervised Learning, Overview of Basic Clustering Methods, K-Means Clustering, Data Cleansing, Derived Attributes, Discretizing Numeric Attributes, Attribute Reduction Techniques, Principal Components Analysis (PCA) for Attribute Reduction **Introduction to Advance Machine Learning:** Introduction, Need and Model of Reinforcement Learning and Deep Learning	8
6	**Application of Artificial Intelligence in Electrical Engineering:** Voltage control, Protection System, Static Security Assessment, Condition Monitoring, Schedule Maintenance of Electrical Power Transmission Networks **Application of Machine Learning in Electrical Engineering:** Load forecasting, Voltage stability assessment, Demand Side Management, Predicting User Preference, Load Pattern Classification, Wind speed forecasting.	6

Text Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2nd Edition, Pearson Education
2. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications, PHI.
3. M. Gopal, Applied Machine Learning, McGraw Hill
4. Kevin Warwick, Arthur O. Ekwue, Raj Aggarwal, Artificial Intelligence Techniques in Power Systems, Institution of Electrical Engineers, 1997
5. Morteza, Somayeh, Mohammadi, Moloud, Milad, Application of Machine Learning and Deep Learning Methods to Power System Problems, Springer, 2022

Reference Books:

1. J. Zurada, Introduction to Artificial Neural Systems, Jaico Publishing House
2. Tom Mitchell, Machine Learning, TMH
3. Harrington, Peter. Machine learning in action. Simon and Schuster, 2012.
4. Bishop, Christopher M., and Nasser M. Nasrabadi. Pattern recognition and machine learning. Vol. 4, no. 4. New York: springer, 2006.
5. Athem Ealpaydin, Introduction to Machine Learning, PHI
6. C. Bishop, Neural Networks for Pattern Recognition, Oxford University Press.
7. Ajay Kumar Vyas, Harsh S. Dhiman, Kamal Kant Hiran, S. Balamurugan, Artificial Intelligence for Renewable Energy Systems, WIley, 2022

Web Reference /Video Courses

1. **NPTEL Course: Artificial Intelligence: Search Methods for Problem Solving, Prof. Deepak Khemani, IIT Madras**
2. **NPTEL Course: Introduction to Machine Learning, Prof. S. Sarkar, IIT Kharagpur**

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEDO7024	**Electrical Machine Design**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**		**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO7024	**Electrical Machine Design**	**20**	**20**	**20**	**80**	**3**	**-**	**-**	**100**

Course Objectives	1. To explore the design philosophies adopted in design of electrics machines and transformers 2. To introduce software tools used in design of electrics machines and transformers
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Understand the construction and performance characteristics of electrical machines. 2. Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines 3. Understand the principles of electrical machine design and carry out a basic design of an ac machine. 4. Use software tools to do electrical machine design calculations.

Module	Contents	Hours
1	Introduction: Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.	04
2	Transformers: Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers	07
3	Induction Motors: Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of poly-phase machines, magnetizing current, short circuit current, circle diagram, operating characteristics	10
4	Synchronous Machines: Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.	10
5	Machines for special Applications: Introduction to structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines; Sizing of motors for Electric Vehicles, design of EV grade Induction motor.	04
6	Computer aided Design (CAD): Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design.	04

Text/ Reference Books:-

1. A. K. Sawhney, A Course in Electrical Machine Design, Dhanpat Rai and Sons, 1970.
2. M.G. Say, Theory & Performance & Design of A.C. Machines, ELBS London.
3. S. K. Sen, Principles of Electrical Machine Design with computer programmes, Oxford and IBH Publishing, 2006.
4. K. L. Narang, A Text Book of Electrical Engineering Drawings, Satya Prakashan, 1969.
5. Shanmugasundaram, G. Gangadharan and R. Palani, Electrical Machine Design Data Book, New Age International, 1979.
6. K. M. V. Murthy, Computer Aided Design of Electrical Machines, B.S. Publications, 2008.
7. Electrical machines and equipment design exercise examples using Ansoft's Maxwell 2D machine design package.

Web Reference /Video Courses

1. NPTEL Course: Modelling and Analysis of Electric Machines, Dr. Krishna Vasudevan, IIT Madras
2. NPTEL Course: Electrical Equipment and Machines: Finite Element Analysis By Prof. S. V. Kulkarni, IIT Bombay

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7011	**Product Life Cycle Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7011	**Product Life Cycle Management**	**20**	**20**	**20**	**80**	3	**--**	**--**	**100**

Course Objectives	1. To familiarize the students with the need, benefits and components of PLM 2. To acquaint students with Product Data Management & PLM strategies 3. To give insights into new product development program and guidelines for designing and developing a product 4. To familiarize the students with Virtual Product Development
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation. 2. Illustrate various approaches and techniques for designing and developing products. 3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc. 4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module	Contents	Hours
1	**Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM	10
2	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09

3	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
4	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	05
5	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
6	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

References:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Assessment:

Internal Assessment for 20 marks: Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7012	**Reliability Engineering**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7012	**Reliability Engineering**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To familiarize the students with various aspects of probability theory 2. To acquaint the students with reliability and its concepts 3. To introduce the students to methods of estimating the system reliability of simple and complex systems 4. To understand the various aspects of Maintainability, Availability and FMEA procedure
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand and apply the concept of Probability to engineering problems 2. Apply various reliability concepts to calculate different reliability parameters 3. Estimate the system reliability of simple and complex systems 4. Carry out a Failure Mode Effect and Criticality Analysis

Module	Contents	Hours
1	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	08
2	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	08
3	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
4	**Reliability Improvement:** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
5	**Maintainability and Availability:** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05

6	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

References:

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7013	**Management Information System**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7013	**Management Information System**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. The course is blend of Management and Technical field. 2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built 3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage 4. Identify the basic steps in systems development
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Explain how information systems Transform Business 2. Identify the impact information systems have on an organization 3. Describe IT infrastructure and its components and its current trends 4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making 5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Contents	Hours
1	**IntroductiontTo Information Systems (IS):** Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	04
2	**Data and Knowledge Management:** Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management **Business intelligence (BI):** Managers and Decision Making, BI for Data analysis and Presenting Results	07
3	**Ethical issues and Privacy:** Information Security. Threat to IS, and Security Controls	07
4	**Social Computing (SC):** Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	07
5	**Computer Networks** Wired and Wireless technology, Pervasive computing, Cloud computing model.	06
6	**Information System within Organization:** Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process.	08

	Acquiring Information Systems and Applications: Various System development life cycle models.	

References:

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7014	**Design of Experiments**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7014	**Design of Experiments**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To understand the issues and principles of Design of Experiments (DOE) 2. To list the guidelines for designing experiments 3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action 2. Apply the methods taught to real life situations 3. Plan, analyze, and interpret the results of experiments

Module	Contents	Hours
1	**Introduction** 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments 1.4 Response Surface Methodology	06
2	**Fitting Regression Models** 2.1 Linear Regression Models 2.2 Estimation of the Parameters in Linear Regression Models 2.3 Hypothesis Testing in Multiple Regression 2.4 Confidence Intervals in Multiple Regression 2.5 Prediction of new response observation 2.6 Regression model diagnostics 2.7 Testing for lack of fit	08
3	**Two-Level Factorial Designs** 3.1 The 2^2 Design 3.2 The 2^3 Design 3.3 The General2^k Design 3.4 A Single Replicate of the 2^k Design 3.5 The Addition of Center Points to the 2^k Design, 3.6 Blocking in the 2^k Factorial Design 3.7 Split-Plot Designs	07

4	**Two-Level Fractional Factorial Designs** 4.1 The One-Half Fraction of the 2^k Design 4.2 The One-Quarter Fraction of the 2^k Design 4.3 The General 2^{k-p} Fractional Factorial Design 4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	07
05	**Response Surface Methods and Designs** 5.1 Introduction to Response Surface Methodology 5.2 The Method of Steepest Ascent 5.3 Analysis of a Second-Order Response Surface 5.4 Experimental Designs for Fitting Response Surfaces	07
06	**Taguchi Approach** 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

References:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Practical Experiment Designs for Engineers and Scientists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T. Voss

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7015	**Operations Research**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7015	**Operations Research**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. Formulate a real-world problem as a mathematical programming model. 2. Understand the mathematical tools that are needed to solve optimization problems. 3. Use mathematical software to solve the proposed models.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness. 2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change. 3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems. 4. Understand the applications of integer programming and a queuing model and compute important performance measures

Module	Contents	Hours
1	**Introduction to Operations Research**: Introduction, Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem**: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem**: Introduction, Types of Integer Programming Problems,	14

	Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
2	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05
3	**Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	05
4	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
5	**Game Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	05
6	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7016	**Cyber Security and Laws**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7016	**Cyber Security and Laws**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To understand and identify different types cybercrime and cyber law 2. To recognized Indian IT Act 2008 and its latest amendments 3. To learn various types of security standards compliances
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand the concept of cybercrime and its effect on outside world 2. Interpret and apply IT law in various legal issues 3. Distinguish different aspects of cyber law 4. Apply Information Security Standards compliance during software design and development

Module	Contents	Hours
1	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	04
2	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	09
3	**Tools and Methods Used in Cyberline:** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	06
4	**The Concept of Cyberspace** : E-Commerce, The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law, The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	08
5	**Indian IT Act:** Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	06

6	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	06

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information Technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes by Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security,* Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings*, Cryptography and Network Security,* Pearson Publication
8. Websites for more information is available on: The Information Technology ACT, 2008- TIFR: https://www.tifrh.res.in
9. Website for more information: A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primerprofessionals-33538

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7017	**Disaster Management and Mitigation Measures**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7017	**Disaster Management and Mitigation Measures**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To understand physics and various types of disaster occurring around the world 2. To identify extent and damaging capacity of a disaster 3. To study and understand the means of losses and methods to overcome /minimize it. 4. To understand role of individual and various organization during and after disaster 5. To understand application of GIS in the field of disaster management 6. To understand the emergency government response structures before, during and after disaster
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Get to know natural as well as manmade disaster and their extent and possible effects on the economy. 2 Plan of national importance structures based upon the previous history. 3 Get acquainted with government policies, acts and various organizational structure associated with an emergency. 4 Get to know the simple do's and don'ts in such extreme events and act accordingly.

Module	Contents	Hours
1	**Introduction** 1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
2	**Natural Disaster and Manmade disasters:** 2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion 2.2 Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
3	**Disaster Management, Policy and Administration** 3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. 3.2 Policy and administration: Importance and principles of disaster management policies, command and coordination of in disaster management, rescue operations-how to start with and	06

	how to proceed in due course of time, study of flowchart showing the entire process.	
4	**Institutional Framework for Disaster Management in India:** 4.1 Importance of public awareness, Preparation and execution of emergency management program. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. 4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
5	**Financing Relief Measures:** 5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. 5.2 International relief aid agencies and their role in extreme events.	09
6	**Preventive and Mitigation Measures:** 6.1 Pre-disaster, during disaster and post-disaster measures in some events in general 6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication 6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. 6.4 Do's and don'ts in case of disasters and effective implementation of relief aids.	06

References:

1. 'Disaster Management' by Harsh K. Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S. Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elsevier Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications. (Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Assessment:

Internal Assessment for 20 marks: Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)

4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7018	**Energy Audit and Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7018	**Energy Audit and Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation. 2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management 3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To identify and describe present state of energy security and its importance. 2. To identify and describe the basic principles and methodologies adopted in energy audit of a utility. 3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities. 4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities 5. To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Contents	Hours
1	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
2	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
3	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10

4	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
5	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
6	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

References:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO7019	**Development Engineering**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO7019	**Development Engineering**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development 2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas 3. An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals 4. To understand the Nature and Type of Human Values relevant to Planning Institutions
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Apply knowledge for Rural Development. 2. Apply knowledge for Management Issues. 3. Apply knowledge for Initiatives and Strategies 4. Develop acumen for higher education and research. 5. Master the art of working in group of different nature. 6. Develop confidence to take up rural project activities independently

Module	Contents	Hours
1	**Introduction to Rural Development:** Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development, Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	08
2	**Post-Independence Rural Development:** Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	04
3	**Rural Development Initiatives in Five Year Plans:** Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	06

4	**Post 73rd Amendment Scenario:** 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04
5	**Values and Science and Technology:** Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	10
6	**Ethics:** Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	04

References:

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V., Conflicting Rationalities: -Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 407

Assessment:

Internal Assessment for 20 marks: Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL701	**Electrical Drives and Control Lab**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**2**		**1**	**1**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL701	**Electrical Drives and Control Lab**	---	---	---	---	--	**25**	**25**	**50**

Course Objectives	1. To impart practical knowledge on electrical drives and its control
Course outcomes	Upon successful completion of this course, the learner will be able : 2. To analyze the dynamic performance of ac and dc drives. 3. To analyze the dynamics of electrical braking in ac and dc drives 4. To analyze the control aspects and the performance of power electronic drives. 5. To use simulation tools to evaluate the performance of ac and dc drive

Syllabus:

Same as that of Course Drives and Control (EEC701) with the following additions: - Starting of DC/AC motors, Speed Control of DC Motor with Half Controlled Converter, Dual Converter, Speed Control of Wound Rotor Induction Motor, Control of Special Machines like Brushless DC (BLDC) Motor, Permanent Magnet Synchronous Motor (PMSM), Stepper Motor, Switched Reluctance Motor (SRM), Synchronous Reluctance Motor (SyRM).

Suggested List of Laboratory Experiments:

1. Measurement of Moment of Inertia by Retardation Test
2. Study of Different Speed Sensing, Current Sensing and Voltage Sensing devices used for closed loop controlled drive.
3. Developing Sensor/interfacing Circuits required for the drive.
4. Single phase fully-controlled rectifier fed DC drive/Single phase half controlled rectifier fed DC drive / Three phase fully controlled rectifier fed DC drive/ Three phase half controlled rectifier fed DC drive/Dual Converter controlled fed DC drive. (Simulation/ Hardware)
5. Chopper Controlled DC drive. (Simulation/ Hardware)
6. Closed loop Control of DC drive (Simulation/ Hardware).
7. Simulation of Starting of DC motor (Conventional resistance start and any one Soft-start scheme)
8. Dynamic braking, Plugging of DC motor.
9. Plugging of three phase Induction Motor.
10. V control and V/f control of Induction Motor using PWM Inverter.
11. Rotor resistance control of IM
12. Slip Power Recovery Scheme (Static Scherbius Drive).
13. Hands on Experience in Programming a general purpose three phase Induction Motor Industrial Drive.
14. Vector Control of three phase Induction Motor (Simulation/Hardware).
15. DTC of three phase Induction Motor (Simulation/Hardware).
16. Control of Special Machines like Brushless DC (BLDC) Motor, Permanent Magnet Synchronous Motor (PMSM), Stepper Motor, Switched Reluctance Motor (SRM), Synchronous Reluctance Motor (SyRM)

Any other experiment based on the syllabus which will help students to understand the topic/concept.

Term work:

Term work shall consist of minimum eight experiments with minimum six hardware experiments.

The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical and Oral Examination:

Practical and Oral examination shall be based on entire syllabus of experiments conducted in **'EEL701: Electrical Drives and Control Lab'** and '**EEC701: Electrical Drives & Control**' syllabus

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL702	**Simulation Lab-III**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**2**		**1**	**1**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL702	**Simulation Lab-III**	---	---	---	---	--	**25**	**25**	**50**

Course Objectives	The course is aimed: 1. To understand basic block sets of different simulation platform used in electrical /electronic circuit design. 2. To understand use and coding in different software tools used in electrical/ electronic circuit design
Course outcomes	Upon successful completion of this course, the learner will be able to 1. Develop the skill to use the software packages to model and program electrical and electronics systems 2. Model different electrical and electronic systems and analyze the results 3. Articulate importance of software packages used for simulation in laboratory experimentation /research/industry by analyzing the simulation results. 4. Simulate circuits for performance analysis.

Suggested Software Tools to be Used for Simulation Lab-II:

1. Students should be encouraged to use open source softwares such as SCILAB, LTSPICE, Texas Instrument's 'Webbench', Ngspice, Solve Elec etc. for carrying out the lab simulation listed below.
2. Use of Professional Licensed versions of softwares like MATLAB, Proteus, LabVIEW, NI Multisim, PSpice, PSim, PSCAD, TINA etc. is also allowed.
3. Use of 'Python' platform for simulating components/ circuit behaviour should also be emphasized
4. Many of the following suggested experimentation can be carried out on Virtual lab platform

Suggested List of Laboratory Experiment: Minimum eight experiments need to be performed from various subjects domain. Some of the simulation experiments can also be selected based on the department elective offered

Power Electronics Design and Control

1. Simulation of a Buck or Boost or Buck-Boost DC-DC converter for switched mode power supplies (any one converter)
2. Simulation of feed-back compensator for closed- loop control of Buck or Boost or Buck-Boost DC-DC converter for extraction of energy from renewable energy sources (any one converter)
3. Simulation single phase or three phase SPWM technique for control of bridge inverter for an AC load
4. Simulation of a single-phase bridge inverter for an AC load
5. Simulation a feed-back compensator for a single-phase bridge inverter
6. Simulation of a feedback compensator for a flyback converter for Laptop charger /for LED lighting system /mobile phone charger or any other application.
7. Simulation of digital control of a DC-DC converter

EPS-III: (Virtual Power Lab experiments @https://www.vlab.co.in/broad-area-electrical-engineeringor any other simulation tools to be used)

1. To study the Synchronization of alternator with infinite bus bar.

2. To determine the direct axis reactance (Xd) and quadrature axis reactance (Xq) of synchronous machine.
3. To determine positive sequence, negative sequence and zero sequence reactances of an alternator.
4. To Study the over-current relay and the effect of PSM and TSM.
5. To determine the sub-transient (xd"), transient (xd') and steady state reactance (xd) of a synchronous machine.
6. To Study the Ferranti Effect of a transmission line/cable.
7. To study the differential Protection of a three phase delta-delta connected transformer.
8. To study the Protection of a three phase Induction Motor using Numerical Relay.

Microgrid/ Smart-grid:

1. Simulation of DC-DC Converters (unidirectional /Bidirectional) with Voltage mode control / current mode control for DC Microgrid application.
2. Simulation of DC-AC Converter (Inverter) with Voltage mode control / current mode control for AC Microgrid application.
3. Simulation of DC-AC Converter (Inverter) with grid connected mode operation for AC Microgrid application.
4. Simulation of power sharing between two (or more) DC-DC Converters in DC Microgrid scenario
5. Simulation of power sharing between two Inverters in AC Microgrid scenario
6. Simulation/Emulation of smart grid technologies

High voltage Engineering: (Virtual Power Lab experiments @https://www.vlab.co.in/broad-area-electrical-engineeringor any other simulation tools to be used)

1. Study of Impulse Voltage Generator
2. Parametric Analysis of Impulse Voltage Waveform
3. Study of Impulse Current Generator
4. Parametric Analysis of Impulse Current Waveform
5. Critical Flashover of a Sphere Gap using IVG
6. Study of Rectangular Pulse Current Generator
7. Functioning of Voltage Doubler
8. 3-Stage Cockroft Walton Voltage Multiplier
9. Application of High Voltage D.C. Test Source

Any other simulations / algorithms based on semester VII syllabus, which will help students to understand topic / concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on all the laboratory experiments carried out in **EEL702- Simulation Lab-III**

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL703	**Power Electronics Design Lab**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**2**		**1**	**1**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL703	**Power Electronics Design Lab**	---	---	---	---	--	**25**	**25**	**50**

Course Objectives	1. To provide hands on / skill-sets to model / design and implement the power electronics systems/ subsystems 2. To impart knowledge on practical aspects of power electronics converters design
Course outcomes	Upon successful completion of this course, the learner will be able to 1. Illustrate design of auxiliary circuits for Power Electronic systems. 2. Analyse the requirements, model and design a compensator for a power electronic converter. 3. Create a power electronic converter for a particular application. 4. Implement control algorithm for a power electronic converter in hardware / simulation platform

Suggested Power Electronics (PE) Design Lab exercises:

Group 1: PE Converter Hardware

1. Implementation of a Buck or Boost or Buck-Boost DC-DC converter for switched mode power supplies (any one converter)
2. Model and design of feed-back compensator for closed- loop control of Buck or Boost or Buck-Boost DC-DC converter for extraction of energy from renewable energy sources (any one converter)
3. Implement a single-phase bridge inverter for an AC load
4. Model and design a feed-back compensator for a single-phase bridge inverter
5. Model and design a feedback compensator for a flyback converter for Laptop charger /for LED lighting system /mobile phone charger or any other application.
6. Implement any power electronic converter for a specific application.

Group 2: PE Converter Control – Coding (programming)

1. Implement single phase or three phase SPWM technique for control of bridge inverter for an AC load
2. Implementation of microcontroller / DSP code for voltage mode control (VMC) of DC-DC converter
3. Implementation of microcontroller / DSP code for current mode control (CMC) of DC-DC converter
4. Implementation of microcontroller / DSP code for VMC/ CMC of an inverter
5. Implementation of microcontroller / DSP code for v/f control of induction motor / any other drive application
6. Implementation of any control coding for any PE Converter.

Group 3: Aux System / Protection / Heatsink

1. Design of Gate driver circuits for different power semi-conductor switches (Si devices or Wide band gap devices like SiC or GaN etc.)
2. Design of Snubber circuit and analysing its impact on the operation of switch used in PE converter or inverter
3. Design of heat sink for a PE converter and verify its thermal performance

4. Design AC/DC voltage and Current Sensing (isolated/ or non-isolated) circuit for feedback control of a PE converter
5. Design of over current / short circuit protection system for any PE converter
6. Design of any specific auxiliary systems commonly used in Power Electronic systems.

Term work Requirements:

a. Design / Modelling and Implementation of **minimum one exercise** from each group mentioned above (total three at least).
b. Detailed report including all the details of design / modelling and implementation (with photographs) shall be submitted as a part of term-work.
c. Institute shall arrange a visit to a Power Electronic industry or seminar (by students) based on survey of power electronic converters or power electronic systems for specific applications. Report for the same shall be submitted as a part of the term-work.

References Books:

1. Mohan, Ned. et.al, "Power Electronics Converters, Applications and Design", Wiley India Pvt. Ltd., New Delhi.
2. L. Umanand, Bhatt, "Design of Magnetic Components for Switched Mode Power Converters", John Wiley & Sons

Web Courses:

1. **NPTEL course:** Design of Power Electronic Converters, Prof. Shabari Nath, IIT Guwahati.
2. **NPTEL course:** Advanced Power Electronics and Control, Prof. Avik Bhattacharya, IIT Roorkee

Term work:

Term work shall consist of **minimum three exercises with detailed reports as mention in requirements**. The distribution of marks shall be as follows:

Lab Performance (design/ modelling/ implementation)	:15 marks
Industry Visit / Seminar Report	:05 marks
Attendance	:05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on experiments carried out in **EEL703**

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEP701	**Major Project - I**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**6$**	**--**	**3**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEP701	**Major Project - I**	--	--	--	--	--	50	-	50

$ indicates work load of Learner (Not Faculty)

Course Objectives	1. To design and develop a complex electrical/electronic/digital circuit/ interdisciplinary problem with practical relevance 2. To understand basic concepts of circuit/ system design while developing the project. 3. To enable the students to gain hands-on experience independently proposing and implementing the project and thus acquire the necessary confidence to deal with complex electrical/electronic/digital systems. 4. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Identify problems based on societal /research needs. 2. Apply Knowledge and skill to solve societal problems in a group. 3. Develop interpersonal skills to work as member of a group or leader. 4. Draw the proper inferences from available results through theoretical/ experimental/ simulations. 5. Analyse the impact of solutions in societal and environmental context for sustainable development. 6. Use standard norms of engineering practices 7. Excel in written and oral communication. 8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning. 9. Demonstrate project management principles during project work

Major Project -Topic Selection and Approval Guidelines

1. The group may be of maximum FOUR (04) students.
2. Students should propose project ideas & finalize the project idea in consultation with guide/ HOD. Students should select a problem which addresses some real life applications.
3. Students should identify different components/ devices, instruments, simulation/emulations software tools required for the project.
4. Students should submit implementation plan in the form of Gantt/ PERT/ CPM chart, which will cover weekly activity of project.
5. A log-book to be prepared by each group to record the work progress in terms of milestones per week by students. Weekly comment, remarks to be put by guiding faculty.

Application Domains:

List of key application domains from where students are encouraged to derive Major Projects topics (but not limited to):

1) Smart Agriculture solutions

2) Power converter applications in various Applications
3) IoT based applications in power systems
4) AI/ML applications in disaster management
5) Renewable Energy
6) Energy Conservation
7) Energy Storage
8) Battery Charging and Protection
9) Fire Safety
10) Electrical System Protection
11) Lighting Control
12) Wireless Power Transfer
13) Electrical Components Testing
14) Electrical Parameters Measurement
15) Non-conventional Electricity Generation
16) Laboratory Equipment
17) E-Mobility / Electric Vehicles
18) Video Surveillance Systems
19) Robotics for Hazardous applications
20) Waste Management System
21) Smart City Solutions
22) Smart Classrooms and learning Solutions
23) Design of Electrical Equipment
24) PLC based automation system
25) Power system Monitoring System

Students can identify the Major project topic either from above suggested domains or any other relevant electrical engineering domains. The inter-disciplinary nature of the project is also desirable.

Guidelines for Assessment of Major Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of major project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for Major Project- I shall be as below;
  - Marks awarded by guide/supervisor based on log book : 20
  - Marks awarded by review committee : 20
  - Quality of Project report : 10

Review/progress monitoring committee may consider following points for assessment as mentioned in general guidelines. Two reviews shall be conducted based on presentation given by students group based on the following criteria:

Assessment criteria of Major Project-I.

Major Project shall be assessed based on following criteria;

1. Quality of literature survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness

6. Societal impact
7. Innovativeness
8. Cost effectiveness
9. Effective use of skill sets
10. Effective use of standard engineering norms
11. Contribution of an individual's as member or leader
12. Clarity in written and oral communication

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEC801	**Electrical System Design, Management and Auditing**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		4	**--**	**4**	**--**	**4**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC801	**Electrical System Design, Management and Auditing**	**20**	**20**	**20**	**80**	**03**	**-**	**-**	**100**

Course Objectives	To impart knowledge of 1. Designing electrical distribution network 2. Electrical energy audit in the distribution system
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To do sizing, selecting transformer, switchgear and cable as required for distribution system 2. To illustrate Engineering knowledge in energy audit and energy efficient technologies to improve energy efficiency 3. Describe the energy conservation through energy monitoring and targeting 4. Analyse and Evaluate the energy audit data for targeting possible opportunities of energy saving

Module	Contents	Hours
1	Introduction: Types of electrical Projects, Types of electrical system, review of components of electrical system, different plans/ drawings in electrical system design, single line diagram in detail, Tendering, Estimation	05
2	Design of Power Distribution System: Different types of distribution systems and selection criteria, Electrical Earthing, Electrical load size, L.F, D.F, future estimates, substation equipment options, design considerations in transformer selection, sizing and specifications; Selection of HT/LT switchgears, metering, switchboards and MCC, protection systems, coordination and discrimination. IS standards applicable in above design	10
3	Selection / Sizing of Cable and Auxiliary system: Cables selection and sizing, cable installation and management systems, bus bars design; Basics of selection of emergency/backup supplies, UPS, DG Set, Batteries; Preliminary design of interior lighting system. IS standards applicable in above designs	07
4	Energy Monitoring and Targeting: Defining monitoring and targeting. Elements of monitoring and Targeting. Analysis techniques for energy optimization, Cumulative Sum of Differences (CUSUM), Electricity billing. Energy Management of Electrical Systems: Electrical load management and maximum demand control, Power factor improvement and its benefit, selection and location of capacitors, distribution and transformer losses.	10
5	Energy Audit: Introduction to Energy Conservation Act 2001, Energy Audit: Definition-need, Types of energy audit, Energy Management (audit) approach understanding energy costs, Bench marking, Maximizing system efficiencies, optimizing input energy requirement, fuel and energy substitution. Energy Audit instruments. Electrical Energy Performance Assessment: Motors and	10

	Variable Speed Drives, Lighting Systems. Basics of HVAC system assessment for electrical energy usage.	
6	**Energy Efficient Technologies:** Energy efficient BLDC Fans, Smart lighting system for indoor and outdoor applications, Maximum Demand controllers, Automatic Power Factor Controllers, Energy Efficient Motors, Soft starters, Variable Frequency Drives, Energy Efficient Transformer. Energy saving potential of each technology. Use of Energy Management system (EMS) and Building Management System (BMS).	10

Text Books:

1. Handbook of Electrical Installation Practice, Fourth Edition, by Geofry Stokes, Blackwell Science
2. Energy-Efficient Electric Motor, Third Edition, By Ali Emadi, New Marcel Dekker, Inc., 2005.
3. Electrical Energy Efficiency: Technologies and Applications by Andreas Sumper and Angelo Baggini, John Wiley & Sons, Ltd., 2012
4. Electrical Calculations and Guidelines for Generating Stations and Industrial Plants by Thomas E. Baker, CRC Publications, 2012
5. Electrical Installations Handbook, Third Edition, by Gunter Seip, MCD Verilag, 2000
6. Electrical Installation Designs, Fourth Edition by Bill Atkinson, Roger Lovegrove and Gary Gundry, John Wiley & Sons, Ltd, 2013.
7. Handbook of International Electrical Safety Practices, by Princeton Energy Resources International, Scrivener Publishing, 2010.
8. Designing with Light: Lighting Handbook, by Anil Valia, Lighting System
9. Energy Management Handbook||, by W.C. Turner, John Wiley and sons
10. Handbook on Energy Audits and Management||, by Amit Kumar Tyagi, TERI
11. Introduction to Efficient Electrical System Design, by Stephen Ayraud and Albert Thumann, The Fairmount Press

Reference Books:

1. Energy Auditing Made Simple||, by P. Balasubramanian, Seperation Engineers (P) Ltd
2. University of Mumbai, Electrical Engineering, Rev. 2016-17 Page 51
3. Electrical Installation Calculations: for Compliance with BS 7671:200, Fourth Edition, by Mark Coates, Brian Jenkins, John Wiley & Sons, Ltd, 2010
4. Energy Management Principles, by C.B. Smith, Peragamon Press
5. Energy Conservation Guidebook, by Dale R.Patrick, Stephon Fadro, E. Richardson, Fairmont Press
6. Handbook of Energy Audits||, by Albert Thumann, William J. Younger, Terry Niehus, CRC Press

Web Reference /Video Courses

1. http://www.energymanagertraining.com/
2. http://www.bee-india.nic.in/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8011	**Power Quality and FACTs**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8011	**Power Quality and FACTs**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To get awareness about non-linear loads in power system. 2. To understand the concept of Flexible AC Transmission System 3. To introduce the operation of various FACTS controllers.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Analyze the problems due to non-linear loads 2. Suggest the solution to improve power quality. 3. Illustrate the aspects of flexible ac transmission system over conventional ac transmission system and analyze the concept of load compensation. 4. Categorize the static shunt and series compensation for transmission line. 5. Outline the concept of voltage and phase angle regulators

Module	Contents	Hours
1.	Power Quality Introduction: Disturbances, Unbalance, Distortion, Voltage Fluctuations, Flicker, Quality Assessment	03
2.	Harmonics and its effects : Definition of harmonics, odd and even harmonics, Harmonic phase rotation and phase angle relationship, Causes of voltage and current harmonics, individual and total harmonic distortion with problems, Power assessment under waveform distortion with numerical. Effects of harmonics on rotating Machines, Transformers and Cables, Overloading of Neutral conductor	07
3.	Power quality improvement: Power factor when both voltage and current are sinusoidal, Power factor compensation using capacitor (vector diagram and numerical included), power factor when voltage is sinusoidal and current is non-sinusoidal (numerical included), Effect of capacitor compensation in power factor improvement under non-sinusoidal condition. Mitigation of harmonics- Passive filters- Advantages and disadvantages of passive filters- Active filters- shunt connection, series connection and hybrid connection, Instantaneous PQ theory.	10
4.	General concept of FACTS and Load Compensation: Transmission Interconnections, Flow of Power in AC system, What Limits the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of controllable Parameters, Basic Types of FACTS Controllers, Benefits from FACTS Technology, Objectives in load compensation, ideal compensator, Practical considerations, Power factor correction and Voltage Regulation in single phase systems	08
5.	Static shunt and series compensators: Objectives of shunt compensation, Methods of controllable VAR generation, Variable impedance type static Var generator (TCR, TSR, TSC, FC-TCR), Switching converter type Var	08

	generators, basic operating principle. Objectives of series compensation, Variable impedance type series compensation (only GCSC, TSSC and TCSC), Switching converter type series compensation (only SSSC)	
6.	**Static voltage and phase angle regulators-** Objectives of voltage and phase angle regulators- TCVR and TCPAR	03

Text Books:-

1. "Power System Harmonics" Jos Arrillaga, Neville R Watson
2. "Electric Power Quality" , G.T.Heydt
3. "Electric Power Systems and Quality" , Roger C. Dugan,Mark F. McGranaghan, H.Wayne Beatyd
4. "IEEE-519 Standard
5. 'Hingorani N.G.. & Gyugi L., —Understanding FACTS : Concepts and Technology of Flexible AC Transmission Systems,|| Wiley-1EEE Press.
6. Timothy J. E. Miller —Reactive power control in Electric Systems,|| Wiley India Edition.

Reference Books:-

1. "Power System Quality Assessment", J. Arrillaga, N.R.Watson, S.Chen
2. "Power Quality" , C. Shankaran, CRC press
3. "Reactive power control in electric systems" by Timothy J. E. Miller
4. "Power Quality Enhancement Using Custom Devices" Arindam Ghosh, Gerard Ledwich
5. "Power Electronics" Ned Mohan, Undeland, Robbins, John Wiley Publication
6. "Power System Analysis- Short Circuit Load Flow and Harmonics" J.C.Das.
7. "Flexible AC transmission system" by Yong Hua Song Institution of Electrical Engineers, London

Website Reference/ Video Courses:

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8012	**Automation and Control**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8012	**Automation and Control**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	To impart the fundamentals knowledge in the field of Automation and Control
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. Understand basic terminologies and concepts associated with Automation and Control 2. Demonstrate comprehension of various Robotic sub-systems 3. Understand kinematics and dynamics to explain exact working pattern of robots

Module	Contents	Hours
1.	**Introduction:** Basic concepts of Automation: Definition, three laws, DOF; Elements of Robotic Systems: Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance. Automation: Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Levels of Automations	06
2.	**Robot Grippers and Sensors:** Types of Grippers, Design aspects for gripper, Force analysis for various basic gripper system. Sensors for Robots: Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.	08
3.	**Drives and Control Systems:** Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems, Control Systems -Types of Controllers. Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Control System Components such as Sensors, Actuators and others.	06
4.	**Kinematics:** Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and Static forces in manipulators:-Jacobians, singularities, static forces, Jacobian in force domain. Dynamics:- Introduction to Dynamics, Trajectory generations	08
5.	**Machine Vision System:** Vision System Devices, Image acquisition, Masking, Sampling and quantization, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation. Robot Programming :- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands,	06

	subroutines.	
6.	**Modeling and Simulation for manufacturing Plant Automation:** Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.	05

Text Books:-

1. John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 04
2. Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.
3. Shimon Y. Nof, Handbook of Industrial Robotics, John Wiley Co, 01.
4. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
5. Industrial Automation: W.P. David, John Wiley and Sons

Reference Books:-

1. Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 02.
2. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8013	**Advanced Electric Drives**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8013	**Advanced Electric Drives**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	To impart the knowledge of 1. The advanced control techniques used in induction motor (IM) drives 2. The control of Sinusoidal Surface Permanent Magnet (SPM) synchronous machine (PMSM) drives
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. To select suitable V/f control scheme of IM based on the application. 2. To illustrate vector control and indirect vector control of IM. 3. To explain how to achieve sensorless vector control of IM. 4. To discuss various adaptive control schemes used in IM drives 5. To analyze direct torque control (DTC) used in induction motor drives. 6. To describe the speed control schemes used in PMSM drives

Module	Contents	Hours
1.	**Introduction:** Variable frequency operation of three phase symmetrical induction machine, Scalar control methods – Voltage fed inverter control: Open loop V/f control; Closed loop V/f control with slip regulation; Closed loop V/f control with torque and flux control, Current controlled voltage fed inverter drive, Current fed inverter drive with speed and flux control, Efficiency optimization control by flux program.	08
2.	**Vector control of Induction Motor (IM):** Introduction, Direct or feedback vector control, Flux vector estimation – Voltage model and current model, Indirect or feed forward vector control, Slip gain tuning, Stator flux oriented vector control.	10
3.	**Sensorless vector control of IM:** Slip calculation, Direct synthesis from state equations, Model Referencing Adaptive System (MRAS), Speed adaptive flux observer, Extended Kalman filter.	05
4.	**Adaptive control of IM:** Self tuning control, MRAC, Sliding mode control, Fuzzy control, Neural control.	05
5.	**Direct Torque and Flux Control of IM**: Conventional Direct torque and flux control (direct torque control (DTC)) of IM using switching table of inverter voltage vectors.	05
6.	**Synchronous Motor Drives:** Sinusoidal SPM Machine Drives: V/Hz control, self-control, Vector control.	06

Text Books:-

1. Modern Power Electronics and A.C. Drive||, B. K. Bose, PHI.
2. Electric Motor Drives: Modeling, Analysis and Control||, R.Krishnan,.PHI
3. Control of Electrical drives||, W. Leonhard, Springer-Verlag,

Reference Books:-

1. Power Semiconductor Controlled Drives||, G. K. Dubey, Prentice-Hall International.

2. Fundamentals of Electrical Drives||, G. K. Dubey, Narosa Publishing House.
3. Analysis of Electric Machinery||, P.C. Krause, McGraw Hill, New York

Website Reference/ Video Courses:

Assessment:
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8014	**High Power Switching Converters**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8014	**High Power Switching Converters**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To understand and select high power devices, gain knowledge about power modules, suitable packaging and latest market trends. 2. To understand and analyse high power converters and the protection needed for the converters. 3. To keep abreast with the latest technologies and research going on in different areas related to high power converters. 4. To enhance the knowledge of practical aspects in the design of Power Converters. 5. To deliver technological solution in the field of power electronics.
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. Analyze and understand high power devices and practical issues in implementing high power converters. 2. Understand protection aspects and design considerations to build proper power electronics systems. 3. Design closed loop control and discretize controllers for using digital control methods. 4. Analyze and design converters in the fields of drives, power generation and energy conversion, industrial applications, extraction of energy from renewable sources

Module	Contents	Hours
1.	High power switching devices: Review of high power devices - diodes, SCRs, GTOs and IGBTs-ratings and switching characteristics, view of power device market trend, series connected devices, voltage equalization techniques-static and dynamic, constraints in paralleling IGBTs, intelligent power modules, packages for high power devices, wide band gap devices.	04
2.	High power converters and Protection: Multi pulse controlled rectifiers-12 pulse, introduction to higher pulse controlled rectifiers, Cascaded H bridge multilevel inverters, Modular Multi level converters, Practical Aspects in Building Three-Phase Power Converters- Motor drives, Grid applications, Protection aspects-Over current, Over voltage, temperature, snubber design-component selection, basics of resonant snubber and regenerative snubber, numerical.	10
3.	Design considerations: Electrical specifications, Mechanical specifications, Environmental specifications, EMI/EMC specifications, Hardware specifications, Thermal Management, Selection of switching frequency, Selection of switching device and topology, control and isolation, cost.	06

4.	Closed-Loop control: Analog PWM controllers, Digital control-advantages, Signal conditioning and sampling, digital implementation of PWM modulator-single update and double update mode, PI & PR controller discretization, effect of computational delay, Processors in converter control, Grid synchronization techniques, introduction to non-linear control methods.	08
5.	High power AC drives: Line side requirements, motor side challenges, switching device constraints, converter configurations, control aspects, case studies of drive application.	05
6.	Grid interfaced converters: Requirements and challenges, high power grid interfaced converters, current control, voltage control, grid synchronization, filter design, dc link voltage control, case studies on grid interfacing of renewable energy sources.	06

Text Books:-

1. Dorin O. Neacsu, "Switching Power Converters, Medium and High Power", CRC press, Taylor & Francis group, second edition, 2017.
2. Bin Wu, "High Power Converters and AC drives", IEEE press, John Wiley & Sons.
3. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
4. Simon Ang, Alejandro Oliva, "Power-Switching Converters", Taylor and Francis group.
5. A Yazdani, R. Iravani, "Voltage- Sourced Converters in Power Systems", Wiley, IEEE press.
6. B. Jayant Baliga, "Silicon Carbide Power Devices", World Scientific, 2005.

Reference Books:-

1. R. Teodoresco, M. Liserrie,P. Rodr´ıguez "Grid Converters for Photovoltaic and Wind Power Systems", John Wiley and Sons.
2. L. Umanad, "Power Electronics: Essentials & Applications", Wiley.
3. V. Ramanarayanan, "Course Material on Switched Mode Power Conversion", 2007.
4. M. Jamil, M. Rizwan, D.P Kothari, "Grid Integration of Solar Photovoltaic Systems", CRC press, Taylor & Francis.
5. Peter Friedrichs, T. Kimoto, L. Ley and G. Pensl, "Silicon Carbide, Volume 2: Power Devices and Sensors", Wiley Publications, 2011.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8021	**Power System Planning and Reliability**	**Theory**	**Pract./Tut.**	**Theory**	**Pract /Tut.**	**Total**
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8021	**Power System Planning and Reliability**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	Student shall be able 1. To use reliability theory as a tool for decision support for design, operation and planning of electric power system. 2. To familiarize the students with various aspects of probability theory. 3. To acquaint the students with reliability and its concepts. 4. To introduce the students to methods of estimating the system reliability of simple and complex systems.
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. To explain the basic modelling of power system components for reliability evaluation and planning. 2. To describe load forecasting models for short-term and long-term power system planning. 3. To describe the methodologies to solve generation system reliability calculation and generation planning. 4. To describe how to calculate reliability indices for combined generation and transmission systems. 5. To carry out planning and reliability for distribution system.

Module	Contents	Hours
1.	Power System Planning and Load Forecasting: Objectives of power system planning, Short term, medium term and long term planning; Classification and characteristics of loads, Load forecasting methods: Extrapolation, Co-Relation Techniques; Energy forecasting, Weather load model, Peak load forecasting	08
2.	Basic Concepts of Reliabilit:y Failure analysis and Reliability parameters, Hazard models and Bath-tub curve, Series and Parallel Systems, Continuous Markov process, Frequency and Duration approach	08
3.	Generation Planning and Reliability: Generation system model, Capacity Outage Probability Table, Recursive algorithm for systems including derated states, Evaluation of Loss of Load Expectation, Evaluation of Loss of Energy Expectation	08
4.	Composite Generation and Transmission Systems: Radial configurations, Conditional probability approach, Network configurations System and load point indices, Application to practical systems	06
5.	Distribution Planning and Reliability: Evaluation techniques, Additional interruption indices, Application to radial systems	06
6.	Impact of Renewable Energy penetration: Impact analysis of high renewable energy penetration on stability and reliability of power system. Case studies based on Solar PV and Wind generation loss.	05

Text / Reference Books:-

1. Power System Planning - R.N. Sullivan, Tata McGraw Hill Publishing Company Ltd.
2. Modern Power System Planning - X. Wang & J.R. McDonald, McGraw Hill Book Company.
3. Electrical Power Distribution A.S. Pabla Tata McGraw Hill Publishing Company Ltd.
4. Reliability Evaluation of Engineering System - Roy Billinton & Ronald N. Allan, Springer Publication.
5. Reliability Evaluation of Power System - Roy Billinton & Ronald N. Allan, Springer Publication.
6. Electrical Power Distribution Engineering - T. Gonen, McGraw Hill Book Company.

Website Reference/ Video Courses:

1. **NPTEL Course:** Operation and Planning of Power Distribution Systems By Prof. Sanjib Ganguly, IIT Guwahati

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8022	**Lighting System Design**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8022	**Lighting System Design**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To introduce various laws of illumination, lighting parameters, light sources, luminaries and their characteristics to be used for lighting design. 2. To introduce lighting design considerations for interior and exterior applications. 3. To adapt to the LED based solid state lighting with different lighting control technologies and standards.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Identify and describe the various laws of illumination, lighting parameters, light sources, luminaries and their Photometric characteristics. 2. Identify and describe various LED lighting components / subsystems, thermal management and lifetime studies. 3. Formulate and design an Interior Lighting system through standards, design considerations and calculation for different application areas. 4. Formulate and design an Exterior Lighting system through standards, design considerations and calculation for different application areas. 5. Identify and describe different Lighting Control schemes. 6. Identify and describe Solid-State Lighting technology, it's applications in Lighting for health and safety and solar powered schemes.

Module	Contents	Hours
1.	Introduction: Review of Light, Color and Photometry: Laws of illumination, illumination entities. Radiometric and photometric standards, Photometric measurement procedure-assessment of lamp efficacy, Color temperature, Colorimetry- Measurement of CRI, Glare, Solid-State Lighting: Drivers for LED lamps, standards and regulations, LED luminaries, LED Light Distributions,	04
2.	Lamps and Luminaries: Lamp: Review of development, construction and characteristics: Incandescent lamp, Discharge lamps, induction lamp, and LED lamp; LED Lighting Components and Subsystems, OLEDs, light-emitting polymers (LEPs) Thermal Management and Lifetime Studies; Luminaire: optical control, Control gear: ballast, standard and electronic, Luminaries photometry, Luminaire testing procedures	08
3.	Interior Lighting Design & Calculation: Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Indoor lighting design by lumen method, by point by point method. Applications: residential, educational institute, industries, sports centers, commercial premises: retail stores, offices etc. Applicable standards.	12
4.	Exterior Lighting Design & Calculation: Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Applicable standards	06

5.	**Lighting Control:** Introduction to Lighting Control, Controls, Selection of Lighting Controls, Design of Lighting Control Scheme, Lighting and LEED, Daylighting control, Controlling LED Lighting Systems, Smart Lighting Fixtures, Digital Lighting Networks, DMX control.	04
6.	**Recent trends in Lighting:** Smart Street Lighting with Remote Monitoring and Control System, Solar Powered LED Lighting, Tunable White Lighting and RGB LED based Colored Lighting. Lighting for health and safety, Circadian Rhythm and Human Centric Lighting. DC Microgrid based Lighting System	05

Text Books:-

1. Anil Valia, Designing with Light – A Lighting Handbook, International Lighting Academy
2. M. Nisa Khan, Understanding LED Illumination, CRC Press 2013
3. Anil Valia, LED LIGHTING SYSTEMS All you need to know, International Lighting Academy
4. National Lighting Code- 2011
5. Kao Chen, Energy Management in Illumination Systems, CRC Press.
6. John L. Fetters, The Hand Book of Lighting Surveys and Audits, CRC Press.

Reference Books:-

1. Illuminating Engineering Society, —The IES Lighting Handbook, 10th Edition
2. J. L. Lindsey and S. C. Dunning, —Applied Illumination Engineering, Third Edition, Fairmont Press, 2016
3. Lamps and Lighting – Edited by J.R. Coaton and A.M. Marsden, 4th Edition
4. Lighting for health and safety – N.A. Smith, Butterworth-Heimann.
5. Human Factors in Lighting – Peter R. Boyce, Taylor & Francis.

Website Reference/ Video Courses:

1. **NPTEL Course:** Illumination Engineering, Prof. N.K. Kishore**,** IIT Kharagpur

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8023	**Cyber Physical Systems**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8023	**Cyber Physical Systems**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To understand design, and analysis of cyber-physical systems - the tight integration of computing, control, and communication. 2. To explore various applications for CPS like in smart-grids, smart buildings, electric vehicle systems etc.
Course outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Understand the Cyber-Physical Systems in the real world with hardware and software platforms. 2. Illustrate various automated control design aspects 3. Describe various methods of safety assurance in CPS 4. Correlate the safety aspects and attack related issues in CPS 5. Illustrate the impact of attack and defense against on CPS deployment in the fields like smartgrid, vehicular systems etc.

Module	Contents	Hours
1.	Introduction: Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS; CPS HW platforms: Processors, Sensors, Actuators, CPS Network, CPS SW stack RTOS, Scheduling Real Time control tasks.	06
2.	CPS Hardware platforms: Embedded systems, Hybrid systems, Control theory and systems, Computer-aided verification and synthesis, Complex networks, Programming models, Application areas: Transportation, medical devices, aerospace	08
3.	CPS software components: Mapping software components to ECUs, CPS Performance Analysis: effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion	06
4.	Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques. Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise.	06
5.	Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis: Basic introduction and examples, Timed and Hybrid Automata, Definition of trajectories, zenoness, Formal Analysis: Flow pipe construction, reachability analysis, Analysis of CPS Software, Weakest Pre-conditions, Bounded Model checking	08
6.	Secure Deployment of CPS: Attack models, Secure Task mapping and Partitioning, State estimation for attack detection; Case study: Vehicle ABS hacking, Power Distribution; Case study: Attacks on Smart grid.	05

Text Books:-

1. Lee, Edward Ashford, and Sanjit Arunkumar Seshia, Introduction to embedded systems: A Cyber-physical systems Approach, Lee & Seshia, 2011.
2. Alur, Rajeev, Principles of Cyber-Physical Systems, MIT Press, 2015.\
3. Raj Rajkumar, Dionisio de Niz and Mark Klein, Cyber-Physical Systems, Addison Wisley, 2017
4. Wolf, Marilyn. High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing. Elsevier, 2014**.**
5. T. D. Lewis "Network Science: Theory and Applications", Wiley, 2009.
6. P. Tabuada, "Verification and control of hybrid systems: a symbolic approach", Springer-Verlag 2009.
7. C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007.
8. Constance Heitmeyer and Dino Mandrioli, "Formal methods for real-time computing", Wiley publisher, 1996

Assessment:
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEDO8024	**Electric Vehicle System Design**	Theory	Pract./Tut.	Theory	Pract /Tut.	Total
		3	**--**	**3**	**--**	**3**

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEDO8024	**Electric Vehicle System Design**	**20**	**20**	**20**	**80**	**03**	**--**	**-**	**100**

Course Objectives	1. To illustrate the design philosophies used in the EV domain. 2. To explore the selection of power and control architecture of EV drives 3. To study the design aspects of EV battery packs and other auxiliary systems
Course outcomes	**Upon successful completion of this course, the learner will be able to** 1. To select and size the electric motor for a particular EV application and performance criteria 2. To select and size the battery pack to meet desired EV performance and 3. To design the EV drive system with functional safety considerations. 4. To illustrate the use of hybrid energy source for EV performance improvement 5. To illustrate the design aspects of Automotive Subsystem 6. To design the EV chargers and charging infrastructure

Module	Contents	Hours
1.	**Selection and Sizing of EV Electric Motors:** Electric Vehicle modelling, Tractive force calculations, Design considerations for 2Wand 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit. Vehicle Power Demand during Driving Cycles. Application Examples of EV /HEV motors with vehicles and motor specifications.	07
2.	**Selection and Sizing of Energy Storage for EV:** Selection of type of Battery pack for 2W and 4W EVs; Battery pack sizing: Design considerations: Range per charge, range anxiety, EV motor power requirement; Impact of road conditions, environmental conditions and traffic conditions. Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis.	08
3.	**Automotive Subsystem Design:** Electronic Control Unit (ECU) and its Control Features, Communications between ECUs. Acceleration and braking control, regenerative braking; Automotive Steering Systems. Design considerations of HVAC controller	06
4.	**EV System integration:** EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements.	04
5.	**Design of EV Chargers:** Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities. Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards	08
6.	**Functional Safety of Automotive Electronics:**	06

	Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262. Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event.	

Text / Reference Books:-

1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines and Drives Design, Analysis and Application by K. T. Chau, IEEE Press and Wiley, 2015
3. I. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press. 2005
5. Sheldon Williamsom, Energy Management Strategies for Electric and Plug-in Hybrid Vehicles, Springer 2013
6. J. Larminie and J. Lowry, Electric Vehicle Technology Explained, Wiley, 2003
7. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018

Website Reference/ Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by Prof. Amit Kumar Jain D IIT Delhi
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics, by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras,
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati
4. Infineon's IGBT Simulation Tools: https://www.infineon.com/cms/en/tools/landing/igbt.html
5. Semikron Semisel: https://www.semikron.com/service-support/semisel-simulation.html

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8021	**Project Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8021	**Project Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques. 2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Apply selection criteria and select an appropriate project from different options. 2. Write work break down structure for a project and develop a schedule based on it. 3. Identify opportunities and threats to the project and decide an approach to deal with them strategically. 4. Use Earned value technique and determine & predict status of the project. 5. Capture lessons learned during project phases and document them for future reference

Module	Contents	Hours
1	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)	05
2	**Initiating Projects:** How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics.	06
3	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface; Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).	08
4	**Planning Projects:** Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	06

5	**5.1 Executing Projects:** Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings **5.2 Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit **5.3 Project Contracting** Project procurement management, contracting and outsourcing,	08
6	**6.1 Project Leadership and Ethics:** Introduction to project leadership, ethics in projects, Multicultural and virtual projects **6.2 Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	06

References:

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Project Management, Gido Clements, Cengage Learning
4. Project Management, Gopalan, Wiley India
5. Project Management, Dennis Lock, 9th Edition, Gower Publishing England

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8022	**Finance Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8022	**Finance Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques. 2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Understand Indian finance system and corporate finance 2 Take investment, finance as well as dividend decisions

Module	Contents	Hours
1	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
2	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
3	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09

4	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	10
5	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
6	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

References:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8023	**Entrepreneurship Development and Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8023	**Entrepreneurship Development and Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To acquaint with entrepreneurship and management of business 2 Understand Indian environment for entrepreneurship 3 Idea of EDP, MSME
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Understand the concept of business plan and ownerships 2 Interpret key regulations and legal aspects of entrepreneurship in India 3 Understand government policies for entrepreneurs

Module	Contents	Hours
1	**Overview of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
2	**Business Plans and Importance of Capital to Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship and Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
3	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
4	**Indian Environment for Entrepreneurship:** key regulations and legal aspects, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc.	08
5	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08

6	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	05

References:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8024	**Human Resource Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8024	**Human Resource Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To introduce the students with basic concepts, techniques and practices of the human resource management 2 To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations 3 To familiarize the students about the latest developments, trends & different aspects of HRM 4 To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Understand the concepts, aspects, techniques and practices of the human resource management. 2 Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective. 3 Gain knowledge about the latest developments and trends in HRM. 4 Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Contents	Hours
1	**Introduction to HR** • Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions • Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues	05
2	**Organizational Behaviour (OB)** • Introduction to OB Origin, Nature and Scope of Organizational Behaviour, Relevance to Organizational Effectiveness and Contemporary issues • Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness • Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behaviour • Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor); • Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development, Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	07

3	**Organizational Structure &Design** • Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. • Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. • Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	06
4	**Human resource Planning** • Recruitment and Selection process, Job-enrichment, Empowerment – Job Satisfaction, employee morale • Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning Training & Development: Identification of Training Needs, Training Methods	05
5	**Emerging Trends in HR** • Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR. Organizational Change, Culture, Environment • Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation	06
6	**HR & MIS:** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM:** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations:** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

References:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, 2016, Pearson Publications

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3, then part (b) will, be from any module other than module 3)

4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8025	**Professional Ethics and Corporate Social Responsibility (CSR)**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8025	**Professional Ethics and Corporate Social Responsibility (CSR)**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To understand professional ethics in business 2 To recognized corporate social responsibility
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Understand rights and duties of business 2 Distinguish different aspects of corporate social responsibility 3 Demonstrate professional ethics 4 Understand legal aspects of corporate social responsibility

Module	Contents	Hours
1	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
2	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
3	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
4	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
5	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
6	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

References:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8026	**Research Methodology**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8026	**Research Methodology**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To understand Research and Research Process 2 To acquaint students with identifying problems for research and develop research strategies 3 To familiarize students with the techniques of data collection, analysis of data and interpretation
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Prepare a preliminary research design for projects in their subject matter areas 2 Accurately collect, analyze and report data 3 Present complex data or situations clearly 4 Review and analyze research findings

Module	Contents	Hours
1	**Introduction and Basic Research Concepts** **1.1** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology **1.2** Need of Research in Business and Social Sciences **1.3** Objectives of Research **1.4 Issues** and Problems in Research **1.5** Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	09
2	**Types of Research** **2.1**. Basic Research **2.2**. Applied Research **2.3.** Descriptive Research **2.4.** Analytical Research **2.5**. Empirical Research **2.6** Qualitative and Quantitative Approaches	07
3	**Research Design and Sample Design** **3.1** Research Design – Meaning, Types and Significance **3.2** Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	07

4	**Research Methodology** **4.1** Meaning of Research Methodology **4.2**. Stages in Scientific Research Process: **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f.** Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report	08
5	**Formulating Research Problem** **5.1** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	04
6	**Outcome of Research** **6.1** Preparation of the report on conclusion reached **6.2** Validity Testing & Ethical Issues **6.3** Suggestions and Recommendation	04

References:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8027	**IPR and Patenting**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8027	**IPR and Patenting**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To understand intellectual property rights protection system 2 To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures 3 To get acquaintance with Patent search and patent filing procedure and applications
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 understand Intellectual Property assets 2 assist individuals and organizations in capacity building 3 work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Contents	Hours
01	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
04	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc.), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08

06	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

REFERENCE BOOKS:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellectual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting, Interpretation of Patent Specifications and Claims, New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8028	**Digital Business Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8028	**Digital Business Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 To familiarize with digital business concept 2 To acquaint with E-commerce 3 To give insights into E-business and its strategies
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Identify drivers of digital business 2 Illustrate various approaches and techniques for E-business and management 3 Prepare E-business plan

Module	Content	Hours
1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts, Difference between physical economy and digital economy. **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services), Opportunities and Challenges in Digital Business	09
2	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system **Application Development:** Building Digital business Applications and infrastructure	06
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, managing Risks in e –business, Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06

5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
6	**Materializing e-business:** From Idea to Realization-Business plan preparation Case Studies and presentations	08

References:

1. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade, Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective- DoI:10.1787/9789264221796-enOECD Publishing

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then, part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEIO8029	**Environmental Management**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	**--**	**3**	**--**	**3**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEIO8029	**Environmental Management**	**20**	**20**	**20**	**80**	**3**	**--**	**--**	**100**

Course Objectives	1 Understand and identify environmental issues relevant to India and global concerns 2 Learn concepts of ecology 3 Familiarise environment related legislations
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1 Understand the concept of environmental management 2 Understand ecosystem and interdependence, food chain etc. 3 Understand and interpret environment related legislations

Module	Contents	Hours
1	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	10
2	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
3	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
4	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	10
5	Total Quality Environmental Management, ISO-14000, EMS certification.	05
6	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

References:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, **T V Ramachandra and Vijay Kulkarni, TERI Press**
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000

6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL801	**Electrical System Design and Audit Lab**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**2**		**1**	**1**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL801	**Electrical System Design and Audit Lab**	---	---	---	---	--	**25**	**25**	**50**

Course Objectives	To explore the effectiveness of various energy efficient technologies from design and utilization perspective.
Course outcomes	Upon successful completion of this course, the learner will be able: 1. Prepare the SLD for electrical system 2. Evaluate the energy efficiency of the electrical systems 3. Size and select the cable for electrical distribution network 4. Analyse the impact of various energy efficient technologies 5. Illustrate the impact of fuel substitution on energy consumption 6. Design energy efficient electrical system

Syllabus: Same as that of Courses of Sem-VIII EEC801: Electrical System Design, Management and Auditing

Suggested List of Tutorials/Case Studies/ Experiments

1) Tutorial on developing of Single line diagram of your own house
2) Tutorial on illumination system for the given installation
3) Tutorial on EELD (Energy Efficient Lighting Design) in comparison to Standard lighting design in terms of LPD
4) Tutorial on designing of power distribution network for a given installation
5) Tutorial on sizing and selection of Cables for electrical distribution network
6) Tutorial Motor retrofitting by Energy Efficient Motor
7) Tutorial on CUSUM analysis of a given installation
8) Case Study on analysing the effectiveness of power factor improvement towards improving energy efficiency
9) Case Study on analysing effectiveness of VFD in comparison to Damper control
10) Case study on fuel substitution
11) Experimentation to analyse energy efficiency of VFD based Pumping System
12) Experimentation to analyse energy efficiency of different lamps (T5, T8, CFL, and LED lamp)
13) Experimentation to analyse the effectiveness of power factor improvement based installation
14) Conduction of preliminary audit of any section / facility/ department of engineering institute or nearby industry
15) Conduction of detailed audit of any section / facility/ department of engineering institute or nearby industry

Any other experiment/ case study / tutorial based on the syllabus which will help students to understand the topic/concept.

Term work:

Term work shall consist **of minimum eight tutorials /case studies/ experiments**.

The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire syllabus of '**EEC801: Electrical System Design, Management and Auditing' and EEL801**

ELECTRICAL ENGINEERING - SEMESTER-VII						
Course code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEL802	**Measurement and Instrumentation Lab**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	**2**		**1**	**1**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEL802	**Measurement and Instrumentation Lab**	---	---	---	---	--	**25**	**25**	**50**

Course Objectives	1. To get acquainted with analog and digital measurement and instrumentation 2. To illustrate the challenges in real time measurements
Course outcomes	Upon successful completion of this course, the learner will be able to 5. Understand the construction, principle and characteristics of different types of digital measuring instruments 6. Apply the knowledge about different instruments and can identify the best suitable instrument for a required typical measurement. 7. Learn about the digital programming of different types of circuits. 8. Understand the conversion of digital to analog signal and vice versa.

Suggested list of experiments:

1. Experiment demonstrating concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.
2. Experiment demonstrating errors in measurements.
3. Measurements of R, L and C using bridge or LCR meter
4. Measurement of very low and high resistance
5. Experiment with Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.
6. Measurement of Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers, Hall Sensors.
7. Measurement of high voltage /current
8. Isolated and un-isolated measurement
9. Use of Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
10. Use of DSO to capture transients like a step change in R-L-C circuit.
11. Usage of DSO for steady state periodic waveforms produced by a function generator. Selection of trigger source and trigger level, selection of time-scale and voltage scale. Bandwidth of measurement and sampling rate.
12. Download of one-cycle data of a periodic waveform from a DSO and use values to compute the RMS values using a C program.
13. Analog Signal processing and Digital Signal Processing
14. Measurement and instrumentation using microcontroller boards like Aurdino/pic18F/ MSP430

Any other experiment related to measurement and instrumentation can be conducted.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference
1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Reference books:

1. Alan S Morris (2001), Measurement and Instrumentation Principles, 3rd/e, Butterworth Hienemann
2. David A. Bell (2007), Electronic Instrumentation and Measurements 2nd/e, Oxford Press
3. S. Tumanski (2006), Principle of Electrical Measurement, Taylor & Francis
4. Ilya Gertsbakh (2010), Measurement Theory for Engineers, Springer

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on all the laboratory experiments carried out in **EEL802- Measurement and Instrumentation Lab**

ELECTRICAL ENGINEERING - SEMESTER-VIII						
Course Code	Course Name	Teaching scheme (Contact Hours)		Credits Assigned		
EEP801	**Major Project - II**	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		--	12$	--	6	6

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEP801	**Major Project - II**	--	--	--	--	--	**100**	**50**	**150**

$ indicates work load of Learner (Not Faculty)

Course Objectives	5. To design and develop a moderately complex electrical/electronic/digital circuit with practical applications. 6. To understand basic concepts of circuit design while developing the project. 7. To enable the students to gain hands-on experience independently proposing and implementing the project and thus acquire the necessary confidence to deal with complex electrical/electronic/digital systems.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 10. Identify problems based on societal /research needs. 11. Apply Knowledge and skill to solve societal problems in a group. 12. Develop interpersonal skills to work as member of a group or leader. 13. Draw the proper inferences from available results through theoretical/ experimental/ simulations. 14. Analyse the impact of solutions in societal and environmental context for sustainable development. 15. Use standard norms of engineering practices 16. Excel in written and oral communication. 17. Demonstrate capabilities of self-learning in a group, which leads to life-long learning. 18. Demonstrate project management principles during project work

<u>Guidelines for Assessment of Major Project- II:</u>

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of major project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for Major Project- I shall be as below;
  - Marks awarded by guide/supervisor based on log book : 40
  - Marks awarded by review committee : 40
  - Quality of Project report : 20

Review/progress monitoring committee may consider following points for assessment as mentioned in general guidelines. Two reviews shall be conducted based on presentation given by students group based on the following criteria:

<u>Assessment criteria of Major Project-II.</u>

Major Project shall be assessed based on following criteria;

13. Quality of literature survey/ need identification
14. Clarity of Problem definition based on need.
15. Innovativeness in solutions
16. Feasibility of proposed problem solutions and selection of best solution
17. Cost effectiveness
18. Societal impact
19. Innovativeness
20. Cost effectiveness
21. Effective use of skill sets
22. Effective use of standard engineering norms
23. Contribution of an individual's as member or leader
24. Clarity in written communication

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines.

Oral Examination:

Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the University of Mumbai. Students should be motivated to publish a paper in Conferences/students competitions based on the work.

Major Project II shall be assessed based on following points:

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication