Item No. - 124
AC- 23/7/2020

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. - 124
AC- 23/7/2020

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Second Year B.E. Electrical Engineering**
2	Eligibility for Admission	**After Passing First Year Engineering as per the Ordinance 0.6242**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6242**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New** / ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year: 2020-2021**

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 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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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 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	SBL-I: Applied Electrical Engineering Lab	--	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	SBL-I: Applied Electrical Engineering Lab	--	--	--	--	--	50	--	50
EEM301	Mini Project – 1A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**175**	**100**	**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	SBL-II : PCB Design and Fabrication Lab	--	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	SBL-II: PCB Design and Fabrication Lab	--	--	--	--	--	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

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

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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	Total
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	**The course is aimed:** 1. To familiarize with the Laplace Transform, Inverse Laplace Transform of various functions, and its applications. 2. To acquaint with the concept of Fourier Series, its complex form and enhance the problem solving skills 3. To familiarize the concept of complex variables, C-R equations, harmonic functions, its conjugate and mapping in complex plane. 4. To understand the basics of Linear Algebra and its applications 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. Apply the concept of Laplace transform to solve the real integrals in engineering problems. 2. Apply the concept of inverse Laplace transform of various functions in engineering problems. 3. Expand the periodic function by using Fourier series for real life problems and complex engineering problems. 4. Find orthogonal trajectories and analytic function by using basic concepts of complex variables. 5. Illustrate the use of 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.	**07**

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.	**07**
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.	**07**
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. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
2. 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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	Total
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**-**	**-**	**-**	**100**

Course Objectives	**The course is aimed:** 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.	**09**
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.	**06**
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.	**06**

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	**The course is aimed:** 1. To study the concepts of magnetism and energy conversion. 2. To familiarize with the operational characteristics of DC machines and their applications. 3. To learn the 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 and analyze the significance of the DC machines performance parameters. 3. Implement various starting methods and speed control methods for DC machines applications 4. Evaluate the working of various sensors, transducers and analog / digital instruments used in electrical and electronic measurements. 5. Analyze the use and 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.	**05**
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.	**09**
3	**DC Machines:** Review of construction and components of DC machine, commutator and brushes, concept of back EMF, and torque equations, Types of DC machines; Armature reaction, Characteristics of DC generators 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.	**08**
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.	**08**

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	**The course is aimed:** 1. To learn basics of electrical power systems and its different components. 2. To acquaint 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. Study 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.	**06**
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).	**06**
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).	**05**
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	**The course is aimed:** 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. Analyze the performance of various rectifiers and filter circuits. 2. Illustrate the use DC and AC parameters of BJT in analysis of amplifier circuits. 3. Apply the knowledge of MOSFET's DC/ AC parameters in analysis of amplifier and switching applications of MOSFET. 4. Understand the functioning of OP-AMP and design OP-AMP based circuits. 5. Illustrate the 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).	**05**
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 H-parameter Model and r_e 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. Introduction BJT's hybrid-pi model.	**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).	**07**

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)	**05**
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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	**Total**
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	**The course is aimed:** 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 all the experiments carried out & Oral examination will be based on entire syllabus of **EEC305 Analog Electronics.**
The distribution of marks for practical/ oral examination shall be as follows:

- Practical Exam : 15 marks
- Oral Exam : 10 marks

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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	**Total**
Test-I	Test-II	Average						
-	**-**	**-**	**-**	**-**	**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 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 all the 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-I) 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	**The course is aimed:** 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. Illustrate the understanding of Repair and maintenance of common electrical 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.**	**06**

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)**	**10**

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	**The course is aimed:** 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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract.	Oral	**Total**
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 study the 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 study the probability distributions and expectations. 4. To acquaint with the concepts of vector spaces used in the field of machine learning and engineering problems. 5. To familiarize with the concepts of Quadratic forms and Singular value decomposition. 6. To learn 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. Demonstrate the use of Correlation and Regression to the engineering problems in data science, machine learning and AI. 3. Illustrate understanding of 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 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.	**07**

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:** 2.1 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.	**07**
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.	**07**
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. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
2. 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	**The course is aimed:** 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 the 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	**07**
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.	**06**
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	**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. 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	**The course is aimed:** 1. To understand working of logic families and logic gates. 2. To study the 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 conversion of various 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. Illustrate the use of PLDs to implement the given logical problem.

Module	Detailed Contents	Hours
1	**Fundamentals of Digital Systems and Logic families:** 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	**07**
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	**10**
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.	**05**

	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)	**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. 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: Digital Electronic Circuits By Prof. Goutam Saha (IIT Kharagpur)**
   https://swayam.gov.in/nd1_noc20_ee32/preview
2. **Course: Digital Circuits and Systems - Video course By Prof. S. Srinivasan (IIT Madras)**
   https://nptel.ac.in/courses/117/106/117106086/

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	**The course is aimed:** 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	**07**
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	**06**

	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.	**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.	**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. 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**

Semester IV								
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	**The course is aimed:** 1. To learn the history of electric hybrid electric vehicles (EV & HEV) and emphasize the need and importance of EV-HEV for sustainable future. 2. To study the fundamental concepts and principles of electric and hybrid electric vehicles drive train topologies 3. To develop a thorough understanding of the key elements of EV/HEV: Electric Machines for Propulsion Applications and Energy Sources 4. To 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.	**07**
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.	**05**
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	**10**

	energy sources for EV/HEV, hybridization of different energy sources. EV battery chargers: AC and DC, Fast chargers and related 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.	**08**
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			
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	Term Work	Pract./ Oral	Oral	**Total**
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 / Oral Examination:

Practical exam will be based on all the laboratory experiments carried out and Oral examination will be based on entire syllabus of **EEC402-Electrical AC Machines-I**
The distribution of marks for practical examination shall be as follows:

- Practical Exam : 15 marks
- Oral Exam : 10 marks

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	**The course is aimed:** 1. To introduce core programming basics and program design with functions using Python programming language. 2. To study the use of procedural statements like assignments, conditional statements, loops and function calls. 3. To learn the supported data structures like lists, dictionaries and tuples in Python. 4. To 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. Illustrate the skill of object oriented programming in Python to develop applications in electrical engineering 4. Understand different File handling operations 5. Understand the design of 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.	**04**

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.

Practical/ Oral Examination:

Practical / Oral examination will be based on all the lab experiments carried out and the entire syllabus of EEL402- Python Programming Lab. The distribution of marks for practical examination shall be as follows: Practical Exam- 15 marks and Oral Exam -10 marks.

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	**The course is aimed:** 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 5. Realize the implementation of digital interface with power electronics converters

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 all 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**

The distribution of marks for practical examination shall be as follows:

- Practical Exam : 15 marks
- Oral Exam : 10 marks

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	**The course is aimed:** 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.	**06**
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.	**10**
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	**The course is aimed:** 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

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