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UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17
Under

FACULTY OF TECHNOLOGY

Electrical Engineering

Second Year with Effect from **AY 2017-18**
Third Year with Effect from **AY 2018-19**
Final Year with Effect from **AY 2019-20**

As per **Choice Based Credit and Grading System**
with effect from the AY 2016–17

From Co-coordinator's Desk:

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 Technology of University of Mumbai, has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's), course objectives and course outcomes 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. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of Studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enable 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, not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes. Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. **Choice Based Credit and Grading System** were implemented for First Year of Engineering (Undergraduate) from the academic year 2016-2017. Subsequently this system will be carried forward for Second Year of Engineering (Undergraduate) in the academic year 2017-2018 and so on.

Dr. Suresh K. Ukarande
Coordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and to achieve recognition of the institution or program meeting certain specified standards. The main-focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as a Chairman, Board of Studies in Electrical Engineering of University of Mumbai, happy to state here that, Program Educational Objectives (PEOs) were finalized for undergraduate program in Electrical Engineering, more than ten senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs and POs of undergraduate program in Electrical Engineering are listed below;

Program Educational Objectives (PEOs)

- *Graduates will have successful career in industry or pursue higher studies to meet future challenges of technological development.*
- *Graduates will develop analytical and logical skills that enable them to analyze and design Electrical Systems and their Controls.*
- *Graduates will achieve professional skills to expose themselves by giving an opportunity as an individual as well as team.*
- *Graduates will undertake research activities in emerging multidisciplinary fields.*

Program Outcomes (POs)

- **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

- **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Dr. S. R. Deore,
Chairman,
Board of Studies in Electrical Engineering,
Member - Academic Council
University of Mumbai

Program Structure for
SE Electrical Engineering
University of Mumbai
(With Effect from 2017-18)

Scheme for Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EEC401	Applied Mathematics - IV	4	-	1	4	-	1	5
EEC402	Power System - I	3	-	1	3	-	1	4
EEC403	Electrical Machines – II	4	-	-	4	-	-	4
EEC404	Electromagnetic Field and wave Theory	3	-	1	3	-	1	4
EEC405	Analog and Digital Integrated Circuits	3	-	-	3	-	-	3
EEC406	Electrical Network	3	-	1	3	-	1	4
EEL401	Simulation Lab - I	-	2	-	-	1	-	1
EEL402	Electrical Machines Lab - II	-	2	-	-	1	-	1
EEL403	Electronics Lab - II	-	2	-	-	1	-	1
EEL404	Electrical Workshop	-	2	-	-	1	-	1
Total		**20**	**8**	**4**	**20**	**4**	**4**	**28**

Examination Scheme for Semester IV

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term Work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
EEC401	Applied Mathematics - IV	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC402	Power System - I	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC403	Electrical Machines - II	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC404	Electromagnetic Field and wave Theory	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC405	Analog and Digital Integrated Circuits	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC406	Electrical Network	80	32	20	8	25	10	-	-	-	-	-	-	125
EEL401	Simulation Lab - I	-	-	-	-	25	10	-	-	25	10	-	-	50
EEL402	Electrical Machines Lab - II	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL403	Electronics Lab - II	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL404	Electrical Workshop	-	-	-	-	25	10	-	-	25	10	-	-	50
Total		**480**	**-**	**120**	**-**	**200**	**-**	**-**	**-**	**50**	**-**	**50**	**-**	**900**

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC401	**Applied Mathematics-IV (abbreviated as AM-IV)**	**4**	**1**	**4**	**1**	**5**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs)		
		Test 1	Test 2	Avg				
EEC401	Applied Mathematics-IV	20	20	20	80	3	25	125

Course Objectives	• To develop analytical insight of the student to prepare them for graduates studies in Electrical Engineering. • To enhance their ability to solve and analyze Electrical Engineering problem. • To provide students with a strong mathematical foundation to acquire the professional competence knowledge and skills.
Course Outcomes	Students will be able • To develop the proactive approach towards the selection of methods to a solution of engineering problems. • To identify different probability distribution, learn sampling technique, compute Eigen values and Eigen vectors and evaluate complex integrals and use their application in Electrical Engineering problems.

Pre-requisites:
Basics of Complex numbers, Analytic Function, Matrices, Symmetric, Orthogonal and Unitary matrices, Rank, Normal form, Solution of system of linear equations, L. I. & L. D. vectors, Basics of Probability.

1		**Calculus of Variation:**	**06**
	1.1	Euler's Langrange equation, solution of Euler's Langrange equation (only results for different cases for Function) independent of a variable, independent of another variable, independent of differentiation of a variable and independent of both variables	
	1.2	Isoperimetric problems, several dependent variables	
	1.3	Functions involving higher order derivatives: Rayleigh-Ritz method	
2		**Linear Algebra: Vector Spaces**	**06**
	2.1	Vectors in n-dimensional vector space: properties, dot product, cross product, norm and distance properties in n-dimensional vector space.	
	2.2	Vector spaces over real field, properties of vector spaces over real field, subspaces.	

	2.3	The Cauchy-Schwarz inequality, Orthogonal Subspaces, Gram-Schmidt process.	
3		**Linear Algebra: Matrix Theory**	**10**
	3.1	Characteristic equation, Eigen values and Eigen vectors, properties of Eigen values and Eigen vectors	
	3.2	Cayley-Hamilton theorem (without proof), examples based on verification of Cayley- Hamilton theorem.	
	3.3	Similarity of matrices, Diagonalisation of matrices.	
	3.4	Functions of square matrix, derogatory and non-derogatory matrices.	
4		**Probability**	**10**
	4.1	Baye's Theorem (without proof)	
	4.2	Random variable: Probability distribution for discrete and continuous random variables, Density function and distribution function, expectation, variance.	
	4.3	Moments, Moment Generating Function.	
	4.4	Probability distribution: Binomial distribution, Poisson & normal distribution (For detailed study)	
5		**Correlation**	**04**
	5.1	Karl Pearson's coefficient of correlation, Covariance, Spearman's Rank correlation,	
	5.2	Lines of Regression.	
6		**Complex integration**	**12**
	6.1	Complex Integration: Line Integral, Cauchy's Integral theorem for simply connected regions, Cauchy's Integral formula.	
	6.2	Taylor's and Laurent's Series	
	6.3	Zeros, singularities, poles of f(z), residues, Cauchy's Residue theorem.	
	6.4	Applications of Residue theorem to evaluate real Integrals of different types.	

Reference Books:

Text books:

1. H.K. Das, "*Advanced engineering mathematics*", S . Chand, 2008
2. A. Datta, *"Mathematical Methods in Science and Engineering"*, 2012
3. B.S. Grewal, *"Higher Engineering Mathematics"*, Khanna Publication
4. P.N.Wartilar & J.N.Wartikar, "*A Text Book of Applied Mathematics*" Vol. I & II, Vidyarthi Griha Prakashan., Pune.

Reference Books:

1. B. V. Ramana, *"Higher Engineering Mathematics"*, Tata Mc-Graw Hill Publication
2. Wylie and Barret, *"Advanced Engineering Mathematics"*, Tata Mc-Graw Hill 6th Edition
3. Erwin Kreysizg, *"Advanced Engineering Mathematics"*, John Wiley & Sons, Inc
4. Seymour Lipschutz "*Beginning Linear Algebra*" Schaum's outline series, Mc-Graw Hill Publication

5.Seymour Lipschutz "*Probability*" Schaum's outline series, Mc-Graw Hill Publication

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

Term work:
Term work shall consist of minimum eight tutorials and assignments (minimum 2).
The distribution of marks for term work shall be as follows:

Tutorials	:15 marks
Assignments	:05 marks
Attendance (Theory and Tutorial)	:05 marks

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

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

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC402	**Power System-I (abbreviated as PS-I)**	**3**	**1**	**3**	**1**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs)		
		Test 1	Test 2	Avg				
EEC402	Power System-I	20	20	20	80	3	25	125

Course Objectives	• To learn Basic structure of electrical power systems, different component of power system network. • To get knowledge of mechanical and electrical design of transmission systems. • To learn representation of transmission systems for performance evaluation.
Course Outcomes	Students will be able • To illustrate the general structure of power system. • To illustrate purpose of different mechanical components of overhead transmission lines. • To determine transmission line parameters for different configurations. • To analyze the performance of short, medium and Long transmission lines. • To analyze the performance of transmission line for different loading conditions. • To illustrate safety norms and regulations related to underground cables and grounding techniques.

Module	Contents	Hours
1	**Introduction:** Basic structure of power system: generation, transmission and distribution, single line diagram of typical AC supply system, comparison between AC and DC supply system, various system of electric power transmission, choice of economic voltage for transmission, Transmission and Distribution network in India.	02
2	**Mechanical Design of Overhead lines:** Main component of overhead lines, line supports, span, conductor configuration, sag in overhead lines, calculation of sag for equal and unequal supports, effect of ice and wind loading, insulators, type of insulators, potential distribution across insulator string, string	07

	efficiency, methods for improving string efficiency **(*Numerical)**	
3	**Transmission 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, composite and bundled conductor, inductance of three phase line with symmetrical and unsymmetrical spacing, concept of GMR and GMD, necessity of transposition, inductance of three phase double circuit line with symmetrical and unsymmetrical spacing, inductance of bundle conductor 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 **(*Numerical)**	12
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(P.U.)system, advantage of Per Unit system ,p.u. impedance diagram, representation of load **(*Numerical)**	03
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, Power circle diagram **(*Numerical)**	07
6	**Underground Cable and Power System Earthing:** **Underground Cable:** Classification and construction of cable ,insulation resistance of cable, capacitance of single core and three core cable, grading of cable, intersheath grading, capacitance grading **Power system Earthing:** Earthing definition, soil resistivity, step and touch potentials, measurement of earth resistance, soil resistivity, neutral grounding and its methods.	05

Note: *Numerical should be covered in Tutorials.

Books Recommended:

Text Books:

1. Wadhwa C.L. 'Electrical power system', New Age International,4th edition,2005
2. J B. Gupta, 'A Course In Power Systems', S. K. Kataria & Sons, 2009
3. Soni M.L., Bhatanagar U.S, Gupta P.V, 'A course in electrical power', Dhampat Rai and Sons., 1987
4. D. P. Kothari, I. J. Nagrath, 'Modern Power System Analysis', Mc Graw Hill
5. B.R. Gupta, 'Power System Analysis And Design', S.Chand

Reference Books:

1. Stevenson, Modern power system analysis, TMH publication
2. Mehta V.K., Principle of power system, S Chand

Assessment:

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

Term work:

Term work shall consist of minimum eight tutorials and assignments (min two). The distribution of marks for term work shall be as follows:

Tutorial	:15 marks
Assignments	:05 marks
Attendance (Theory and Tutorial)	:05 marks

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

Theory Examination:

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

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC403	**Electrical Machine–II (abbreviated as EMC-II)**	**4**	**-**	**4**	**-**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs)		
		Test 1	Test 2	Avg				
EEC403	Electrical Machine-II	20	20	20	80	3	-	100

Course Objectives	• To impart the knowledge of working principle, operations, performance and applications of single phase and three phase Transformers. • To understand the design of transformer with its cooling system. • To understand the performance parameters of transformers
Course Outcomes	Students will be able • To illustrate the working principle of single phase and three phase transformer • To illustrate the working principle of auto-transformer • To analyse various type of connections of three phase transformer. • To analyse performance of transformer under various operating conditions • To illustrate various design aspects of transformer. • To analyse the characteristics of CT and VT.

Module	Contents	Hours
1	**Single phase Transformer :-** Review of EMF equation, Equivalent Circuit, Phasor diagram, voltage regulation, Losses and Efficiency. Condition for Maximum Efficiency, All day Efficiency, Separation of Hysteresis and Eddy current losses. Parallel Operation: No load Operation, On load Operation: - Equal Voltage Operation and Unequal Voltage Operation, Testing of Transformer: - Polarity Test, OC and SC test, Sumpner's Test, Impulse test	10
2	**Autotransformer:-** Working, Advantages of Autotransformer over Two winding Transformer, Disadvantages. Introduction to High Frequency Transformer, Pulse Transformer, Isolation Transformer and its applications.	04
3	**Three Phase Transformers-** Construction and parts of transformer (design approach), Three phase transformer connections and phasor	10

	groups. Parallel operation, Excitation Phenomenon in transformers, Harmonics in three phase transformers, Suppression of harmonics, Oscillating neutral phenomenon, Switching in transient phenomenon, Open delta or V- connection, Three phase to two phase conversion (Scott connection).	
4	**Introduction to machine design**, Magnetic, Electrical, Conducting and Insulating materials used in machines. **Design of Single phase and Three phase transformers:-** Output equation, Main Dimensions, Specific electric and magnetic loadings, Design of core, Selection of the type of winding, Design of LV and HV windings, Design of insulation.	12
5	**Performance measurement of Transformers** Resistance and leakage reactance of the winding, Mechanical forces, No load current; Cooling of transformers – design of cooling tank and tubes. Relevant IS standards.	08
6	**Current Transformers** - Introduction, Terms and Definitions, Accuracy class, Burden on CT, Vector diagram of CT **Voltage Transformers** - Introduction, Theory of VT, Specifications for VT, Terms & definitions, Accuracy classes & uses, Burdens on VT, Connection of VTs	04

Books Recommended:

Text Books:

1. Bimbhra P. S., Electric Machinery , Khanna Publisher,
2. Bimbhra P. S., Generalized Machine Theory, Khanna Publisher,
3. E. G. Janardanan, Special Electrical Machines, PHI
4. V. K. Mehta, Principles of Electrical Machines, S Chand Publication
5. Switchgear & Protection by Sunil.S.Rao, Khanna Publications
6. A. K. Sawhney, "Electrical Machine Design", Dhanpat Rai & Co
7. M. V. Deshpande, "Design and Testing of Electrical Machines", PHI Learning

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. Vedam Subramanyam, *Electrical Drive-concept and applications*, TMH Publication
4. A. E. Fitzgerald, Kingsly, Stephen., *Electric Machinery,* Tata McGraw Hill

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

Theory Examination:

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

University of Mumbai						
Course code	**Course Name**	**Teaching scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC404	**Electromagnetic Fields and Waves (Abbreviated as EFW)**	**3**	**1**	**3**	**1**	**4**

Course Code	Course Name	Examination Scheme						
		Theory					Term work	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (Hrs)		
		Test 1	Test 2	Avg				
EEC404	Electromagnetic Fields and Waves	20	20	20	80	03	25	125

Course Objectives	• To impart the knowledge of electro-physics. • Expose students Electric and magnetic field and their application in electrical engineering
Course Outcomes	Students will be able • To apply knowledge of mathematics and physics in electrical engineering field. • To analyse electrostatic and static magnetic fields. • To analyse the effect of material medium on electric and magnetic fields. • To analyse and formulate time varying electric and magnetic fields. • To analyse wave generation and its propagation in different media. • To analyse static magnetic field and electrostatic field distribution using software tool.

Module	Contents	Hours
1	**Vector Basics**: Concept of Scalar and Vector, Co-ordinate System: Rectangular, Cylindrical and Spherical Co-ordinate System, Co-ordinate and vector transformation, (Numerical on line, Surface and Volume Integrals)	04
2	**Static Electric Fields:** Coulomb's Law in Vector Form, Electric Field Intensity, Definition, Principle of Superposition, Electric Field due to point charges, Electric Field due to line charge (one and two conductor transmission lines), Electric Field due to an infinite uniformly charged sheet, Definition and physical interpretation of gradient, Electric scalar potential, Relationship	08

	between potential and electric field and its application on Surface voltage gradient on conductor, Potential due to electrical dipole and flux lines, Electric Flux Density, Gauss Law, Definition and physical Significance of Divergence, Divergence theorem	
3	**Static Magnetic Fields:** The Biot-Savart's Law in vector form, Magnetic Field intensity due to a finite and infinite wire carrying a current I, Magnetic field intensity on the axis of a circular loop carrying a current I, Ampere's circuital law and its application on A solid cylindrical conductor and Infinitely long co-axial transmission line, Magnetic flux density, Definition and physical Interpretation of Curl, The Lorentz force equation for a moving charge and its applications on Force on a wire carrying a current I placed in a magnetic field, Torque on a loop carrying a current I, Magnetic moment, Magnetic Vector Potential.	08
4	**Electric and Magnetic Fields in Materials**: Poisson's and Laplace's equation and its application on Estimation and control of electric stress, control of stress at an electrode edge, Electric Polarization, Definition of Capacitance, Capacitance of two parallel plate, Co-axial, Spherical and Capacitance of two conductor of a single phase line, Electrostatic energy and energy density, Boundary conditions for electric and magnetic field, Electric current, Current density, Point form of ohm's law, Continuity equation for current, Definition of Inductance, Inductance of loops and solenoids, Flux linkage within and outside the conductor producing the flux, Energy density in magnetic fields.	08
5	**Time varying Electric and Magnetic Fields:** Faraday's law, Maxwell's Second Equation in integral form from Faraday's Law, Equation expressed in point form, Displacement current, Ampere's circuital law in integral form, Modified form of Ampere's circuital law as Maxwell's first equation in integral form, Equation expressed in point form, Maxwell's four equations in integral form and differential form.	04
6	**Wave theory:** Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in phasor form, Wave equation in phasor form, Plane waves in free space and in a homogenous material, Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect.	04

Books Recommended:

Text books:

1. W. Hayt., "Engineering electromagnetic", McGraw Hill, 4th edition, 1987.
2. Edminister, "Schaum's series in electromagnetic" McGraw Hill publications, 3rd edition, 1986.
3. N. Narayan Rao, " Elements of Electromagnetic", PHI publication, 4th edition, 2001.
4. E.C. Jordan & K.G. Balmain "Electromagnetic Waves and Radiating Systems." Prentice Hall of India 2nd edition 2003. (Unit IV, V). McGraw-Hill, 9th reprint
5. G.S.N. Raju, " Electromagnetic Field Theory and Transmission Lines" Pearson publications, fifteenth impression,2013.
6. S. K. Singh.,"Fundamentals of High Voltage Engineering", Dhanpat Rai & Co. First edition,2014.
7. Dr. B.R. Gupta.,"Power System Analysis and Design", S. Chand, First edition,1998.
8. John D. Kraus & Keith R. Carver "Electromagnetics", McGraw-Hill Inc. 1973.

Reference books:

1. Fenmann, "Lectures on physics", Vol – 2, Addition Wesley, 1965
2. S. seely, "Introduction to electromagnetic fields", McGraw Hill, 1958.
3. David K. cheng, "Field and electromagnetic", Addison Wesley, 2nd edition, 1999.
4. Corson and lerrain, "Electromagnetic", CBS publications, 2nd edition, 1986.
5. Ramo, Whinnery and Van Duzer: "Fields and Waves in Communications Electronics" John Wiley & Sons (3rd edition 2003)
6. M.N.O.Sadiku: "Elements of Engineering Electromagnetics" Oxford University Press, Third edition.
7. David K.Cherp: "Field and Wave Electromagnetics - Second Edition-Pearson Edition.
8. David J.Grithiths: "Introduction to Electrodynamics- III Edition-PHI
9. John Reitz, Frederick Milford, Robert Christy, "Foundations of Electromagnetic Theory" Pearson publications, fourth impression,2013.

Assessment:

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

Term work:

Term work consists of minimum eight tutorials (at least one on each module) and assignments (min. 2). The distribution of the term work shall be as follows:

Tutorials :15 marks
Assignments :05 marks
Attendance (Theory and Tutorial) :05 marks

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

Theory Examination:

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

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC405	**Analog and Digital Integrated Circuits (abbreviated as ADIC)**	**3**	**-**	**3**	**-**	**3**

Course Code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)		
		Test 1	Test 2	Avg				
EEC405	Analog and Digital Integrated Circuits	20	20	20	80	3	-	100

Course Objectives	• To introduce the basic building blocks, theory and applications of linear integrated circuits. • To develop ability among students for problem formulation, system design and solving skills
Course Outcomes	Students will be able • To illustrate various performance parameters and characteristics of operational amplifier. • To illustrate various linear and non-linear application of operational amplifiers. • To design and analyse linear voltage regulators and multivibrators. • To do various conversion of number systems and illustrate logic families. • To build, design and analyse combinational circuits. • To build, design and analyse sequential circuits.

Module	Contents	Hours
1	**Operational Amplifiers: Fundamentals** Introduction to Differential amplifier, Block diagram of Op-amp Basics of an Op-amp, Op-amp parameters, Frequency response	03
2	**Application of Operational Amplifiers** Voltage follower, design of inverting and non- inverting amp, adder, subtractor, integrator and differentiator, V to I and I to V converter, Schmitt trigger, sample and hold circuits, active filters: first order LPF, Instrumentation amplifier (3 Op-amp) with applications, Optical isolation amplifier	08

3	**Linear Voltage Regulators –** IC -78xx, 79xx, LM 317. Design of adjustable voltage source using IC- LM317, Low Dropout (LDO) voltage regulator **IC-555-** Functional block diagram, Applications of IC 555, Design of Multivibrator (Monostable and Astable)	06
4	**Logic families -** Review of Number formats: Binary, hexadecimal, BCD and their basic math operations (addition and subtraction) Introduction to Logic gates and Boolean Algebra. Specifications of Digital IC, Logic Families: TTL,CMOS logic families, Comparison of TTL and CMOS, Interfacing of TTL and CMOS	06
5	**Combinational Logic Circuit -** K-Maps and their use in specifying Boolean expressions upto 4 variables, Minterm, Maxterm, SOP and POS implementation Implementing logic function using universal gates, Binary Arithmetic circuits: Adders, Subtractors (Half and Full), Multiplier, 2 bit comparators, Designing code converter circuit - binary to gray, Gray to Binary, Multiplexer (ULM), De- multiplexers.	08
6	**Sequential Logic Circuits -** Comparison of combinational & sequential circuit **Flip-flops -** SR, T, D, JK, Master Slave JK, Converting one flip-flop to another, Use of debounce switch **Counters-** Modulus of counter, Design of Synchronous, Asynchronous counters, Ripple counters, Up/Down Counter, Ring counter, **Shift Registers** – Right and left shift registers	05

Books Recommended:

Text Books:

1. Gayakwad Ramakant A, Op-amps and Linear Integrated Circuits, Prentice Hall PTR,
2. Boatkar K. R., "Integrated Circuits", Khanna Publication.
3. D. Roy Choudhury, Shali B Jain, "Linear Integrated Circuits" New Age International Publication.
4. Millman and Halkias, '*Integrated Electronics*', Tata McGraw Hill,
5. A. Anand Kumar, *"Fundamentals of Digital Circuits"*, PHI-2009
6. Jain R.P., *"Modern Digitals Electronics*", Tata McGraw Hill, 1984.
7. Roger L. Tokheim, "Digital Electronics", Tata McGraw Hill

Reference Books:

1. Design with OPAMP analog Ics by Sergio Franco. McGraw Hill 1998 2nd edition.
2. Boylestad Robert and Nashelsky Louis - '*Electronic Devices and Circuits*', Prentice-Hall of India,
3. Newman D.A., '*Electronic Circuit Analysis and Design'*, McGraw Hill International.

4. David Bell, *Electronic Devices and Circuits,*5e Oxford University Press
5. George Clayton, Steve Winder, *'Operational Amplifiers',* Newnes
6. Alan b. Marcovitz, "*Introduction to logic Design",* McGraw Hill International 2002.
7. Malvino & Leach, *"Digital principal and Application"*, Tata McGraw Hill, 1991.
8. Bignell James& Donovan Robert "*Digital Electronics",* Delmar, Thomas Learning, 2001.
9. Jog N.K. *'Logic Circuits",* 2nd Edition, Naidu Publishers & Printers Pvt. Ltd 1998.
10. Paul M. Chirlian, *"Analysis and Design of Integrated Electronic Circuits"*, 2nd Edition, John Wiley and Sons
11. Morris M. Mano. "*Digital Design",* Prentice Hall International – 1984.
12. Donald D. Givone, "Digital Priciples and Designs" Tata McGraw Hill

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

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

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC406	**Electrical Network (abbreviated as EN)**	**3**	**1**	**3**	**1**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs)		
		Test 1	Test 2	Avg				
EEC406	Electrical Network	20	20	20	80	3	25	125

Course Objectives	• To impart the knowledge of various fundamental techniques for analysis of electrical network from application point of view. • To mold creative engineers needed in education and industrial development along with problem solving skills.
Course Outcomes	Students are able • To analyze electrical network using different Network theorems. • To analyze electrical network using Graph theory. • To analyze the effect of switching conditions on Electrical networks using Differential equations. • To analyze the effect of switching conditions on Electrical networks using Laplace Transform. • To develop transfer function model of system using two port network parameters. • To analyze time domain behavior from pole zero plot

Module	Contents	Hours
1	**Solution of Network:** **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	10
2	**Graph Theory and Network Topology:** Introduction, Graph of network, Tree, Co-tree, Loop incidence matrix,	05

	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.	
3	**First Order and Second Order Differential Equations:** Behaviors of network elements under switching condition and their representation, Solution of initial and final condition in RL, RC and RLC networks for AC and DC sources.	05
4	**The Laplace Transform:** The Laplace transform and its application to network analysis, transient and steady state response to step, ramp and impulse signals.	05
5	**Two port parameters:** Open circuit, short circuit, transmission and hybrid Parameters, relationships between parameter sets, reciprocity and symmetry conditions, parallel connection of two port networks	05
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

Note: Numerical should be covered in Tutorials.

Books Recommended:

Text Books:

1. W H Hayt, S M Durbin, J E Kemmerly, '*Engineering Circuit Analysis'*, 7th Edition Tata McGraw-Hill Education.
2. M. E. Van Valkenburg, '*Network Analysis'*, 3rd Edition, PHI Learning.
3. D. Roy Choudhury, '*Networks and Systems'*, 2nd Edition, New Age International.
4. M. E. Van Valkenburg, '*Linear Circuits'*, Prentice Hall.

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, Inc.
3. C. L.Wadhwa, '*Network Analysis and synthesis*', New Age international.
4. B. Somanathan Nair, "Network Analysis and Synthesis", Elsevier Publications

Assessment:

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

Term work:

Term work consists of minimum eight tutorials (at least one on each module) and assignments (min. 2). The distribution of the term work shall be as follows:

Tutorials :15 marks
Assignments :05 marks
Attendance (Theory and Tutorial) :05 marks
The final certification and acceptance of term-work ensures the minimum passing in the term-work.

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

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL401	**Simulation Lab-I (abbreviated Sim Lab-I)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg					
EEL401	Simulation Lab-I	-	-	-	-	25	-	25	50

Course Objectives	• To understand basic block sets of different simulation platform used in electrical system design. • To understand coding in different programming software's used in electrical system design
Course Outcomes	Students are able • To simulates electrical circuits for their performance analysis. • To develop algorithms for electrical circuits for their performance analysis. • To simulates electronic circuits for their performance analysis. • To develop algorithms for electronic circuits for their performance analysis.

Suggested List of Laboratory Experiment:

1. Introduction to basic block sets of simulation platform.
2. Simulation of single phase bridge rectifier without filter
3. Simulation of single phase bridge rectifier with filter
4. Simulation of UJT as a relaxation oscillator
5. Algorithm on matrix operations
6. Simulation for OC and SC test of single phase transformer
7. Simulation of transmission line model
8. Algorithms to determine transmission line performance and parameters
9. Algorithm for generation of standard test signals
10. Simulation of differential equations
11. Simulation to verify different network theorems with dependent and independent sources
12. Simulation of DC motor performance characteristics
13. Simulation / Algorithms to draw the pole zero plot of electrical network
14. Simulation / Algorithms to draw the response of electrical network for standard test signals.

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

Term work:

Term work consists of minimum 8 simulation / algorithms (at least one on each domain). 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.

Practical/Oral Examination:

Practical/Oral examination will be based on entire syllabus.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL402	**Electrical Machine Lab-II (abbreviated EMC Lab-II)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg					
EEL402	Electrical Machine Lab - II	-	-	-	-	25	25	-	50

Course Objectives	• To impart the knowledge of working principle, operations, performance and applications of single phase and three phase Transformers. • To understand the performance parameters of transformers
Course Outcomes	Students will be able • To demonstrate the working principle of single phase and three phase transformer • To demonstrate the working principle of auto-transformer • To analyse various type of connections of three phase transformer. • To analyse performance of transformer under various operating conditions • To analyse the characteristics of CT and VT.

Syllabus: Same as that of Course EEC403 Electrical Machine - II

Suggested List of Laboratory Experiment:

1. O.C & S.C. Test on 1Φ Transformer
2. Sumpner's Test on 1Φ Transformer
3. Separation of iron loss into hysteresis and eddy current loss components in a1Φ Transformer
4. Load Test on 1Φ Transformer
5. Open circuit & Short circuit test on three phase transformer
6. Parallel operation of transformers
7. Scott connection of transformer
8. Open Delta connection of transformer

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

Term work:

Term work shall consist of minimum 6 experiments. The distribution of marks shall be as follows:

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

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

Practical/Oral Examination:

Practical/Oral examination will be based on entire syllabus.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL403	**Electronics Lab-II (abbreviated EL Lab-II)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg					
EEL403	Electronics Lab-II	-	-	-	-	25	25	-	50

Course Objectives	• To introduce the basic building blocks, theory and applications of linear integrated circuits. • To develop ability among students for problem formulation, system design and solving skills
Course Outcomes	Students will be able • To demonstrate various performance parameters and characteristics of operational amplifier. • To demonstrate various linear and non-linear application of operational amplifiers. • To build, design, and analyse linear voltage regulators and multi vibrators.. • To build, design and analyse combinational circuits. • To build, design and analyse sequential circuits.

Syllabus: Same as that of Course EEC405 Analog and Digital Integrated Circuits.

Suggested List of Laboratory Experiments:

1. Linear applications of op-amp
2. Non linear applications of op-amp
3. Active filters
4. Design and implementation of variable voltage regulator using IC 317
5. Design and implementation of astable multivibrator
6. Design and implementation of monostable multivibrator
7. Design and implementation of VCO.
8. Implementing a Binary to Gray, gray to binary or Binary to XS3 code converter using gate ICs.
9. Constructing flip-flops like SR, D, JK and T using all NAND gates and a debounce

switch.

10. Designing a mod N counter where N <14 using J K flip-flops and D flip-flops.
11. Design of a ripple counter
12. Design two bit comparator using gate ICs.
13. Building of a ring counter and twisted ring counter using D flip-flop ICs.
14. 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.

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

Term work:

Term work shall consist of minimum 10 experiments. The distribution of marks for term work shall be as follows:

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

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

Practical/Oral Examination:

Practical/Oral examination will be based on entire syllabus.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL404	**Electrical Workshop (abbreviated EW/S)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg					
EEL404	Electrical Workshop	-	-	-	-	25	-	25	50

Course Objectives	• To introduce the basic laboratory instruments used for measurement purpose. • To develop the ability to handle electrical equipment.
Course Outcomes	Students will be able • To demonstrate various electrical and electronic measuring equipment's. • To identify various electrical and power electronic components. • To repair and do maintenance of households appliances. • To identify and use different low voltage protective switchgears. • To identify and use different wiring accessories and tools.

Syllabus:-

Module	Contents	Hours
1	**Introduction of lab equipment's and electrical elements:** Introduction to different equipment in the lab (multi-meter, CRO, DSO, power supplies, function generators); Resistors, presets, potentiometers, inductors (iron core and ferrite core), capacitors of different ratings. Electromagnetic Relays, MOVs,	03
2	**Introduction to different electronic components:** different ratings, packages, terminals, sizes and shapes, testing methods of diodes (rectifier, ultrafast, schotkey, power, zener, LED), transistors(BJT), SCRs, GTOs, MOSFETs, IGBTs, DIACs, TRIACs, intelligent power modules (IPM) (Minimum Three) Different PCB connectors, Terminal, Terminal Blocks; Transformers used for electronic circuits (pulse, high frequency)	03

3	**Commonly used ICs:** Data sheet reading of commonly used ICs (buffers,opto-couplers, gate drivers, PWM ICs, Real time clock ICs, PLL ICs, seven segment display and driver) (Minimum Three)	04
4	**Hardware implementation of Electronics circuits:** Soldering techniques and equipments, PCB Layout (artwork) design using software and Fabrication ~~itching~~ process. Testing and debugging process of assembled circuits	06
5	**Residential/ Industrial Wiring:** Wiring materials, selection of wire, different switching and protection devices (MCBs/ Fuses/Relays), Cables and cable management Estimation and costing of residential wiring (Simple numerical on wiring of single room), connection of energy meter and distribution board, wiring standards (IS-732, section 4)	04
6	**Repair of house hold appliances and machines:** Testing, fault finding, Dismantling, assembling and testing after repairs of house hold appliances like fan and regulator, heater, geyser, mixer, **washing machine**, microwave oven etc.(minimum Two) Troubleshooting charts for 1 ph and 3ph transformers and motors (Minimum one transformer and one motor)	04

Books Recommended:

:

1. J. B. Gupta Electrical Installation Estimating & costing
2. Raina Bhattachraya Estimating dsign & costing
3. Allasappan & Ekambarm Estimating design & costing
4. S L Uppal Estimating & costing
5. Surjit Singh Electrical Estimating & costing
6. K B. Bhatia: Electrical Appliances

Suggested List of Laboratory Experiments:

1. Study of different symbols and tools used in Electrical Engineering
2. Identify values of different resistors and capacitor using color code and DMM
3. Identify different types of cables/wires, switches and their uses.
4. 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.
10. Verifying the fusing time of rewireable fuses.
11. To identify terminology of various semiconductor devices.

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

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.

Oral Examination:
Oral examination will be based on entire syllabus.