UNIVERSITY OF MUMBAI

Bachelor of Engineering

Electrical Engineering (Sem. V to VIII), Revised course

(REV- 2012) from Academic Year 2014 -15,

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

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 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) and 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, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester 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. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, 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 also 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 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 twenty senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for undergraduate program in Electrical Engineering are listed below;

- To provide the overall strong technical foundation to formulate, solve and analyse engineering problems during undergraduate program.
- To prepare students to demonstrate an ability to identify, formulate and solve electrical based issues.
- To prepare students to demonstrate an ability in the area of design, control, analyse and interpret the electrical and electronics systems.
- To prepare students for successful career in industry, research and development.
- To develop the ability among students for supervisory control and data acquisition for power system application.
- To provide opportunity for students to handle the multidisciplinary projects.
- To create the awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

The affiliated institutes may include their own PEOs in addition to the above list

To support the philosophy of outcome based education, in addition to stated PEOs, objectives and expected outcomes are also included in the curriculum. I know, this is a small step taken to enhance and provide the quality education to the stake holders.

Chairman,
Board of Studies in Electrical Engineering,
University of Mumbai

Third Year Electrical Engineering (Semester V to VIII), Revised course (Rev 2012) from Academic Year 2014 -15

(Electrical Engineering)

Scheme for Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./ Tut.	Theory	Pract./Tut.	Total
EEC501	Protection and Switchgear Engineering	4	2	4	1	5
EEC502	Electrical Machines - II	4	2	4	1	5
EEC503	Electromagnetic Fields and Waves	3	2	3	2	5
EEC504	Power Electronics	4	2	4	1	5
EEC505	Communication Engineering	3	2	3	1	4
EEC506	Business Communication and Ethics	-	2**+ 2	-	2	2
Total		**18**	**14**	**18**	**10**	**26**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. / oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
EEC501	Protection and Switchgear Engineering	20	20	20	80	03	25	25	150
EEC502	Electrical Machines - II	20	20	20	80	03	25	25*	150
EEC503	Electromagnetic Fields and Waves	20	20	20	80	03	25	--	125
EEC504	Power Electronics	20	20	20	80	03	25	25	150
EEC505	Communication Engineering	20	20	20	80	03	25	-	125
EEC506	Business Communication and Ethics	--	--	--	--	-	25	--	25
Total		**--**	**--**	**100**	**400**	**--**	**150**	**75**	**725**

* **Includes both Practical and Oral examination**

****Theory for entire class to be conducted (common for all program)**

Scheme for Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./Tut.	Theory	Pract./Tut.	Total
EEC801	Design, Management and Auditing of Electrical Systems	4	2	4	1	5
EEC802	Drives and Control	4	2	4	1	5
EEC803	Power System Planning and Reliability	3	2	4	1	5
EEE80X	Elective- II	4	2	4	1	5
EEC805	Project- II	--	12 ##	--	6	6
Total		**15**	**20**	**16**	**10**	**26**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. / oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
EEC801	Design, Management and Auditing of Electrical Systems	20	20	20	80	03	25	--	125
EEC802	Drives and Control	20	20	20	80	03	25	25*	150
EEC803	Power System Planning and Reliability	20	20	20	80	03	25	--	125
EEE80X	Elective- II	20	20	20	80	03	25	--	150
EEC805	Project- II	--	--	--	--	--	50	100	150
Total		**--**	**--**	**80**	**320**	**--**	**150**	**125**	**700**

* **Includes both Practical and Oral examination**

X- **Indicates elective one to seven**

Work load of learner in Semester-VII is equivalent to 12 hrs / wk

Course Code	Elective I	Course Code	Elective II
EEE701	High Voltage Engineering	EEE801	Flexible AC Transmission Systems
EEE702	Analysis and Design of Power Switching Converters	EEE802	Electric and Hybrid Electric Vehicle Technology
EEE703	Power System Modelling	EEE803	Power Quality
EEE704	Digital Signal Controllers and its Application	EEE804	Smart Grid Technology
EEE705	Advanced Lighting Systems	EEE805	Power System Dynamics and Control
EEE706	Renewable Energy and Energy Storage Systems	EEE806	Non-linear Control System
EEE707	Optimization Techniques and its Applications	EEE807	Entrepreneurship Development

Project Guidelines

Project –I and II: Students groups and load of faculty per week

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

Faculty Load: In semester VII - 1 (one) period of 1/2 hour per week per project group

In semester VIII - 2 (Two) period of 1 hour each per week per project group

Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

- **Project oral must be conducted by appointing external examiner**

Note: This aspect is discussed in FOT, where project load for students in VII semester is 3 hrs and in VIII semester it is 6 hrs

University of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEC501	Protection and Switchgear Engineering (Abbreviated as PSE)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC501	Protection and Switchgear Engineering (Abbreviated as PSE)	20	20	20	80	03	25	25	150

Course Code	Course Name	Credits
EE501	**Protection and Switchgear Engineering**	**5**
Course Objectives	• To impart the basic knowledge on power system protection concepts, substation equipment and protection schemes	
Course Outcomes	• This knowledge leads to the in depth understanding of how the power system and the major apparatus used in the system are being protected against faults and abnormal conditions	

Module	Contents	Hours
1	**Instrument Transformers:** Current Transformers - Introduction, Terms and Definitions, Accuracy class, Burden on CT, Vector diagram of CT, Magnetization curve of CT, Open circuited CT secondary, Polarity of CT and connections, Selection of CT for protection ratings, Types & construction, Multi wound CTs, Intermediate CTs, Transient behavior, Application for various protections. Voltage Transformers - Introduction, Theory of VT, Specifications for VT, Terms & definitions, Accuracy classes & uses, Burdens on VT, Connection of VTs, Residually connected VT, Electromagnetic VT, CVT & CVT as coupling capacitor, Transient behavior of CVT, Application of CVT for protective relaying.	04
2	**Substation Equipment:** **Switching Devices**:- Isolator & Earthling Switch(Requirements & definitions, Types of construction, Pantograph isolators, Ratings),	12

	Contactors(Basic working principle, Terms & definitions, Contactors as starters for motors, Rated characteristics/utilization category of contactors), Circuit Breakers (working principle, Construction, operating mechanisms, Arc initiation, arc quenching principles, ratings & applications of MCB, MCCB, ELCB, air circuit breakers, oil circuit breakers, SF_6 circuit breakers, vacuum circuit breakers, Mechanical life, electrical life and testing of circuit br3eakers), Switch Boards, Acquaintance with ISI Standards **HRC Fuses & their applications**-Introduction, types of devices with fuse, definitions, construction, fuse link of HRC fuse, Action of HRC fuse, shape of fuse element, specification of a fuse link, characteristics of fuse, cut-off, classification & categories, selection of fuse links, fuse for protection of motor, discrimination, fuse for protection of radial lines/meshed feeders, equipment incorporating fuses, high voltage current limiting fuses, expulsion type high voltage fuses, drop out fuse.	
3	**Introduction to Protective relaying:** About protective relaying, Shunt & Series Faults, causes and Effects of faults, Importance of protective relaying, Protective zones, primary & Back-up protection, Back-up protection by time grading principle, desirable qualities of protective relaying, some terms in protective relaying, Distinction between relay unit, protective scheme and Protective system, Actuating quantities, Thermal Relays Electromechanical relays and static relays, Power line carrier channel, programmable relays, system security, role of engineers. **Electromagnetic relays** - Introduction, basic connections of relay, Auxiliary switch, sealing and auxiliary relays, measurement in relays, Pick up, drop off, Attracted armature & induction disc relays, Thermal, bimetal relays, Frequency relays, under/over voltage relays, DC relays, All or nothing relays. **Different Principles of protection** - Over current& earth fault (non-directional & directional types) , differential protection, distance protection (Working Principle of Impedance relay, Causes and remedies of Over reach-under reach, Reactance and Mho relay, Power swing blocking relay).	10
4	**Protection schemes provided for major apparatus:** **Generators** - Stator side(Differential , Restricted Earth fault, protection for 100% winding, Negative phase sequence, Reverse power, turn-turn fault), Rotor side (Field suppression, field failure, Earth fault, turn to turn fault) **Transformers**-Differential protection for star delta Transformer, Harmonic restraint relay, REF protection, Protection provided for incipient faults (Gas actuated relay). **Induction motors** - Protection of motor against over load, short circuit, earth fault, single phasing, unbalance, locked rotor, phase reversal, under voltage, winding temperature.	12

5	**Protection of Transmission Lines:** Feeder protection - Time grading, current grading , combined time & current grading protection provided for Radial, Ring Main, Parallel, T-Feeder. Bus Zone Protection - Differential protection provided for different types of bus zones. LV, MV, HV Transmission Lines - Protection provided by over current, earth fault, Differential and Stepped distance protection. EHV & UHV Transmission lines - Need for auto reclosure schemes, Carrier aided distance protection (Directional comparison method), Power Line Carrier Current protection (Phase comparison method).	06
6	**Introduction to Static & Numerical Relays** Advantages and Disadvantages, Revision and application of op-amps, logic gates, DSP, Signal sampling, Relays as comparators (Amplitude & phase), Distance relays as comparators.	04

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Oral Examination on the entire syllabus at the end of semester.

The distribution of marks for the term work shall be as follows:

Laboratory work (experiments)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

Books Recommended:

Text Books:

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

Reference Books:

1. Fundamentals of protection by Paithanker & Bhide.S.R, P.H.I
2. Static Relays by Madhava Rao, TMH
3. A text book on Power system Engineering by Soni, Gupta, Bhatnagar & Chakraborthi, Dhanpat Rai & Co

4. Protective Relaying by Lewis Blackburn, Thomas.J.Domin
5. Power System Protection by P.M.Anderson, Wiley Interscience

Minimum of 8 Tutorials / Practical Recommended:

1) Demonstration of working parts of the switching / Protective devices

2) Demonstration of protection kits for major apparatus used in power system

3) Visit to the substation & a report attached with the term work

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC502	Electrical Machines-II (Abbreviated as EMC-II)	Theory	Pract./Tut.	Theory	Pract./tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC502	Electrical Machines-II (Abbreviated as EMC-II)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC502	**Electrical Machines- II**	**5**
Course Objectives	• To impart the knowledge of working principle, operations, performance and applications of Induction Motors and 3φ Transformers.	
Course outcomes	• Students will be able to understand the engineering fundamentals of induction motor and transformers. • Gain an ability to design and conduct performance experiments, as well as to identify, formulate and solve machine related problems.	

Module	Contents	Hours
1	**Three Phase Transformers- Construction & Phasor groups:** Construction, Three phase transformer connections and phasor groups.	05
2	**Three Phase Transformers- Operation:** Parallel operation, Excitation Phenomenon in transformers, Harmonics in three phase transformers, Disadvantages of harmonics in transformers, Suppression of harmonics, Oscillating neutral phenomenon, Switching in transient phenomenon, Open delta or V- connection, Three phase to two phase conversion (Scott connection).	12
3	**Three Phase Induction Motors-Introduction:** Construction, Principle of operation, Rotor frequency, Rotor emf, Current	

	and Power, Induction motor phasor diagram, Analysis of Equivalent circuit, Torque-speed characteristics in braking, motoring and generating regions, Effect of voltage and frequency variations on Induction motor performance, Losses and efficiency, Power stages, No load and block rotor test, Circle diagram, Applications of 3Φ IM	13
4	**Three Phase Induction Motors- Speed Control and Starting:** Speed control methods including V/f method (excluding Slip power recovery scheme), Starting methods, High torque motors, Cogging and crawling, Basic principle of Induction Generator.	10
5	**Single phase Induction Motor-Introduction:** Principle of operation, Double field revolving theory, Equivalent circuit of single phase induction motor, Determination of equivalent circuit parameters from no load and block rotor test.	04
6	**Single phase Induction Motor- Starting Methods:** Staring methods, Split phase starting- Resistance spilt phase, capacitor split phase, capacitor start and run, shaded pole starting, Reluctance starting. Calculation of capacitor at starting. Applications of 1ϕ IM	04

***Includes both Practical and Oral examination**

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Practical and Oral examination:
The distribution of marks shall be as follows:
Performance of Experiments : 15 marks
Oral examination : 10 marks
Term work: Term work shall consist of minimum **Eight** experiments, Assignments (minimum **Two**).
The distribution of marks for the term work shall be as follows:
Laboratory work (experiments) : 10 marks
Assignments : 10 marks
Attendance : 05 marks
The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. 'Electrical Machinery', by Dr. P.S.Bhimhra, VII Edition, Khanna Publication

2. 'Generalized Theory of Electrical Machines', by Dr. P.S.Bhimhra, V Edition,Khanna Publication
3. 'Electrical Machines', by Nagrath and Kothari.TMH Publication.
4. 'Electrical Machines', by Charles I. Hubert, Pearson Education

Reference Book:

1. 'Performance and Design of AC Machines', by M.G.Say, CBS Publication
2. 'Electrical Machinery', by Fitzgerald and Kingsley, Mc. Graw Hill
3. 'Electrical Machines, Drives, and Power System', by Theodore Wildi, Pearson Education
4. 'Electrical Machines', by Smarajit Ghosh, Pearson

List of Experiments Recommended:

1. Load test on three phase squirrel cage IM
2. Load test on three phase slip ring IM
3. No load and Blocked rotor test on three phase IM
4. Circle diagram of three phase IM
5. Load test on Single phase IM
6. No load and Blocked rotor test on Single phase IM
7. Study of starting methods of 1Φ Induction motors.
8. Open circuit & Short circuit test on three phase transformer
9. Parallel operation of transformers
10. Scott connection of transformer
11. Open Delta connection of transformer.
12. Making various 3 Φ transformer connections using identical 1Φ transformers.

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract./tut.	Total
EEC503	Electromagnetic Fields and Waves (Abbreviated as EFW)	3	2	3	2	5

Course Code	Course Name	Credits
EEC503	**Electromagnetic Fields and Waves**	**05**
Course Objectives	• Expose students Electric and magnetic field and their application in electrical engineering	
Course Outcomes	• Students will be familiar with the various concepts Electric and magnetic field and their practical application in electrical engineering	

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC503	Electromagnetic Fields and Waves (Abbreviated as EFW)	20	20	20	80	03	25	--	125

Module	Contents	Hours
1	**Vector Basics**: Introduction to Co-ordinate System – Rectangular – Cylindrical and Spherical Co-ordinate System – Introduction to line, Surface and Volume Integrals – Definition of Curl, Divergence and Gradient .	04

2	**Static Electric Fields:** Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Principle of Superposition – Electric Field due to discrete charges, Electric field due to continuous charge distribution - Electric Field due to line charge– Electric Field on the axis of a uniformly charged circular disc – Electric Field due to an infinite uniformly charged sheet. Electric Scalar Potential – Relationship between potential and electric field - Potential due to infinite uniformly charged line – Potential due to electrical dipole - Electric Flux Density – Gauss Law Introduce applications of electrostatic fields – electrostatic discharge, high dielectric constant material.	08
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 and rectangular loop carrying a current I – Ampere's circuital law and simple applications. Magnetic flux density – The Lorentz force equation for a moving charge and applications – 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 – Electric Polarization-Nature of dielectric materials- Definition of Capacitance – Capacitance of various geometries using Laplace's equation – Electrostatic energy and energy density – Boundary conditions for electric fields – Electric current – Current density – point form of ohm's law – continuity equation for current. Definition of Inductance – Inductance of loops and solenoids – Definition of mutual inductance – simple examples. Energy density in magnetic fields –magnetic boundary conditions. Estimation and control of electric stress- control of stress at an electrode edge.	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.	04

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work:

Term work consists of minimum six tutorials (one on each module) and three simulation or experiments.

The distribution of the term work shall be as follows:

Tutorials and simulation/experiments (Journal)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

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.

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.

Course Code	Course Name	Credits

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC504	Power Electronics (Abbreviated as PE)	Theory	Pract./Tut.	Theory	Pract./tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC504	Power Electronics (Abbreviated as PE)	20	20	20	80	03	25	25	150

EEC504	Power Electronics	5
Course Objectives	• To impart knowledge of basic operation of power semiconductor devices, converters and their applications	
Course Outcomes	• Solid background in fundamentals of power electronics and exposure to state of the art technologies and its control aspects which is used in practice	

Module	Contents	Hours
1	**Thyristors :** Basic operation of silicon controlled rectifier, two transistor analogy, Static and Dynamic characteristics, Gate characteristics, Firing circuits - R, RC, ramp triggering of UJT, Commutation circuits, Protection circuit of SCR, Basic operation and characteristic of Triac, GTO, Diac.	08
2	**Other power semiconductor devices:** Basic operation and characteristics of power diodes, power BJTs, power MOSFETs, IGBTs, Comparison of devices, applications, need for driver circuits and snubber circuits, heat sinks.	04
3	**Controlled Rectifiers:** Single phase half wave rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load, freewheel diode, harmonic analysis of input current and input power factor for single phase fully controlled rectifier, effect of source inductance (concept only), single phase dual converter, Three phase semi converter and full converter with R load, Applications, Numerical for calculation of output voltage, single phase PWM rectifier, basic working principle and applications.	12
4	**Inverter:** Principle of operation, Performance parameters, Single phase voltage source bridge Inverters, Three phase VSI (120° and 180° conduction mode), control of inverter output voltage , PWM techniques-Single PWM, Multiple PWM, Sinusoidal PWM, Introduction to Space vector modulation, Current source inverters, comparison of VSI and CSI, Applications.	12
5	**DC to DC Converter**: Basic principle of dc to dc conversion, switching mode regulators – Buck, Boost, Buck-Boost, Cuk regulators, concept of bidirectional dc to dc converters, all with resistive load and only CCM mode, Applications, Numerical included.	06
6	**AC voltage controllers:** On-Off and phase control, Single phase AC voltage controllers with R and RL loads. **Cyclo converters, Matrix converter:** Basic working principle.	06

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work shall consist of following minimum **six** experiments, Assignments (minimum **Two**).

The distribution of marks for the term work shall be as follows:

Laboratory work (experiments)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

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

Books Recommended:

Text Books:

1. "Power Electronics" M.H.Rashid, Prentice-Hall of India
2. "Power Electronics", Ned Mohan, Undeland, Robbins, John Wiley Publication
3. "Power Electronics", P.C Sen, Tata McGrawhill
4. "Power Electronics: Devices, Circuits and Matlab Simulations" by Alok Jain, Penram International publishing Pvt Ltd
5. "Power Electronics", V.R Moorthi, Oxford University press
6. "Thyristors & their applications", Ramamurthy
7. "Power Electronics", M.D Singh and Khanchandani, Tata McGrawhill

Reference Books:

1. "Power Electronics", Landers, McGraw Hill
2. "Power Electronics", P.S Bhimbra, Khanna Publishers
3. "Elements of power electronics" Philip T Krein, Oxford University Press
4. "Power Electronics for Technology", Ashfaq Ahmed, Pearson
5. "Power Electronics", Joseph Vithayathil, Tata McGrawhill

Suggested Experiments:

1. V-I Characteristics of SCR
2. Firing Circuit of SCR
3. MOSFET/IGBT characteristics
4. Single phase half controlled rectifier circuit
5. Single phase fully controlled rectifier circuit
6. Three phase half /fully controlled rectifier circuit with R load
7. Single phase Inverter

8. Three phase Inverter
9. Triac-Diac circuit
10. Buck converter
11. Boost Converter
12. Implementation of PWM techniques

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract./tut.	Total
EEC505	Communication Engineering (Abbreviated as CE)	3	2	3	1	4

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC505	Communication Engineering (Abbreviated as	20	20	20	80	03	25	-	125

	CE								

Course Code	Course Name	Credits
EEC505	Communication Engineering	4
Course Objectives	• To make the students aware of various technicalities related to analog and digital communication, such as modulation, demodulation, channel band width and coding. • They should be able to differentiate between coding at the source as well as at the channel.	
Course Outcomes	• Students will be familiar with the techniques involved in the field of Radio Communication • Students will be able to detect and correct the errors that occur due to noise during transmission using channel coding techniques • Students will be able to understand the significance of communication systems in power system such as PLCC.	

Module	Contents	Hours
1	**Introduction:** Types of signals, Signal spectrum and band width, Fourier Series, Fourier Transform, Analog and Digital communication system (block diagram).	04
2	**Analog Communication:** Analog Modulation Demodulation Techniques (AM, FM & PM), Amplitude Modulation (AM) - DSBFC, DSBSC, SSB generation, Frequency Modulation (FM) - Noise Triangle, Pre-emphasis and De-emphasis, generation Techniques, Phase Modulation (PM) - Generation Techniques, Radio Receivers, TRF and Superhyterodyne Receivers, AGC Methods, FM Receivers.	10
3	**Information Theory:** Concept of information, Entropy of discrete system, Transmission rate and channel capacity of noisy channels, Shannon's theorem on channel capacity, sampling theorem, Source encoding: Shannon – Fano algorithm, Huffman technique.	06
4	**Digital Communication** : PCM, Delta Modulation and Adaptive delta modulation, ASK, FSK, PSK-BPSK, DPSK (Transmitter Receiver block diagram, Waveforms, Spectrum).	08
5	**Coding Techniques (Algorithmic Approach):** Linear block codes (coding and decoding), Cyclic codes (generation), Convolution codes (generation only, state diagram and code tree not included).	06
6	**Overview of different types of communication** : Power Line Carrier communication, Satellite communication, OFC (Block Diagram only).	02

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work shall consist of minimum **Eight** experiments, Assignments (minimum **Two**)

The distribution of marks for the term work shall be as follows:

Laboratory work (experiments)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

Books Recommended:

Text Books:

1. Tomasi W. "Advanced Electronics Communication systems", PGI, 4th Edition1998.
2. Taub & Schiling, "Principles of Communication Systems", McGraw Hill, 2nd Ed. 1987.
3. John C. proakis, "Digital Communication", McGraw Hill International, 1995.
4. Haykin S, John Wiley & Sons, "Digital Communication", 3rd Ed. 1995.

Reference Books:

1. Lathi B.P., "Modern Digital and Analog Communication System, Oxford University Press, 3rd Edition 1998.
2. Dennis Roddy and John Coolen, "Electronic Communications", Prentice Hall of India, 3rd Ed. 1992.

List of Experiments Recommended:

1. AM principle and demodulation using diode detector circuit.
2. Balanced Modulator
3. FM generation
4. Radio receiver characteristics like sensitivity, selectivity, image rejection
5. ASK system
6. FSK system
7. PSK system – BPSK, DPSK
8. Signal sampling
9. Pulse code modulation

10. Linear block codes

Course Code	Course/Subject Name	Credits
EEC506	**Business Communication & Ethics[&]**	**2**

[&] Common with All Engineering Programs

Pre-requisite

- FEC206 Communication Skills

Objectives

1. To inculcate in students professional and ethical attitude, effective communication skills, teamwork, skills, multidisciplinary approach and an ability to understand engineer's social responsibilities.
2. To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career.
3. To inculcate professional ethics and codes of professional practice
4. To prepare students for successful careers that meets the global Industrial and Corporate requirement' provide an environment for students to work on Multidisciplinary projects as part of different teams to enhance their team building capabilities like leadership, motivation, teamwork etc.

Outcomes: A learner will be able to …..

1. communicate effectively in both verbal and written form and demonstrate knowledge of professional and ethical responsibilities
2. Participate and succeed in Campus placements and competitive examinations like GATE, CET.
3. Possess entrepreneurial approach and ability for life-long learning.
4. Have education necessary for understanding the impact of engineering solutions on Society and demonstrate awareness of contemporary issues.

Module	Unit No.	Topics	Hrs
1.0	**1.0**	**Report Writing**	**07**
	1.1	Objectives of report writing	
	1.2	Language and Style in a report	

	1.3	Types of reports	
	1.4	Formats of reports: Memo, letter, project and survey based	
2.0	**2.0**	**Technical Proposals**	**02**
	2.1	Objective of technical proposals	
	2.2	Parts of proposal	
3.0	**3.0**	**Introduction to Interpersonal Skills**	**07**
	3.1	Emotional Intelligence	
	3.2	Leadership	
	3.3	Team Buliding	
	3.4	Assertiveness	
	3.5	Conflict Resolution	
	3.6	Negotiation Skills	
	3.7	Motivation	
	3.8	Time Management	
4.0	**4.0**	**Meetings and Documentation**	**02**
	4.1	Strategies for conducting effective meetings	
	4.2	Notice	
	4.3	Agenda	
	4.4	Minutes of the meeting	
5.0	**5.0**	**Introduction to Corporate Ethics and etiquettes**	**02**
	5.1	Business Meeting etiquettes, Interview etiquettes, Professional and work etiquettes, Social skills	
	5.2	Greetings and Art of Conversation	
	5.3	Dressing and Grooming	
	5.4	Dinning etiquette	
	5.5	Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions)	
6.0	**6.0**	**Employment Skills**	**06**
	6.1	Cover letter	
	6.2	Resume	
	6.3	Group Discussion	
	6.4	Presentation Skills	
	6.5	Interview Skills	
		Total	**26**

List of Assignments

1. Report Writing (Synopsis or the first draft of the Report)
2. Technical Proposal (Group activity, document of the proposal)
3. Interpersonal Skills (Group activity and Role play)
4. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
5. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
6. Corporate ethics and etiquettes (Case study, Role play)
7. Cover Letter and Resume
8. Printout of the PowerPoint presentation

Term Work

Term work shall consist of all assignments from the list.

The distribution of marks for term work shall be as follows:

- Assignments : **20 marks**
- Project Report Presentation: **15 marks**
- Group Discussion: **10 marks**
- Attendance : **05 marks**

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

References

1. Fred Luthans, "*Organizational Behavior*" , Mc Graw Hill, edition
2. Lesiker and Petit, "*Report Writing for Business*" , Mc Graw Hill, edition
3. Huckin and Olsen, "*Technical Writing and Professional Communication*", McGraw Hill
4. Wallace and Masters, "*Personal Development for Life and Work*" , Thomson Learning, 12th edition
5. Heta Murphy, "*Effective Business Communication*" , Mc Graw Hill, edition
6. R.C Sharma and Krishna Mohan, "*Business Correspondence and Report Writing*",
7. B N Ghosh, "*Managing Soft Skills for Personality Development*", Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "*BCOM*", Cengage Learning, 2nd edition
9. Bell . Smith, "Management Communication" Wiley India Edition,3rd edition.
10. Dr. K. Alex ,"Soft Skills", S Chand and Company
11. Dr.KAlex,"SoftSkills",S Chand and Company
12. R.Subramaniam, "Professional Ethics" Oxford University Press 2013.

University of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
	Power System Analysis	Theory	Pract./Tut.	Theory	Pract./tut.	Total

Course Code	Course Name (Abbreviated as PSA)	Examination Scheme							
		Theory					Term work	Prac/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC601	Power System Analysis (Abbreviated as PSA)	20	20	20	80	03	25	-	125

EEC601

Course Code	Course Name	Credits
EEC601	**Power System Analysis**	**5**
Course Objectives	• To give the students basic knowledge of the various faults and it's analysis • To give the students basic knowledge of transients occurring in power system	
Course Outcomes	• Students will be able to analyze various types of faults occurring in power system • Engineering knowledge in effects of faults and mitigation of transients	

		4	2	4	1	5

Module	Contents	Hours
1	**Symmetrical Fault Analysis:** Introduction to synchronous machine, basic construction and operation and equivalent circuit diagram , short circuit of synchronous machine: no load and loaded machine, transient on a transmission line, selection of Circuit breaker, short circuit MVA, algorithm for SC studies, Z Bus formulation, symmetrical fault analysis using Z bus **(numerical on Z bus formulation upto 3x3 matrix).**	14
2	**Unsymmetrical Fault Analysis:** Symmetrical component transformation, phase shift in star-delta transformers, sequence impedances and sequence network of transmission line, synchronous machine and transformer, power invariance, construction of sequence network of a power system. Fault analysis of unsymmetrical faults, single line to ground (SLG) fault, line to line (L-L) fault, double line to ground (LLG) fault, open conductor faults, bus impedance matrix method for analysis of unsymmetrical shunt faults.	14
3	**Power System Transients**: Review of transients in simple circuits, recovery transient due to removal of short circuit, arcing grounds, capacitance switching, current chopping phenomenon. Travelling waves on transmission lines, wave equation, reflection and refraction of waves, typical cases of line terminations, attenuation, Bewely lattice diagram. Lightning phenomenon, mechanism of Lightning stroke, shape of Lightning voltage wave, over voltages due to Lightning, Lightning protection problem, significance of tower footing resistance in relation to Lightning, insulator flashover and withstand voltages, protection against surges, surge arresters, surge capacitor, surge reactor and surge absorber, Lightning arrestors and protective characteristics, dynamic voltage rise and arrester rating.	08
4	**Insulation Coordination:** Volt time curve, over voltage protection, ground wires, insulation coordination based on lightning, surge protection of rotating machines and transformers	02
5	**Corona:** Phenomenon of corona, Disruptive critical voltage, Visual critical voltage, corona loss, factors affecting corona loss, Radio interference due to corona, practical considerations of corona loss, corona in bundled conductor lines, corona ring, corona pulses- their generation and properties in EHV lines, charge voltage (q-V) diagram and corona loss.	04
6	**Uncompensated Transmission Line**: Electrical Parameters, Fundamental Transmission Line equation, Surge Impedance and Natural Loading, the uncompensated line on Open circuit, the uncompensated line under load- Effect of line length, load power and power factor on voltage and reactive power, Maximum power and stability	06

	considerations.	

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work shall consist of minimum Five Tutorials and Three simulations.

The distribution of marks for the term work shall be as follows:

Laboratory work/Tutorials (Journal)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

Books Recommended:

Text Books:

1. Wadhwa C.L. *Electrical power system*, New Age International,4th edition,2005
2. Hadi Saadat, Power System Analysis, TMH publications,2002
3. D. P. Kothari, I. J. Nagrath, Modern *Power System Analysis*, Mc Graw Hill,3rd edition,2006
4. B.R. Gupta, *Power System Analysis And Design*, S.Chand,4th edition,2007
5. Begamudre R.D. "Extra High Voltage AC Transmission Engineering", New Age International, 2nd edition
6. Soni M.L., Bhatanagar U.S, Gupta P.V, A *course in electrical power*, Dhnapat Rai sons
7. Timothy J.E.Miller, "Reactive Power Control in Electric Systems" Wiley India Pvt Ltd. 2010.

Reference Books:

1. Stevenson, *Modern power system analysis*, TMH publication
2. Turan Gonen, Modern power system analysis, Wiley,1988
3. Mehta V.K., *Principle of power system*, S Chand,4th edition,2005.
4. Arthur R. Bergen, Vijay Vittal, "Power System Analysis", Pearson Publication, Second Edition.

Tutorial /Assignment based on following topics:

1) Symmetrical Fault Analysis
2) Bus Impedance formulation and symmetrical fault analysis using Z Bus
3) Symmetrical Component
4) Unsymmetrical Fault Analysis
5) Unsymmetrical Fault Analysis
6) Travelling Waves and Corona

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC602	Electrical Machines-III (Abbreviated as EMC-III)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC602	Electrical Machines-III (Abbreviated as EMC-III)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC602	Electrical Machines-III	5
Course Objectives	• To impart the knowledge of working principle, operations, performance and applications of 3φ Synchronous Generators and Synchronous Motors • To develop the d-q model of 3φ Synchronous Machines and Induction Machines	
Course outcomes	• Students will be able to understand the engineering fundamentals of synchronous machines. • Gain an ability to design and conduct performance experiments, as well as to identify, formulate and solve machine related problems.	

Module	Contents	Hours
1	**Synchronous Generator:** Construction, Emf induced in ac winding, winding factors, armature reaction, phasor diagram, OC and SC test, voltage regulation by EMF, MMF, ZPF, ASA, Saturated synchronous reactance method, power flow and maximum power conditions, parallel operation, effect of changing mechanical torque, effect of changing excitation, effect of excitation on alternator connected to infinite bus.	20
2	**Salient Pole Synchronous Generators**: Blondel's two reaction theory, power angle characteristics, synchronizing power and torque.	06
3	**Synchronous Motor:** Principle of operation, phasor diagram, power flow and maximum power conditions, excitation circles, power circles, V curves and O curves, power factor control (Effect of change in excitation on power factor), Hunting, Dampers, Starting methods, Starting against high torques, Measurement of X_d and X_q.	12
4	**Theory of Synchronous Machine:** The ideal synchronous machine, synchronous machine Inductances, Transformation to Direct and Quadrature axis variables, Basic machine relations in dq0 variables, Steady state Analysis.	05
5	**Theory of Induction Machine:** The ideal Induction machine, Transformation to d-q variables, Basic machine relations in d-q variables, Steady state Analysis.	03
6	**Sequence Reactance of Synchronous Generator (Only for practical)** Measurement of positive, negative and zero sequence reactance of Synchronous generator.	02

***Includes both Practical and Oral examination**

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Practical and Oral examination:
The distribution of marks shall be as follows:
Performance of Experiments : 15 marks
Oral examination : 10 marks

Term work:
Term work shall consist of minimum **seven** experiments, Assignments (minimum **Two**).

The distribution of marks for the term work shall be as follows:

Laboratory work (experiments)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

Books Recommended:

Text Books:

1. Electrical Machinery by P.S.Bimhhra, VII Edition, Khanna Publisher
2. Electrical Machines by Nagrath and Kothari.TMH Publication.
3. Electrical Machinery by Fitzgerald and Kingsley, Second Edition, Mc Graw Hill Book Company
4. Generalized Theory of Electrical Machines by Dr. P.S.Bimhhra, V Edition, Khanna Publishers
5. Electrical Machines by Smarajit Ghosh, Pearson Education

Reference Books:

1. Performance and Design of AC Machines by M.G.Say, CBS Publishers
2. Electrical Machines, by Charles I. Hubert, Pearson Education
3. Electrical Machines, Drives, and Power System, by Theodore Wildi, Pearson Education

List of Laboratory Experiments Recommended:

1. Construction details of Synchronous machine
2. Regulation of alternator by direct loading.
3. Regulation of alternator by EMF and MMF method
4. Regulation of alternator by ZPF, ASA and saturated synchronous reactance method.
5. To study the Excitation required to maintain terminal voltage of an alternator constant.
6. V and inverted V curves of synchronous motor
7. Determination of X_d and X_q by slip test.
8. Synchronization of Alternators.
9. Parallel operation of alternators.
10. Starting methods of synchronous motor.
11. Use of Synchronous motor as a synchronous condenser.
12. Performance curves of synchronous motor by conducting brake test with rated excitation.
13. To determine positive sequence, negative sequence and zero sequence reactance of an alternator

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEC603	Utilization of Electrical Energy (Abbreviated as UEE)	3	1	3	1	4

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC603	Utilization of Electrical Energy (Abbreviated as UEE)	20	20	20	80	03	25	25	150

Course Code	Course Name	Credits
EE603	**Utilization of Electric Energy**	**4**
Course Objectives	• To impart the basic knowledge of some major applications which utilizes electrical energy.	
Course Outcomes	• Recognize the need for technical change & ability to learn in the broadest knowledge of Technical Advancement in Traction, Illumination and other	

	Applications.

Module	Contents	Hours
1	**Systems of Traction:** Diesel Traction, Electric Traction, Various systems of Track Electrification like DC, single phase, Three phase & Composite system. Train Movement & Energy Consumption-Typical Speed /Time Curves, Mechanics of Train Movement, Power & Energy output from the driving axles, Specific Energy consumption, Factors affecting Specific Energy consumption, Dead weight, Accelerating weight and Adhesive weight.	12
2	**Electric Traction Motors & Control:** Suitability of DC/AC motors for traction purpose, Starting & speed control by using rheostat method, series parallel method, Thyristor control method. Power supply for electric traction - Current collection systems and related overhead equipment, substations - location & Distribution System, substation equipment, Traction SCADA & Signaling.	06
3	**Illumination Engineering:** Basic terms in lighting systems, Laws of illumination, Polar curves, Photometry, Measurement of illumination, sources of light, study of different types of lamps ,types of luminaires , various factors related to luminaire selection, their control, and their features .Types of lighting systems, Recommended Illuminance levels for various tasks/activities/ locations.	10
4	**Electric Vehicle (EV) and Hybrid Electric Vehicles (HEV):** Architectures of hybrid EV/HEV power system, Energy Sources for EV /HEV applications, Type of motors used in EV/HEV and their comparison.	03
5	**Other applications of Electrical Energy:** Terminology, Refrigeration cycle, Vapor compression type, vapor absorption type, Electrical circuit of a Refrigerator, Room Air conditioner window type & split type	03
6	**Electric heating & Welding:** Basic working principle of Arc furnace, Induction furnace, Power supply requirement for furnaces, Electric welding equipment & power supply requirements.	02

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.

End Semester Examination: Some guidelines for setting the question papers are six questions to be set each of 20 marks. Out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work shall consist minimum of eight practicals / tutorials.

The distribution of marks for the term work shall be as follows:

Laboratory work/Tutorials (Journal)	: 10 marks
Assignments	: 10 marks
Attendance	: 05 marks

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

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

Books Recommended:

Text Books:

1. Utilization of Electric Energy by J.B.Gupta, SK Kataria & Sons
2. Utilization of Electric Energy by R.K.Rajput, Laxmi Publications(P) Ltd
3. Generation, Distribution and Utilization of Electric Energy by C.L.Wadhwa, Wiley Eastern Ltd
4. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.

Reference Books:

1. Art & Science of Utilization of Electric Energy by H.Partap, Dhanpat Rai & Sons
2. Electric Traction By H.Partap, Dhanpat Rai & sons
3. Designing with light-A Lighting Handbook By Anil Valia, Lighting System
4. Generation and Utilization of Electric Energy by S.Sivanagaraju, Pearson Education India
5. 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

Website Reference:

http://nptel.iitm.ac.in :Introduction to Hybrid and Electric Vehicles - Web course

Tutorials:

Numerical on Module 1, 2 &3

Practicals :

1) Study & Testing of various lamps
2) Measurement of lux levels by using Luxmeter
3) Visit to a railway workshop near by
4) Demonstration of Air conditioning system

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC604	Control System-I (Abbreviated as CS-1)	Theory	Pract./Tut.	Theory	Pract./tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC604	Control System – I (Abbreviated as CS-1)	20	20	20	80	03	25	--	125

Course Code	Course Name	Credits
EEC604	**Control System-I**	**5**
Course Objectives	• To model a system using transfer function and state space.	