UNIVERSITY OF MUMBAI

Bachelor of Engineering

Electrical Engineering (Sem. VII 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

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

(Electrical Engineering)

Scheme for Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./Tut.	Theory	Pract./Tut.	Total
EEC701	Power System Operation and Control	4	2	4	1	5
EEC702	High Voltage DC Transmission	3	2	3	1	4
EEC703	Electrical Machine Design	4	2	4	1	5
EEC704	Control System – II	4	2	4	1	5
EEE70X	Elective I	4	2	4	1	5
EEC706	Project- I	--	6#	--	3	3
Total		**19**	**16**	**19**	**8**	**27**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. / oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
EEC701	Power System Operation and Control	20	20	20	80	03	25	--	125
EEC702	High Voltage Transmission	20	20	20	80	03	25	—	125
EEC703	Electrical Machine Design	20	20	20	80	03	25	25	150
EEC704	Control System – II	20	20	20	80	03	25	25*	150
EEE70X	Elective I	20	20	20	80	03	25	—	125
EEC706	Project- I	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**50**	**725**

*** Includes both Practical and Oral examination**

X- **Indicates elective one to seven**

 # workload of learner in sem-VII is equivalent to 6 hrs/wk

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

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
EEC701	Power System Operation and Control (Abbreviated as PSOC)	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					
EEC701	Power System Operation and Control (Abbreviated as PSOC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEC701	**Power System Operation and Control**	**5**
Course Objectives	• To impart knowledge in power system operation and its control. • To study steady state and transient analysis in power system.	
Course outcomes	• Student should be capable to analyze power system problem and find out its solutions.	

Module	Contents	Hours
1	**Load Flow Studies:** Network model formulation, Y bus formation and singular matrix transformation. Load flow problem, Gauss Seidel (GS) methods. Newton Raphson methods (NR) (Polar, Rectangular form). Decoupled, Fast Decoupled load flow and comparison. Concept of DC loads flow.	10
2	**Economic System Operation:** Generator operating cost:- input-output, Heat rate and IFC curve, Constraints in operation, Coordinate equation, Exact coordinate equation, Bmn coefficients, transmission loss formula. Economic operation with limited fuel supply and shared generators, Economic exchange of power between the areas Optimal unit commitment and reliability considerations	08
3	**Automatic Generation and control:** Load frequency control problem, Thermal Governing system and transfer	12

	function. Steam Turbine and Power system transfer function. Isolated power system:- static and dynamic response PI and control implementation Two area load frequency control, static and dynamic response Frequency biased Tie line Bias control-implementation and effect Implementation of AGC, AGC in restructured power system, under frequency load shedding, GRC, Dead band and its effect.	
4	**Inter Change of Power and Energy:** Multiple utility interchange transaction, Other types of transactions, Power Pool.	04
5	**Power System Stability:** Types of Stability Study, Dynamics of synchronous machine, Power angle equation, Node elimination technique, Simple Systems, Steady state stability, Transient stability, Equal area criteria and its applications, Numerical solution of swing equation, Modified Euler's method.	10
6	**Voltage stabilty:** Introduction, reactive power transmission, short circuit capacity, Problems of reactive power transmission, rotor angle stability and voltage stability, surge impedance loading, P-V and V- Q curve, various methods of voltage control –shunt and series compensation. Voltage Control- Tap changing transformers, Booster transformers, Static voltage compensators, Thyristorised series voltage injection	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 shall consist of minimum four programs or four Simulations based on above syllabus and four tutorials covering the entire syllabus

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. Kothari. D. P, Nagrath. I. J., 'Modern Power System Analysis', TMH Publication, Third Edition, 2008
2. Kothari. D. P, Nagrath. I. J., 'Power System Engineering', TMH Publication, Second Edition, 2008
3. George Kausic. 'Computer Aided Power System Analysis', Prentice Hall Publication.2008
4. Chakrabarti .A, Halder. S, 'Power System Analysis- Operation and Control', PHI, Second Edition 2008.
5. Allen. J. Wood., Bruce. F. Wollenberg., 'Power Generation operation and Control', Wiley India, Second Edition, 2007.
6. Prabha Kundur , 'Power System Stability and Control' , TMH Publication,2008.

Reference Books:

1. Soman. S. A, Kharphade. S. A, and Subha Pandit 'Computer Methods for Large Power System Analysis, an Object Oriented Approach', Kluwer Academic Publisher New York 2001
2. Anderson P.M, Fouad A.A, 'Power System Control and Stability', Wiley Inter-Science, 2008 Edition
3. Kimbark E W, 'Power System Stability', Volume I, and III, Wiley Publication.
4. Jr W.D. Stevenson., G. J. Grainger. 'Elements of Power System'. Mc-Graw-Hill, Publication.
5. Hadi Saadat, Power System Analysis**,** TMH Publication ,Second Edition, 2002
6. S.Sivanagaraju, G.Sreenivasan Power System Operation and Control, pearson Publication,2010.

Recommended Programs and Simulations

1. Y bus formation by singular matrix transformation Y bus formation by adding one element at a time.
2. Gauss Siedel Load flow
3. Optimal loading of generator
4. Transient stability of single machine.
5. Simulation of LFC of Isolated power system under different conditions
6. Simulation of LFC of Two Area power system under different conditions

University of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEC702	High Voltage DC Transmission (Abbreviated as HVDCT)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		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					
EEC702	High Voltage DC Transmission (Abbreviated as HVDCT)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEC702	**High Voltage DC Transmission**	**4**
Course Objectives	• To give the students in depth knowledge of the configuration and working of HVDC system	
Course outcomes	• Student should able to analyze HVDC system and its impact on existing power system.	

Module	Contents	Hours
1	**Introduction to HVDC transmission**: Early discoveries and applications, , Limitation and advantages of AC and DC transmission, Economic factors, Classification of HVDC links, Components HVDC Transmission system, Application of DC transmission , Ground Return Advantages and Problems	4
2	**Analysis of the Bridge rectifier:** Analysis of six pulse converter with grid control but no overlap, Current and phase relations, Analysis of six pulse converter with grid control and overlap less than 60^0, Relation between AC and DC quantities, Analysis with overlap greater than 60^0, Rectifier operation and inverter operation, Equivalent circuit of rectifier and inverter, Multi bridge converter, Numerical from converter circuits and multiple bridge converter.	10
3	**Control:** Basic means of control, Limitation of manual control, Constant current	6

	verses constant voltage control, Desired features of control, Actual control characteristics, Significance of current margin, Power reversal, Alternative Inverter Control Mode.	
4	**Converter Firing Control:** Control Implementation, Converter Firing Control Schemes.	4
5	**Faults and protection:** Malfunction of mercury arc valves, By pass valves:- transfer of current from main valves to bypass valves and back to main valves (both rectifier and inverter), Commutation failure: causes and analysis, double commutation failure, Protection against over current, over voltage, Surge arrester.	8
6	**Harmonics & Filters:** Characteristics Harmonics and Un-Characteristics Harmonics, Causes, Consequences, Trouble Caused by Harmonics, Means of Reducing Harmonics, Filters, AC & DC Filters.	4

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 two programs or two Simulations based on above syllabus and six tutorials covering the entire syllabus

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

Simulation/programs and tutorial : 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. Edward Wilson Kimbark "Direct Current Transmission" Wiley publication Inter science
2. K R Padiyar "HVDC power transmission systems" second edition, New Age International (p)Ltd
3. S. Kamkshaiah and V Kamraju "HVDC transmission" Tata McGraw Hill Education Pvt. Ltd, New Delhi

Reference Books:

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

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC703	Electrical Machine Design (abbreviated as EMD)	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					
EEC703	Electrical Machine Design (abbreviated as EMD)	20	20	20	80	03	25	25	150

Course Code	Course Name	Credits
EEC703	**Electrical Machine Design**	**5**
Course Objectives	• To impart knowledge of various aspects of Electrical Machine Design and make them aware of recent trends in design.	
Course outcomes	• Students will be able to relate the physical dimensions of different parts of the machine to the rating • Students will be exposed to the optimization in design.	

Module	Contents	Hours
1	**Introduction**: Introduction to machine design, Magnetic, Electrical, Conducting and Insulating materials used in machines.	05
2	**Design of Single phase and Three phase transformers** Review on construction and parts of transformer, 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,	10
3	**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/ radiators, IS: 1180, IS: 2026.	08
4	**Design of Three phase Induction motors:**	10

	Output equation, Choice of specific electric and magnetic loadings, Standard frames, Main dimensions, Design of stator and rotor windings, Stator and rotor slots, Design of stator core, air gap, Design of squirrel cage rotor, end rings, Design of wound rotor, Types of enclosures.	
5	**Performance measurement of three phase Induction motors:** Calculation of leakage reactance for parallel sided slot, Carter's coefficients, Concept of B_{60}, Calculation of No load current, Short circuit current, Calculation of maximum output from Circle diagram, Dispersion coefficient, IS325, IS1231, IEC 60034. Design criteria of Energy efficient Induction motor.	09
6	**Design examples of Transformers and Induction Motors.**	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:

1. The complete design of one Three phase transformer and one Three phase induction motor with standard frame size; Minimum four sheets (full imperial size) covering the diagrams of individual parts and the assembled views. At least one sheet should be using AUTOCAD. Design should be based on the Indian Standard Specifications.
2. A combined report (group of maximum four students) on recent trends in transformer and induction machine manufacturing should be submitted.
3. Minimum three assignment covering complete syllabus.

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. A.K. Sawhney, "Electrical Machine Design", Dhanpat Rai & Co
2. M.V.Deshpande, "Design and Testing of Electrical Machines", PHI Learning.
3. M.G.Say, "Performance & Design of AC Machines", Pitman

4. Indrajit Dasgupta, “Design of Transformers”, TMH

Reference Book:

1. K.L.Narang, “Electrical engineering Drawing”, Satya Prakashan, New Delhi
2. K.G. Upadhyay, “Design of Electrical Machines “, New age publication.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEC704	Control System _ II (abbreviated as CS - 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					
EEC704	Control System – II (abbreviated as CS - II)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC704	**Control System – II**	**5**
Course Objectives	• Learning how to improve performance of any system using various techniques like state space , Bode plot, and Digital control • Learning the automation of systems using PLC.	
Course outcomes	• Students will have knowledge of different compensating methods and the automation of basic systems using PLC	

Module	Contents	Hours
1	**Introduction to controllers and controllers Design**: Lag, lead and lead-lag network, cascade and feedback compensation and concept of Proportional, Integral and derivative controllers (all these with no numerical), design of gain compensation, lag, lead, lag-lead compensators through frequency response technique (simple design problems).	06
2	**PID controllers**: Introduction to different form of PID controllers, textbook and industrial form, issues in implementation of industrial PID, and modifications in the form of PID controllers, reverse acting controller.	04
3	**Design Via state Space**: Introduction to controller design via gain adjustment, controllability, alternative approach to controller design, introduction to observer(estimator), observability, alternative approach to observer design, steady state error design via integral control.	12
4	**Digital control System:** introduction to digital control system, Modeling the digital computer, Pulse transfer function, Block diagram reduction, concept of stability in digital control system, Digital system stability via the s-plane (using Routh-Hurwitz) Steady state error, Transient response on Z	10

	plane (no numerical), cascade compensation via s-plane, implementation of digital compensator.	
5	**Programmable Logic Controllers**: Introduction to PLC, Input output field devices, block diagram of PLC, input output module, power supply, programming unit, processing unit, rack assembly, memory unit, relay ladder logic circuit , addressing modes in PLC, relationship of data file to I/O module.	06
6	**Fundamentals of PLC programming**: PLC program execution, ladder diagram programming language, instructions set of PLC, simple programs using these instructions, jump and loop instruction, shift instruction, troubleshooting PLC.	10

***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 should consist of four practical on PLC, four programs / simulation on rest of the syllabus and one test paper.

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

Practical Work (Design, drawing sheets, report on recent trends) :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. Control system engineering by Norman Nise 2nd to latest edition
2. Control Engineering: An Introductory course by Wilkie J., Johnson M., Katebi R., Palgrave MacMillan, Ist to latest edition
3. Industrial Control Electronics: Devices, Systems and Applications by Bartelt, Delmar Thomson Learning, 1st edition

4. Introduction to Programmable Logic Controller by Dunning G, Delmar Thomson Learning , 2nd edition

Reference books:

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

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEE701	High Voltage Engineering (Abbreviated as HVE)	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					
EEE701	High Voltage Engineering (Abbreviated as HVE)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE701	**High Voltage Engineering**	**5**
Course Objectives	• To provide an understanding of high-voltage phenomena and to present the basic of high-voltage insulation design and testing • To understand the modern numerical tools available in high-voltage equipment design.	
Course outcomes	• Able to know the fundamentals properties of the materials and their failure mechanisms to get appropriate and optimal design. • Students will be aware of testing of different dielectric materials and the major requirements for setting up of HV Laboratories.	

Module	Contents	Hours
1	**Electrostatic Fields, their control and estimation:** Electric field stress, its control and estimation, Analysis of electrical field intensity in Homogenous Isotropic Single dielectric and multi dielectric system, Numerical methods-Finite difference, Finite Element and Charge simulation methods for the estimation of Electric Field Intensity, Surge voltage, their distribution and control	06
2	**Conduction and breakdown in air and other gaseous dielectrics in electric fields:** Collision Processes, Ionization processes, Townsend's current growth equation-Primary and secondary processes, Townsend's criterion for	09

	breakdown in electronegative gases. Limitation of Townsend's theory, Paschen's law, Breakdown in non-uniform fields and corona discharges, Post-breakdown phenomenon and application, Practical considerations in using gas for insulation purposes.(Numerical on Townsend's theory, Paschen's law)	
3	**Breakdown in liquid and solid dielectrics** Liquid Dielectrics, Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids. Solid dielectrics, Intrinsic, Electro-mechanical and Thermal breakdown, Breakdown of solid dielectrics in practice**,** Breakdown of composite insulation, Properties of composite dielectrics**,** Solid dielectrics used in practice, Application of insulating materials in electrical power apparatus, electronic equipments.	8
4	**Generation & Measurement of High voltage and Currents:** Generation of HV DC, HV AC and Impulse voltage, Generation of impulse currents, Tripping and control of impulse generators, Measurement of HVDC-High ohmic series resistance with micro-ammeter, HVAC and impulse voltage-Resistance and capacitance voltage dividers, Spark gap for measurement of High DC, AC and impulse voltages. Measurement of High DC, AC and impulse currents (Numerical based on impulse generation, high DC voltage generation, optimum number of stages).	11
5	**Testing and evaluation of dielectric materials and power apparatus:** Non-destructive testing of dielectric materials, DC resistivity measurement, Dielectric and loss factor measurement, Partial discharge measurement, Testing of insulators, bushing, isolators, circuit breakers, cable, transformers, high voltage motors , surge diverters, Radio interference measurement.	10
6	**High Voltage laboratory–design, planning and layout:** Size and dimensions of the equipment and their layout, Classification of HV laboratory, Earthing and its importance.	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 would consists of at least 02 practical/02 simulations/ a report on visit to any HV lab and 06 assignments

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. Naidu M. S. and Kamraju V., high voltage engg. TMH publications second ed.,1995
2. Wadhwa C. L. ,High voltage engg ,Wiley Eastern ltd., first ed., 1994
3. Kuffel E. and Abdullah M. 'Introduction to High voltage engg, Pergamon, 1970.
4. Kuffel E. 'High voltage engg, Pergamon, 1984.

Reference Books:

1. E. Kuffel, W. S. Zaengl and J. Kuffel High Voltage Engineering Fundamentals Second Edition Elsevier Publication
2. Dieter Kind and Kurt Feser High Voltage Test Techniques (SBA Electrical Engineering Series) by Shankars Book Agency Pvt. Ltd.

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE702	Analysis and Design of Power Switching Converters (abbreviated ADPSC)	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					
EEE702	Analysis and Design of Power Switching Converters (abbreviated ADPSC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE702	**Analysis and Design of Power Switching Converters**	**5**
Course Objectives	• To make students understand the concepts and basic operation of efficient switched-mode power conversion, including basic circuit operation, analysis of different conduction modes and magnetics design.	
Course outcomes	• Gain knowledge in design of converters including selection of various components and fabrication converters for specific applications	

Module	Contents	Hours
1	**Basic DC to DC converters:** Buck Converter, Boost Converter, Buck – Boost , Continuous (CCM) and Discontinuous mode(DCM) of operation, boundary between CCM and DCM, CUK converter, introduction to SEPIC converter, Calculation of output voltage ripple, Numericals	10
2	**Switching Power Supplies:** Overview of switching power supplies, Isolated dc/dc converters, Transformer core utilization, - Fly back and Forward Converters– duty	08

	cycle derivation, waveforms, Comparison of converters, Numericals	
3	**Control Aspects:** Voltage mode control- PWM and feed forward control, Current mode control, Slope compensation, comparison of voltage and current mode control, Power supply protection, Electrical isolation in the feedback loop, Designing to meet power supply specifications, PI and Type III controllers	04
4	**Converter Design:** Selection of output filter capacitor, Selection and design of high frequency Inductor and high frequency transformer, Selection of switches, Snubber circuit design, PWM ICs, Design of driver circuits, Necessity of EMI filter, Thermal resistance , Selection of Heat sinks , Simple heat sink calculations	12
5	**Switched mode inverters:** Review of single phase and three phase bridge inverters, PWM techniques, Detailed analysis of sinusoidal PWM- Effect of m_a and m_f, Analysis of harmonic spectrum, Space vector modulation- switching sequence, duration of zero and active vectors, Introduction to multilevel inverters	08
6	**Applications:** DC/DC converter as Power factor Corrector (active shaping of the line current), in Renewable energy systems , Applications of inverters in power systems, renewable energy systems, drives etc.	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: Mini project on "Design, Implementation and Testing of a dc to dc converter for specific application"

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) Mohan N. Undeland . T & Robbins W., “Power Electronics Converters , Application and Design” John Wiley, 3rd edition
2) Umanand L., Bhat S.R., “Design of magnetic components for switched Mode Power converters” , Wiley Eastern Ltd.
3) “Power Electronics: Devices, Circuits and Matlab Simulations” by Alok Jain, Penram International publishing (India Pvt, Ltd)
4) “Power Electronics”, Joseph Vithayathil, Tata McGrawhill
5) “Power Electronics” M.H.Rashid, Prentice-Hall of India

Reference Books:

1. Robert. W. Erickson, D. Maksimovic “Fundamentals of Power Electronics”, Springer International Edition,
2. Philip T Krein, “Elements of power electronics”, Oxford University Press
3. Billings K.H., “Handbook of Switched Mode Power Supplies”, McGraw Hill
4. IEEE Transactions on Power Electronics

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE703	Power System Modelling (abbreviated PSM)	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					
EEE703	Power System Modelling (abbreviated PSM)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE703	**Power System Modelling**	**5**
Course Objectives	• To impart the knowledge of mathematical modeling of electrical power system • To study the steady state and dynamic behavior of power system	
Course outcomes	• Students will be familiar with modeling of different elements of power system • They will be able to do the system planning and expansion for future demand in power system	

Module	Contents	Hours
1	**Introduction:** Components of power system, Need for power system modeling, dqo transformation, α-β transformation.	4
2	**Synchronous machine modeling:** Physical description, Mathematical description of synchronous machine in abc frame of reference, synchronous machine model in dq0 frame of reference (rotating frame) and pu representation.	12
3	**Excitation system modeling:** Excitation system requirements, Elements of excitation system, Types of excitation system and modeling of excitation systems.	6

4	**Transmission line and Transformer modeling:** Transmission line, d-q transformation using α-β variables. Transformer modeling such as auto-transformer, tap-changing & phase-shifting transformer.	10
5	**SVC and Load modeling:** Static VAR compensators, Basic concept of load modeling, modeling of induction motor.	8
6	**Modeling of non-electrical component:** Simplified models of non-electrical components like boiler, steam & hydro-turbine & governor system.	8

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 **Eight** experiments, Assignments (minimum **Two**).

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

Practical Work (Design, drawing sheets, report on recent trends) :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:

Reference Books:

1. Power System Dynamics & Control – Kundur, IEEE Press , New York
2. Power System Operation & Control – P.S.R. Murthy
3. "Electrical Energy System Theory – an introduction" by Olle Elgerd. TMH Publishing Company 2nd Edition, New Delhi
4. "Power System Analysis" – John J. Granier and W.D. Stevenson Jr, 4th Edition, McGraw Hill International student edition.
5. "Power System Modeling and Fault Analysis" – Nasser Tleis, Elsevier publication.

University Of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE704	Digital Signal Controllers and its Application (abbreviated DSCA)	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					
EEE704	Digital Signal Controllers and its Application (abbreviated DSCA)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE704	**Digital Signal Controllers and its Application**	**5**
Course Objectives	• To impart knowledge of digital signal controllers along with their applications in power system and power electronics fields. • To realize real time system in digital domain through programming of DSC	
Course outcomes	• Students will understand the basics of design and implementation of DSC based systems	

Module	Contents	Hours
1	**Introduction** Review of microprocessor, microcontroller and digital signal processors architecture, Fixed and floating-point processors Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Floating Point Numbers. Review of commonly used DSP processors and their applications, introduction to TMS320C2000 digital signal controller (DSC)	06
2	**DSC Architecture and Peripherals** Overview of TMS320C2000 Digital signal controller family – Features, Architecture, Interrupt and Reset, Memory map - On-chip memories: Flash, RAM, and Boot ROM, Clock system- Digital I/O -CPU Timers – Analog to Digital Converter (ADC), Pulse Width Modulator (PWM), High Resolution PWM, Capture Module, Quadrature Encoder Pulse (QEP) Module Communication Interface and protocols.	10

3	**DSC Programming** Code development process, Assembly language programming, Linker, C Compiler, Code Composer Studio (CCS) and online debugging tools	06
4	**Mathematical tools for Real Time DSC implementation:** Review of numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method. Implementation of digital filters and transformations	6
5	**DSC Applications in Power Electronics:** Speed control of Induction motor, BLDC motor, Digital control of DC/DC converter, LED Lighting.	8
6	**DSP Applications in Power Systems** Implementation of Active filters in DSP under balanced and unbalanced condition, harmonic oscillator and 3ϕ phase lock loop, Static VAR Compensator, Hardware in Loop simulations. Design of a DSP controlled Converter/Inverter system:	12

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 would consists of minimum 08 practicals / simulations and 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:

Reference Book:

1. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
2. Digital Signal Processing in Power System Protection and Control By Waldemar Rebizant, Janusz Szafran, and Andrzej Wiszniewski, Springer.
3. Digital Power Electronics and Applications By *Fang Lin Luo , Hong Ye and Muhammad Rashid,* Elsevier Academic Press.

4. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
5. Power Electronics, Converters, Applications & Design by N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt. Ltd.
6. Modern Power Electronics and AC Drives by B. K Bose, Pearson Education
7. DSP Based Electromechanical Motion Control by Hamid Toliyat and Steven Campbell, CRC Press

List of recommended experiments:

The experiments to be performed using CCS with TMS320F280xx family controllers.
Write program for DSC (Any four)

- Generation of sine wave
- Sense a non-sinusoidal voltage/current and find out harmonic content in it
- Generation of Sine-PWM signals
- Implementation of dq reference transformations
- Implementation of Harmonic Oscillator
- PLL implementation

DSP Controlled Applications (Any two)

- Closed loop control of DC-DC converter
- Power factor correction in converters
- LED lamp intensity control
- Solar PV based converter / inverter system
- Speed control of BLDC / PMSM motor
- Communication System protocol implementation

University Of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE705	**Advanced Lighting Systems** (abbreviated ADLS)	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					
EEE705	Advanced Lighting Systems (abbreviated ADLS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE705	**Advanced Lighting Systems**	**5**
Course Objectives	• To learn the various design philosophies used in lighting system. • To understand the state of the art of lighting control and solid state lighting.	
Course Outcomes	Students will be able to: • Design the lighting system for various applications. • Understand and design lighting control system for achieving the energy efficiency. • Grasp the basic and details of futuristic solid state lighting.	

Module	Contents	Hours
1	**Introduction**: Review of Light, Color and Photometry: Laws of illumination, illumination entities. Radiometric and photometric standards, Photometric measurement procedure- assessment of lamp efficacy, Color temperature, Colorimetry- Measurement of CRI, Glare	03
2	**Lamps and Luminaries:** Lamp: Review of development, construction and characteristics: Incandescent lamp, Discharge lamps: fluorescent lamps, CFL, mercury vapor, sodium vapor, metal halide, induction lamp, and LED lamp. Luminaire: optical control, Control gear: ballast, standard and electronic, Luminaries photometry, Luminaire testing procedures.	07

3	**Interior Lighting Design & Calculation:** Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Indoor lighting design by lumen method, by point by point method. Applications: residential, educational institute, industries, sports centers, commercial premises: retail stores, offices etc. Applicable standards.	12
4	**Exterior Lighting Design & Calculation:** Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Applicable standards.	06
5	**Lighting Control:** Introduction to Lighting Control, Controls, Selection of Lighting Controls, Design of Lighting Control Scheme, Lighting and LEED, Lighting Controls and the ASHRAE/IES 90.1-1999, Personal Lighting Control, Day-lighting control, Lighting control for Fluorescent Lamps and Electronic Ballasts in Frequently Switched Applications, Linear Fluorescent Dimming Ballasts, Dimming of High-Intensity Discharge Lamps, Controlling LED Lighting Systems, Smart Lighting Fixtures Digital Lighting Networks, DMX control, BACnet: Building Automation Standard Protocol,:	10
6	**Solid-State Lighting:** LED as a light source, color quality of Light, efficacy evaluation, thermal Management, drivers for LED lamps, Lighting Control, Protocol, standards and regulations, LED luminaries, Indoor Lighting Applications, Street & Roadway Lighting, Outdoor Utility Area, and Solar Powered LED Lighting.	10

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:

1. Four lab experiments based on study of lamps and luminaries operation and construction parameters measurements
2. Group study report on observation and analysis of existing lighting installation (at least 4) at following areas: commercial/ non commercial, industries/offices, indoor/outdoor, sports center etc.
3. Minimum two designs on interior and exterior lighting based on specific applications. Design calculation and computer aided design

Term work shall consist of lab experiments / group study and CAD design as described above.
The distribution of marks for the term work shall be as follows:

Laboratory work (Experiments, Group studies and Journal)	: 10 marks.
Group Case Studies	: 10 marks.
Attendance (Practical and Theory)	: 5 marks.

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

Books Recommended:

Text Books:

1. "Designing with light: Lighting Handbook", by Anil Valia, International Lighting Academy 2002
2. "Lamps and Lighting", by M.A. Cayless and A.M. Marsden; Edward Arnold
3. "Interior Lighting for Designers", by Gary Gorden, John Wiley & Sons Inc.
4. "Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications", by Craig DiLouie, The Fairmount Press, 2006
5. "Automated Lighting", by Richard Cadena, Second Edition, Focal Press, 2010
6. "Solid State Lighting Reliability: Components to Systems", by W.D. van Driel l X.J. Fan, Springer, 2013
7. "LED Lighting Systems: All you need to know", by Anil Valia, International Lighting Academy, 2012
8. "LEDs for Lighting Applications", by Patrick Mottier, ISTE Ltd and John Wiley & Sons, Inc. 2009
9. "LED Lighting", by Sal Cangeloso, Published by O'Reilly Media, Inc., 2012

Reference Book:

1. "IESNA lighting Handbook", by D.L. Dilaura, K. W. Houser, R.G.Mistrick and G. Steffy, Illuminating Engineering Society of North America, 10th edition 2011
2. "Simplified Design for Building Lighting", by M.Schiler, John Wiley & Sons Inc
3. IS 3646- Part I: 1992, Code of practice for interior illumination, BIS publication

University Of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEE706	Renewable Energy and Energy Storage Systems (abbreviated REESS)	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					
EEE706	Renewable Energy and Energy Storage Systems (abbreviated REESS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE706	Renewable Energy and Energy Storage Systems	**5**
Course Objectives	• To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization. • To relate and study the various energy storage technology and their significance in the context of renewable energy based applications.	
Course outcomes	• Students will understand the basics of utilization of renewable energy sources, related power systems configurations and basis for futuristic power grid scenario.	

Module	Contents	Hours
1	**Introduction**: Review of worlds production and reserves of commercial energy sources, India's Production and reserves, energy alternatives, Review of conventional and non conventional energy sources. Distributed generation, Future trends in power generation and distribution.	04
2	**Solar Energy:** Review of solar thermal applications-solar thermal conversion devices and storage applications. Review of solar photovoltaic (PV) cells, principle of power generation using solar PV; Solar PV cell model, emerging solar cell technologies; Solar PV modules from solar cells, Mismatch in module , hot spots in the module , Bypass diode, Design and structure of PV modules , PV module power output , I-V and power curve of module;	14

	BOS of PV system**,** battery charge controllers, MPPT, and different algorithms for MPPT, distributed MPPT, Types of PV systems; Design methodology of standalone PV system. Solar PV Micro-inverters. Power quality and protection issues, review of regulatory standards.	
3	**Wind Energy**: Review of wind energy system and its components, types of wind turbines, characteristics; Power generation and control in wind energy systems, performance calculations of wind energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	08
4	**Fuel Cell**: Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications.	05
5	**Other Sources:** Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro.	03
6	**Energy Storage** Forms of energy storage, importance of storage system in new power generation scenario; Types, characteristics and performance evaluation of: batteries, ultra-capacitors, flywheels, SME, pumped hydro storage system; Applications of Energy storage in distributed generation, smart grid systems, Electric and Hybrid electric vehicles. Hybrid power system based on renewable energy and energy storage.	14

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 would consists of minimum 08 practicals / simulations and 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:

Reference Book:

1. Chetan Singh Solanki , *Solar Photo Voltaics* , PHI Learning Pvt Ltd., New Delhi,2009
2. Hashem Nehrir and Caisheng Wang, Modeling *and control of fuel cells: Distributed Generation Applications,* IEEE Press, 2009
3. J.F. Manwell and J.G. McGowan, *Wind Energy Explained, theory design and applications*, Wiley publication
4. D. D. Hall and R. P. Grover, *Biomass Regenerable Energy,* John Wiley, New York, 1987.
5. Felix A. Farret and M. Godoy Simoes, *Integration of Alternative Sources of Energy*, 2006, John Wiley and Sons.
6. M. Ehsani, Y. Gao, and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, Second Edition, CRC Press.
7. S. Chakraborty, M. G. Simões and W. E. Kramer, *Power Electronics for Renewable and Distributed Energy System,* Springer 2013
8. Ahmed Faheem Zobaa, *Energy storage – Technologies and Applications,* InTech Publication 2013.
9. N. Femia • G. Petrone, G. Spagnuolo and M. Vitelli, *Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems,* CRC Press, 2013

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE707	Optimization Techniques and its Applications (abbreviated OTA)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ tut.	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE707	Optimization Techniques and its Applications (abbreviated OTA)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE707	**Optimization Techniques and its Applications**	**05**
Course Objectives	• To teach Conventional and Evolutionary Techniques for obtaining optimal solutions in a numerical form.	
Course Outcomes	• Students will be capable of analyzing various techniques and choosing the best technique for any particular application.	

Module	Contents	Hours
1	**Introduction:** Optimization Techniques, Conventional Techniques, Evolutionary Techniques.	02
2	**Linear Programming:** Simplex method, Revised simplex method, Duality in linear programming	05
3	**Non-linear Programming**: Quadratic Programming with Kuhn-Tucker conditions and Wolfe's Modified simplex method , Geometric programming	05
4	**Dynamic Programming (DP):** Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem. Integer Programming: Gomory's cutting plane method, Branch and bound algorithm.	12
5	**Genetic Algorithm**: Definition and concept used in GA, coding of variables, fitness function.	12

	General algorithm of GA, Unconstrained and constrained optimization using Genetic Algorithm, global optimization using GA. Particle swarm Optimization Algorithm: Basic fundamentals, general PSO Algorithm.	
6	**Applications to power system**: Economic Load Dispatch and Unit commitment problem using dynamic Programming, GA and Particle swam optimization techniques.	12

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 five computer programs/simulations covering 80% of syllabus.

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. Modern Optimization Techniques with Applications in Electric Power Systems. By Soliman Abdel-Hady Soliman, Abdel-Aal Hassan Mantawy, Springer LLC 2012
2. Operations Research Theory and applications, J.K.Sharma, Macmilan, third edition.
3. Engineering Optimization Theory and Practice, S. S. Rao, New Age International Publishers.
4. J.C. Pant: Introduction to Optimization, Jain Brothers, 2004
5. Optimization of Power System Operation, By Jizhong Zhu, August 2009, Wiley-IEEE Press

Reference Books:

1 David G Luenberger, “Linear and Non Linear Programming”, 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 1973

2 Kalyanmoy Deb, “Optimization for Engineering Design-Algorithms and Examples”, Prentice Hall India- 1998.

3 Systems & Control , Stanislaw H. Zak, Oxford

University of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
		Theory	Pract. /Tut.	Theory	Pract.tut.	Total
EEC801	Design, Management and Auditing of Electrical System (abbreviated as DMAES)	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					
EEC801	Design, Management and Auditing of Electrical System (abbreviated as DMAES)	20	20	20	80	03	25	-	150

Course Code	Course Name	Credits
EEC801	Design, Management and Auditing of Electrical System	**5**
Course Objectives	1) To give the students basic knowledge of designing electrical distribution network 2) To give the students basic knowledge of electrical energy audit in the distribution system	
Course outcomes	1) Students will be sizing, selecting transformer, switchgear and cable as required for distribution system 2) Engineering knowledge in energy audit and energy efficient technologies to improve energy efficiency	

Module	Contents	Hours
1	**Introduction** Types of electrical Projects, Types of electrical system, review of components of electrical system, different plans/ drawings in electrical system design, single line diagram in detail,	02
2	**Design of Power Distribution System** Different types of distribution systems and selection criteria, temporary and permanent power supply, electrical load size, L.F, D.F, future estimates, substation equipment's options, design considerations in transformer selection, sizing and specifications, IS standards applicable in above design	08

3	**Design of Switchgear Protection and Auxiliary system** Selection of HT/LT switchgears, metering, switchboards and MCC, protection systems, coordination and discrimination. Cables selection and sizing, cable installation and management systems, busbars design; Basics of selection of emergency/backup supplies, UPS, DG Set, Batteries; Preliminary design of interior lighting system. IS standards applicable in above designs	16
4	**Energy Monitoring and Targeting:** Defining monitoring and targeting. Elements of monitoring and Targeting. Analysis techniques for energy optimization, Cumulative Sum of Differences (CUSUM). Electricity billing. **Energy Management of Electrical Systems:** Electrical load management and maximum demand control, Power factor improvement and its benefit, selection and location of capacitors, distribution and transformer losses.	04
5	**Energy Audit:** Introduction to Energy Conservation Act 2001 and ECBC 2007. Energy Audit: Definition,-need, Types of energy audit, Energy Management (audit) approach-understanding energy costs, Bench marking, Maximizing system efficiencies, optimizing input energy requirement, fuel and energy substitution. Energy Audit instruments. **Electrical Energy Performance Assessment**: Motors And Variable Speed Drives, Lighting Systems. Basics of HVAC system assessment for electrical energy usage.	10
6	**Energy Efficient Technologies**: Maximum Demand controllers, Automatic Power Factor Controllers, Energy Efficient Motors, Soft starters, Variable Speed Drives, Energy Efficient Transformer. Energy saving potential of each technology. **Energy Efficient System Design:** Lighting System; Use of Energy Management system (EMS) and Building Management System (BMS).	08

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:

It is desirable to invite the Certified or Practicing Energy auditor to showcase and present some case-studies of actual energy audits carried out which will help the students to relate the course contents with actual practice. Two group (preferably group of 6-8 students) assignments

should be given to carry out the preliminary Electrical Energy Audit and appropriate report should be presented as a part of the term work

Term work shall consist of minimum six experiments/ tutorials and two group assignments.

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

Laboratory work (Experiments simulations/tutorials and Journal) :10 marks.
Group assignments :10 marks.
Attendance (Practical and Theory) : 5 marks.

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

Books Recommended:

Text books:

1. "Handbook of Electrical Installation Practice" Fourth Edition, by Geofry Stokes, Blackwell Science
2. "Energy-Efficient Electric Motor", Third Edition, By Ali Emadi, New Marcel Dekker, Inc., 2005.
3. "Electrical Energy Efficiency: Technologies And Applications" by Andreas Sumper and Angelo Baggini, John Wiley & Sons, Ltd., 2012
4. "Electrical Calculations and Guidelines for Generating Stations and Industrial Plants" by Thomas E. Baker, CRC Publications, 2012
5. "Electrical Installations Handbook" , Third Edition, by Gunter Seip, MCD Verilag, 2000
6. "Electrical Installation Designs", Fourth Edition by Bill Atkinson, Roger Lovegrove and Gary Gundry, John Wiley & Sons, Ltd, 2013.
7. "Handbook of International Electrical Safety Practices", by Princeton Energy Resources International, Scrivener Publishing, 2010.
8. "Designing with Light: Lighting Handbook", by Anil Valia, Lighting System
9. "Energy Management Handbook", by W.C. Turner, John Wiley and sons
10. "Handbook on Energy Audits and Management", by Amit Kumar Tyagi, TERI
11. "Introduction to Efficient Electrical System Design" , by Stephen Ayraud and Albert Thumann, The Fairmount Press

*Reference books***:**

1. "Energy Auditing Made Simple", by P. Balasubramanian, Seperation Engineers (P) Ltd
2. "Electrical Installation Calculations: for Compliance with BS 7671:200", Fourth Edition, by Mark Coates, Brian Jenkins, John Wiley & Sons, Ltd, 2010
3. "Energy Management Principles", by C.B.Smith, Peragamon Press
4. "Energy Conservation Guidebook", by Dale R.Patrick, Stephon Fadro, E. Richardson, Fairmont Press
5. "Handbook of Energy Audits", by Albert Thumann, William J. Younger, Terry Niehus, CRC Press

Websites:

www.energymanagertraining.com

www.bee-india.nic.in

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEC802	Drives and Control (Abbreviated as DC)	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					
EEC802	Drives and Control (Abbreviated as DC)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC802	**Drives and Control**	**5**
Course Objectives	• To expose the students to the Engineering fundamentals of various Drives and its control, Dynamic operation and their Applications.	
Course outcomes	• Gain an ability to design and conduct performance experiments, as well as to identify, formulate and solve drives related problems.	

Module	Contents	Hours
1	**Electrical Drives: Introduction &Dynamics** Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives, Fundamental Torque equations, Speed Torque conventions and Multi-quadrant Operation, Equivalent values of Drive Parameter, Measurement of Moment of Inertia, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy-Loss in Transient Operations, Steady State Stability, Load Equalization	10
2	**Selection of Motor Power Rating:** Thermal Model of Motor for Heating and Cooling, Classes of Motor Rating, Determination of Motor Rating.	04
3	**Control of Electrical Drives:** Modes of Operation, Speed Control, Drive Classification, Closed loop Control of Drives	04
4	**DC Drives:** Review of Speed Torque relations for Shunt, Series and Separately excited Motors, Review of Starting, Braking (Regenerative, Dynamic, Plugging),	

	Review of Speed control, Controlled rectifier fed DC drives (separately excited only): Single phase fully-controlled Rectifier, Single phase Half controlled Rectifier, Three phase fully-controlled Rectifier, Three phase Half-controlled Rectifier, Dual Converter Control, Chopper Control – Motoring and Braking of separately excited and Series Motor. (No numerical from this module)	06
5	**AC Drives:** Induction Motor drives, Review of Speed-Torque relations, Review of Starting methods, Braking (Regenerative, Plugging and AC dynamic braking), Transient Analysis, Speed Control: Stator voltage control, Variable frequency control from voltage source, Static Rotor Resistance control, Slip Power Recovery - Static Scherbius Drive, Review of d-q model of Induction Motor, Principle of Vector Control, Block diagram of Direct Vector Control Scheme, Comparison of Scalar control and Vector control, Basic Principle of Direct Torque Control (block diagram) of induction motor. Introduction to Synchronous Motor Variable Speed drives.	18
6	**Special Motor Drives:** Stepper Motor drives- Types, Torque vs. Stepping rate characteristics, Drive circuits, Introduction to Switched reluctance motor drives and Brushless DC motor drives.	06

***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 **Six** experiments and **Two** simulations, 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. Fundamentals of Electrical Drives by G.K.Dubey, Narosa Publication
2. A First Course on Electrical Drives by S.K.Pillai, New Age International.
3. Electrical Drives: Concepts and Applications by Vedam Subramanyam, T.M.H
4. Modern Power Electronics and AC Drives by B.K.Bose, Prentice Hall PTR
5. Special Electrical Machines by E.G. Janardanan, PHI

Reference Books:

1. Electric Motor Drives: Modeling, Analysis and Control by Krishnan.R, PHI
2. Power Electronics by Joseph Vithayathil, Tata McGraw Hill
3. Power Semiconductor Controlled Drives by G. K. Dubey, Prentice Hall International.

List of Laboratory Experiments Recommended:

1. Measurement of Moment of Inertia by Retardation test
2. Study of different Speed Sensing, Current Sensing and Voltage Sensing devices.
3. Single phase fully-controlled rectifier fed DC drive/Single phase half controlled rectifier fed DC drive / Three phase fully-controlled rectifier fed DC drive/ Three phase half-controlled rectifier fed DC drive/Dual Converter controlled fed DC drive. (Simulation/ Hardware)
4. Chopper Controlled DC drive. (Simulation/ Hardware)
5. Closed loop Control of DC drive.
6. Simulation of Starting of DC motor (Conventional resistance start and any one Soft start scheme)
7. Dynamic braking, Plugging of DC motor.
8. Plugging of 3φ Induction Motor.
9. Simulation of V control and V/f control of Induction motor using PWM Inverter.
10. Transient Analysis of 3φ Induction Motor (Simulation)
11. Hands on Experience in Programming a general purpose 3φ Induction Motor Industrial Drive.
12. Demonstration of Vector Control of 3φ Induction Motor (Simulation).
13. Demonstration of Direct Torque Control of 3φ Induction Motor (Simulation).
14. Study of Special Motor Drives.

University of Mumbai						
Subject Code	**Subject Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEC803	Power System Planning and Reliability (abbreviated as PSPR)	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	2	3	1	4

Subject Code	Subject Name	Examination Scheme							
		Theory					Term work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC803	Power System Planning and Reliability (abbreviated as PSPR)	20	20	20	80	03	25	-	125

Subject Code	**Subject Name**	**Credits**
EEC803	**Power System Planning and Reliability**	**4**
Course Objectives	• To understand the different power system planning and forecasting, techniques and reliability evaluation in terms of basic reliability indices.	
Course outcomes	• Should be able to make a Generation System Model for the Power system in terms of frequency and duration of failure. • Should be able to calculate reliability indices of the power system based on system model and the load curve. • Should be able to plan a small Generation and Transmission system, predict its behavior, and do the required change in order to achieve reliability.	

Module	**Contents**	**Hours**
1	**Load Forecasting:** Introduction, Classification of Load, Load Growth Characteristics, Peak Load Forecasting, Extrapolation and Co-Relation methods of load Forecasting, Reactive Load Forecasting, Impact of weather on load forecasting.	06
2	**System Planning:** Introduction to System Planning, Short, Medium and Long Term strategic planning, Reactive Power Planning**.** Introduction to Generation and Network Planning, D.C load flow equation,	06

	Introduction to Successive Expansion and Successive Backward methods.	
3	**Reliability of Systems:** Concepts, Terms and Definitions, Reliability models, Markov process, Reliability function, Hazard rate function, Bathtub Curve. Serial Configuration, Parallel Configuration, Mixed Configuration of systems, Minimal Cuts and Minimal Paths, Methods to find Minimal Cut Sets, System reliability using conditional probability method, cut set method and tie set method.	08
4	**Generating Capacity: Basic probability methods and Frequency & Duration method**: Basic Probability Methods: Introduction, Generation system model, capacity outage probability table, recursive algorithm for rated and derated states, Evaluation of: loss of load indices, Loss of load expectation, Loss of energy. Frequency and Duration Method: Basic concepts, Numericals based on Frequency and Duration method.	08
5	**Operating Reserve:** General concept, PJM method, Modified PJM method.	04
6	**Composite generation and transmission system:** Data requirement, Outages, system and load point indices, Application to simple system	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 shall consist of minimum 02 computer programs/simulations and six tutorials covering the entire syllabus.

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. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company
2. Electrical Power System Planning – A.S Pabla, Macmillan India Ltd.
3. Reliability Evaluation of Power System - Roy Billinton and Ronald N Allan, Springer Publishers

Reference Book:

1. Reliability Assessment of Large Electric Power Systems - Roy Billinton and Ronald N Allan, Kluwer academic publishers, 1988
2. Reliability Evaluation of Engineering System- Roy Billinton and Ronald N Allan, Springer Publishers
3. Electrical Power System Planning: Issues, Algorithms and Solutions – Hossein Seifi and M.S Sepasian, Springer Publishers
4. Modern Power System Planning – X. Wang and J.R. McDonald, McGraw Hill

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE801	Flexible AC Transmission Systems (abbreviated as FACTS)	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					
EEE801	Flexible AC Transmission (abbreviated as FACTS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE801	**Flexible AC Transmission**	**5**
Course Objectives	• To understand problems in high voltage AC transmission • To find solutions to various problems in AC transmission using power electronic devices.	
Course outcomes	• Students should be able suggest proper solution to mitigate the problems in power system	

Module	Contents	Hours
1	**FACTS Concepts and General System Considerations**: Transmission Interconnections, Flow of Power in AC system, What Limits the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of controllable Parameters, Basic Types of FACTS Controllers, Brief Description and Definitions, Benefits from FACTS Technology	6
2	**Load Compensation**: Objectives in load compensation, ideal compensator, Practical considerations, Power factor correction and Voltage Regulation in single phase systems, Approximate reactive power characteristics with example, Load compensator as a voltage regulator, Phase balancing and power factor correction of unsymmetrical loads	12
3	**Static shunt compensators:** Objectives of shunt compensation, Methods	12

	of controllable VAR generation, Variable impedance type static Var generator(TCR,TSR,TSC,FC-TCR), Switching converter type Var generators, basic operating principle	
4	**Static series compensation**: Objectives of series compensation- Variable impedance type series compensation(only TSSC) , Switching converter type series compensation(only SSSC)	08
5	**Static voltage and phase angle regulators-** Objectives of voltage and phase angle regulators- TCVR and TCPAR, Switching converter based voltage and phase angle regulators	06
6	**Unified Power Flow Controller (UPFC):** Basic operating principle, Conventional transmission control capabilities	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 shall consist minimum Five Tutorials /and experiments and Three simulations.

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

Tutorial/experiments/simulations : 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. 'Hingorani N.G.. & Gyugi L., "Understanding FACTS : Concepts and Technology of Flexible AC Transmission Systems," Wiley-1EEE Press
2. Timothy J. E. Miller "Reactive power control in Electric Systems," Wiley India Edition.

Reference Books:

1. Yong Hua Song "Flexible AC transmission system" Institution of Electrical Engineers, London
2. Arindam Ghosh and Gerard Ledwich, " Power Quality Enhancement Using Custom Power Devices," Kluwer Academic Publishers

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE802	Electric and Hybrid Electric Vehicle Technology (abbreviated as EHEVT)	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					
EEE802	Electric and Hybrid Electric Vehicle Technology (abbreviated as EHEVT)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE802	**Electric and Hybrid Electric Vehicle Technology**	**5**
Course Objectives	• To introduces the fundamental concepts, principles, analysis and design of electric and hybrid electric vehicles.	
Course outcomes	• Students will understand the basics of new unconventional vehicular power systems, their current technology and future trends in automotive industry.	

Module	Contents	Hours
1	**Introduction:** Basics of vehicles mechanisms**,** history of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, Power/Energy supplies requirements for EV/HEV applications, vehicle power source characterization, and transmission characteristics.	06
2	**Drive-train Topologies:** Review of electric traction, various electric drive-train topologies, basics of hybrid traction system, various hybrid drive-train topologies, power flow control in drive-train topologies, fuel efficiency analysis.	06
3	**DC and AC Machines for Propulsion Applications:** Electric system components for EV/HEV, suitability of DC and AC machines for EV/HEV applications, AC and DC Motor drives. Advanced permanent magnet and switch reluctance machines, configuration and control of drives.	10

4	**Energy Sources for EV/HEV:** Requirements of energy supplies and storage in EV/HEV, Review of batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV, characteristics and comparison of energy sources for EV/HEV, hybridization of different energy sources.	08
5	**Modeling and design of the drive trains:** Modeling and analysis of EV/HEV drive train, sizing of motor, and design of traction power electronics, various vehicle subsystems.	10
6	**Energy Management Strategies and Energy Efficiency:** EV/HEV energy management strategies, classification and comparison of various energy management strategies, energy efficiency comparison for various EV and HEV variants	08

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 will consist of four **assignments**, minimum two **simulations.**

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

Laboratory work (simulations/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:

Reference Book:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
4. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives,*
5. B.D. McNicol and D.A.J. Rand, *Power Sources for Electric Vehicles,* Elsevier Publications*. 1998*
6. N.Mohan, T.M.Undeland, W.P Robbins, *Power Electronics, Converters, Applications & Design,* Wiley India Pvt. Ltd., 2003
7. Modern Power Electronics and AC Drives by B. K Bose, Pearson Education

Website Reference:

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

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE803	Power Quality (abbreviated as PQ)	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					
EEE803	Power Quality (abbreviated as PQ)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE803	**Power Quality**	**5**
Course Objectives	• To get awareness about non-linear loads in power system • To understand how non-linear loads affects power quality • To study the solution to improve power quality	
Course outcomes	• Students should be able to analyze the problems due to non-linear load and suggest solution for the same	

Module	Contents	Hours
1	**Introduction:** Disturbances, Unbalance, Distortion, Voltage Fluctuations, Flicker, Quality Assessment	06
2	**Harmonics:** Definition of harmonics, odd and even harmonics, Harmonic phase rotation and phase angle relationship, Causes of voltage and current harmonics, non-sinusoidal voltage and current waveform equations(numerical included), individual and total harmonic distortion with problems, Power assessment under waveform distortion with numerical	10
3	**Power Quality monitoring & standards:** Introduction, transducers current transformers, voltage transformers, Power quality instrumentation, Harmonic monitoring, Power quality standards IEEE 519	06
4	**Effects of harmonics:** Rotating Machines – Transformers – Cables – Capacitors – Harmonic resonance – Voltage Notching – EMI (Electromagnetic Interference) –	06

	Overloading of Neutral conductor– Protective relays and Meters	
5	**Power factor and its improvement under sinusoidal and non-sinusoidal conditions:** Power factor when both voltage and current sinusoidal, Power factor compensation using capacitor (vector diagram and numerical included), power factor when voltage is sinusoidal and current is non-sinusoidal (numerical included), Effect of capacitor compensation in power factor improvement under non-sinusoidal condition.	12
6	**Harmonic mitigation and power factor improvement** Mitigation of harmonics- Passive filters- Advantages and disadvantages of passive filters- Active filters-shunt connection, series connection and hybrid connection(Detailed diagram with inverters and its working), Power factor improvement using shunt active filter(both reactive power and harmonic power compensation), Generating reference currents for shunt active filter using Instantaneous PQ Theory	08

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 shall consist of minimum **Six** tutorials/experiments and **Two** simulations,

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

Laboratory work (simulations/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. "Power System Quality Assessment", J. Arrillaga, N.R.Watson, S.Chen
2. "Power Quality" , C. Shankaran, CRC press
3. "Reactive power control in electric systems" by Timothy J. E. Miller
4. "Power Quality Enhancement Using Custom Devices" Arindam Ghosh, Gerard Ledwich
5. "Power Electronics" Ned Mohan, Undeland, Robbins, John Wiley Publication
6. "Power System Analysis- Short Circuit Load Flow and Harmonics" J.C.Das.

7. “Understanding Power Quality Problems,Voltage Sag and Interruptions ” Math H.J.Bollen

Reference Book:

a. “Power System Harmonics” Jos Arrillaga, Neville R Watson
b. “Electric Power Quality” , G.T.Heydt
c. “Electric Power Systems and Quality” , Roger C. Dugan,Mark F. McGranaghan, H.Wayne Beaty
d. “IEEE-519 Standard”

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE804	Smart Grid Technology (abbreviated as SMT)	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					
EEE804	Smart Grid Technology (abbreviated as SMT)	20	20	20	80	03	25	-	125

Course Code	**Course Name**	**Credits**
EEE804	**Smart Grid Technology**	**5**
Course Objectives	• To impart knowledge of futuristic power grid technology and the path on which development is taking place.	
Course outcomes	• Students will get an exposure to the fundamentals of various technologies and tools which will play vital role in formation of the Smart grids in near future.	

Module	**Contents**	**Hours**
1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional grid & smart grid, Concept of Resilient & Self Healing Grid. Present development & International policies in Smart Grid. Case studies of Smart Grid. CDM opportunities in Smart Grid.	08
2	**Smart Grid enabling Technologies:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.	08
3	**Smart Measurement and Monitoring Technologies:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Wide Area	08

	Measurement System(WAMS), Phase Measurement Unit(PMU).	
4	**Microgrids and Distributed Energy Resources:** Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Review of fundamentals and Integration of renewable energy sources. Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage. Microgrid and Smart grid comparison.	08
5	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.	08
6	**Communication Technology for Smart Grid:** Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication; Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. IP based protocols.	08

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 six tutorial/simulations and assignments (Min 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. Smart Grid:Fundamentals of Design and Analysis by James Momoh, IEEE Press and Wiley Publications
2. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley

3. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response” CRC Press
4. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
5. Jean Claude Sabonnadière, Nouredine Hadjsaïd, “Smart Grids”, Wiley Blackwell

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEE805	Power System Dynamics and Control (PSDC)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	POE	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE805	Power System Dynamics and Control (PSDC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE805	**Power System Dynamics and Control**	**5**
Course Objectives	• To study the system dynamics and its control which has a significant bearing on integrality of the system following major disturbances.	
Course outcomes	• The students will be able to analyse system dynamics and its control	

Module	Contents	Hours
1	**Synchronous Machine Modeling And Representation :** Basic equations of synchronous machine, dqo transformation, Per unit-voltage- flux- torque- power equations and reactance, Equivalent circuit d-q axis, Voltage current flux linkage relation- phasor representation- rotor angle-steady state equivalent circuit. Three phase short circuit, Magnetic saturation and representation Simplifications for large scale studies, Constant flux linkage model.	14
2	**Excitation System:** Excitation system requirement, Elements of excitation system, Types of excitation system, Dynamic performance measures, Control and protective functions, Basic elements of different types of excitation system.	10
3	**Small Signal Stability (SSS):** Fundamental concept of stability of dynamic system, Eigen properties of state matrix, SSS of single machine infinite bus system, Effect of AVR on synchronizing and damping torque, Power system stabilizer, SSS of multi-machine system, Special techniques to analyze large system, Characteristics	12

	of SSS, SSS Enhancement.	
4	**Voltage Stability:** Basic concepts, Voltage collapse, Voltage stability analysis, Prevention of voltage collapse.	12

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 four, computer programs or four Simulations, and four tutorials covering the entire syllabus.

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.

Recommended Computer Simulations:

1. Demonstration of the Three-Phase Programmable Source, Sequence Analyzer, and abc_dq0 transformation blocks.
2. Synchronous generator powered by hydraulic turbine with excitation and governor systems.
3. Torque amplification study: IEEE second benchmark on sub synchronous resonance (case 1A)
4. Performance of Three PSS for Inter area Oscillations.
5. Transient stability of a two-machine transmission system with Power System Stabilizers (PSS) and Static Var Compensator (SVC).

Books Recommended:

Text Books:

1. Prabha Kundur , Power System Stability and Control , TMH Publication,2008
2. Padiyar K R, Power System Dynamics- Stability and Control, BSP Publication.

Reference Books:

1. Kimbark E W, Power System Stability, Volume I, III, Wiley publication.
2. Jr W.D. Stevenson., G. J. Grainger. Elements of Power System. Mc-Graw-Hill Publication.

3. Anderson P.M, Fouad A.A, Power System Control and Stability, Wiley Inter-Science, 2008 Edition
4. Saur P W, Pai M A, Power System Dynamics and Stability, Pearson Education Asia
5. Pai, Sen Gupat, Padiyar, Small Signal Analysis of Power System, Narosa Publication, 2007 Edition.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEE806	Nonlinear control system (abbreviated as NCS)	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					
EEE806	Non-linear control system (abbreviated as NCS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE806	Non-linear control system	**5**
Course Objectives	• The aim of the course is to learn to recognize nonlinear control problems, to master the most important analysis techniques for nonlinear systems, and to learn how to use practical tools for nonlinear control design.	
Course Outcomes	• Students will have knowledge of the complexity of nonlinear systems and various tools for the analysis and control of nonlinear systems.	

Module	Contents	Hours
1	Characteristics of nonlinear systems, multiple equilibria, limit cycle, jump phenemona, method of analysis, clasisification of nonlinearities, Common Physical Nonlinearities.	06
2	**Phase Plane Analysis**: Phase Plane Method, phase portraits, Analytical Methods for the Construction of Phase Trajectories, Graphical Method of Construction of Phase Trajectory, Qualitative behavior of Linear systems, phase plane analysis of nonlinear systems, Multiple equilibria, existence of limit cycles, Linearization techniques.	08
3	**Describing Function Analysis of Nonlinear Systems**: Introduction, Basic Definition of Describing Function, Basis of Describing Function Analysis, Describing Function for Typical Nonlinearities (saturation, dead zone, relay, backlash, hysteresis) , Closed Loop Stability Using Describing Function, Stability of the Limit Cycles, Relative Stability from Describing Function.	08
4	**Stability of Systems**: Concept of stability, Stability analysis of autonomous and nonautonomous systems. LaSalle Invariance Principle, stability in the	12

	sense of Lyapunov and absolute stability. Zero - input and BIBO stability. Second (or direct) method of Lyapunov stability theory for continuous and discrete time systems.	
5	**Passivity**: Power and energy of passive systems, Definitins, passivity and small gain, Passivity of linear time invariant systems, strictly positive real functions .	06
6	**Frequency domain analysis of feedback systems**: Circle, popov criteria, Popov's stability criterion, generalized circle criterion,	08

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 should consist of four programs/simulation and one test paper.

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

Practical Work (Design, drawing sheets, report on recent trends) :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. Nonlinear Systems: Third Edition by H. Khalil, 2002.
2. M. Vidyasagar Nonlinear System Analysis, Second Edition, Prentice Hall.
3. Modern Control Engineering by Dr. K. P. Mohandas, Sanguine publishers,
4. Non linear control systems Analysis and design, Horacio Márquez, John Wiley and sons Introduction to Programmable Logic Controller by Dunning G, Delmar Thomson Learning , 2nd edition

Reference books:

1. Modern control system engineering by K. Ogata, printice Hall.
2. Automatic Control System: George J. Thaler Brown, Jaico Publications
3. Control Systems Theory and Application: Samarjit Ghosh, Pearson Education
4. Systems & Control , Stanislaw H. Zak, Oxford

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE807	Entrepreneurship Development (Abbreviated as ED)	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					
EEE807	Entrepreneurship Development (Abbreviated as ED)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE807	**Entrepreneurship Development**	**5**
Course Objectives	• To understand the concept and process of Entrepreneurship, its contribution, role in the growth & development of individual and the nation.	
Course Outcomes	• Acquiring Entrepreneurial knowledge &Spirit and be Enterprising in all walks of life	

Module	Contents	Hours
1	**Entrepreneurship Concept:** Entrepreneur, Entrepreneurship, Rural Entrepreneurship, Women Entrepreneurship, Factors affecting Entrepreneurial growth, Motivation, competencies, mobility, EDPs.	06
2	**Start-UP:** Small Enterprises an introduction to framework, Ownership structures, Retail Entrepreneurship in India, Pre-feasibility Analysis, Project identification and selection, Project formulation, Project Appraisal, Financing of Enterprises, Feasibility report preparation and evaluation criteria	12
3	**Support:** Institutional finance to Entrepreneurs, Lease financing and hire purchase, Institutional support to Entrepreneurs, Taxation benefits to Small scale industries, Government Policies & Regulations, International Business.	10

4	**Business Management:** Nature and scope, Fundamentals of Management, Management of Working Capital, Inventory, Production & operation, Marketing, Human Resource and TQM.	10
5	**Monitoring and Evaluation of Business:** Accounting, Growth strategies, sickness in small business, e-commerce, Franchising, Intellectual Property Rights.	06
6	**Case studies:** Case studies of Entrepreneurs, Model proposals and Feasibility reports to be discussed.	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 should consist of Minimum of 6 Tutorials / Practicals Recommended:

1) Case study on an important topic in each module to be prepared by the students
2) At the end of semester, a complete Business Proposal report to be submitted and presented by the students.

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

Practical Work (Design, drawing sheets, report on recent trends) :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. Entrepreneurial Development, S.S.Kanaka, S.Chand & Company
2. Entrepreneurship Development, SL Gupta, Arun Mittal, International Book House, Pvt Ltd
3. Entrepreneurship, Rober D.Hisrich, Michael P.Peters, Dean.A.Shepherd,Tata McGraw-Hill

Reference Books:

1. Entrepreneurship, Rajeev Roy, OXFORD university Press
2. Entrepreneurship-Creating & Leading an Entrepreneurial organization, Arya Kumar, Pearson

3. Entrepreneurship-A south Asian Perspective, DF Kuratko, TV Rao, Cengage Learning
4. Entrepreneurship Development in India , Dr.CB Gupta, Dr.NP Srinivasan, Sultan Chand & Sons