AC 14/07/2016
Item No. 4.9

UNIVERSITY OF MUMBAI

Revised Syllabus for the

M.E. Electrical Engineering
(Power System Engineering)

(As per Choice Based Credit and Grading System with effect from the academic year 2016–2017)

From Co-ordinator's Desk:

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

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) 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, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Choice Based Credit and Grading System were implemented for First Year Master of Engineering from the academic year 2016-2017. Subsequently this system will be carried forward for Second Year Master of Engineering in the academic year 2017-2018.

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

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and 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 post-graduate program in Electrical Engineering (Power System Engineering), more than ten senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for post-graduate program in Electrical Engineering (Power System Engineering) are listed below;

Program Educational Objectives (PEOs)

- To create the competent & skilled engineers to ensure them the careers and employment and in this way fulfill the requirement of Multinational industries.
- To develop the strong ability in data analysis & their report towards an application for design and development of power systems.
- Expose them by giving an opportunity as an individual as well as team.
- Inculcate professional and ethical attitude and ability to relate power system issues to society at large.
- Facilitate strong base of basic scientific & engineering knowledge with professional ethics, lifelong learning attitude society globally.
- Be successful innovative and entrepreneur in the power system field via consultancy work.

Program Outcomes (POs)

- Able to demonstrate & competent enough in basic knowledge in Mathematics, Engineering and Technology to obtain the solution of engineering problem.
- Have ability to formulate the engineering problem, design the setup for experimentation, analysis and interpretation of the result data, report preparation.

- Develop the competency to design power system, control systems, engineering software's, simulated model and solutions etc as per desired specification & requirement as applicable/useful to public/society.
- Demonstrate the ability to work on basic engineering discipline as well as multi-disciplinary engineering teams to achieve the solution of engineering problem.
- Strong competency in using modern engineering tools like MATLAB / Simulink, for solution of electrical engineering problems.
- Able to use the acquired knowledge and professional skill and project as well as budget management towards betterment of the society.
- Understand the needs of the society worldwide in the context of his professional knowledge to ensure environmental safety and better sustainability.
- Capable to apply ethical principles with committed professional ethics and duties towards the solution of complex engineering problems.
- Motivate to work independently as well as a member of team or team leader in multi functionaries and diversified knowledge platforms.
- Develop an effective inter personnel communication skill at large with public and professional bodies. They will be able to comprehend the data and accordingly will prepare technical design details, datasheets, reports, documentation etc.
- Inculcate the lifelong learning in the purview of updates /upgrade in engineering and technology.
- Investigate the complex engineering problems using acquired knowledge in electrical engineering to develop industrial level solutions in the interest of society.

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

Program Structure for
M.E. Electrical Engineering (Power System Engineering)
University of Mumbai
(With Effect from 2016-17)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PSC101	Applied Linear Algebra*	04	----	----	04	----	----	04
PSC102	Electrical Power System Modeling	04	----	----	04	----	----	04
PSC103	Advanced Power System Analysis	04	----	----	04	----	----	04
PSDLO101X	Department Level Optional Course-I	04	----	----	04	----	----	04
ILO101X	Institute Level Optional Course-I	03	----	----	03	----	----	03
PSL101	Laboratory-I	----	02	----	----	01	----	01
PSL102	Laboratory-II	----	02	----	----	01	----	01
Total		**19**	**04**	**----**	**19**		**02**	**21**

Subject Code	Subject Name	Examination Scheme							
		Theory			End Sem. Exam	Exam Duration (in Hrs)	Term Work	Pract. /Oral	Total
		Internal Assessment							
		Test 1	Test 2	Avg.					
PSC101	Applied Linear Algebra*	20	20	20	80	03	---	---	100
PSC102	Electrical Power System Modeling	20	20	20	80	03	---	---	100
PSC103	Advanced Power System Analysis	20	20	20	80	03	---	---	100
PSDLO101X	Department Level Optional Course-I	20	20	20	80	03	---	---	100
ILO101X	Institute Level Optional Course-I	20	20	20	80	03	---	---	100
PSL101	Laboratory-I	---	---	---	---	---	25	25	50
PSL102	Laboratory-II	---	---	---	---	---	25	25	50
Total		**100**	**100**	**100**	**400**	**---**	**50**	**50**	**600**

***Common for M.E. Electrical Engineering in Power System Engineering and PowerElectronics & Drives**

Program Structure for
M.E. Electrical Engineering (Power System Engineering)
University of Mumbai
(With Effect from 2016-17)

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PSC201	Power Quality Issues &Mitigations**	04	----	----	04	----	----	04
PSC202	Power System Dynamics & Control	04	----	----	04	----	----	04
PSC203	Advanced Power System Protection	04	----	----	04	----	----	04
PSDLO202X	Department Level Optional Course-II	04	----	----	04	----	----	04
ILO202X	Institute Level Optional Course-II	03	----	----	03	----	----	03
PSL201	Laboratory-III	----	02	----	----	01	----	01
PSL202	Laboratory-IV	----	02	----	----	01	----	01
Total		**19**	**04**	**----**	**19**		**02**	**21**

Subject Code	Subject Name	Examination Scheme							
		Theory			End Sem. Exam	Exam Duration (in Hrs)	Term Work	Pract. /Oral	Total
		Internal Assessment							
		Test 1	Test 2	Avg.					
PSC201	Power Quality Issues & Mitigations**	20	20	20	80	03	---	---	100
PSC202	Power System Dynamics & Control	20	20	20	80	03	---	---	100
PSC203	Advanced Power System Protection	20	20	20	80	03	---	---	100
PSDLO202X	Department Level Optional Course-II	20	20	20	80	03	---	---	100
ILO202X	Institute Level Optional Course-II	20	20	20	80	03	---	---	100
PSL201	Laboratory-III	---	---	---	---	---	25	25	50
PSL202	Laboratory-IV	---	---	---	---	---	25	25	50
Total		**100**	**100**	**100**	**400**	**---**	**50**	**50**	**600**

** **Common for M.E. Electrical Engineering in Power System Engineering and PowerElectronics & Drives**

Program Structure for
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Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theor	Pract.	Tut.	Theory	Pract.	Tut.	Total
PSS301	Special Topic Seminar	-	06	-	-	03	-	03
PSD301	Dissertation–I	-	24	-	-	12	-	12
Total		-	30	-	-	15	-	15

Subject Code	Subject Name	Examination Scheme						
		Theory						
		Internal Assessment			End Sem. Exam.	Term Work	Pract. /Oral	Total
		Test1	Test 2	Avg.				
PSS301	Special Topic Seminar	-	-	-	-	50	50	100
PSD301	Dissertation–I	-	-	-	-	100	-	100
Total		-	-	-	-	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theor	Pract.	Tut.	Theory	Pract.	Tut.	Total
PSD401	Dissertation–II	-	30	-	-	15	-	15
Total		-	30	-	-	15	-	15

Subject Code	Subject Name	Examination Scheme						
		Theory						
		Internal Assessment			End Sem. Exam.	Term Work	Pract. /Oral	Total
		Test1	Test 2	Avg.				
PSD401	Dissertation–II	-	-	-	-	100	100	200
Total		-	-	-	-	**100**	**100**	**200**

Note:

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher
- **End Semester Examination:** In all six questions to be set, each of 20 marks, out of these any four questions to be attempted by students. Each question will comprise of mixed questions from different units of the subjects.

Subject Code	Department Level Optional Course-I	Subject Code	Department Level Optional Course-II
PSDLO1011	Power Electronics in Power System #	PSDLO2021	Evaluation of Power System Reliability
PSDLO1012	Renewable Energy Systems and Energy Storage#	PSDLO2022	Advanced Control System#
PSDLO1013	Restructured Power System	PSDLO2023	Power Conditioning Systems for Renewable Energy#
PSDLO1014	Industrial Drives and Control	PSDLO2024	EHV AC Transmission System#

 # Common for M.E. Electrical Engineering in Power System Engineering and Power Electronics & Drives

Subject Code	Institute Level Optional Course-I	Subject Code	Institute Level Optional Course-II
ILO1011	Product Lifecycle Management	ILO2021	Project Management
ILO1012	Reliability Engineering	ILO2022	Finance Management
ILO1013	Management Information System	ILO2023	Entrepreneurship Development and Management
ILO1014	Design of Experiments	ILO2024	Human Resource Management
ILO1015	Operation Research	ILO2025	Professional Ethics and Corporate Social Responsibility (CSR)
ILO1016	Cyber Security and Laws	ILO2026	Research Methodology
ILO1017	Disaster Management and Mitigation Measures	ILO2027	IPR and Patenting
ILO1018	Energy Audit and Management	ILO2028	Digital Business Management
		ILO2029	Environmental Management

Subject Code	Subject Name	Credits
PSC101	**Applied Linear Algebra**	**04**
Course Objectives	• To introduce students to the fundamental concepts of linear algebra culminating in abstract vector spaces and linear transformations. • To enable the student to solve large systems of linear equations using direct matrix factorization, iterative numerical methods, and computer software with the understanding and knowledge of the underlying mathematical concepts.	
Course Outcomes	• Students will be familiar with the properties of matrices including how to use them to solve linear systems of equations and how they are used in linear transformations between vector spaces. • Students will understand how to choose appropriate numerical methods to solve a particular linear algebra problem.	

Module	Contents	Hours
1	**Vector space:** Solution of homogeneous and non-homogeneous systems of linear equations, Vector space, subspace, span, linear independence, basis, dimension, kernel (or null) and image (or range) subspaces, invariant subspaces, change of basis and similarity transform, linear functions and transformations.	12
2	**Matrices:** norms, and condition number, Symmetric matrices and positive definite matrices.	04
3	**Solution of linear systems:** LU and Cholesky factorizations. Effect of round off errors. Standard Iterative methods for linear systems (Jacobi and Gauss-Seidel Iterations).	08
4	**Orthogonalization and Least-squares:** Orthogonality and SVD, QR factorization using Gram-Schmidt process of orthogonalization, Normal equation, Full rank and Rank deficient Least square problem.	08
5	**Eigenvalues:** Eigen values and Eigen vectors, Diagonalization of matrices, Canonical representations (Unitary & Non - unitary transform), Schur Decomposition, Power iteration, inverse iteration, Rayleigh quotient iteration, QR algorithm, computing the SVD.	12
6	**Application of Linear algebra:** Application in graphs and networks and Fourier Transform.	04

Assessments:

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.

Books Recommended:

Text Books:

1. Golub& Van Loan, Matrix Computation, John Hopkins University Press.
2. Gilbert Strang, Linear Algebra and its Applications, Cengage Learning.
3. Watkins, Fundamentals of Matrix Computations, Wiley series of Tech.
4. Madhumangal Pal, Advanced Algebra, PHI Learning.

Reference Books:

1. Trefethen and Bau, Numerical Linear Algebra.
2. Lorenzo Sadun, Applied Linear Algebra The Decoupling Principle, American Mathematical Society.

Subject code	Subject name	Credits
PSC102	**Power System Modeling**	**04**
Course Objective	• To describe characteristics and appropriate mathematical models for representations models for representation of synchronous machine, transmission line, transformer, induction motor, excitation systems and non-electrical components in power system dynamic studies. Review of steady state and transient performance characteristic of synchronous machine	
Course Outcome	• The course will help prepare students to describe characteristics and develop appropriate mathematical models of power system network components	

Module	Contents	Hours
1	**Introduction:** Components of power system. The need for modeling of power system, different areas of power system analysis.	4
2	**Modeling of Synchronous Machine:**Synchronous Machine, Park's Transformation, Per Unit Quantities, Equivalent Circuits of synchronous Machine, Determination of parameters of equivalent circuits, Analysis of Steady State Performance, Transient Analysis of synchronous machine	12
3	**Modeling of non-electrical Components:**Simplified models of non-electrical components like boiler, steam &hydro-turbine & governor system.	8
4	**Modeling of Transmission Line and Transformer:** Modeling of Transmission line, Transformation to D-Q components, steady state equations, D-Q transformation using $\alpha - \beta$ variables. Transformer modeling such as tap-changing & phase-shifting transformer.	8
5	**Modeling of excitation system:**Types of excitation systems, Modeling of excitation system components, Models of standard excitation systems	8
6	**Modeling of SVC and Loads:**Type of SVC and controllers, SVC control characteristics, modeling of SVC. Basic load modeling concepts, modeling of induction motors	8

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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.

Books Recommended:

Text books:

1. "Power system Dynamics Stability and Control" P Kundur, Tata McGraw Hill

Reference books:

1. "Power system Dynamics Stability and Control" K R Padiyar B S Publication.
2. "Power system Dynamics Stability" Peter W. Sauer and M APai Pearson Education Asia.
3. "Power system Control and Stability" P M Anderson and A.A Fouad.
4. "Power Systems Modeling and Fault Analysis" Nasser Tleies, Elsevier, 2008.

Subject code	Subject name	Credits
PSC103	**Advanced Power System Analysis**	**04**
Course Objective	• To understand various Optimization Techniques applicable in Power System and Optimal Power flow solution methods. • To understand the concept of power System Security. • To apply state estimation in power system.	
Course Outcome	• Upon successful completion of this course, students will be able to apply optimization techniques in economic generation dispatch and optimum power flow. Also would be able to apply state estimation and unit commitment methods to operate the power system reliably in secured mode.	

Module	Contents	Hours
1	**Load Flow Analysis:** Revision of load flow studies using Gauss-seidal, N.R & FDLF method. AC-DC load flow: Introduction, Converter model	4
2	**Optimization Techniques**: Introduction to optimization & optimization techniques, Linear programming: Introduction, formulation of linear programming model, formulation of general linear programming problem. **Dynamic programming**: Introduction, Dynamic programming approach, formulation of dynamic programming problems. **Nonlinear Programming:** Introduction, unconstrained optimization, constrained optimization: equality and inequality constrtaints, Lagrange multiplier method, Gradient search method.	10
3	**Optimal Power Flow**: Optimal power flow formulation, Economic Dispatch of generator Neglecting Losses and Generator Limits, Economic Dispatch Neglecting Losses and Including Generator Limits, Economic Dispatch including Losses. OPF solution techniques: Lagrange multiplier method, Linear programming OPF, Interior point method.	10
4	**Unit Commitment**: Brute Force technique, Constraints in Unit Commitment, Priority List Method, Dynamic programming methods of unit commitment, DP Algorithm, Forward DP Approach. Alternative Approaches of Unit Commitment: Security Constraints in Unit Commitment	8
5	**Operations in Power System Security:** Security levels of system, Functions of system security: System monitoring, Contingency Analysis, Security constrained optimal power flow. Linear Sensitivity Factor: DC Load Flow, Generation shift Sensitivity Factor, Line Outage Distribution Factor. AC Power Flow Security Analysis. AC Power flow security	8

	Analysis with Contingency case selection and ranking: System PI for Line Power Flows and Voltage Analysis.	
6	**State Estimation**: Methods of Least Squares, Maximum Likelihood Weighted Least- Squares Estimation: Matrix Formulation, State Estimation by Orthogonal Decomposition: Orthogonal Decomposition Algorithm, Detection and Identification of Bad Measurements, Network Observability and Pseudo- Measurements	8

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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.

Books Recommended:

Text Books:

1. Prem Kumar Gupta, Dr. D. S. Hira, Operation Research, S. Chand, Revised Edition 2011.
2. Allen. J. Wood., Bruce. F. Wollenberg., Power Generation operation and Control, Wiley India, Second Edition, 2007.
3. HadiSaadat, Power System Analysis**,** TMH Publication, Second Edition, 2002.
4. Kothari. D. P, Nagrath. I. J., Modern Power System Analysis, TMH Publication, Third Edition, 2008
5. P. Venkatesh, B. V. Manikanand, S. Charles Raja, A. Srinivasan, Electrical Power System Analysis, Security and Deregulation, PHI, 2012.
6. Dr. K. Uma Rao, Power System Operation and Control, Wiley India, 2013.

Reference Books:

1. Computer Methods in Power System Analysis: G.W. Stage A.H. Elabiad, McGraw Hill Book Co.
2. Computer Techniques in Power System Analysis: M.A. Pai, Tata McGraw Hill Publication.
3. Electric Energy System Theory: O.I. Elgard, Tata McGraw Hill Publication.
4. Computer Aided Power System Operation and Analysis: R.N. Dhar, Tata McGraw Hill Publication.
5. By J.C. Das, Power System Analysis: Short-Circuit Load Flow and Harmonics, CRC press, Second Edition

Subject Code	Subject Name	Credits
PSDLO1011	**Power Electronics in Power System**	**04**
Course Objectives	• To know the basic principle of conventional active and reactive power flow control in power systems and problems associated with long distance power transmission. • To make students aware how power electronics devices can be used to find solution to the problems in long distance power transmission.	
Course Outcomes	• Students should be able to select and implement proper compensator to solve the problems occurring in long distance power transmission.	

Module	Contents	Hours
1	**Introduction**: Steady state and dynamic problems in AC systems- Transmission interconnections- Flow of power in an AC system- 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- In perspective: HVDC or FACTS	10
2	**Static shunt compensators:**Objectives of shunt compensation, Methods of controllable Var generation- Variable impedance type static Var generators (TCR, TSR, TSC,FC-TCR), Switching converter type Var generators.	10
3	**Static series compensation:**Objectives of series compensation- Variable impedance type series compensation-TSSC and TCSC , Basic operating control schemes for TSSC and TCSC, Switching converter type series compensators - SSSC, Transmitted power versus transmission angle characteristic	08
4	**Static voltage and phase angle regulators:**Objectives of voltage and phase angle regulators, Approaches to TCVR and TCPAR, Switching converter based voltage and phase angle regulators	08
5	**Compensation using DSTATCOM and DVR:**Compensating single phase loads using DSTATCOM, Ideal three phase shunt compensator structure, Series compensation of power distribution system using DVR- Rectifier supported DVR, DC Capacitor supported DVR(Fundamental Frequency series compensator characteristic)	08
6	**Unified Power Quality Conditioner:**UPQC configurations, Right shunt UPQC characteristics, Left shunt UPQC characteristics	04

Assessment:

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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.

Books Recommended:

Text Books:

1. Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems," IEEE Press.
2. ArindamGhosh and Gerard Ledwich, " Power Quality Enhancement Using Custom Power Devices," Kluwer Academic Publishers
3. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty "Electrical Power System Quality" , McGraw Hill
4. J. Arrillaga, N.R.Watson and S.Chen " Power System Quality Assessment," John Wiley & Sons
5. Yong Hua Song "Flexible AC transmission system" Institution of Electrical Engineers, London
6.

***Reference Book/* Journals:**

1. Jos Arrillaga and Neville R Watson "Power System Harmonics" Wiley Publications
2. G.T.Heydt , "Electric Power Quality," Stars in a Circle Publications
3. IEEE Transaction on Power Systems
4. IEEE Transaction on Power Delivery
5. IEEE Transaction on Power Electronics

Subject Code	Subject Name	Credits
PSDLO1012	**Renewable Energy Systems and Energy Storage (RESES)**	**04**
Course Objective	• 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 Outcome	Learner will be able to • Understand current scenario of depleting world's production and reserves of fossil fuels, bad impact of fossil fuel power plants on environment and the means of mitigating these issues with different renewable energy alternatives based distributed generation. • Understand the process of power generation through solar thermal and solar photovoltaics, I-V and P-V characteristics of SPV with various essential parameters and power optimization using MPPT techniques to determine the requirements of solar PV modules and power topologies and their control. • Understand the various other renewable sources like Wind Energy system (WES), concept Fuel cell technology tidal, wave, biomass and their • Understand and describe the importance of various forms of energy storage, importance of storage system in new power generation scenario, their characteristics and performance with various applications • Analyze and calculate the power sharing and fault scenarios in hybrid combinations renewable energy sources and energy storage elements.	

Module	Contents	Hours
1	**Introduction:** Review of reserves and production of commercial energy sources, India's production and reserves, energy alternatives, Review of non conventional energy sources. Distributed generation: merits and demerits, renewable energy policies of India; Issues with large scale integration of renewable energy sources (RES) and role of energy storage in its mitigation.	05

2	**Solar Energy:** Review of solar thermal applications-solar thermal conversion systems and components 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: Issues of mismatch and hot spots in the PV modules, means of Mitigation. Design and structure of PV modules, PV module power output, I-V and power curve of module. 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. Review of regulatory standards. Design of rooftop solar PV plant	12
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 power processing, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	08
4	**Fuel Cell Technology:** 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 Energy Alternatives:** Review of other nonconventional sources, their features and applications:Biomass, Tidal, Wave, Geothermal, and Micro-hydroelectric generation	06
6	**Energy Storage:** Forms of energy storage (ES), 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. Assessment of reliability and stability enhancement in renewable energy system. Examples of hybrid power generation based on renewable energy and energy storage.	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.

Books Recommended:

Reference Book:

1. Heinrich Ha¨berlin, *Photovoltaics :System Design And Practice*, John Wiley and Sons. 2012
2. HashemNehrir and Caisheng Wang, Modeling *and control of fuel cells: Distributed Generation Applications,* IEEE Press, 2009
3. J.F. Manwelland 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. S. Chakraborty, M. G. Simões and W. E. Kramer, *Power Electronics for Renewable and Distributed Energy System,* Springer 2013
7. Ahmed FaheemZobaa, *Energy storage – Technologies and Applications,* InTech Publication 2013.
8. Robert A. Huggins, Energy Storage, Springer 2010
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

Subject Code	Subject Name	Credits
PSDLO1013	**Restructured Power System**	**04**
Course Objective	Introduction to the power sector market, trading and bidding.	
Course Outcome	Learner will be able to • Understand the current scenario of power sector in India. • Understand different trading methods and bidding process in power sector.	

Module	Contents	Hours
1	**Power Sector in India:** Introduction to various institutions in Indian Power sector such as CEA, Planning Commissions, PGCIL, PFC, Ministry of Power, state and central governments, REC, utilities and their roles. Critical issues / challenges before the Indian power sector, Salient features of Electricity act 2003, Various national policies and guidelines under this act.	08
2	**Power sector restructuring and market reform:** Different industry structures and ownership and management modelsfor generation, transmission and distribution. Competition in theelectricity sector- conditions, barriers, different types, benefits andchallenges Latest reforms and amendments.Different market and trading models / arrangements, open access, keymarket entities- ISO, Genco, Transco, Disco, Retailco, Power market types, Energy market, Ancillary service market, transmission market,Forward and real time markets, market power.	12
3	**Electricity Markets Pricing and Non-price issues:** Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices. Non price issues in electricity restructuring (quality of supply and service, standards of performance by utility, environmental and social considerations) Global experience with electricity reforms in different countries.	14
4	**Transmission Planning and pricing:** Transmission planning, Different methods of transmission pricing, Different transmission services, Congestion issues and management,Transmission cost allocation methods, Locational marginal price, firmtransmission right.Transmission ownership and control, Transco and ISO, Transmissionpricing Model in India, Availability based tariff, role of load dispatchcenters (LDCs) Salient features of Electricity act 2003, Price based Unit commitment, concept of arbitrage in Electricity markets, game theory methods in Power System, and security constrained unit commitment. Ancillary services for restructuring, Forward ancillary service auction. Power purchase agreements.	14

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Books Recommended:

Text Books:

1. "Know Your Power", A citizens Primer On the Electricity Sector, Prayas Energy Group, Pune
2. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
3. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy

References:

1. Regulation in infrastructure Services: Progress and the way forward - TERI, 2001
2. Maharashtra Electricity Regulatory Commission Regulations and Orders - www.mercindia.com
3. Various publications, reports and presentations by Prayas, Energy Group, Pune www.prayaspune.org
4. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.org
5. Electricity Act 2003 and National Policies – www.powermin.nic.in
6. Market Operations in Electric Power Systems Forecasting, Scheduling and Risk Management – Mohammad Shadepur, Hatim Yatim, Zuyi Li.
7. Bhanu Bhushan, "ABC of ABT - A primer on Availability Tariff" - www.cercind.org

Website:

1. www.mercindia.com
2. www.cercind.org
3. www.prayaspune.org

Subject code	Subject name	Credits
PSDLO1014	**Industrial Drives and Control**	**04**
Course Objective	• To study and modify the speed torque characteristics of AC drives for different types of loads. • Able to design power electronics and drives systems for various applications	
Course Outcome	• Students will be able to apply the knowledge of electrical drive system for various applications which have electric drives as their enabling technology.	

Module	Contents	Hours
1	**Pre-requisite: AC machine for drives:** Introduction, torque production, equivalent circuit, torque-speed curve, variable frequency operation constant V/F operation, variable stator current operation. **synchronous machine**: introduction to permanent magnet motor, synchronous reluctance motor	6
2	**Scalar control of induction machine:** scalar control methods(voltage fed inverter control and current fed inverter control),efficiency optimization control by flux program	6
3	**Vector control of induction machine:** Dynamic d-q Model, synchronously rotating reference frame (Kron equation) stationary frame (Stanley equation), introduction, direct or feedback vector control, flux vector estimation, indirect or feed forward vector control, vector control of line side PWM rectifier, stator flux oriented vector control, vector control of current fed inverter drive, sensorless vector control, direct torque and flux control, adaptive control.	18
4	**Wound rotor induction motor control:** Static rotor resistance control, static scherbius drive, improvement in power factor, introduction to variable speed constant frequency(VSCF) generation	6
5	**Sinusoidal SPM Machine Drives**: V/Hz control ,self control model ,vector control ,field weakening mode	6
6	**Special machine drives:** Synchronous reluctance machine drive, switched reluctance machine drive, wound field synchronous machine drive	6

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End Semester Examination: Some guidelines for setting the question papers are as, sixquestions 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.

Books Recommended:

Text Books:

1. "Modern Power Electronics and A.C. Drive", B. K. Bose, PHI.
2. "Electric Motor Drives: Modeling, Analysis and Control" ,R.Krishnan,.PHI
3. "Control of Electrical drives", W. Leonhard, , Springer-Verlag.

Reference Books:

1. "Power Semiconductor Controlled Drives",G. K. Dubey, Prentice-Hall International.
2. "Fundamentals of Electrical Drives", G. K. Dubey, Narosa Publishing House.
3. "Analysis of Electric Machinery" P.C. Krause, McGraw Hill, New York
4. "Power Electronics and Motor Drives" Bimal Bose, Elsevier,Academic Press, 2006

Subject Code	Subject Name	Credits
ILO1011	**Product Life Cycle Management**	**03**
Course Objectives	• . To familiarize the students with the need, benefits and components of PLM • To acquaint students with Product Data Management & PLM strategies • To give insights into new product development program and guidelines for designing and developing a product • To familiarize the students with Virtual Product Development	
Course Outcomes	Learner will be able to… • Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation. • Illustrate various approaches and techniques for designing and developing products. • Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc. • Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plan	

Module	Detailed Contents	Hrs
01	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	12
02	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09
03	**Product Data Management (PDM):**Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	06
04	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques,	06

	Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	
05	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	06
06	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	06

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2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

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

Subject Code	Subject Name	Credits
ILO1012	**Reliability Engineering**	**03**
Course Objectives	• To familiarize the students with various aspects of probability theory • To acquaint the students with reliability and its concepts • To introduce the students to methods of estimating the system reliability of simple and complex systems • To understand the various aspects of Maintainability, Availability and FMEA procedure	
Course Outcomes	Learner will be able to… • Understand and apply the concept of Probability to engineering problems • Apply various reliability concepts to calculate different reliability parameters • Estimate the system reliability of simple and complex systems • Carry out a Failure Mode Effect and Criticality Analysis	

Module	Detailed Contents	Hrs
01	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	10
02	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	10
03	**System Reliability** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	**Reliability Improvement** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	10
05	**Maintainability and Availability** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement.	05

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

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4. Only Four question need to be solved.

REFERENCES:

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

Subject Code	Subject Name	Credits
ILO1013	**Management Information System**	**03**
Course Objective	• The course is blend of Management and Technical field. • Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built • Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage • Identify the basic steps in systems development • Define and analyze various MIS management responsibilities, including planning, budgeting, project management, and personnel management • Discuss critical ethical and social issues in information systems	
Course Outcomes	Learner will be able to… • Explain how information systems Transform Business • Identify the impact information systems have on an organization • Describe IT infrastructure and its components and its current trends • Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making • Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses	

Module	Detailed Contents	Hrs
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	7
02	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	9
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	6
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	10

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4. Only Four question need to be solved.

REFERENCES:

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

Subject Code	Subject Name	Credits
ILO1014	**Design of Experiments**	**03**
Course Objectives	1. To understand the issues and principles of Design of Experiments (DOE). 2. To list the guidelines for designing experiments. **3.** To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization	
Course Outcomes:	Learner will be able to… • Plan data collection, to turn data into information and to make decisions that lead to appropriate action. • Apply the methods taught to real life situations. • Plan, analyze, and interpret the results of experiments	

Module	Detailed Contents	Hrs
01	**Introduction:** Strategy of Experimentation, Typical Applications of Experimental Design, Guidelines for Designing Experiments, Response Surface Methodology.	06
02	**Fitting Regression Models:** Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of new response observation, Regression model diagnostics, Testing for lack of fit.	08
03	**Two-Level Factorial Designs:** The 2^2Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^kDesign, The Addition of Center Points to the 2^kDesign, Blocking in the 2^kFactorial Design, Split-Plot Designs.	07
04	**Two-Level Fractional Factorial Designs:** The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design, The General 2^{k-p} Fractional Factorial Design, Resolution III Designs, Resolution IV and V Designs, Fractional Factorial Split-Plot Designs.	07
05	**Conducting Tests:** Testing Logistics, Statistical aspects of conducting tests, Characteristics of good and bad data sets, Example experiments, Attribute Vs Variable data sets.	07
06	**Taguchi Approach:** Crossed Array Designs and Signal-to-Noise Ratios, Analysis Methods, Robust design examples.	04

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4. Only Four question need to be solved.

REFERENCES:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss
6. Philip J Ross, "Taguchi Technique for Quality Engineering," McGraw Hill.
7. Madhav S Phadake, "Quality Engineering using Robust Design," Prentice Hall.

Subject Code	Subject Name	Credits
ILO1015	Operations Research	03
Course Objectives	• Formulate a real-world problem as a mathematical programming model. • Understand the mathematical tools that are needed to solve optimization problems. • Use mathematical software to solve the proposed models.	
Course Outcomes	Learner will be able to… • Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand. • Understand the relationship between a linear program and its dual, including strong duality and complementary slackness. • Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change. • Solve specialized linear programming problems like the transportation and assignment problems. • Solve network models like the shortest path, minimum spanning tree, and maximum flow problems. • Understand the applications of, basic methods for, and challenges in integer programming • Model a dynamic system as a queuing model and compute important performance measures	

Module	Detailed Contents	Hrs
01	**Introduction to Operations Research***:* Introduction, Historical Background, Scope of Operations Research , Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools , Structure of the Mathematical Model, Limitations of Operations Research	02
02	**Linear Programming***:* Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, *Simplex Method* Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, ***Duality***, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis	06
03	**Transportation Problem***:* Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem***:* Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem	06
04	**Integer Programming Problem***:* Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique.	06

	Introduction to Decomposition algorithms.	
05	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	06
06	**Simulation***:* Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation *Monte-Carlo Method:* Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	04
07	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	04
08	**Games Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	04
09	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	04

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REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Subject Code	Subject Name	Credits
ILO1016	Cyber Security and Laws	03
Course Objectives	• To understand and identify different types cyber crime and cyber law • To recognized Indian IT Act 2008 and its latest amendments • To learn various types of security standards compliances	
Course Outcomes	Learner will be able to… • Understand the concept of cyber crime and its effect on outside world • Interpret and apply IT law in various legal issues • Distinguish different aspects of cyber law • Apply Information Security Standards compliance during software design and development	

Module	Detailed Contents	Hrs
01	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cybercafé and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	10
03	**Tools and Methods Used in Cyberline:** Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	**The Concept of Cyberspace:** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8
05	**Indian IT Act.:** Cyber Crime and Criminal Justice : Penalties, Adjudication and Appeals Under the IT Act, 2000,IT Act. 2008 and its Amendments	8
06	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

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4. Only Four question need to be solved.

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Subject Code	Subject Name	Credits
ILO1017	Disaster Management and Mitigation Measures	03
Course Objectives	• To understand the various types of disaster occurring around the world • To identify extent and damaging capacity of a disaster • To study and understand the means of losses and methods to overcome /minimize it. • To understand role of individual and various organization during and after disaster • To know warning systems, their implementation and based on this to initiate training to a laymen • To understand application of GIS in the field of disaster management • To understand the emergency government response structures before, during and after disaster	
Course Outcomes	Learner will be able to… • Understand natural as well as manmade disaster and their extent and possible effects on the economy. • Planning of national importance structures based upon the previous history. • Understand government policies, acts and various organizational structure associated with an emergency. • Know the simple do's and don'ts in such extreme events and act accordingly	

Module	Detailed Contents	Hrs
01	**Introduction:** Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	**Natural Disaster and Manmade disasters**: Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion . Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	06
03	**Disaster Management, Policy and Administration:** Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06

04	**Institutional Framework for Disaster Management in India:** Importance of public awareness, Preparation and execution of emergency management programme. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
05	**Financing Relief Measures**: Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
06	**Preventive and Mitigation Measures**: Pre-disaster, during disaster and post-disaster measures in some events in general, Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication. Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	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. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.

4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P. Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Subject Code	Subject Name	Credits
ILO1018	Energy Audit and Management	03
Course Objectives	• To understand the importance energy security for sustainable development and the fundamentals of energy conservation. • To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management • To relate the data collected during performance evaluation of systems for identification of energy saving opportunities	
Course Outcomes	**Learner will be able to…** • To identify and describe present state of energy security and its importance. • To identify and describe the basic principles and methodologies adopted in energy audit of an utility. • To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities. • To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities • To analyze the data collected during performance evaluation and recommend energy saving measures	

Module	Detailed Contents	Hrs
01	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, Lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery,	10

	use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

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. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Subject Code	Subject Name	Credits
PSL101	**Laboratory-I**	**01**

Module	Detailed content
1	Eigen analysis of small scale system
2	Computer programs of un-constrained optimization techniques
3	Computer programs of constrained optimization techniques
4	Programming/Simulations of Load flow analysis of 3-4 bus systems
5	Simulations of Contingency analysis.
6	Analysis of Linear Algebra
7	Simulation of a transmission line with Static Series/Shunt Compensation
8	Simulations of UPQC

Minimum Six Practical/Simulation/Program should be performed based on above contents

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair ofinternal and external examiners

Subject Code	Subject Name	Credits
PSL102	**Lab Practice II**	**01**

Module	Detailed content
1	Simulation examples of abc to dq0 transformation
2	Simulation examples of dq0 to abc transformation
3	Simulation model of transmission line
4	Simulation model of single machine connected to infinite bus system
5	Steady state analysis of synchronous machine simulation model
6	Transient analysis of synchronous machine simulation model
7	Simulations of DC Drives
8	Simulations of Synchronous Rectifier
9	Simulations of PWM Inverter

Minimum Six Practical/Simulation/Program should be performed based on above contents

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PSC201	**Power Quality Issues and Mitigation**	**04**
Course Objective	• To know various power quality issues, it causes and effects • To understand effects of harmonics due to non-linear load • To learn mitigation methods for harmonics	
Course Outcome	Students should be able: • To identify the problems in power system due to harmonics • To suggest solutions to the problems due to power quality	

Module	Contents	Hours
1	**Introduction:** Power Quality, Importance of power quality, Power Quality, Evaluation, Terms and definitions of power quality issues as per IEEE std. 1159, Transients, Long-Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage Fluctuation, Power Frequency Variations	4
2	**Voltage Sags And Interruptions:** Sources of Sags and Interruptions, Estimating Voltage Sag, Performance, Fundamental Principles of Protection, Solutions at the End-User Level, Motor-Starting Sags, Utility System Fault-Clearing Issues	7
3	**Transient Overvoltages:** Sources of Transient Overvoltages, Principles of Overvoltage Protection, Devices for Overvoltage ProtectionUtility Capacitor-Switching Transients, Utility System Lightning Protection, Managing Ferro-resonance, Switching Transient Problems with Loads	7
4	**Fundamentals of Harmonics:** Harmonic Distortion, Voltage versus Current Distortion, Harmonics versus Transients, Harmonic Indexes, Harmonic Sources from Commercial Loads, Harmonic Sources from Industrial Loads, Locating Harmonic Sources, System Response Characteristics, Effects of Harmonic Distortion, Interharmonics	10
5	**Power Factor Compensation:** Linear circuits with Sinusoidal Supply-Basic relationship**,** complex power, apparent power, power factor and power factor compensation, Non-Linear circuits with Sinusoidal Supply-Basic relationship**,** complex power, apparent power, power factor and power factor compensation, Linear circuits with non-Sinusoidal Supply-Basic relationship**,** complex power, apparent power, power factor and power factor compensation.Non-Linear circuits with non-Sinusoidal Supply-Basic relationship**,** complex power, apparent power, power factor and power factor compensation.	12
6	**Power Quality Mitigation Techniques:** Passive Filters, Shunt Active Filters, Series Active Filters, Unified Power Quality Compensators	08

Assessments:

Internal: Assessment consists of two tests out of which; one should be compulsory classTest (on minimum 02 Modules) and the other is either a class test or assignment on liveproblems 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 attemptedby students. Minimum 80% syllabus should be covered in question papers of end semester examination.

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Books Recommended:

Text Books:

1. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty, "Electrical Power System Quality," MC Graw Hill
2. G.T.Heydt , "Electric Power Quality," Stars in a Circle Publications
3. J. Arrillaga, N.R.Watson and S.Chen, "Power System Quality Assessment," John Wiley & Sons
4. W. Shepherd and P. Zand, "Energy flow and power factor in non-sinusoidal circuits" Cambridge university press
5. IEEE-519: 1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
6. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley & Sons, First Edition 2015

Reference Book/Journals:

1. Jos Arrillaga, B.C.Smith, Neville R Watson and A.R.Wood, "Power System Harmonics Analysis" Wiley 1997
2. Math H.J.Bollen, " Understanding Power Quality Problems,Voltage Sag and Interruptions " Wiley-IEEE Press
3. IEEE Transactions on Power Systems
4. IEEE Transactions on Power Delivery
5. IEEE Transaction on Power Electronics

Subject code	Subject name	Credits
PSC202	**Power System Dynamics and Control**	**04**
Course Objective	• To review fundamental aspects of dynamic systems and to illustrate the nature of small signal and transient stability problems, identifying factors influencing them. To present analytical techniques useful in the study of small signal and transient stability	
Course Outcome	• The course content will help prepare students for a detailed treatment of the various aspects of the small signal and transient stability analysis	

Module	Contents	Hours
1	**Introduction: Power System stability:** Basic concepts and definitions: Rotor angle stability, Voltage stability or voltage collapse and Mid-term and long-term stability. Classification of stability.	6
2	**Synchronous Machine Representation in Stability Studies:** Simplification essential for large-scale studies, Simplified model with amortisseurs neglected, Constant flux linkage model and reactivecapability limits.	12
3	**Small Signal Stability:** Fundamental concepts of stability of dynamic system, Eigen properties of the state matrix, Small signal stability of asingle machine infinite bus system, Effects of excitation system,Power system stabilizer, Small signal stability of multi-machinesystems and Methods of improving small signal stability.	15
4	**Transient Stability:** An elementary view of transient stability, Numerical integration methods, Simulation of power system dynamicresponse, Analysis of unbalanced faults and Methods of improvingtransient stability.	15

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End Semester Examination: Some guidelines for setting the question papers are as, sixquestions 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.

Books Recommended:

Text books:

1. "Power system Dynamics Stability and Control" P Kundur, Tata McGraw Hill

Reference books:

1. "Power system Dynamics Stability and Control" K R Padiyar B S Publication.
2. "Power system Dynamics Stability" Peter W. Sauer and M A Pai Pearson Education Asia.
3. "Power system Control and Stability" P M Anderson and A.A Fouad.

Subject code	Subject name	Credits
PSC203	**Advanced Power System Protection**	**04**
Course Objective	• To understand basic philosophy of digital power system protection , PMU, transient response of PMU and application of PMU	
Course Outcome	• The students can understand digital protection system, PMU and its application in power system protection.	

Module	Contents	Hours
1	**Introduction**: Computer Relay Architecture, Analog To Digital Converter ,Anti-Alising Filters, Function Of Protection System, Phasor Representation Of Sinusoids, Sampled Data, Discrete Fourier Transform	5
2	**Protection of machines and buses**: Digital Bus Protection, Motor And Generator Protection. **Developments in New Relaying Principle**: Travelling Waves On Single Phase And On Three Phase, Travelling Wave Due To Fault.	7
3	**Phasor Estimation of Nominal Frequency Inputs**: Phasors Of Nominal Frequency Signals, Formulas For Updating Phasors Non-recursive Updates. **Phasor Estimation at Off-Nominal Frequency Inputs**: Types Of Frequency Excursions Found In Power Systems DFT Estimate at Off-Nominal Frequency With A Nominal Frequency Clock, Input Signal At Off-Nominal Frequency	9
4	**Phasor Measurement Units and Phasor:** Data Concentrators: Introduction ,A Generic PMU, The Global Positioning System, Hierarchy For Phasor Measurement Systems ,Communication Options For PMUs, Functional Requirements Of PMUSs 1 The Evolution of "Synchrophasor" Standard 2 File Structure of "Synchrophasor" Standard **Transient Response of Phasor Measurement Units**: Introduction, Nature Of Transients In Power System	9
5	**Protection Systems with Phasor Inputs**: Introduction, Differential Protection Of Transmission Lines, Distance Relaying Of Multi terminal Transmission Lines, Adaptive Protection, Adaptive Out-Of-Step Protection, Security Versus Dependability. Transformer, Adaptive System Restoration, Control Of Backup Relay Performance, Hidden Failures	9
6	**Electromechanical Wave Propagation**: Introduction, The Model, Electromechanical Telegrapher's Equation, Continuum Voltage Magnitude, Effects On Protection Systems, Overcurrent Relays, Impedance Relays.	9

Assessments:

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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.

Books Recommended:

Text Books:

1. Anderson PM, "Power system protection," McGraw-hill, 1999.
2. Singh LP, "Digital protection"
3. A.G Phasdke and J.S Throp, " Synchronized Phasor measurements and their Applications"
4. Arun Phadke and James S Throp " Computer analysis relaying for power system"
5. Waldemar Rebizant, Janusz Szafran, Andrez Wiszniewski, "Digital signal processing in power system protection and control.

Reference Books:

1. Badriram & Vishwakarma, "Power system protection and SWG," Mcgraw Hill
2. Madhav aRao TS, "Power system protection with static relays and Microprocessor application," McGraw hill
3. 4. Mason CR, "The art and science of protective relaying," John Wiley & sons
5. Chapman & Hall, "Electrical Power System Protection"
6. J. Lewis Blackburn & T.J. Domin, "Protective Relaying Principles & Applications"
7. J. Arrillanga and C. P. Arnold " Computer Analysis of power system"
8. Xi Fang, Student member, IEEE, "Smartgrid: the new and improved power grid – a survey.

Subject code	Subject name	Credits
PSDLO2021	Evaluation of Power System Reliability	04
Course Objective	• To use reliability theory as a tool for decision support for design, operation and planning of electric power system.	
Course Outcome	• Students will be able to apply the knowledge of reliability to design secure and reliable networks.	

Module	Contents	Hours
1	**Introduction**: Basic notions of power system reliability, Morkov model, failure rate, repair rate, hazard rate. Network modeling- series system, parallel system and complex systems. cut set and tie set method, fault trees	8
2	**Generating capacity –Probability methods**: Generation system model, Capacity outage calculations, reliability indices using loss of load probability, Scheduled outages, Forced outage rate uncertainty. Loss of Energy indices. **Generating capacity – frequency and duration method**: Generation model, System risk indices, example	8
3	**Interconnected systems**: Reliability evaluation of two interconnected systems, Unit commitment and operating constraints, Operating Reserve, single and multistage expansion.	8
4	**Composite power system reliability evaluations:** Conditional probability approach, System and load point indices concept and numerical evaluation. Data requirement for composite system reliability evaluation	8
5	**Distribution systems**: Evaluation technique, customer-oriented indices, load point and energy oriented indices, inclusion of weather effects. Common mode failures.	7
6	**Substation and switching stations**: Active and Passive failure, Effect and simulation of failure modes, Reliability indices of substations based on overload capability of transformers. Monte Carlo simulation-concept and application.	9

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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.

Books Recommended:

1. Roy Billinton and Ronald N Allan, 'Reliability Evaluation of Power System', Plenum, Press, 1984
2. Roy Billinton and Ronald N Allan, “Reliability evaluation of Engineering System-Concepts and Tecniques” second edition plenum press, 1992
3. Roy Billinton and Ronald N Allan 'Reliability Assessment of Large Electric Power Systems', Kluwer academic publishers, 1988
4. Roy Billinton, Wenyuan Li “Reliability assessment of electric power systems using Monte Carlo methods” Plenum, Press, 1994

Subject Code	Subject Name	Credits
PSDLO2022	Advanced Control Systems	04
Course Objective	• To make students understand the concept of nonlinear control, Adaptive Control and Sliding mode control. • To study the behavior of nonlinear systems using various techniques.	
Course Outcome	• The Students will be able to understand the nonlinear system behavior by phase plane and describing function methods. • The Students will be able toanalysethe stability of nonlinear system by Lyapunov method. • Students will be familiar with the concept of Adaptive Control and Sliding mode control.	

Module	Contents	Hours
1	**Nonlinear Control Systems** : Definition of nonlinear systems, Difference between linear and nonlinear systems, Characteristics of nonlinear systems, Common physical nonlinearities	04
2	**Phase plane analysis of nonlinear systems**: Phase plane method - basic concept, trajectories, phase portrait, singular points and their classification, limit cycle and behavior of limit cycle, Construction of phase trajectories using delta method, Stability analysis using phase trajectory.	10
3	**Describing Function Analysis (DF**): Derivation of general DF, DF for different nonlinearities, saturation, dead zone, relay and their combinations, Stability analysis of nonlinear systems via describing function method.	08
4	**Lyapunov Stability Analysis**: Stability of equilibrium state, asymptotic stability, graphical representation, Lyapunov stability theorems, stability analysis of linear systems, nonlinear systems, construction of Lyapunov functions using Krasovskii method, variable gradient method	10
5	**Introduction to Adaptive Control System:** Definition of adaptive control system, functions of adaptive control, gain scheduling, model reference, series and parallel schemes and their industrial applications.	08
6	**Introduction to Sliding mode Control :** Introduction, concept of variable structure control (VSC), ideal sliding motion and chattering, switching function, reachability condition, properties of sliding motion	08

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Books Recommended:

Text Books:

1. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.
2. K. Ogata, "Modern Control Engineering", 3 ed. Prentice Hall of India (P) Ltd., New Delhi.
3. Dr. K.P. Mohandas, “Modern Control Engineering”, revised edition, Sanguine Publishers,Bangalore, 2006.
4. Hassan K. Khalil, “Nonlinear Systems, 3rd edition, Prentice Hall.

Reference Books:

1. Gene F. Franklin, J David Powell, Abbas Emami-Naeini, “Feedback Control of DynamicSystems”, 5ed Pearson Educations.
2. Shankar Sastry, Marc Bodson, "Adaptive Control", Prentice Hall of India (P) Ltd., 1993.
3. John Doyle, Bruce Francis, Allen Tannenbaum, ìFeedback Control Theoryî.
4. Norman Nise, “Control system Engineering”, 4 ed.Wiley International Editionî.
5. Christopher Edwards, Sarah K. Spurgeon, “Sliding Mode control: Theory andApplication”, 1998.
6. Karl J. Astrom, B. Wittenmark, “Adaptive Control”, 2 nd Edition, Pearson Education Asia,First Indian Reprint, 2001

Subject Code	Subject Name	Credits
PSDLO2023	**Power Conditioning Systems for Renewable Energy (PCSRE)**	04
Course Objectives	• To introduce the distributed generation system based on renewable energy resources. • To know the practical aspects of design of power conditioning systems (PCS) for renewable energy sources (RES). • To know the control implementation for PCS	
Course Outcomes	Learner will be able • To identify and describe various topologies of DGs based on use of various combinations of RES. • To identify and describe the various regulatory standards applicable in PCS for RES. • To design the power conditioning systems for solar PV applications. • To identify and describe the design considerations for the power conditioning systems for wind energy systems. • To identify and describe the design considerations for the power conditioning systems for fuel cell systems. • To model and design compensator for power conditioning systems.	

Module	Contents	Hours
1	**Introduction renewable sources:** Review of renewable energy sources, operating principles and characteristics of: Solar PV, Wind Energy Systems (WES), Fuel cells; Economics and statistics related to renewable energy. Review of energy storage systems with Batteries and ultracapacitors. Categorization of energy sources	08
2	**Distributed generation system:** Basic concepts, various topologies and design considerations for standalone systems and grid connected systems, Power quality and protection issues, review of regulatory standards related to various aspects of renewable energy systems	06
3	**Design of power conditioning system for Solar PV:** MPPT (maximum power point tracking), Design of DC-DC converters for MPPT, MPPT algorithms, Implementation of MPPT control through DSP controllers. Topologies for grid connected and standalone applications: single phase and three phase systems, Design of multi stage solar PV grid connected and standalone systems. Low and high power Applications. Integration of ES-battery and ultracapacitor for performance improvement	12
4	**Design of power conditioning system for WES:** Topologies of WES, design considerations for WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines, Matrix converter topology for grid connected system.	08

5	**Design of power conditioning system for Fuel Cells:** Review of fuel cell technology, Design of DC-DC converters for PEM fuel cell, MPPT in Fuel Cell, Design considerations for multi-stage converter / inverter system for grid connected operations. Integration of ES	08
6	**Design of compensator for voltage and current control modes:** Modeling of the system, derivation of transfer function compensator for voltage and current control modes, design of PI and Type III controller in power conditioning systemfor renewable energy sources	06

Assessment:

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Books Recommended:

Text Books:

1. "Power Electronics, Converters, Applications & Design",N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.
2. "Voltage Source Converters in Power Systems: Modeling, Control and Applications", AmirnaserYezdani, and Reza Iravani, IEEE John Wiley Publications
3. "Power Switching Converters: Medium and High Power", DorinNeacsu, CRC press, Taylor &Francis, 2006
4. M.H.Rashid, "Power Electronics Hand book", Academic Press,2001

References books /websites

1 "DSP Based Electromechanical Motion Control", Hamid Toliyat and Steven Campbell, CRC Press

2 "Digital Signal Processors - Architectures, Implementations, and Applications", Sen M. KuoandWoon-SengGan Prentice Hall

3 "Fuel Cell System", Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.

4 "Wind Energy Explained, theory design and applications," J.F. Manwell, J.G. McGowan Wiley publication

5 "Fuel Cell Systems Explained," James Larminie, Andrew Dicles, Wiley publication

6 "Principles of Solar Engineering", D. Y. Goswami, F. Kreith and J. F. Kreider, Taylor and Francis, Philadelphia, 2000

7 "Biomass Regenerable Energy", D. D. Hall and R. P. Grover, John Wiley, New York, 1987.

Subject code	Subject name	Credits
PSDLO2024	**EHV AC transmission system**	**04**
Course Objective	• To understand basic philosophy of EHV AC transmission. • To understand the concept of voltage gradient and effect of electrostatic field. • To understand the electromagnetic interference, AN, RI. • To understand basic concepts of design of EHV AC transmission system.	
Course Outcome	• Upon successful completion of this course, students will be able to understand effects of electrostatic field and electromagnetic interference for EHV AC transmission system.	

Module	Contents	Hours
1	**Introduction to EHV AC transmission:** Configuration, special features of EHV lines, power transfer ability, properties of bundled conductor, inductance and capacitance of EHV lines, positive-negative and zero sequence impedance, line parameters for modes of propagation	8
2	**Voltage gradients of conductors:** Bundled conductors, R-L-C calculations of EHV line configuration, Electrostatics- Field of sphere gap, field of line charges and their properties, charge potential relations for multi conductors, surface voltage gradient on conductor, distribution of voltage gradient on sub-conductors of bundled system.	10
3	**Electric field under transmission lines and its computation:** Calculation of electrostatic field in EHV AC lines, effect on humans, animals and plants, electrostatic induction in un-energized circuit of doubled circuit lines, electromagnetic interference, traveling wave expression and solution, reflection and refraction coefficients of traveling waves, lumped parameters of distributed lines.	10
4	**Corona in EHV lines:** Power loss due to corona, corona loss formulae, charge voltage diagram, attention of traveling waves due to corona, Audio Noise(AN)- its generation, characteristics, limitations and measurements, relation between single phase and three phase AN levels. Radio Interference(RI)- corona pulses generation, properties, limits, frequency spectrum of RI field of lines, mode of propagation, excitation function, measurement of RI and RIV.	10
5	**Design of EHV transmission system:** Overhead line insulators-ceramic and nonceramic types, insulator performance in polluted environments, EHV cable transmission- underground cables and gas insulated transmission lines, Insulation characteristics of long air gap lines, design of EHV lines based on steady state and transient limits, insulation coordination.	10

Assessments:

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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.

Books Recommended:

Text Books:

1. EHVAC Transmission Entrepreneurship Theory at crossroads, Paradigms and Praxis, Biztrantra, 2nd edition, 2005.
2. Prasama Chandra, Projects- Planning, Analysis Selection, Implementation and Reviews, Tata McGraw-Hill, 1996.

Reference Books:

1. Extra High Voltage AC Transmission Engineering ByRakosh Das Begaumudre, Wiley Eastern limited, New Delhi – 1987.
2. Performance Operation and Control of EHV Power Transmission System ByA.Chakrabarti, D.P. Kothari, Mukhopadhyay, Wheelers Publisher.

Subject Code	Subject Name	Credits
ILO2021	Project Management	03
Course Objectives	• To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques. • To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.	
Course Outcomes	Learner will be able to… • Apply selection criteria and select an appropriate project from different options. • Write work break down structure for a project and develop a schedule based on it. • Identify opportunities and threats to the project and decide an approach to deal with them strategically. • Use Earned value technique and determine & predict status of the project. • Capture lessons learned during project phases and document them for future reference	

Module	Detailed Contents	Hrs
01	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
02	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
03	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	8
04	**Planning Projects:** Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6
05	**Executing Projects:** Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. **Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement;	8

	change requests and scope creep. Project audit. **Project Contracting** Project procurement management, contracting and outsourcing,	
06	**Project Leadership and Ethics:** Introduction to project leadership, ethics in projects. Multicultural and virtual projects. **Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	6

Assessment:

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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. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

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4. Only Four question need to be solved.

REFERENCES:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Subject Code	Subject Name	Credits
ILO2022	**Finance Management**	**03**
Course Objectives	• Overview of Indian financial system, instruments and market • Basic concepts of value of money, returns and risks, corporate finance, working capital and its management • Knowledge about sources of finance, capital structure, dividend policy	
Course Outcomes	Learner will be able to… • Understand Indian finance system and corporate finance • Take investment, finance as well as dividend decisions	

Module	Detailed Contents	Hrs
01	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market. **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
02	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
03	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	10

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4. Only Four question need to be solved.

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Subject Code	Subject Name	Credits
ILO2023	Enterpreneurship Development and Management	03
Course Objectives	• To acquaint with entrepreneurship and management of business • Understand Indian environment for entrepreneurship • Idea of EDP, MSME	
Course Outcomes	Learner will be able to… • Understand the concept of business plan and ownerships • Interpret key regulations and legal aspects of entrepreneurship in India • Understand government policies for entrepreneurs	

Module	Detailed Contents	Hrs
01	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08
06	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	05

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4. Only Four question need to be solved.

REFERENCES:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Subject Code	Subject Name	Credits
ILO2024	Human Resource Management	03
Course Objectives	• To introduce the students with basic concepts, techniques and practices of the human resource management. • To provide opportunity of learning Human resource Management (HRM) processes, related with the functions, and challenges in the emerging perspective. • To familiarize the students about the latest developments, trends & different aspects of HRM. • To acquaint the student with the importance of behavioral skills, Inter-personal, inter- group in an organizational setting. • To prepare the students as future organizational change facilitators, stable leaders and managers, using the knowledge and techniques of human resource management.	
Course Outcomes	Learner will be able to… • Gain knowledge and understand the concepts about the different aspects of the human resource management. • Understand and tackle the changes and challenges in today's diverse, dynamic organizational setting and culture. • Utilize the behavioral skill sets learnt, in working with different people, teams & groups within the national and global environment. • Apply the acquired techniques, knowledge and integrate it within the engineering/ non engineering working environment emerging as future engineers and managers.	

Module	Detailed Contents	Hrs
01	**Introduction to HR:** Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	5
02	**Organizational Behavior (OB) :** Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues, Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness, Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	7
03	**Organizational Structure & Design:** Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of	6

	power; Politics at workplace, Tactics and strategies.	
04	**Human resource Planning:** Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning. Training & Development: Identification of Training Needs, Training Methods	5
05	**Emerging Trends in HR :** Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment, Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	6
06	**HR & MIS:** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

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4. Only Four question need to be solved.

REFERENCES:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Subject Code	Subject Name	Credits
ILO2025	Professional Ethics and Corporat Social Resonsibility (CSR)	03
Course Objectives	• To understand professional ethics in business • To recognized corporate social responsibility	
Course Outcomes	Learner will be able to… • Understand rights and duties of business • Distinguish different aspects of corporate social responsibility • Demonstrate professional ethics • Understand legal aspects of corporate social responsibility	

Module	Detailed Contents	Hrs
01	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
06	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

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REFERENCES:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Subject Code	Subject Name	Credits
ILO2026	**Research Methodology**	**03**
Course Objectives	• To understand Research and Research Process • To acquaint students with identifying problems for research and develop research strategies • To familiarize students with the techniques of data collection, analysis of data and interpretation	
Course Outcomes	Learner will be able to… • Prepare a preliminary research design for projects in their subject matter areas • Accurately collect, analyze and report data • Present complex data or situations clearly • Review and analyze research findings	

Module	Detailed Contents	Hrs
01	**Introduction and Basic Research Concepts:** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology, Need of Research in Business and Social Sciences , Objectives of Research, **Issues** and Problems in Research, Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	**10**
02	**Types of Research:** Basic Research, Applied Research, Descriptive Research, Analytical Research, Empirical Research, Qualitative and Quantitative Approaches	**08**
03	**Research Design and Sample Design :** Research Design – Meaning, Types and Significance, Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	**08**
04	**Research Methodology :** Meaning of Research Methodology, Stages in Scientific Research Process **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f**. Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report	**08**
05	**Formulating Research Problem:** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**
06	**Outcome of Research:** Preparation of the report on conclusion reached, Validity Testing & Ethical Issues, Suggestions and Recommendation	**04**

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REFERENCES:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd ed), Singapore, Pearson Education

Subject Code	Subject Name	Credits
ILO2027	**IPR and Patenting**	**03**
Course Objectives	• To understand intellectual property rights protection system • To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures • To get acquaintance with Patent search and patent filing procedure and applications	
Course Outcomes	Learner will be able to… • understand Intellectual Property assets • assist individuals and organizations in capacity building • work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting	

Module	Detailed Contents	Hr
01	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) activein IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	06
04	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
06	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publicationetc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

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REFERENCE BOOKS:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield,2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph&Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. LousHarns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. PrabhuddhaGanguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
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11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, PritiMathur, AnshulRathi**,** IPR: Drafting,Interpretation of Patent Specifications and Claims**,** New India Publishing Agency
14. Vivien Irish, 2005,Intellectual Property Rights for Engineers,IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Subject Code	Subject Name	Credits
ILO2028	Product Life Cycle Management	03
Course Objectives	• To familiarize with digital business concept • To acquaint with E-commerce • To give insights into E-business and its strategies	
Course Outcomes	The learner will be able to ….. • Identify drivers of digital business • Illustrate various approaches and techniques for E-business and management • Prepare E-business plan	

Module	Detailed content	Hours
1	**Introduction to Digital Business:** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy, **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business,	09
2	**Overview of E-Commerce: E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system, **Application Development:** Building Digital business Applications and Infrastructure	06
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business, Security Threats to e-business - Security Overview, Electronic Commerce Threats, Encryption, ryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
6	**M Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

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REFERENCES:

1. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective -DOI:10.1787/9789264221796-en OECD Publishing

Subject Code	Subject Name	Credits
ILO2029	**Environmental Management**	**03**
Course Objectives	• Understand and identify environmental issues relevant to India and global concerns • Learn concepts of ecology • Familiarise environment related legislations	
Course Outcomes	• Learner will be able to… • Understand the concept of environmental management • Understand ecosystem and interdependence, food chain etc. • Understand and interpret environment related legislations	

Module	Detailed Contents	Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

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4. Only Four question need to be solved.

REFERENCES:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, **T V Ramachandra and Vijay Kulkarni, TERI Press**
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Subject Code	Subject Name	Credits
PSL201	Lab Practice III	01

Module	Detailed content
1	Simulations of Switched Mode Power Supply
2	Simulations of Power Factor Correction Scheme.
3	Simulations of Bidirectional Converter
4	Simulations of Multilevel inverter
5	Simulations of AC Drives
6	Simulations of various types of fault.
7	Simulations of various types of Protection Schemes.
8	Simulation model of SVC
9	Simulation model of SVC with controller

Minimum Six Simulations should be performed based on above contents

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assesment

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PSL202	**Laboratory IV**	**01**

Module	Detailed content
1	Generation of various signals such as sine, cos, square, exponential.
2	Generation of various sequences such as unit impulse, unit step, unit ramp, sine, cos
3	Linear Convolution of two input sequences.
4	To find FFT/DFT of a sequence
5	Simulations of Uncompensated Transmission Line.
6	Harmonic Analysis and Simulation of transmission system
7	Harmonic Analysis and Simulation Electrical Machines
8	Harmonic Analysis and Simulation of Power Electronic Devices

Minimum Six Simulations should be performed based on above contents

Term work: Term work consists of performing 08 practical mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PSS301	Seminar	03

Guidelines for Seminar:

- Seminar should be based on thrust areas in Electrical Engineering.
- Students should undergo literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Program.
- Seminar assessment should be based on following points:
  - Quality of Literature survey and Novelty in the topic.
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

IMPORTANT NOTE:

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions/Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes Literature Survey, Problems Identification, Analysis and Interpretation of Results and Technical Paper Writing in the beginning of 3rd Semester.

Subject Code	Subject Name	Credits
PSD301/ PSD401	Dissertation (I and II)	12 + 15

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt the solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Program.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai.

Students should publish at least one paper based on the work in reputed International/ National Conference / Refereed Journal.