Jharkhand University of Technology

Ranchi

Master of Technology

Course Structure & Syllabus

Department of Electrical Engineering

December 2021

(With effect from Academic Year 2021-22)

Table of Contents

StructureofM.Tech.

(The course structure is as per the Clause 6 mentioned in the JUT Academic Ordinances for M.Tech Programmes with effect from Academic Year 2021-22).

(Totalcredits = 68)

1st Sem:(*Totalnumber of credits=21*)

2 Core Subjects	2*3	=	6 Credits
3Programme Electives	3*3	=	9 Credits
1 Compulsory Course	1*2	=	2 Credits
2 Labs	2*2	=	4 Credits
1 Audit Course			None credit

2nd Sem:(*Totalnumberof credits=21*)

2 Core Subjects	2*3	=	6 Credits
2 Programme Electives	2*3	=	6 Credits
1 Open Elective	1*3	=	3 Credits
1 Compulsory MinorProject	1*2	=	2 Credits
2 Labs	2*2	=	4 Credits
1 Audit Course			None credit

3rd Sem:(*Totalnumberof credits=10*)

Dissertation Phase I	=	10Credits

4th Sem:(*Totalnumberof credits= 16*)

Dissertation Phase II	=	16Credits

Examinations and Assessment Method

(This is as per the Clause 10 mentioned in the JUT Academic Ordinances for M.Tech Programmes with effect from Academic Year 2021-22).

1. In each semester, the theory marks of each subject shall be distributed as follows-

End Semester Examination	**60 Marks**
Internal Assessment	**40 Marks**

2. Internal Assessment in respect of Theory marks of each subject in each semester shall be distributed as follows-

Internal Assessment	**Marks**
Mid Semester Exam	20
Class Test, Quizzes and Assignment	20
Total	40

3. Practical/ Viva Voce Examination marks shall be distributed as follows-

Internal Assessment	**Marks**
Viva Voce examination by External examiner	20
Practical performed during the examination	30
Lab record/ Performance in practical during the semester	50
Total	100

4. Presentation at the end of Third Semester 100 marks

5. Final presentation on the Dissertation at the end of the Fourth Semester-

Evaluation	**Marks**
External examiner	60
Supervisor(s)	100
Other committee members	40
Total	200

6. Method of Converting percentage marks to grades

Percentage of Marks Obtained	**Letter Grade**	**Grade Point**
90% and above	A+	10
80% to less than 90%	A	9
70% to less than 80%	B+	8
60% to less than 70%	B	7
50% to less than 60%	C+	6
40% to less than 50%	C	5
Less than 40%	F	0
Failed due to shortage of attendance	I	0

Course Structure

Department of Electrical Engineering

Specialization-Control System

SEMESTER- I				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	CS1101	Core- I	Non-Linear System	3
02.	EE1102	Core- II	Soft Computing Techniques	3
03.	CS1103	Programme Elective- I	1. Mathematical Methods in Control	3
	CS1104		2. Digital Control System	
	EE1105		3. Power Electronics Converters	
04.	CS1106	Programme Elective- II	1. Design Aspects in Control	3
	CS1107		2. Electric and Hybrid Vehicles	
	CS1108		3. Industrial Process Control	
05.	CS1109	Programme Elective- III	1. Linear System Theory and Design	3
	CS1110		2. Robust Control Theory	
	EE1111		3. SCADA System and Applications	
06.	RMC 1101	Compulsory Paper	Research Methodology & IPR	2
07.	CS1201	Lab- I	Control System Lab	2
08.	EE1202	Lab- II	Simulation Lab- I	2
09.	**A10001**	**Audit I**	English for research paper writing	-
	A10002		Professional ethics	
	A10003		Constitution of India	
	A10004		Stress management by yoga	
Total Credits				**21**

SEMESTER- II				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	CS2101	Core- III	Optimal Control Theory	3
02.	EE2102	Core- IV	Renewable Energy System	3
03.	CS2103	Programme Elective- IV	1. Advanced Control System	3
	CS2104		2. Adaptive Control Theory	
	CS2105		3. Stochastic Filtering and Identification	
04.	CS2106	Programme Elective- V	1. Computational Methods	3
	CS2107		2. Sensor Based Control	

	EE2108		3. Advanced Power Electronics	
05.	EE2109	Open Elective- I	1. Model Order Reduction	3
	EE2110		2. Industrial Safety	
	EE2111		3. Cost Management of Engineering Projects	
06.	EE2201	Lab- III	Simulation Lab- II	2
07.	EE2202	Lab- IV	Electrical Drives Lab	2
08.	EES2203	Mini Project	Mini Project	2
09.	**A20001**	Audit- II	Disaster management	-
	A20002		Value education	
	A20003		Soft skills	
	A20004		Personality development through life enlightenment skills	
Total Credits				**21**

SEMESTER- III			
S. No	**Course Code**	**Course/ Subject**	**Credits**
01.	EED3201	DISSERTATION Phase- I	10
Total Credits			**10**

SEMESTER- IV			
S. No	**Course Code**	**Course/ Subject**	**Credits**
01.	EED4201	DISSERTATION Phase- II	16
Total Credits			**16**

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Course Structure

Department of Electrical Engineering

Specialization-Power System

SEMESTER- I				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	PS1101	Core- I	Power System Dynamics	3
02.	EE1102	Core- II	Soft Computing Techniques	3
03.	PS1103	Programme Elective- I	1. Advanced Power System Analysis	3
	PS1104		2. Wind and Solar Systems	
	EE1105		3. Power Electronics Converters	
04.	PS1106	Programme Elective- II	1. Smart Grid	3
	PS1107		2. Dynamics of Electrical Machines	
	PS1108		3. Power System Operation and Control	
05.	PS1109	Programme Elective- III	1. HVDC and FACTS	3
	PS1110		2. Special Electrical Machines	
	EE1111		3. SCADA System and Applications	
06.	RMC 1101	Compulsory Paper	Research Methodology & IPR	2
07.	PS1201	Lab- I	Power System Lab	2
08.	EE1202	Lab- II	Simulation Lab- I	2
09.	**A10001**	Audit- I	English for research paper writing	-
	A10002		Professional ethics	
	A10003		Constitution of India	
	A10004		Stress management by yoga	
Total Credits				**21**

SEMESTER- II				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	PS2101	Core- III	Power System Analysis	3
02.	EE2102	Core- IV	Renewable Energy System	3
03.	PS2103	Programme Elective- IV	1. Restructured Power Systems	3
	PS2104		2. Electrical Machine Modeling and Drives	
	PS2105		3. Electrical Power Distribution System	
04.	PS2106	Programme Elective- V	1. Power Quality	3
	PS2107		2. Digital Protection of Power System	
	EE2108		3. Advanced Power Electronics	

05.	EE2109	Open Elective- I	1. Model Order Reduction	3
	EE2110		2. Industrial Safety	
	EE2111		3. Cost Management of Engineering Projects	
06.	EE2201	Lab- III	Simulation Lab- II	2
07.	EE2202	Lab- IV	Electrical Drives Lab	2
08.	EES2203	Mini Project	Mini Project	2
09.	**A20001**	Audit- II	Disaster management	-
	A20002		Value education	
	A20003		Soft skills	
	A20004		Personality development through life enlightenment skills	
Total Credits				**21**

SEMESTER- III				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	EED3201	DISSERTATION Phase- I	PROJECT-I	10
Total Credits				**10**

SEMESTER- IV				
S. No	**Course Code**	**Course**	**Subject**	**Credits**
01.	EED4201	DISSERTATION Phase- II	PROJECT-II	16
Total Credits				**16**

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Detailed Syllabus

Department of Electrical Engineering

Specialization-Control System

1st Semester

CS1101	Core- I	Non-Linear System	3

Course Content

Unit-1. Introduction to nonlinear systems, Fundamental properties: Existence &uniqueness, Dependence on initial conditions & parameters.

Unit-2. Phase plane analysis. And describing function methods for analysis of nonlinear systems.

Unit-3. Limit cycles & oscillations. Examples of phenomena, models & derivation of system equations.

Unit-4. Linearization, nonlinear control systems design by feedback linearization, input output Linearization.

Unit-5 Lyapunov stability: autonomous systems invariance principle, linear systems and linearization, non-autonomous systems. Linear time varying systems.

TextBooks

1. H.K.Khalil,"*Nonlinearsystems"*,3rdedition,PrenticeHall,2001
2. J.J.E.SlotineandW.Li,"*Appliednonlinearsystems"*,PrenticeHall,1991.
3. NijemjerandA.Vanderschaft,"*Nonlineardynamicalcontrolsystems"*,Springer,1989
4. Alberto Isidori, "*Nonlinear Control System*", Vol I and II, Springer, 1999

Reference Books

1. M. Vidyasagar, "*Nonlinear Systems Analysis*", Society for Industrial and Applied Mathematics, 2002
2. S. Strogatz, "*Nonlinear Dynamics and Chaos*", Westview Press, 2001

EE1102	Core- II	Soft Computing Techniques	3

Course Content

Unit-1. Introduction to soft computing: Human brain and Biological Neurons, Model of an artificial neuron, Comparison between artificial and biological neural network, Characteristics of Artificial Neural Network (ANN), Basic concepts of ANN, Classification of ANN.

Unit-2. Perceptron model and linear separability: Multilayer perceptron model, back

propagation learning, supervised, unsupervised and competitive learning, Architecture and training algorithm of Hopfield network, Radial basis function network, Kohonen self-organizing feature map, counter propagation network.

Unit-3. Introduction to fuzzy sets and operations: fuzzy relations, measure of fuzziness, fuzziness and probability theory, membership function and their features, fuzzification, de-fuzzification, fuzzy inference system (FIS), fuzzy inference methods, Mamdani and Takagi-Sugeno fuzzy method.

Unit-4. Genetic algorithm concepts and working principle: differences between GAs and traditional methods, similarities between GAs and traditional methods, fitness function, reproduction, crossover and mutation operators in binary coded and real coded GAs, concept of schema, constraint handling in GAs.

Unit-5. Nature Inspired Optimization techniques: Introduction to Particle Swarm Optimization, Artificial Bee Colony, Differential evolution, flower pollination, etc. and their hybridization.

TextBooks

1. P.D. Wasserman, "*Neural Computing Theory and Practice*".
2. B. Yegnanarayana, "*Artificial Neural Networks*".
3. Fu Limin, "*Neural Networks in Computer Intelligence"*.
4. S.N. Sivanandam, S. Sumathi and S.N. Deepa, "*Introduction to Neural Networks using Matlab 6.0*".
5. S. Rajasekaran and G.A. VijayalakshmiPai, "*Neural Networks, Fuzzy Logic and Genetic Algorithms*".
6. N.P. Padhy, "*Artificial Intelligence and Intelligent Systems*".
7. K. Deb, "*Optimization for Engineering Design*".
8. K. Deb, "*Multi objective Optimization using Evolutionary Algorithms*".

CS1103	Programme Elective- I	Mathematical Methods in Control	3

Course Content

Unit-1. Linear Spaces– Vectors and Matrices, Transformations, Norms, Matrix Factorization.

Unit-2. Eigen value, Eigenvectors and Applications, SVD and Applications Projections and Least Square Solutions.

Unit-3. Probability, Random variables, Probability distribution and density functions Joint density and conditional distribution Functions of random variables and random vectors.

Unit-4. Random Processes and properties.

Unit-5. Response of Linear systems to stochastic inputs, PSD theorem.

Text Books

1. G.Strang,"*Introduction to Linear Algebra*",4thEdition,Wellesley-CambridgePress,2009.

2. Papoulis&Pillai,"*Probability, random variable and stochastic processes*",McgrawHill,2002

ReferenceBook

1. H.Stark&J.W.Woods,"*Probability and random processes with application to signal processing*",PearsonEducation Asia, 2002
2. JAGubner:"*Probability and Random processes for Electrical and Computer engineers*",Cambridge Univ.Press. 2006

CS1104	Programme Elective- I	Digital Control System	3

Course Content

Unit-1: Introduction to Digital Control systems: Data conversion and quantization, Sampling process- Mathematical modeling- Data reconstruction and filtering of sampled signals- Hold devices- z transform and inverse z transform - Relationship between s plane and z- plane- Difference equation - Solution by recursion and z-transform- Discretization Methods.

Unit-2:Analysis of Digital Control Systems: Digital control systems- Pulse transfer function - z transform analysis of closed loop and open loop systems- Modified z- transfer function- Multirate z-transform.

Unit-3: Stability Analysis: Stability of linear digital control systems - Stability tests- Steady state error analysis- Root loci - Frequency domain analysis- Bode plots- Nyquist plot s- Gain margin and phase margin.

Unit-4: Design of Digital Control Systems: Cascade and feedback compensation by continuous data controllers- Digital controllers-Design using bilinear transformation- Root locus based design- Digital PID controllers

Unit-5: Advance Design of Digital Control Systems: State variable models- Interrelations between z- transform models and state variable models - Controllability and Observability, Response between sampling instants using state variable approach - Pole placement using state feedback – Servo Design- State feedback with Integral Control- Deadbeat Control by state feedback and deadbeat observers- Dynamic output feedback.

TextBooks

1. K.Ogata,"*Discrete-time Control Systems'*,Ed.2,Prentice-Hall,1995.
2. M. Gopal, "*Digital Control and State Variable Methods*", Tata McGraw Hill Publishing Company, Third Edition, 2009
3. K. Ogata, "*Discrete Time Control Systems*", Addison-Wesley Longman Pte. Ltd., Indian Branch, Delhi, 1995.

ReferenceBooks

1. G. F. Franklin, J.D. Powell, and M.L. Workman, "*Digital control of Dynamic Systems*", AddisonWesley Longman, Inc., Menlo Park, CA, 1998.

2. C. H. Houpis and G.B. Lamont, "*Digital Control Systems*", McGraw Hill Book Company, 1985.
3. C. L. Philips and H.T NagleJr., "*Digital Control System Analysis and Design*", Prentice Hall, Inc., Englewood Cliffs, N.J., 1984.

EE1105	Programme Elective- I	Power Electronics Converters	3

Course Content

Unit-1. Power semi-conductor Devices, Characteristics and rating of thyristor, Power Diodes, Power Transistors, TRIAC, MOSFETs, GTOs, IGBT, MCT Firing circuit, protection scheme and Commutation techniques.

Unit-2. Line-commutated rectifiers, single and three-phase rectifiers (controlled/uncontrolled), performance analysis, harmonics, Ripple reduction techniques, Introduction to multi-pulse converters, Dual Converter

Unit-3. DC to DC Converters: Study of single and multi-quadrant Chopper, Switch-mode DC-DC Converters, pulse width modulation, Non isolated and isolated Topologies, continuous and discontinuous modes of operations, steady-state analysis, energy storage elements design, higher-order topologies.

Unit-4. Inverters: Inverters, single and three-phase inverter configurations, voltage and current source inverters and their operating modes, voltage control in inverters and harmonic reduction using PWM strategies, Introduction to Multi-level Inverters, Rotary Inverter and their applications.

Unit-5. AC-AC voltage controllers, configurations, performance analysis, harmonics, Cyclo-converters, introduction to Matrix converters and their applications.

Text Books

1. P.C. Sen, "*Power Electronics*", McGrawHill, 1st Ed., 2001
2. P.S. Bimbhra, "*Power Electronics*", Khanna Publishers, 5th ed., 2012
3. MH Rashid, "*Power Electronics: Circuits, Devices & Applications*." Pearson, 5th ed., 2012.
4. Cyril W.Lander, "*Power Electronics*", McGraw-Hill; 2nd edition,1987
5. JosephVidyathil, "*Power Electronics Principles and Applications*", TMH,2010.

CS1106	Programme Elective- II	Design Aspect In Control	3

Course Content

Unit-1:Introduction to System Modelling: Review of System Modelling, FOPDT and SOPDT systems and identification Smith Predictor and its variations, PID Controllers – review PID Tuning – Ziegler Nichols, Cohen-Coon techniques.

Unit-2:State Feedback: State feedback review – pole placement, Eigen structure assignment, Eigen structure – time response relation.

Unit-3:Controller Dynamics: Controller gain selection, controller robustness, disturbance rejection.

Unit-4:Compensator and Dynamics: Frequency Domain Loop Shaping, Lag, Lead and Lag-lead compensators, Zero dynamics in servo control, Unstable zero dynamics – control design.

Unit-5:Control schemes and Design: Sliding mode control – adaptive control - Model controller - model reference adaptive control, Observer – concept and design, Case studies – Applications

TextBooks

1. U Itkis, "*Control Systems of Variable Structure*.", New York,Wiley, 1976
2. A S I Zinober, "*Deterministic Control of Uncertain Systems"*, British Library, 1990
3. F.G., Shinskey, "*Process Conrol Systems: Applications, Design and Tuning"* 3rd Edition McGrawHill Book Co, 1988.

ReferenceBooks

1. D.E.Seborg, T.F. Edgar, and D.A. Mellichamp, "*Process Dynamics and Control"*, John Wiley, 2004.
2. B. Wayne Bequette, "*Process control: modeling, design, and simulation",*Prentice Hall PTR, 2003.
3. Arther E Gelb & Vender Velde, "*Multiple input Describing function and Nonlinear System Design"*, MC Graw Hill 1968.

CS1107	Programme Elective- II	Electric and Hybrid Vehicles	3

Course Content

Unit-1: Introduction to Hybrid Electric Vehicles and Conventional Vehicles: Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies; Conventional Vehicles: Basics of vehicle performance, vehicle power

source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Unit-2: Hybrid Electric Drive-trains: Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Unit-3: Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit-4: Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices, Electrical overlay harness and communications.

Unit-5: Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies, Rule and optimization based energy management strategies (EMS).Case studies-Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Books:

1. C. Mi, M. A. Masrur and D. W. Gao, "*Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*", , John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, "*Hybrid Electric Vehicles: Energy Management Strategies*", Springer, 2015.

Reference Books:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "*Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*", CRC Press, 2004.
2. T. Denton , "*Electric and Hybrid Vehicles*", Routledge, 2016.

CS1108	Programme Elective- II	Industrial Process Control	3

Course Content

Unit-1:Introduction to Process Control: Process control principles, Process control block, diagram, loop components—sensor and transmitter, controller, final control element. Process transfer functions - process lag and dead-time, Self-regulating and non-self-regulating processes. Process instrumentation diagram: Symbols and interconnections.

Unit-2:Sensor and Transmission: Process control sensors and transmitter, thermal sensors, mechanical sensors, analog signal conditioning—instrumentation amplifier, signal isolation, and filter, Analog signal transmission systems, Analog process controller, P, PI, PD and PID modes of operation, controller-tuning methods, on-off controllers.

Unit-3:Digital Process Controller: Digital process controllers— theory, Digital controller in a process control loop, analog-to digital and digital-to- analog converters, Realization of digital controller. Final control elements: Actuators, Positioners and control valves. Recorders: Analog, digital and data loggers. Control loop characteristics. Controllability and stability.

Unit-4:Control schemes: Ratio-control, cascade control, feed -forward control and multi-loop control-P1Dcontrol. Process loop tuning-process reaction method, Ziegler-Nichols method and frequency response methods.

Unit-5: Special topics in Process Control: Characteristics of chemical processes, Chemical reactors, pH and blending processes, delay time and its effect. Flow control, pressure control, level control, and temperature control. Computer control of processes, Direct digital control and supervisory control.

TextBooks

1. Johnson D Curtis, "*Instrumentation Technology"*, (7th Edition) Prentice Hall India, 2002.
2. Bob Connel, "*Process Instrumentation Applications Manual"*, McGrawHill, 1996
3. Shinskey, F.G., "*Process Control Systems: Applications, Design and Tuning"* (3rd Edition) McGrawHill Book Co, 1988.

Reference Books

1. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, "*Process Dynamics and Control"*, John Wiley, 2004
2. B. Wayne Bequette, "*Process control: modeling, design, and simulation",* Prentice Hall PTR, 2003
3. Stuart A. Boyer: "*SCADA-Supervisory Control and Data Acquisition"*, Instrument Society of America Publications,USA,1999

CS1109	Programme Elective- III	Linear System Theory and Design	3

Course Content

Unit-1: Introduction to Linear systems with Examples, Math Preliminaries I - Vector Spaces, Bases, Coordinate Transformation, Invariant Subspaces, Inner product, Norms, Math Preliminaries II - Rank, Types of Matrices, Eigen values, Eigen vectors, Diagonalization, Matrix Factorization.

Unit-2: State Transition Matrix, Solutions to LTI Systems, Solutions to LTV Systems, Equilibrium points, Linearization, Types of Linearization with Examples, Stability, Types of Stability, Lyapunov Equation.

Unit-3: Controllability, Reachability, Stabilizability, Tests, Controllable and Reachable Subspaces, Grammians, Controllable Decomposition, Observability, Constructibility, Detectability, Tests, Subspaces, Grammians, State Estimation, Observable Decomposition

Unit-4: Kalman Decomposition, Pole Placement, Controller Design, Observer Design, Duality, Minimal Realization.

Unit- 5: Basics of Optimal Control, LQR, Ricatti Equation, LMIs in Control.

Text Books:

1. Chi-Tsong Chen, "*Linear System Theory and Design*", Oxford University Press.
2. John S. Bay, "*Linear System Theory*".
3. Thomas Kailath, "*Linear System*", Prentice Hall, 1990
4. Gillette, "*Computer Oriented Operation Research*", Mc-Graw Hill Publications.
5. K. Hoffman and R. Kunze, "*Linear Algebra*", Prentice-Hall (India), 1986.
6. G.H. Golub and C.F. Van Loan, "*Matrix Computations*", North Oxford Academic, 1983.

CS1110	Programme Elective- III	Robust Control Theory	3

Course Content

Unit-1: Review of classical feedback control Review of classical feedback control: The control problem, Transfer functions, deriving linear models, Frequency response, Feedback control, Closed loop stability, evaluating closed - loop performance, Controller design, Loop shaping, Shaping closed loop transfer functions.

Unit-2: Elements of Linear System Theory Internal stability of feedback systems, Stabilizing controllers, System norms, Input - Output Controllability, perfect control and plant inversion, Constraints on S and T.

Unit-3: Modeling of uncertain systems, Signals and Norms, Lyapunov theory for LTI

systems, Passive systems–frequency domain, Passive systems–time domain Robust Stability and performance, Stabilizing controllers – Co-prime factorization. LQR, LQG problems, Ricatti equations and solutions, Ricatti equation solution through LMI, H-infinity control and mu-synthesis, Linear matrix inequalities for robust control

Unit-4: The parametric stability margin. Interval Polynomials Kharitnov's Theorem. Generalized Kharitnov Theorem. Small Gain Theorem,Robust Performance

Unit-5: Limitations: on Performance in SISO Systems Limitations imposed by RHP - zeros, Limitations imposed by RHP - poles, Performance requirements imposed by disturbances and commands, Limitations imposed by input constraints, Limitations imposed by uncertainty. Limitations on Performance in MIMO Systems Constraints on S and T, Functional Controllability, Limitations imposed by RHP - zeros, Limitations imposed by RHP - poles, Performance requirements imposed by disturbances, Limitations imposed by input constraints, Limitations imposed by uncertainty.

Text Books:

1. SigurdSkogestad and Ian Postlethwaite, "*Multivariable Feedback Control Analysis and Design*" John Wiley & Sons Ltd., 2nd Edition, 2005.
2. D. W. Gu, P. Hr. Petkov and M. M. Konstantinov "*Robust Control Design with MATLAB*" Spring -Verlag London Ltd., 2005.
3. Kennin Zhou, "*Robust and Optimal Control*", Prentice Hall, Engle wood Cliffs, New Jersy.
4. S. P. Bhattacharrya, H. Chapellat and L. H. Keel,"*Robust Control the parametric approach*" Prentis hall, 1995
5. Michael Green, Canberra, Australia and David J.N. Limebeer, "*Linear Robust Control*" Pearson Education, Inc
6. UweMackenroth - 2004 - Preview - More editions "*Robust Control Systems theory and case studies*" Springer.

EE1111	**Programme Elective- III**	**SCADA System and Applications**	**3**

Course Content

Unit-1: SCADA and PLC: Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions. PLC: Block diagram, programming languages, Ladder diagram, Functional Block diagram, Applications, Interfacing of PLC with SCADA.

Unit-2: SCADA system components: Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server.

Unit-3: SCADA Architecture-Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA /

HMI Systems.

Unit- 4: SCADA Communication-Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols.

Unit-5: Operation and Control Of Interconnected Systems: Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, state estimation, SCADA applications Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries oil gas and water. Case studies, implementation, simulation exercises.

Text Books:

1. Ronald L. Krutz, "*Securing SCADA System*", Wiley Publications.
2. Stuart A Boyer, "*SCADA supervisory control and data acquisition*", ISA, 4th RevisedEdition
3. Sunil S. Rao, "*Switchgear and Protections*", Khanna Publications.
4. Gordon Clarke, Deon Reynders: "*Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*", Newnes Publications, Oxford, UK,2004.
5. S. K. Singh, "*Computer Aided Process Control*", PHI
6. S. Gupta, JP Gupta, "*PC interface For Data Acquiring & Process Control*", 2nd Ed. Instrument Society of America.
7. John W. Web, Ronald A. Reis, "*Programmable Logic Controllers*" 5th Edition, PHI
8. Liptak, B. G. (E.d.), "*Instrument Engineers Handbook*", vol. I to III, Chilton Book Co.
9. Bhatkar, Marshal, "*Distributed Computer control & Industrial Automation*", DekkerPublication.
10. Frank D. Petruzella, "*Programmable Logic Controllers*", 3rd Edition, McGraw Hill.
11. William T. Shaw, "*Cybersecurity for SCADA systems*", PennWell Books, 2006
12. David Bailey, Edwin Wright, "*Practical SCADA for industry*", Newnes, 2003.
13. Michael Wiebe, "*A guide to utility automation: AMR, SCADA, and IT systems for electric power*", PennWell 1999.

RMC 1101	Compulsory paper	Research Methodology & IPR	2

Course Content

Unit-1: Research Problem and Scope for Solution: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Unit-2: Format: Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research

Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit-3: Process And Development: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

Unit-4: Patent Rights: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit-5: New Developments In IPR: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books:

1. Stuart Melville and Wayne Goddard, "*Research methodology: an introduction for science & engineering students*"
2. Wayne Goddard and Stuart Melville, "*Research Methodology: An Introduction*"
3. Ranjit Kumar, 2nd Edition, "*Research Methodology: A Stepby Step Guide for beginners*"

Reference Books:

1. Halbert, "*Resisting Intellectual Property*", Taylor & Francis Ltd ,2007.
2. Mayall, "*Industrial Design*", McGraw Hill, 1992.
3. Niebel, "*Product Design*", McGraw Hill, 1974.
4. Asimov, "*Introduction to Design*", Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " *Intellectual Property in New Technological Age*", 2016.
6. T. Ramappa, "*Intellectual Property Rights Under WTO*", S. Chand, 2008

Detailed Syllabus

Department of Electrical Engineering

Specialization-Control System

2nd Semester

CS2101	Core- III	Optimal Control Theory	3

Course Content

Unit-1. Introduction, static and dynamic optimization, parameter optimization, Necessary conditions for optimal control, Calculus of variations: problems of Lagrange, Mayer and Bolza, Euler- Lagrange equation and transversality conditions.

Unit-2. Lagrange multipliers, Pontryagins maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem,

Unit-3. Dynamic programming: Hamilton-Jacobi-Bellman Equation, Bellman's principle of optimality, multistage decision processes, application to optimal control.

Unit-4. Linear regulator problem: matrix Riccati equation and its solution, tracking problem, computational methods in optimal control,

Unit-5. Application of mathematical programming, singular perturbations, practical examples.

Text Books:

1. Enid R. Pinch, "*Optimal Control and Calculus of variation*", Oxford University Press.
2. Donald Kirk, *Optimal Control Theory, an Introduction*, Prentice Hall, Inc, Englewood Cliffs, New
3. A.P.Sage and C.C.White II, "*Optimum Systems Control*", 2nd Ed., Prentice-Hall, 1977.
4. D.Tabak and B.C.Kuo, "*Optimal Control by Mathematical Programming*", Prentice Hall, 1971.
5. B.D.O. Anderson and J.B.Moore, "*Linear Optimal Control*", Prentice-Hall, 1971.
6. F.L. Lewis , V.L. Symmos, "*Optimal Control*", Second Edition, John Wiley, 1995.
7. M. Gopal ,*Digital Control & State Variable Methods*, TMH.

EE2102	Core- IV	Renewable Energy System	3

Course Content

Unit-1:Global and National Energy Scenario: Over view of conventional & renewable energy sources, need, environmental consequences of fossil fuel use, potential & development of renewable energy sources, types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Energy for sustainable development, renewable

electricity and key elements, Global climate change.

Unit-2:Solar Energy: Solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar-Electrical Power Generation, Solar Photo Voltaic (SVP) system, Different configurations, SPV system components and their characteristics, maximum power point tracking, Stand-Alone and Grid Connected SPV systems, other Miscellaneous Applications of Solar Energy.

Unit-3:Wind Energy &Hydel Energy: Wind Energy Conversion, Potential, Site selection, Types of Wind Power Plants (WPPs), Components of WPPs, Working of WPPs, Characteristics, Betz limit Grid integration issues of WPPs.

Basic working principle of Hydel Energy, Site selection, Classification of hydel systems: Large, small, micro-measurement of head and flow .

Unit-4:Other Sources: Bio-mass Energy: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, Geothermal Energy: Methods of harnessing the energy, potential in India. Ocean Energy: OTEC, Principle's utilization, setting of OTEC plants.

Tidal power: Conventional and latest design of tidal power system

Fuel cell energy: Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

Unit-5: Integrated Energy Systems: Introduction, Integrated Smart infrastructure, Integrated Energy system Modeling, Various Integrated energy schemes, their cost benefit analysis.

Text Books

1. S. P. Sukhatme and J. K. Nayak, "*Solar Energy: Principles of Thermal Collection and Storage*", TMH, New Delhi, 3rd Edition.
2. John Twidell and Tony Weir, "*Renewable Energy Resources*", Taylor and Francis - second edition, 2013.
3. G.D. Rai, "*Non-Conventional Energy Sources*", Khanna Publishers.
4. F. Kreith& J. F. Krieder, "*Principles of Solar Engineering*," Mc.Graw Hill Book Co.
5. L.C.Freris, "*Wind Energy conversion Systems*", Prentice Hall, Inc..

Reference Books

1. Godfrey Boyle, "*Renewable Energy*", Oxford university, press, 3rd edition, 2013.
2. Ahmed and Zobaa, Ramesh C Bansal, "*Handbook of renewable technology*", World scientific, Singapore.
3. Ramesh & Kumar, "*Renewable Energy Technologies*", Narosa.
4. Chetong Singh Solanki, "*Renewable energy technologies – A practical guide for beginners*", PHI.
5. B.H. Khan, "*Non conventional energy source*", TMH-2nd edition.

6. Karlsson, Kenneth Bernard,Skytte, Klaus Morthorst, "*Integrated energy systems modeling*", PublishedinDTU International Energy Report 2015.Z1

CS2103	Programme Elective- IV	Advance Control System	3

Course Content

Unit-1:Nonlinear Control Systems: Introduction to Nonlinear systems and their properties, Common Non-linearities, Describing functions, Phase plane method, Lyapounov's method for stability study, concept of Limit Cycle.

Unit-2:*z*-Plane Analysis of Discrete-Time Control Systems: Introduction, Impulse sampling and data hold, Reconstructing original signal from sampled signals, concept of pulse transfer function, Realization of digital controllers.

Unit-3:Modern Control Design: Stability Analysis: Stability of linear systems, stability types and their definitions for any general system, controllability theorem and its proof, Observability theorem and its proof, Controllable and observable subspaces. Conversion of model to controllable, canonical form and its use for pole placement.

Unit-4:Optimal Control Theory: Introduction to the philosophy of optimal control, formulation of optimal control problem, different performance criterion,

Unit-5: Advanced Control System: Linear quadratic regulator (LQR) and optimum gain matrix, Riccati equations, conceptual models and statistical models for random processes.

TextBooks

1. Bandyopadhyay, M.N., *Control Engineering: Theory and Practice*, Prentice-Hall of India Private Limited (2003).
2. Ogata, K., *Discrete-time Control Systems*, Pearson Education (2005)
3. B. C. Kuo. *Automatic Control Systems*, Prentice – Hall of India, Seventh Edition 1997.

ReferenceBooks

1. Slotine& Li, *Applied Non-Linear Control*, NJ: Prentice-Hall, (1991)
2. John E. Gibson, *Non-linear Automatic Control*, Mc. Graw Hill Book C.(ISE) 2003
3. Hasan K. Khalil, *Non-linear systems*, Prentice-Hall of India, 2002.
4.

CS2104	Programme Elective- IV	Adaptive Control Theory	3

Course Content

Unit-1:Overview of Adaptive Control Systems. Direct and indirect adaptive control. The principle of certainty-equivalence.

Unit-2:Model reference adaptive control. Parametrization of the certainty-equivalence controller. MRAC schemes for linear systems with relative degree one and two. Uniform global asymptotic stability of MRACs: uniform persistency of excitation condition.

Unit-3:Self-Tuning Regulator: Deterministic in-direct self-tuning regulators-Deterministic direct self-tuning regulators -Introduction to stochastic self-tuning regulators – Stochastic indirect self-tuning regulator.

Unit-4:Robust redesign of adaptive control systems. Robustness of adaptive systems. Dead-zone and projection-based techniques. **Adaptive controllers for nonlinear systems**. Adaptive back stepping. Design with over parameterization. Tuning functions method. Output-feedback design.

Unit-5:Tuning of Controllers and Case Studies: Design of gain scheduling controller – Auto-tuning of PID regulator – Stability analysis of adaptive controllers – Application of adaptive control in chemical reactor, distillation column and variable area tank system.

TextBooks

1. Karl J. Astrom and Bjorn Wittenmark, *Adaptive Control*, Pearson Education (Singapore), Second Edition, 2003.
2. Shankar Sastry and Marc Bodson, *Adaptive Control: Stability, Convergence, and Robustness*, Prentice-Hall, 1994.
3. Landau, I.D., Lozano, R., MSaad, M., Karimi, A, *Adaptive Control Algorithms, Analysis and Applications*, 2nd edition, Springer, 2011
4. P. Ioannou and J. Sun, *Robust Adaptive Control*, Upper Saddle River, NJ: Prentice

ReferenceBooks:

1. V VChalam, *Adaptive Control Systems: Techniques and Applications*, CRC Press, 1987.
2. K.S. Narendra and A.M. Annaswamy, *Stable Adaptive Systems*,, Prentice-Hall, 1989.
3. MiroslavKrsti, IoannisKanellakopoulos, and Petar V. Kokotovic, *Nonlinear and Adaptive Control Design*, Wiley-Interscience, 1995
4. Gang Tao, *Adaptive Control Design and Analysis*, Wiley-IEEE Press, 2003.

CS2105	**Programme Elective- IV**	**Stochastic Filtering and Identification**	**3**

Course Content

Unit-1: Introduction: Overview of estimation – parameter and state estimation, system identification.

Unit-2: Parameter Estimation- Deterministic Parameter: Least Squares (batch, weighted, recursive, constrained); Best Linear Unbiased Estimator (BLUE); Cramer-Rao Lower Bound; Max Likelihood Estimation (MLE) etc.

Unit-3: Parameter Estimation- Random Parameter: (Bayesian Estimation)Maximum A Posteriori Estimator (MAP); Minimum Mean Square Error Estimator (MMSE); Linear Minimum Mean Square Error Estimator (LMMSE)

Unit-4: State Estimation: Overview of Stochastic Processes; Mean squared prediction, filtering (Kalman/Kalman-Bucy), smoothing; Extended Kalman Filter (EKF); Particle Filtering (Optional)

Unit-5: System Identification: Parametric models, linear regression; Input Signals; Parameter estimation for system identification (identifiability, consistency, bias); Instrument-Variable Method

Text Books:

1. Papoulis & Pillai, "*Probability, Random Variable and Stochastic Processes*", Mcgraw Hill, 2002.
2. John L. Crassidis and John L. Junkins, "*Optimal Estimation of Dynamic Systems*", CRC, 2nd Edition.
3. Jerry M. Mendel, "*Lessons in Estimation Theory for Signal Processing, Communications and Control*", Prentice-Hall, 1995.

ReferenceBooks:

1. B. D. O. Anderson and J. B. Moore, "*Optimal Filtering*", Dover, 2005.
2. LennartLjung, "*System Identification: A Theory for the User*", Prentice-Hall, 2nd edition, 1998.
3. T. Soderstrom and P. Stoica, "*System Identification*", Prentice-Hall, 1989.

CS2106	**Programme Elective- V**	**Computational Methods**	**3**

Course Content

Unit-1: Formulation and solution of linear system of equations, Gauss elimination, LU, QR decomposition, iteration methods (Gauss-Seidal), convergence of iteration methods.

Unit-2: Singular value decomposition and the sensitivity of rank to small perturbation Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials.

Unit-3: Non-linear regression, multiple linear regression, general linear least squares Vector spaces, Basis vectors, Orthogonal/Unitary transform, Fourier transform, Laplace transform.

Unit-4: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function Graphs and Matrices, simple graph, cyclic graph, complete graph,

Unit-5: Properties of the Laplacian matrix and relation with graph connectivity non-negative matrices. Applications of graph theory to engineering problems.

Text Books:

1. Erwin Kreyszig, "*Advanced Engineering Mathematics*", 9/e, John Wiley & Sons, Inc.
2. M D Greenberg, "*Advanced Engineering Mathematics*", 2/e, Pearson Education.
3. S C Chapra, and R C Canale, "*Numerical Methods for Engineers*", McGraw-Hill.
4. S. P. Venkateshan, PrasannaSwaminathan, "*Computational Methods in Engineering"*, Ane Books
5. Joe D Hoffman, "*Numerical Methods for Engineers and Scientists"*, Second Edition, Marcel Dekker (2001)
6. Gilbert Strang, "*Computational Science and Engineering"*, Wellesley-Cambridge Pres

CS2107	Programme Elective- V	Sensor Based Control	3

Course Content

Course Content

Unit-1: Mechanical and Electromechanical sensor: Definition, Sensor Characteristics, Transfer function, Characteristics, principle of sensing & transduction, classification, Resistive (Potentiometric type).

Unit-2: Introduction to sensors: Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes.

Unit-3: Transducers: Introduction, Classification of Transducers, Advantages and Disadvantages of Electrical Transducers, Transducers Actuating Mechanisms, Resistance Transducers, Variable Inductance Transducers, Capacitive Transducers, Piezoelectric Transducers, Hall Effect Transducers, Thermoelectric Transducers, Photoelectric Transducers.

Unit-4: Signal Condition: Introduction, Functions of Signal Conditioning Equipment, Amplification, Types of Amplifiers, Mechanical Amplifiers Fluid Amplifiers, Optical

Amplifiers, Electrical and Electronic Amplifiers. Configuration of Data Acquisition System, Data Acquisition Systems, Data Conversion.

Unit-5:Smart Sensor: Component of smart sensor, General architecture of smart sensor, Industrial application of smart sensor, Applications Chemical sensors, biosensors, fiber optic sensors, gas sensors.

TextBooks

1. D. Patranabis, "*Sensor & transducers*", 2nd edition, PHI.
2. H.K.P. Neubert, "*Instrument transducers*", Oxford University press.
3. E.A.Doebelin, "*Measurement systems: application & design*",McGraw Hill.

ReferenceBooks

1. H S Kalsi, "*Electronic Instrumentation*", TMH 2nd Ed 2004.
2. Richard Zurawski, "*Industrial Communication Technology*", Handbook 2nd edition, CRC Press, 2015

EE2108	Programme Elective- V	Advanced Power Electronics	3

Course Content

Review of SCR, driving circuits and protection; Modern semiconductor devices: MOSFET, GTO, IGBT, GTO, SIT, SITH, MCT, their operating characteristics

Single and Three-phase converters, effect of load and source impedances; Semi controlled converter, Dual converter, multi-pulse converters. PWM converter, power factor improvement techniques

Voltage and current commutated choppers, dc-dc converters: Buck, Boost, Buck-Boost converters, Cuk converter.

Basic concept of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques, 3-Φ Inverter configurations, Current-Source Inverter. Multi-level inverters

Applications: Drive, power supplies, HVDC Transmission and Static VAR Compensators.

Text Books:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "*Power Electronics – Converters, Applications and Design",* John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "*Power Electronics Circuits, Devices and Applications*", Pearson Education, Fourth Edition. 2014
3. P.S.Bimbra, "*Power Electronics*", Khanna Publishers, Eleventh Edition, 2003
4. N.G. Hingorani, L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001

Reference Books:

1. P.C.Sen, "*Modern Power Electronics*", S. Chand and Co. Ltd., New Delhi, 2000.
2. Vijay K. Sood, "*HVDC and FACTS Controllers Applications of Static Converters in Power Systems*", Kluwer Academic Publishers, Boston, 2004.
3. L. Umanand, "*Power Electronics Essentials and Applications*", Wiley India Ltd., 2009
4. Muhammad H. Rashid, "*Power Electronics Handbook*", Elsevier, 3rd ed., 2011.
5. Bin Wu, "*High Power Converters and AC Drives*", John Willey & sons, Inc., 2006.

EE2109	Open Elective- I	Model Order Reduction	3

Course Content

Unit-1: Introduction to Large Scale Systems and Model Reduction, Principal Component based model reduction methods. Model reduction through aggregation.

Unit-2: Frequency domain-based model reduction techniques - Pade, Routh and Continued fraction approximations.

Unit-3: Classical Model Reduction Methods–Modal reduction.Pade approximation and moment matching, Routh Approximants. Model reduction using step and impulse error minimization techniques. Balanced truncation and Hankel norm minimization.

Unit-4: Introduction to uncertain or interval system. Order Reduction of interval system. Robust Control Techniques. Kharitonov theorem.

Unit-5: State Feedback design techniques for parametric uncertain systems.

Text Books:

1. M. G. Singh, M.S. Mamoud, "*Large Scale Systems Modelling*", International Series on Systems and Control, Pergamemon Press, 1981
2. M.Jamshidi, "*Large Scale Systems: Modelling and Control*", North Holland, New York, 1983
3. Kemin Zhou, John C. Doyle, Keith Glover, "*Robust and Optimal Control*", Prentice Hall, Upper Saddle River, New Jerset, 1996
4. M. Gopal, "*Modern Control Systems Theory*", 2nd Edition, John Wiley, 1993.
5. S. P. Bhattacharyya, H. Chappelat, L. H. Keel, "*Robust Control - The Parametric Approach*", Prentice Hall, NJ, 1995.

EE2110	Open Elective- I	Industrial Safety	3

Course Content

Unit-1: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points

of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-2: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-3: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working andapplications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-4: Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-5: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Books:

1. Higgins & Morrow, "*Maintenance Engineering Handbook*", Da Information Services.
2. H. P. Garg, "*Maintenance Engineering*", S. Chand and Company.
3. Audels, "*Pump-hydraulic Compressors*", Mcgraw Hill Publication.
4. Winterkorn, "*Foundation Engineering Handbook*", Chapman & Hall London.

EE2111	**Open Elective- I**	**Cost Management of Engineering Projects**	**3**

Course Content

Unit-1: Introduction and Overview of the Strategic Cost Management Process, Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and

Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-2: Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit-3: Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision- making problems. Standard Costing and Variance Analysis.

Unit-4: Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based

Unit-5: Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Text Books:

1. *Cost Accounting A Managerial Emphasis*, Prentice Hall of India, New Delhi.
2. Charles T. Horngren and George Foster, *Advanced Management Accounting.*
3. Robert S Kaplan Anthony A. Alkinson, *Management & Cost Accounting.*
4. Ashish K. Bhattacharya, *Principles & Practices of Cost Accounting* A. H. Wheeler publisher.
5. N.D. Vohra, *Quantitative Techniques in Management*, Tata McGraw Hill Book Co. Ltd.

Detailed Syllabus

Department of Electrical Engineering

Specialization-Power System

1st Semester

PS1101	Core- I	Power System Dynamics	3

Course Content

Unit – 1: Stability phenomena, Basic concepts and definitions, Rotor angle stability, Classification of stability, Synchronous machine characteristics, Power versus angle, relationship

Unit – 2: Perunitsystems,Park'sTransformation(modified),Flux-linkageequations. Voltage and current equations. Formulation of State-space equations. Equivalentcircuit.Sub-transientandtransientinductanceandTimeconstants,Simplifiedmodelsofsynchronous machines

Unit – 3: Small Signal Stability: State space concepts, Eigen properties of state matrix, small signal stability of a single machine infinite bus system, PSS, small signal stability of multi-machine systems, small signal stability enhancement

Unit – 4: Transient stability, numerical integration methods, synchronous machine representation, excitation system representation, direct method of transient stability analysis, methods of improving transient stability

Unit – 5: Voltage stability, characteristics: transmission system, generator & load, voltage collapse, classification of voltage stability, analysis, and prevention of voltage collapse

TextBooks:

1. P.Kundur,"*Power system stability and control*",McGrawHillInc.1994.
2. P.M.Anderson&A.A.Fouad,"*Power system control and stability*",Galgotia,NewDelhi.,1981.
3. P. Sauer and M. Pai, "*Power system dynamics and stability*", Prentice Hall, 1998
4. Padiyar K R, "*Power System Dynamics, Stability and Control"*, BS Publications

EE1102	Core- II	Soft Computing Techniques	3

Course Content

Unit-1. Introduction to soft computing: Human brain and Biological Neurons, Model of an artificial neuron, Comparison between artificial and biological neural network, Characteristics of Artificial Neural Network (ANN), Basic concepts of ANN, Classification of

ANN.

Unit-2. Perceptron model and linear separability: Multilayer perceptron model, back propagation learning, supervised, unsupervised and competitive learning, Architecture and training algorithm of Hopfield network, Radial basis function network, Kohonen self-organizing feature map, counter propagation network.

Unit-3. Introduction to fuzzy sets and operations: fuzzy relations, measure of fuzziness, fuzziness and probability theory, membership function and their features, fuzzification, de-fuzzification, fuzzy inference system (FIS), fuzzy inference methods, Mamdani and Takagi-Sugeno fuzzy method.

Unit-4. Genetic algorithm concepts and working principle: differences between GAs and traditional methods, similarities between GAs and traditional methods, fitness function, reproduction, crossover and mutation operators in binary coded and real coded GAs, concept of schema, constraint handling in GAs.

Unit-5. Nature Inspired Optimization techniques: Introduction to Particle Swarm Optimization, Artificial Bee Colony, Differential evolution, flower pollination, etc. and their hybridization.

TextBooks

1. P.D. Wasserman, "*Neural Computing Theory and Practice*".
2. B. Yegnanarayana, "*Artificial Neural Networks*".
3. Fu Limin, "*Neural Networks in Computer Intelligence"*.
4. S.N. Sivanandam, S. Sumathi and S.N. Deepa, "*Introduction to Neural Networks using Matlab 6.0*".
5. S. Rajasekaran and G.A. VijayalakshmiPai, "*Neural Networks, Fuzzy Logic and Genetic Algorithms*".
6. N.P. Padhy, "*Artificial Intelligence and Intelligent Systems*".
7. K. Deb, "*Optimization for Engineering Design*".
8. K. Deb, "*Multi objective Optimization using Evolutionary Algorithms*".

PS1103	**Programme Elective- I**	**Advance Power System Analysis**	**3**

Course Content

Unit 1:Load Flow-Network modeling, concept of primitive network, Formulation of Y-bus Matrix, Sparsity techniques, Newton Raphson method, Decoupled & Fast decoupled Load flow.

Unit 2:Fault Studies -Analysis of balanced and unbalanced three phase faults, fault calculations, Short circuit faults, open circuit faults.

Unit 3:Security Analysis- Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index

ranking.

Unit 4:State Estimation method - Sources of error in measurements, least squares method, WLS method, statistics, identification and correction of bad data, structure and formation of Hessian matrix, Application of power system state estimation.

Unit 5:Voltage Stability- Basic concept of voltage stability, Role of reactive power on voltage stability, P-V and Q-V profiles, voltage collapse proximity indices.

Text Books:

1. Grainger, J.J. and Stevenson, W.D. "*Power System Analysis*" Tata McGraw hill, New Delhi.
2. Wood A.J. andWollenburg B.F., "*Power Generation Operation and Control*", Willey, Student Ed.
3. Arrillaga, J and Arnold, C.P., "*Computer analysis of power systems*" John Wiley and Sons, New York.
4. Nagrath, I.J. and Kothari D.P., "*Modern Power System Analysis*", TMH, New Delhi, 2006.
5. Pai, M.A., "*Computer Techniques in Power System Analysis*", Tata McGraw hill, New Delhi.
6. KundurPrabha, "*Power System Stability and Control*", TATA McGraw-Hill Inc
7. ChakrabartiAbhijeet and HalderSunita, "*Power System Analysis: Operation and Control*", PHI
8. KusicG.L.,"*Computer aided power system analysis*", Prentice Hall India.
9. Anderson P.M.,"*Faulted power system analysis*", IEEE Press.
10. Bergen A.R &VittalVijay,"*Power System Analysis*",Pearson.

PS1104	Programme Elective- I	Wind And Solar Systems	3

Course Content

Unit-1: History of wind power, Indian and global statistics, Introduction of wind park, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed and power-cumulative distribution functions

Unit-2: Wind generator topologies: Review of modern wind turbine technologies, Fixed and variable speed wind turbines, Induction Generators, Doubly-Fed induction generators and their characteristics, Permanent-Magnet Synchronous generators, Power electronics converters. Generator-Converter configurations, Converter control.

Unit-3: Solar photovoltaic: Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell and its working principle, Different types of Solar cells, Series and parallel connections, Technologies-Amorphous, mono crystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar

Systems, Maximum Power Point Tracking (MPPT) algorithms, Converter Control.

Unit-4: Solar Radiation: Sun as a source of energy, Solar radiation, Solar radiation at the Earth's surface, Measurement of Solar radiation-Pyroheliometer, Pyranometer, Sunshine recorder, Prediction of available solar radiation, Solar energy-Importance, Storage of solar energy, Solar pond

Unit-5: Solar Thermal Systems: Principle of conversion of solar radiation into heat, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Solar Thermal Power Plant, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.

Text Books

1. S. P. Sukhatme and J. K. Nayak, "*Solar Energy: Principles of Thermal Collection and Storage*", TMH, New Delhi, 3rd Edition.
2. F.Kreith&J.F.Krieder, "*Principles of Solar Engineering",* Mc.Graw Hill Book Co
3. L.C.Freris, "*Wind Energy conversion Systems"*, Prentice Hall, Inc..

Reference Books

1.Martin A. Green, *"Solar Cells – Operating Principles, Technology and System Applications*", Prentice Hall Inc c.
2. Luis Castaner and Santiago Silvestre, "*Modelling Photovoltaic Systems using P Spice",* John Wiley and Sons d.
3. H.P. Garg and J. Prakash, "*Solar Energy – Fundamentals and Applications",* Tata McGraw-Hill
4. Paul Gipe, "*Wind Energy Comes of Age"*, John Wiley & Sons Inc.
5. Tony Burton et al, "*Wind energy Hand Book"*, John Wiley & Sons Inc.

EE1105	**Programme Elective- I**	**Power Electronics Converters**	**3**

Course Content

Unit-1. Power semi-conductor Devices, Characteristics and rating of thyristor, Power Diodes, Power Transistors, TRIAC, MOSFETs,GTOs, IGBT, MCT Firing circuit, protection scheme and Commutation techniques.

Unit-2. Line-commutated rectifiers, single and three-phase rectifiers (controlled/uncontrolled), performance analysis, harmonics, Ripple reduction techniques, Introduction to multi-pulse converters, Dual Converter

Unit-3. DC to DC Converters: Study of single and multi-quadrant Chopper, Switch-mode DC-DC Converters, pulse width modulation, Non isolated and isolated Topologies, continuous and discontinuous modes of operations, steady-state analysis, energy storage elements design, higher-order topologies.

Unit-4. Inverters: Inverters, single and three-phase inverter configurations, voltage and current source inverters and their operating modes, voltage control in inverters and harmonic reduction using PWM strategies, Introduction to Multi-level Inverters, Rotary Inverter and their applications.

Unit-5. AC-AC voltage controllers, configurations, performance analysis, harmonics, Cyclo-converters, introduction to Matrix converters and their applications.

Text Books

1. P.C. Sen, "*Power Electronics*", McGrawHill, 1st Ed., 2001
2. P.S. Bimbhra, "*Power Electronics*", Khanna Publishers, 5th ed., 2012
3. MH Rashid, "*Power Electronics: Circuits, Devices & Applications*." Pearson, 5th ed., 2012.
4. Cyril W.Lander, "*Power Electronics*", McGraw-Hill; 2nd edition,1987
5. JosephVidyathil, "*Power Electronics Principles and Applications*", TMH,2010.

PS1106	Programme Elective- II	Smart Grid	3

Course Content

Unit-1: Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

Unit-2: Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles(PHEV).

Unit-3: Introduction to Smart Meters, Advanced Metering Infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) &t heir application for monitoring & protection

Unit-4: Demand Response, Tariff Design, Time of the day pricing (TOD), Time of use pricing (TOU), Consumer privacy and data protection, consumer engagement etc. Cost benefit analysis of smart grid projects.

Unit-5: Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

Text Book:

1.Stuart Borlase "*Smart Grid: Infrastructure, Technology and Solutions*",CRCPress2012.

2. JanakaEkanayake, NickJenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*",Wiley2012Distributors, Delhi, 2001
3. Qi Huang, Shi Jing "*Innovative Testing and Measurement Solutions for Smart Grid*", John Wiley & Sons Inc, 2015.
4. Lars.T.Berger, K.Iniewski, "*Smart Grid: Applications, Communications & Security*" Wiley India Pvt. Ltd, Reprint 2015
5. Fereidoon P. Sioshansi, "*Smart Grid: Integrating Renewable, Distributed & Efficient Energy*", Academic Press, 2012.

Reference Book

1. VehbiC. Güngör ,Dilan Sahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, "*Smart Grid Technologies: Communication Technologies and Standards*" IEEE Transactions On Industrial Informatics, Vol.7,No.4, November2011.
2. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang "*SmartGrid –The New and Improved Power Grid: A Survey*",IEEE Transaction on Smart Grids,vol.14,2012.
3. James Momohe "*Smart Grid: Fundamentals of Design and Analysis*,", Wiley-IEEE Press , 2012.
4. Clark W.Gellings, "*The smart grid: Enabling energy efficiency and demand response*", Fairmont Press Inc,2009
5. Qi Huang, Shi Jing "*Innovative Testing and Measurement Solutions for Smart Grid*", John Wiley & Sons Inc, 2015.

PS1107	Programme Elective- II	Dynamics Of Electrical Machines	3

Course Content

Unit-1: Basic Electrical Machine Theory: Electromechanical Analogy – Magnetic Saturation – Rotating field theory – Operation of Induction motor – equivalent circuit – Steady state equations of d.c. machines – operations of synchronous motor – Power angle characteristics.

Unit-2: Electro dynamical equation and their solutions: Spring and Plunger system - Rotational motion – mutually coupled coils – Lagrange's equation – Application of Lagrange's equation solution of Electro dynamical equations.

Unit-3: Dynamics of DC Machines: Separately excited d. c. generations – stead state analysis – transient analysis – Separately excited d. c. motors – stead state analysis – transient analysis – interconnection of machines – Ward Leonard system of speed control.

Unit-4: Induction Machine Dynamics: Induction machine dynamics during starting and braking – accelerating time – induction machine dynamic during normal operation –

Equation for dynamical response of the induction motor.

Unit-5: Synchronous Machine Dynamics: Electromechanical equation – motor operation – generator operation – small oscillations – general equations for small oscillations – representation of the oscillation equations in state variable form.

Text Books:

1. Sen Gupta D.P. and J.W "*Electrical Machine Dynamics*"Macmillan Press Ltd 1980.
2. Bimbhra P.S. "*Generalized Theory of Electrical Machines"* Khanna Publishers 2002.
3. *Electric machinery*, A.E. Fitzgerald,KingsleyMacgraw Hill
4. Bimbhra P.S., *Electrical Machinery*, Khanna Publishers

Reference Books:

1. Adkins and Harley, *General Theory of A.C. machines*
2. Krauss, Wasyncsuk and Sudholf, *Analysis of Electrical Machines and Drives Systems*, John willey
3. Boldea, I., Nasar, Syed A*, "Electric Machine Dynamics*", Macmillan Pub Co
4. Mulukutla S. Sarma, "*Electric Machines: Steady-State Theory and Dynamic Performance"*, West group Publisher

PS1108	Programme Elective- II	Power System Operation And Control	3

Course Content

Unit-1: Economic Operation: Statement of economic dispatch problem-cost of generation-incremental cost curve-coordination equation without loss and with loss, solution by direct method and λ-iteration method (No derivation of loss coefficient).

Unit-2: Unit Commitment: Statement of Unit commitment problem-constraints; spinning reserves, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods-priority list methods-forward dynamic programming approach. Numerical problem only in the priority list method using full load average production cost.

Unit-3: Real power frequency Control: Basics of speed governing mechanism and modelling- speed-load characteristics- load sharing between two synchronous machines in parallel. Control area concept LFC control of single area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC. Two-area system-modelling-static analysis of uncontrolled case-tie line with frequency bias control of two area system-state variable model.

Unit-4: Reactive power-voltage control: Basics of reactive power control. Excitation systems-modelling. Static and dynamic analysis : stability compensation generation and absorption of reactive power. Methods of voltage control-tap changing transformer. System level control using generator voltage magnitude setting, tap setting of OLTC transformer. MVAR injection of switched capacitors to maintain acceptable voltage profile and to

minimize transmission loss.

Unit-5: Demand Forecasting: Perspective, Analytic Methods, Demand Models, Commodity Price Forecasting, Forecasting Errors, System Identification, Econometric Models, Time Series, Time Series Model Development, Artificial Neural Networks, Model Integration, Demand Prediction.

Text Books

1. Allen J.Wood and Bruce F Wollenberg, "*Power Generation, operation and Control*",JohnWiley & Sons,Inc.
2. Chakrabarti&Halder,"*Power system analysis operation and contro*l",Prentice Hall of India.
3. Olle.I.Elgerd,"*Electric Energy System Theory: An introduction*", Tata McGraw Hill Publishing CompanyLimited.
4. D.P.Kothari and I.J.Naghrath, "*Modern Power system Analysis*", Tata McGraw Hill Publishing Company Limited.

Reference Books

1. HadiSaadat ,"*Power System Analysis*" ,TMH .
2. C.L.Wadhwa, "*Power System Analysis*", New Age International.
3. P. Kundur, Neal J. Balu, "*Power System Stability & Control*", IEEE.
4. Robert Miller, James Malinowski, "*Power System Operation*", TataMcGrawHill Publishing Company Ltd.

PS1109	**Programme Elective- III**	**HVDC AND FACTS**	**3**

Course Content

Unit-1: Facts concepts: Reactive power control in electrical power transmission, principles ofconventionalreactivepowercompensators.IntroductiontoFACTS,flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.

Unit-2: Static shunt and series compensators: Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators– SVC,STATCOM,SVCandSTATCOMcomparison.Seriescompensation–objectives of series compensation, thyristor switched series capacitors(TCSC), static series synchronous compensator(SSSC), power angle characteristics, and basic operating control schemes.

Unit-3: Combined compensators: Unified power flow controller (UPFC) – Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC),Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

Unit-4: HVDC transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC Converter station and various equipment's. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit representation of rectifier and inverter configurations

Unit-5:Control of HVDCsystem: Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinctionanglecontrol.Harmonicsintroduction,generation,acfiltersanddcfilters.Introductio ntomultiterminal DC systems and applications, comparison of series and parallel MTDC systems, Voltage Source Converter based HVDC systems

Text Books

1. Hingorani ,L.Gyugyi, '*Concepts and Technology of Flexible AC Transmission System'*, IEEE Press New York, 2000 ISBN –078033 4588.
2. Padiyar, K.R., '*HVDC transmission systems'*, Wiley Eastern Ltd., 2010.
3. Mohan Mathur R. and Rajiv K.Verma , '*Thyristor – based FACTS controllers for Electrical Transmission systems'*, IEEE press, Wiley Inter science , 2002
4. Padiyar K.R., '*FACTS controllers for Transmission and Distribution systems'* New Age International Publishers, 1st Edition, 2007.

PS1110	**Programme Elective- III**	**Special Electrical Machines**	**3**

Course Content

Unit-1: Stepper Motors: Constructional features, Principle of operation, Modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

Unit-2: Switched Reluctance Motors Constructional features, Principle of operation. Torque equation, Characteristics, Control Techniques and Drive Concept.

Unit-3: Permanent Magnet Synchronous Motors and Brushless DC Motors. Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power Controllers, Torque speed characteristics, Self control, Vector control, Current control Schemes. Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessors based controller.

Unit-4:. Servomotors: Servomotor – Types – Constructional features – Principle of

Operation – Characteristics - Control –Microprocessor based applications.

Unit-5: Linear Motors: Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet –Goodness factor – DC Linear Motor (DCLM) types – Circuit equation –DCLM control-applications

Some Other Electrical Motor: Reluctance motor, hysteresis motor, shaded Pole motor, universal Motor.

Text Books

1. Miller, T.J.E., "*Brushless Permanent Magnet and Reluctance Motor Drives*", Clarendon Press, Oxford, 1989.
2. Kenjo, T, "*Stepping Motors and their Microprocessor control"*, Clarendon Press, Oxford.
3. K Venkataratam, "*Special Electrical Machines"*, University press.
4. E.G. Janardanan,*"Special Electrical machines"*, -PHI.

Reference Books:

1. Naser A and Boldea I, "*Linear Electric Motors: Theory, Design and Practical Application"*, Prentice Hall Inc., New Jersey, 1987
2. Floyd E Saner, "*Servo Motor Applications"*, Pittman USA, 1993.
3. Kenjo, T and Naganori, S, "*Permanent Magnet and brushless DC motors"*, Clarendon Press, Oxford, 1989.
4. P.S.Bimbra, "*Generalized Theory of Electrical Machines"*, Khanna publications-5th edition-1995.
5. V.V. Athani, "*Stepper motor: Fundamentals, Appications and Design"*, New Age International .

EE1111	**Programme Elective- III**	**SCADA System and Applications**	**3**

Course Content

Unit-1: SCADA and PLC: Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions. PLC: Block diagram, programming languages, Ladder diagram, Functional Block diagram, Applications, Interfacing of PLC with SCADA.

Unit-2: SCADA system components: Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server.

Unit-3: SCADA Architecture-Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA / HMI Systems.

Unit- 4: SCADA Communication-Various industrial communication technologies- wired

and wireless methods and fiber optics, open standard communication protocols.

Unit-5: Operation and Control Of Interconnected Systems- Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, state estimation, SCADA applications Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries oil gas and water. Case studies, implementation, simulation exercises.

Text Books:

1. Ronald L. Krutz, "*Securing SCADA System*", Wiley Publications.
2. Stuart A Boyer, "*SCADA supervisory control and data acquisition*", ISA, 4th RevisedEdition
3. Sunil S. Rao, "*Switchgear and Protections*", Khanna Publications.
4. Gordon Clarke, Deon Reynders: "*Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*", Newnes Publications, Oxford, UK,2004.
5. S. K. Singh, "*Computer Aided Process Control*", PHI
6. S. Gupta, JP Gupta, "*PC interface For Data Acquiring & Process Control*", 2nd Ed. Instrument Society of America.
7. John W. Web, Ronald A. Reis, "*Programmable Logic Controllers*" 5th Edition, PHI
8. Liptak, B. G. (E.d.), "*Instrument Engineers Handbook*", vol. I to III, Chilton Book Co.
9. Bhatkar, Marshal, "*Distributed Computer control & Industrial Automation*", DekkerPublication.
10. Frank D. Petruzella, "*Programmable Logic Controllers*", 3rd Edition, McGraw Hill.
11. William T. Shaw, "*Cybersecurity for SCADA systems*", PennWell Books, 2006
12. David Bailey, Edwin Wright, "*Practical SCADA for industry*", Newnes, 2003.
13. Michael Wiebe, "*A guide to utility automation: AMR, SCADA, and IT systems for electric power*", PennWell 1999.

RMC 1101	Compulsory paper	Research Methodology & IPR	2

Course Content

Unit-1: Research Problem and Scope for Solution: Meaning of research problem, Sources of research problem, Criteria Characteristics of a goodresearch problem, Errors in selecting a research problem, Scope and objectives of researchproblem. Approaches of investigation of solutions for research problem, data collection, analysis,interpretation, Necessary instrumentations.

Unit-2: Format: Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technicalwriting, how to write report, Paper Developing a Research Proposal, Format of research proposal,a presentation and assessment by a review committee.

Unit-3: Process And Development: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting andDevelopment: technological research, innovation, patenting, development. International Scenario:International cooperation on Intellectual Property. Procedure for grants of patents, patenting underPCT.

Unit-4: Patent Rights: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent informationand databases. Geographical Indications.

Unit-5: New Developments In IPR: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR ofBiological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books:

1. Stuart Melville and Wayne Goddard, "*Research methodology: an introduction for science & engineering students*"
2. Wayne Goddard and Stuart Melville, "*Research Methodology: An Introduction*"
3. Ranjit Kumar, 2nd Edition, "*Research Methodology: A Stepby Step Guide for beginners*"

Reference Books:

1. Halbert, "*Resisting Intellectual Property*", Taylor & Francis Ltd ,2007.
2. Mayall, "*Industrial Design*", McGraw Hill, 1992.
3. Niebel, "*Product Design*", McGraw Hill, 1974.
4. Asimov, "*Introduction to Design*", Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " *Intellectual Property in New Technological Age*", 2016.
6. T. Ramappa, "*Intellectual Property Rights Under WTO*", S. Chand, 2008

Detailed Syllabus

Department of Electrical Engineering

Specialization-Power System

2nd Semester

PS2101	Core- III	Power System Analysis	3

Course Content

Unit-1: Power System: Need for system planning and operational studies — Power scenario in India — Power system components — Representation — Single line diagram — per unit quantities — p.u. impedance diagram — p.u. reactance diagram —Network graph, Bus incidence matrix, Primitive parameters, Bus admittance matrix from primitive parameters — Representation of off nominal transformer — Formation of bus admittance matrix of large power network.

Unit-2: Power Flow Analysis: Bus classification — Formulation of Power Flow problem in polar coordinates — Power flow solution using Gauss Seidel method — Handling of Voltage controlled buses — Power Flow Solution by Newton Raphson method.

Unit-3: Symmetrical Fault Analysis: Assumptions in short circuit analysis — Symmetrical short circuit analysis using Thevenin?s theorem — Bus Impedance matrix building algorithm (without mutual coupling) — Symmetrical fault analysis through bus impedance matrix — Post fault bus voltages — Fault level — Current limiting reactors.

Unit-4: Unsymmetrical Fault Analysis: Symmetrical components — Sequence impedances — Sequence networks — Analysis of unsymmetrical faults at generator terminals: LG, LL and LLG — unsymmetrical fault occurring at any point in a power system — computation of post fault currents in symmetrical component and phasor domains.

Unit-5: Stability Analysis: Classification of power system stability — Rotor angle stability — Swing equation — Swing curve — Power-Angle equation — Equal area criterion — Critical clearing angle and time — Classical step-by-step solution of the swing equation — modified Euler method.

TextBooks:

1. J. J. Grainger & W. D. Stevenson, “Power System Analysis”, McGraw Hill, 2003.
2. A. R. Bergen & Vijay Vittal, “Power System Analysis”, Pearson, 2000.
3. L. P. Singh, “Advanced Power System Analysis and Dynamics”, New Age International, 2006.
4. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, “Power Generation, Operation, and Control”, Wiley, 2014.
5. G. L. Kusic, “Computer aided power system analysis”, Prentice Hall India, 1986.

6. A. J. Wood, "Power generation, operation and control", John Wiley, 1994.
7. P. M. Anderson, "Faulted power system analysis", IEEE Press,1995.

EE2102	Core- IV	Renewable Energy System	3

Course Content

Unit-1:Global and National Energy Scenario: Over view of conventional & renewable energy sources, need, environmental consequences of fossil fuel use, potential & development of renewable energy sources, types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Energy for sustainable development, renewable electricity and key elements, Global climate change.

Unit-2:Solar Energy: Solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar-Electrical Power Generation, Solar Photo Voltaic (SVP) system, Different configurations, SPV system components and their characteristics, maximum power point tracking, Stand-Alone and Grid Connected SPV systems, other Miscellaneous Applications of Solar Energy.

Unit-3:Wind Energy &Hydel Energy: Wind Energy Conversion, Potential, Site selection, Types of Wind Power Plants (WPPs), Components of WPPs, Working of WPPs, Characteristics, Betz limit Grid integration issues of WPPs.

Basic working principle of Hydel Energy, Site selection, Classification of hydel systems: Large, small, micro-measurement of head and flow .

Unit-4:Other Sources: Bio-mass Energy: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, Geothermal Energy: Methods of harnessing the energy, potential in India. Ocean Energy: OTEC, Principle's utilization, setting of OTEC plants.

Tidal power: Conventional and latest design of tidal power system

Fuel cell energy: Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

Unit-5: Integrated Energy Systems: Introduction, Integrated Smart infrastructure, Integrated Energy system Modeling, Various Integrated energy schemes, their cost benefit analysis.

Text Books

1. S. P. Sukhatme and J. K. Nayak, "*Solar Energy: Principles of Thermal Collection and Storage*", TMH, New Delhi, 3rd Edition.
2. John Twidell and Tony Weir, "*Renewable Energy Resources*", Taylor and Francis - second edition, 2013.
3. G.D. Rai, "*Non-Conventional Energy Sources*", Khanna Publishers.

4. F. Kreith& J. F. Krieder, "*Principles of Solar Engineering*," Mc.Graw Hill Book Co.
5. L.C.Freris, "*Wind Energy conversion Systems*", Prentice Hall, Inc..

Reference Books

1. Godfrey Boyle, "*Renewable Energy*", Oxford university, press, 3rd edition, 2013.
2. Ahmed and Zobaa, Ramesh C Bansal, "*Handbook of renewable technology*", World scientific, Singapore.
3. Ramesh & Kumar, "*Renewable Energy Technologies*", Narosa.
4. Chetong Singh Solanki, "*Renewable energy technologies – A practical guide for beginners*", PHI.
5. B.H. Khan, "*Non conventional energy source*", TMH-2nd edition.
6. Karlsson, Kenneth Bernard,Skytte, Klaus Morthorst, "*Integrated energy systems modeling*", PublishedinDTU International Energy Report 2015.Z1

PS2103	Programme Elective- IV	Restructured Power Systems	3

Course Content

Unit-1: Traditional Power Industry Structure, Motivations for restructuring, Fundamentals of restructured system, Restructuring models, Different industry structures and ownership/management forms for generation, transmission and distribution. Different structure model: Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.

Unit-2: Components of restructured systems, key market entities- ISO, TSO, GENCO, TRANSCO, DISCO, RETAILCO, Functions and responsibilities, Trading arrangements: Pool, bilateral & multilateral, Open Access Transmission Systems & Distribution Systems; Power system operation and control: Old vs. New.

Unit-3: Fundamentals of deregulation: Need and conditions for deregulation, Basics of public goodeconomics, Components of Deregulation, Technical, economic & regulatory issues involved in deregulation of power industry. Privatization, Competition in the electricity sector, conditions, barriers, different types, benefits and challenges. Reregulation.

Unit-4: Market development and institutional scenario: Comparative study and global experience of historical evolution, institutional development, contemporary systems, regulation, reforms, deregulation models, market trends, operation, critical issues, challenges, future directions of key electricity markets.

Unit-5: Power market development in India: Institutional structure in Indian Power sector generation, transmission and distribution utilities. SO & LDCs. PFC, REC, ERCs, traders, Power Exchanges and their roles. Availability-based tariff, Open access, Industry structure and regulatory framework, market development, RE policies, RPO, Tariff policies. Policy changes, regulatory changes, Critical issues/challenges before the Indian power sector.

Text Books

1. Loi Lei Lai, "*Power System Restructuring and Deregulation*", John Wiley & Sons Ltd, England, 2001.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, "*Restructured Electric Power Systems: Operation, Trading and Volatility*", Marcel Dekker, Inc., 2001.
3. D. S. Kirschen and G. Strbac, "*Fundamentals of power system economics*", John Wiley & Sons, 2004.
4. Geoffrey Rothwell, Tomas Gomez (Eds.), "*Electricity Economics Regulation and Deregulation*", IEEE Press Power Engineering Series, John Wiley & Sons, 2003.
5. Steven Stoft, "*Power System Economics: designing markets for electricity*", Wiley Interscience, 2002.

ReferenceBook

1. Mohan Munasinghe, "*Electric Power Economics*", Butterworth & Co. (Publishers) Ltd, 1990
2. Richard J. Gilbert, Edward P. Khan, "*International Comparisons of Electricity Regulation*",Cambridge University Press, 2002.
3. Barrie Murray, "*Electricity Market – Investment, Performance and Analysis*" John Wiley and Sons Publications, 1998.
4. Sally Hunt, "*Making Competition Work in Electricity*", 2002, John Wiley Inc.
5. LorrinPhilipson, H. Lee Willis, "*Understanding electric utilities and de-regulation*", Marcel Dekker Pub., 1998.
6. BhanuBhushan, "*ABC of ABT - A primer on Availability Tariff*" - www.cercind.org
7. Sally Hunt and Graham Shuttleworth, "*Competition and Choice in Electricity*".
8. Antonio Conejo, "*Decision Making Under Uncertainty in Electricity Markets*".

PS2104	Programme Elective- IV	Electrical Machine Modeling and Drives	3

Course Content

Unit-1: Review of Electrical Drive: Dynamics of Electrical drive, Conventions and multi-quadrant operation, Transient and steady state stability of Electrical drive, Control of Electrical drive.

Unit-2: Modeling of DC Machine: Theory of operation, Induced EMF, Equivalent circuit and Electromagnetic torque, electromechanical modeling, State-space model ling, Block diagram and Transfer functions. DC motor drives: DC motor and their performance, starting, braking, transient analysis, speed control, Ward-Leonard drives, controlled rectifier fed DC drives, Chopper controlled DC drives.

Unit-3: Dynamic Modeling of Induction Machine: Real-Time model of a two-phase induction machine, Transformation to obtain constant matrices, Three-phase to two phase transformation, Generalized model in arbitrary reference frames, Derivation of commonly

used induction motor models, Per unit model. Induction motor drives: Three-phase I.M. braking, transient operation, variable frequency control from voltage and current source.

Unit-4: Synchronous Machine: Transformation equations for rotating three phase windings, Voltage and power equation for salient and non-salient alternator, their phasor diagrams, Simplified equations of a synchronous machine with two damper coils.

Unit-5: Principle of operation of BLDCM, Trapezoid ally excited BLDCM drive with current control, Permanent Magnet synchronous motor (PMSM) drive, Stepper Motor-Variable reluctance stepper motor, Permanent Magnet stepper motor, Hybrid stepper motor, Introduction to vector control scheme and Switch Reluctance motor.

Text Books:

1. J.M.D. Murphy & F.G. Turnbull, "*Power Electronic control of AC Motors*", Pergamon Press.
2. P. Lloyed&Conard, "*Alternating Current Machines*", IEEE Press.
3. S.K.Pillai, "*A First Course in Electrical Drives*", II Edition, New Age International (P) Ltd.
4. G.K.Dubey, "*Fundamentals of Electrical Drives*", Narosa Publication (P) Ltd.
5. R.Krishnan, "*Electric Motor Drives: Modeling, Analysis & Control*", Prentice-Hall.
6. B.K. Bose, "*Modern Power Electronics & AC Drives*", Prentice- Hall.
7. V. Subrahmanyam, "*Electrical Drives Concept & Application*", Tata McGraw Hill

PS2105	Programme Elective- IV	Electric Power Distribution System	3

Course Content

Unit-1: Load Forecasting Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long-term, Power System Loading, Technological Forecasting.

Unit-2: Distribution Automation Advantages of Distribution Management System (DMS) Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction

Unit-3: Control And Communication Interconnection of Distribution, Control & Communication Systems, Remote Metering, Automatic Meter Reading and its implementation. SCADA: Introduction, Block Diagram, SCADA Applied To Distribution Automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA

Unit-4: Optimality Principles Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial, Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring

Unit-5: Energy Management Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution. Automation in Actual Practice, Urban/Rural

Distribution, Energy Management, AI techniques applied to Distribution Automation

Text Books:

1. A.S. Pabla, "*Electric Power Distribution*", Tata McGraw Hill Publishing Co. Ltd., 4th Ed. 2012
2. M.K. Khedkar, G.M. Dhole, "*A Text Book of Electrical power Distribution Automation*", University Science Press, New Delhi 2017
3. T. Gonen, "*Electric Power Distribution Engineering*", 3rd Edition CRC Press, 2014.
4. A. Short, "*Electric Power Distribution Handbook*", CRC Press, 2003.

PS2106	Programme Elective- V	Power Quality	3

Course Content

Unit-1: Introduction to Power Quality- Terms and definitions: Overloading, under voltage, over voltage. Concepts of transients, short duration variations such as interruption, long duration variation such as sustained interruption. Sags and swells-voltage; sag - voltage, swell - voltage imbalance - voltage fluctuation - power frequency variations, different standards of power quality.

Unit-2: Voltage Sags and Interruptions- Sources of sags and interruptions - estimating voltage sag performance. Thevenin's equivalent source, analysis and calculation of various faulted condition. Voltages sag due to induction motor starting. Estimation of the sag severity, mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.

Unit-3:Overvoltages- Sources of over voltages, Capacitor switching, lightning, Ferro-resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection, shielding, line arresters - protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP.

Unit-4:Harmonics- Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics, Harmonics Vs transients. Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices - inter harmonics – resonance. Harmonic distortion evaluation, devices for controlling harmonic distortion - passive and active filters design. IEEE and IEC standards.

Unit-5: Power Quality Monitoring considerations - monitoring and diagnostic techniques for various power quality problems- modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools. Different power quality monitoring tools. Recent Trends and Advances in Power Quality

Text Books

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty,

"*Electrical Power Systems Quality",* McGraw Hill, 2003.

2. C Sankaran, "*Power Quality"*, CRC press

Reference Books

1. G.T. Heydt, "*Electric Power Quality"*, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. M.H.J Bollen, "*Understanding Power Quality Problems: Voltage Sags and Interruptions"*, (New York: IEEE Press, 1999).
3. J. Arrillaga, N.R. Watson, S. Chen, "*Power System Quality Assessment"*, (New York: Wiley, 1999.

PS2107	Programme Elective- V	Digital Protection Of Power System	3

Course Content

Unit-1: Digital Relay: Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection.

Unit 2:Signal Processing: Curve fitting and smoothing. Least square method, Fourier analysis, Walsh function analysis.

Unit 3:Signal Conditioning: Basic elements of digital protection, Signal conditioning: transducers, surge protection, analog filtering and analog multiplexers.

Conversion subsystem: sampling theorem, signal aliasing. Error, sample and hold circuits,multiplexers, analog to digital conversion. Digital filtering concepts.

Unit 4:Algorithm For Relay Operation: Sinusoidal wave based algorithm, Fourier and Walsh based algorithm, least square and differential equation based algorithm

Unit-5:Digital Protection Of Power Systems: Digital protection of generators, Digital Differential Protection of Transformers, Digital protection of transmission lines (differential, travelling wave based and DFT based)

Fundamental of frequency estimation techniques

TextBooks

1. Singh R. P., "*Digital power system protection*", PHI Ltd., New Delhi.2007
2. Johns A. T. and Salman S. K., "*Digital protection of power system*", IEE power engineering series, IEE Press, London, UK. 1997
3. *Power System protection,* Vol.-4: *Digital protection and signaling*, edited by the Electricity Training Association, IEE press, London, UK.1997
4. S.R. Bhide, "*Digital Power system Protection*" PHI, 2014

EE2108	**Programme Elective- V**	**Advanced Power Electronics**	**3**

Course Content

Course Content

Review of SCR, driving circuits and protection; Modern semiconductor devices: MOSFET, GTO, IGBT, GTO, SIT, SITH, MCT, their operating characteristics

Single and Three-phase converters, effect of load and source impedances; Semi controlled converter, Dual converter, multi-pulse converters. PWM converter, power factor improvement techniques

Voltage and current commutated choppers, dc-dc converters: Buck, Boost, Buck-Boost converters, Cuk converter.

Basic concept of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques, 3-Φ Inverter configurations, Current-Source Inverter. Multi-level inverters

Applications: Drive, power supplies, HVDC Transmission and Static VAR Compensators.

Text Books:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "*Power Electronics – Converters, Applications and Design",* John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "*Power Electronics Circuits, Devices and Applications*", Pearson Education, Fourth Edition. 2014
3. P.S.Bimbra, "*Power Electronics*", Khanna Publishers, Eleventh Edition, 2003
4. N.G. Hingorani, L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001

Reference Books:

1. P.C.Sen, "*Modern Power Electronics*", S. Chand and Co. Ltd., New Delhi, 2000.
2. Vijay K. Sood, "*HVDC and FACTS Controllers Applications of Static Converters in Power Systems*", Kluwer Academic Publishers, Boston, 2004.
3. L. Umanand, "*Power Electronics Essentials and Applications*", Wiley India Ltd., 2009
4. Muhammad H. Rashid, "*Power Electronics Handbook*", Elsevier, 3rd ed., 2011.
5. Bin Wu, "*High Power Converters and AC Drives*", John Willey & sons, Inc., 2006.

EE2109	**Open Elective- I**	**Model Order Reduction**	**3**

Course Content

Unit-1: Introduction to Large Scale Systems and ModelReduction,Principal Component based model reduction methods. Model reduction through aggregation.

Unit-2: Frequency domain-based model reduction techniques - Pade, Routh and Continued fraction approximations.

Unit-3: ClassicalModelReductionMethods–Modalreduction.Padeapproximation andmomentmatching,RouthApproximants. Model reduction using step and impulse error minimization techniques. Balanced truncation and Hankel norm minimization.

Unit-4: Introduction to uncertain or interval system. Order Reduction of interval system. Robust Control Techniques. Kharitonov theorem.

Unit-5: State Feedback design techniques for parametric uncertain systems.

Text Books:

1. M. G. Singh, M.S. Mamoud, "*Large Scale Systems Modelling*", International Series on Systems and Control, Pergamemon Press, 1981
2. M.Jamshidi, "*Large Scale Systems: Modelling and Control*", North Holland, New York, 1983
3. Kemin Zhou, John C. Doyle, Keith Glover, "*Robust and Optimal Control*", Prentice Hall, Upper Saddle River, New Jerset, 1996
4. M. Gopal, "*Modern Control Systems Theory*", 2nd Edition, John Wiley, 1993.
5. S. P. Bhattacharyya, H. Chappelat, L. H. Keel, "*Robust Control - The Parametric Approach*", Prentice Hall, NJ, 1995.

EE2110	Open Elective- I	Industrial Safety	3

Course Content

Unit-1: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-2: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-3: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear

reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working andapplications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-4: Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-5: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Books:

1. Higgins & Morrow, "*Maintenance Engineering Handbook*", Da Information Services.
2. H. P. Garg, "*Maintenance Engineering*", S. Chand and Company.
3. Audels, "*Pump-hydraulic Compressors*", Mcgraw Hill Publication.
4. Winterkorn, "*Foundation Engineering Handbook*", Chapman & Hall London.

EE2111	**Open Elective- I**	**Cost Management of Engineering Projects**	**3**

Course Content

Unit-1: Introduction and Overview of the Strategic Cost Management Process, Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-2: Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and

contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit-3: Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision- making problems. Standard Costing and Variance Analysis.

Unit-4: Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based

Unit-5: Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Text Books:

1. *Cost Accounting A Managerial Emphasis*, Prentice Hall of India, New Delhi.
2. Charles T. Horngren and George Foster, *Advanced Management Accounting.*
3. Robert S Kaplan Anthony A. Alkinson, *Management & Cost Accounting.*
4. Ashish K. Bhattacharya, *Principles & Practices of Cost Accounting* A. H. Wheeler publisher.
5. N.D. Vohra, *Quantitative Techniques in Management*, Tata McGraw Hill Book Co. Ltd.