BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ORISSA

ELECTRICAL ENGINEERING (EE)

7th Semester				8th Semester			
Code	**Subjects**	**L-T-P**	**Credit**	**Code**	**Subjects**	**L-T-P**	**Credit**
	Theory				**Theory**		
HSSM3401	Entrepreneurship Development	3-0-0	3				
				PCEE4402	Power System Protection	3-0-0	3
PCEL4401	Power System Operation and Contr	3-0-0	3				
	Professional Elective-III (Any one)	3-0-0	3		***Professional Elective-V (Any one)***	3-0-0	3
PCEC4401	VLSI Design			PEEI5403	Industrial Instrumentation		
PEEE5409	Flexible AC Transmission System			PEEL5403	Electrical Power Quality		
PEEL5402	Special Electromechanical Devices			PEEI5402	Optimal Control		
PEEE5406	Soft Computing			PEEE5410	Advanced Power Electronics		
PEEE5408	High Voltage DC Transmission						
	Professional Elective-IV (Any one	3-0-0	3		***Free Elective-IV (Any one)***	3-0-0	3
PEEE5407	Industrial Automation and Control			PEEC5418	Satelite Communication Systems		
PEEL5401	Adaptive Signal Processing			PECS5406	Digital Image Processing		
PEEC5414	Advanced Control Systems.			PEEC5405	Embedded Systems		
				PEEI5406	Adaptive Control		
	Free Elective-III (Any one)	3-0-0	3		***Free Elective-V (Any one)***	3-0-0	3
FEEE6402	High Voltage Engg.			FEEE6401	Power Station Engg and Economy		
PEME5407	Mechatronics			HSSM3403	Marketing Management		
PEEC5416	Biomedical Instrumentation			PCME4404	Production & Operations Management		
	Theory Credits		**15**		**Theory Credits**		**12**
	Practical/Sessional				**Practical/Sessional**		
PCEE7401	Power System Lab.	0-0-3	2	PCEL7405	Major Project	0-0-6	7
PCEL7402	Minor Project	0-0-3	3	PCEL7404	Comprehensive Viva-Voce	0-0-3	2
PCEL7403	Seminar / Training Seminar	0-0-3	3				
	Practical/Sessional Credits		**08**		**Practical/Sessional Credits**		**09**
	TOTAL SEMESTER CREDITS		**23**		**TOTAL SEMESTER CREDITS**		**21**
	TOTAL CUMULATIVE CREDITS		**183**		**TOTAL CUMULATIVE CREDITS**		**204**

ENTREPRENEURSHIP DEVELOPMENT (3-0-0)

Module I: Understanding Entrepreneurship

Concept of Entrepreneurship, Motivation for Economic Development and Entrepreneurial Achievement, Enterprise and Society

Why and how to start Business – Entrepreneurial traits and skills, Mind Vrs Money in Commencing New Ventures, Entrepreneurial success and failures, Environmental dynamics and change.

Entrepreneurial Process

Step by step approach to entrepreneurial start up

Decision for Entrepreneurial start up.

Module II: Setting up of a small Business Enterprise.

Identifying the Business opportunity - Business opportunities in various sectors, formalities for setting up small enterprises in manufacturing and services, Environmental pollution and allied regulatory and non-regulatory clearances for new venture promotion in SME sector.

Writing a Business plan, components of a B-Plan, determining Bankability of the project.

Module III: Institutional Support for SME.

Central / State level Institution promoting SME.

Financial Management in small business.

Marketing Management, problems & strategies

Problems of HRM – Relevant Labour – laws.

Sickness in Small Enterprises.

Causes and symptoms of sickness – cures of sickness.

Govt. policies on revival of sickness and remedial measures.

Reference Books:

1. Entrepreneurship Development, Small Business Enterprises, Chavantimath, Pearson.
2. Entrepreneurial Development, S.S. Khanka, S Chand
3. Entrepreneurship, Barringer BR, Ireland R.D., Pearson
4. Entrepreneurship, David H Holt, PHI
5. Entrepreneurship, Kurilko, D.F. and Attodgets RM, Cengage
6. The Dynamics of Entrepreneurial Development & Management, Vasant Desai, HPH.
7. Entrepreneurship, Roy, Oxford
8. Entrepreneurship, Hisrich, Peters, Shepherd, TMH

POWER SYSTEM OPERATION & CONTROL (3-0-0)

Module – I **(14 Hours)**

Fundamentals of Power System (Book No.1, Ch. 1)

Introduction, Single Subscript Notation, Double Subscript Notation, Power in Single Phase AC Circuit, Complex Power, The Power Triangle, Direction of Power Flow, Voltage and Current in Balanced Three Phase Circuits, Power in Balanced Three Phase Circuits, Per- Unit Quantities, Changing the Base in Per- Unit Quantities, Node Equations, The Single Line or One Line Diagram, Impedance and Reactance Diagrams.

Book-1:Ch. 1.1, Ch. 1.2, Ch. 1.3, Ch. 1.4, Ch. 1.5, Ch. 1.6, Ch. 1.7, Ch. 1.8, Ch. 1.9, Ch. 1.10, Ch. 1.11, Ch. 1.12, Ch. 1.13, Ch. 1.14.

The Admittance Models & Network Calculations (Book – 1) Ch. 7 (7.1 To 7.5)

Branch and Node Admittances, Mutually Coupled Branches in Y_{bus}, An Equivalent Admittance Network, Modification of Y_{bus}, The Network Incidence Matrix and Y_{bus}.

Book-1:Ch. 7.1, Ch. 7.2, Ch. 7.3, Ch. 7.4, Ch. 7.5.

Power Flow Solutions (Book – 1, Ch. 9)

The Power-Flow Problem, The Gauss-Seidal Method, The Newton-Raphson Method, The Newton-Raphson Method, Power-Flow Studies in System Design and Operation, Regulating Transformers, The Decoupled Method.

Book-1:Ch. 9.1, Ch. 9.2, Ch. 9.3, Ch. 9.4, Ch. 9.5, Ch. 9.6, Ch. 9.7.

Module – II **(14 Hours)**

Economic Operation of Power System (Book – 1, Ch.13)

Distribution of Load between Units within a Plant, Distribution of Load between Plants, The Transmission-Loss Equation, An interpretation of Transformation **C**, Classical Economic Dispatch with Losses, Automatic Generation Control, Unit Commitment, Solving the Unit Commitment Problems.

Book-1: Ch. 13.1, Ch. 13.2, Ch. 13.3, Ch. 13.4, Ch. 13.5, Ch. 13.6, Ch. 13.7, Ch. 13.8.

Load Frequency Control, Control Area Concept (Book – 2, Ch.9)

Automatic Load-Frequency Control of Single Area Systems: Speed-Governing System, Hydraulic Valve Actuator, Turbine-Generator Response, Static Performance of Speed Governor, Closing the ALFC Loop, Concept of Control Area, Static Response of Primary ALFC Loop, Dynamic Response of ALFC Loop, Physical Interpretation of Results, The Secondary ("Reset") ALFC Loop, Economic Dispatch Control.

Book – 2: Ch. 9.3.1, Ch. 9.3.2, Ch. 9.3.3,Ch. 9.3.1, Ch. 9.3.4, Ch. 9.3.5, Ch. 9.3.6, Ch. 9.3.7, Ch. 9.3.8, Ch. 9.3.9, Ch. 9.3.10, Ch. 9.3.11.

Module – III **(12 Hours)**

Two Area System (Book – 2, Ch.9)

ALFC of Multi-Control-Area Systems (Pool Operation): The Two Area Systems, Modeling the Tie-Line, Block Diagram Representation of Two Area System, Mechanical Analog of Two Area System, Dynamic Response of Two Area System, Static System Response, Tie-Line Bias Control of Multi-area Systems.

Book – 2: Ch. 9.4.1, Ch. 9.4.2, Ch. 9.4.3 Ch. 9.4.1, Ch. 9.4.4, Ch. 9.4.5, Ch. 9.4.6, Ch. 9.4.7, Ch. 9.4.8, Ch. 9.4.9, Ch. 9.4.10.

Power System Stability (Book-1, Ch.16)

The Stability Problem, Rotor Dynamics and the Swing Equation, Further Considerations of the Swing Equations, The Power-Angle Equation, Synchronizing Power Coefficients, Equal- Area Criterion for Stability, Further Applications of the Equal-Area Criterion, Multi-machine Stability Studies: Classical Representation, Step-By-Step Solution of the Swing Curve, Computer Programs for Transient Stability Studies, Factors Affecting Transient Stability.

Book-1:Ch. 16.1, Ch. 16.2, Ch. 16.3, Ch. 16.4, Ch. 16.5, Ch. 16.6, Ch. 16.7, Ch. 16.8, Ch. 16.9, Ch. 16.10, Ch. 16.11.

Text Books:

1) Power System Analysis- By John. J. Grainger & W. D. Stevenson, Jr., TMH, 2003 Edition, Fifteenth Reprint.
2) An Introduction to Electric Energy System Theory- By O. I. Elgerd, TMH, Second Edition.

Reference:

1) Power System Analysis- By Hadi Saadat, TMH, 2002 Edition, Eighth Reprint.
2) Power System Analysis Operation and Control- By A. Chakrabarti and S. Haldar, Third Edition, PHI Publications, 6th Reprint, 2010.

VLSI DESIGN

Module – I **08 Hours**

Introduction: Historical Perspective, VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity and Locality, VLSI Design Styles, Computer-Aided Design Technology.

Fabrication of MOSFETs: Introduction, Fabrication Processes Flow – Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams, Full-Customs Mask Layout Design.

MOS Transistor: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitance.

(Chapter 1 to 3 of Text Book 1 and for Stick Diagram Text Book 2)

Module – II **14 Hours**

MOS Inverters – Static Characteristics: Introduction, Resistive-Load Inverters, Inverters with n-Type MOSFET Load, CMOS Inverter.

MOS Inverters – Switching Characteristics and Interconnect Effects: Introduction, Delay-Time Definitions, Calculation of Delay-Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitics, Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters.

Combinational MOS Logic Circuits: Introduction, MOS Logic Circuits with Depletion nMOS Loads, CMOS Logic Circuits, Complex Logic Circuits, CMOS Transmission Gates (Pass Gates).

(Chapter 5 to 7 of Text Book 1)

Module – III **18 Hours**

Sequential MOS Logic Circuits: Introduction, Behaviour of Bistable Elements, SR Latch Circuits, Clocked Latch and Flip-Flop Circuits, CMOS D-Latch and Edge-Triggered Flip-Flop.

Dynamic Logic Circuits: Introduction, Basic Principles of Pass Transistor Circuits, Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic CMOS Circuit Techniques, High Performance Dynamic CMOS Circuits.

Semiconductor Memories: Introduction, Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM), Non-volatile Memory, Flash Memory.

Design for Testability: Introduction, Fault Types and Models, Ad Hoc Testable Design Techniques, Scan-Based Techniques, Built-In Self-Test (BIST) Techniques, Current Monitoring I_{DDQ} Test.

Text Books:

1. Sung-Mo Kang and Yusuf Leblebici, *CMOS Digital Integrated Circuits: Analysis and Design*, 3rd Edn., Tata McGraw-Hill Publishing Company Limited, 2003.
2. K. Eshraghian and N.H.E. Weste, *Principles of CMOS VLSI Design – a Systems Perspective*, 2nd Edn., Addison Wesley, 1993.

Reference Books:

1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, *Digital Integrated Circuits – A Design Perspective*, 2nd Edn., Pearson Education, 2003.
2. Wayne Wolf, *Modern VLSI Design System – on – Chip Design*, 3rd Edn., Pearson Education, 2003.
3. Debaprasad Das, *VLSI Design*, Oxford University Press, New Delhi, 2010.
4. John P. Uyemura, *CMOS Logic Circuit Design*, Springer (Kluwer Academic Publishers), 2001.
5. Ken Martin, *Digital Integrated Circuit Design*, Oxford University Press, 2000.

FLEXIBLE AC TRANSMISSION SYSTEM (3-0-0)

MODULE-I **(12 Lectures)**

FACTS concept and General System Considerations: Transmission Interconnections, Flow of Power in an AC System, What limits the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Basic Types of FACTS Controllers, Basic Description and Definitions of FACTS Controllers.

Static Shunt Compensation: Objectives of Shunt Compensation, Methods of Controllable VAR Generation, Static VAR Compensators, SVC and STATCOM.

(Chapter-1: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 and 1.7)

(Chapter-5: 5.1, 5.2 and 5.3)

MODULE-II **(12 Lectures)**

Static Series Compensators: Objective of Series Compensation (GCSC, TSSC, TCSC), Variable Impedance Type Series Compensators, Switching Converter Type Series Compensators (SSSC)

Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs).

(Chapter-6: 6.1, 6.2 and 6.3)

(Chapter-7: 7.1 and 7.2)

MODULE-III **(10 Lectures)**

Combined Compensators: Introduction, Unified Power Flow Controller (UPFC), The Interline Power Flow Controller (IPFC), Generalized and Multifunctional FACTS Controllers.

(Chapter-8: 8.1, 8.2, 8.3 and 8.4)

TEXT BOOK:

"***Understanding FACTS: Concepts & Technology of Flexible AC Transmission Systems***" By N.G.Hingorani & L.Gyugyi, IEEE Press, Standard Publishers Distributors, Delhi.

Reference Book:

1) Facts Controllers in Power Transmission & Distribution by K.R.Padiyan, New Age Intermational.
2) Modelling & Simulation in Power Networks, Enrique Acha, Clandio Esquival & H.A.Perez,CA Camcho, John Wiley & Sons.

SPECIAL ELECTROMECHANICAL DEVICES (3-0-0)

Module – I **[13 HOURS]**

Introduction to Special Electrical Motors: Position Control and Stepper Motors, Switched Reluctance Motors, Brushless DC Motors, Linear Motors.

Stepper Motors: Introduction, Synchronous Inductor (or Hybrid) Stepping Motor, Essential Conditions for Satisfactory Operation of a Two Phase Hybrid Step Motor, Very Slow Speed Synchronous Motor for Servo Control, Different Configuration for Switching the Phase Windings, Control Circuits for Stepping Motors, An Open Loop Controller for a 2-Phase Stepping Motor, Variable Reluctance (VR) Stepping Motors, Open Loop Control of a 3-Phase VR Step Motor, Closed-Loop Control of a Step Motor, Characteristics of a Step Motor in Open Loop Drive, Comparison between Open Loop Position Control with Step Motor and a Position Control Servo using a Conventional (DC or AC) Servo Motor, Suitability and Areas of Application of Stepping Motors, 5-Phase Hybrid Stepping Motor, Single Phase Stepping Motor: The Construction, Operating Principle.

(Ch 0.1, 0.2, 0.3, 0.4, Ch 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14, 1.15(1.15.1, 1.15.2))

Module – II **[12 HOURS]**

Switched Reluctance Motor (SRM): Introduction, Improvements in Design of Conventional Reluctance Motors, Some Distinctive Differences between Switched Reluctance (SR) and Conventional Reluctance Motors, Principle of Operation of SRM, Power Converter of SR Motor, A Numerical Example, Rotor Sensing Mechanism and Logic Controller, Derivation of Torque Expression, Prediction of Torque – Speed Characteristics.

Permanent Magnet Materials and Motors: Introduction, Stator Frames (Pole and Yoke Part) of Conventional Permanent Magnet DC (PMDC) Motors, Development of Electronically Commutated DC Motor from Conventional DC Motor.

(Ch 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 3.8, 3.9, 3.12, Ch 4.1, 4.2, 4.3)

Module – III **[11 HOURS]**

Brushless DC Motor (BLDM): Types of Construction, Principle of Operation of BLDM, Sensing and Switching Logic Scheme, Drive and Power Circuits, Theory of BLDM as a Variable Speed Synchronous Motor (assuming Sinusoidal Flux Distribution), Methods of Reducing Torque Pulsations.

Linear Induction Motor (LIM): Development of a Double Sided LIM (DSLIM) from Rotary Type Induction Motor (IM), A Schematic of LIM Drive for Electric Traction, Development of one Sided LIM with Back Iron, Field Analysis of a DSLIM (Fundamental assumptions).

(Ch 5.1, 5.2, 5.3, 5.4, 5.9, 5.10, Ch 6.1, 6.2, 6.3, 6.4)

Text Book:

1)K. Venkataratnam: Special Electrical Machines, Universities Press (India) Private Limited Publication, Hyderabad, 2008.

SOFT COMPUTING (3-0-0)

MODULE-I **(12 Lectures)**

Introduction: Soft Computing Constituents and Conventional Artificial Intelligence, Neuro-Fuzzy and Soft Computing Characteristics.

Fuzzy Sets: Introduction, Basic Definitions and Terminology, Set Theoretic Operations, MF Formulation and Parameterization.

Fuzzy Rules & Fuzzy Reasoning: Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning.

Fuzzy Inference Systems: Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Other Considerations.

(BOOK-1:- Chap-1: 1.1 to 1.3, Chap-2: 2.1 to 2.4, Chap-3: 3.2 to 3.4 & Chap-4: 4.2 to 4.5)

MODULE-II **(14 Lectures)**

Neural Networks: Neuron Abstraction, Neuron Signal Functions, Mathematical Preliminaries, Neural Networks Defined, Architectures: Feed forward and Feedback, Salient Properties and Application Domains of Neural Networks, Multi-layered Network Architectures, Back-propagation Learning Algorithm, Practical Considerations in Implementing the BP Algorithm, Structure Growing Algorithms, Universal Function Approximation and Neural Networks, Applications of Feed Forward Neural Networks, Reinforcement Learning, Radial Basis Function Networks, Regularization Theory Route to RBFNs, Generalized Radial Basis Function Network, Learning in RBFNs, Associative Learning, Hopfield Network, Content Addressable Memory, Bidirectional Associative Memory, Self Organizing Feature Maps, Applications of the Self Organizing Map.

(BOOK-2:-Chap-3: 3.1 to 3.6, Chap-6: 6.1 to 6.2, 6.5 to 6.6 & 6.8 to 6.10, Chap-8: 8.4 to 8.7,

Chap-10: 10.2 & 10.5 to 10.6 & 10.16 and Chap-12: 12.8 to 12.9)

MODULE-III **(08 Lectures)**

Regression & Optimization: System Identification: an Introduction, Least Squares Estimator, Geometric Interpretation of LSE, Recursive Least Squares Estimator.

Derivative-Free Optimization: Genetic Algorithms, Simulated Annealing, random Search, Downhill Simplex Search.

Adaptive Neuro-Fuzzy Inference Systems (ANFIS): ANFIS Architecture, Hybrid Learning Algorithm.

(BOOK-1:- Chap-5: 5.1, 5.3 to 5.5, Chap-7: 7.2 to 7.5 and Chap-12: 12.2 to 12.3)

TEXT BOOK:

1. "***Neuro-Fuzzy and Soft Computing***" By J.-S.R.Jang, C.-T.Sun & E. Mizutani, PHI
2. "***Neural Networks: A Classroom Approach***" By Satish Kumar, TMH Education

Reference Book:

1. "***Neural Networks Fuzzy Logic & Genetic Algorithms; Synthesis & Applications,*** *S.Rajasekaran & G.A. VijayaLaxmi Pai, Prentice Hall, India, May'2006- LakshmiPai*

2.Principle of Soft Computing, S.N. Sivanandan & S.N. Deepa, Wiley India Edition,2010.

HIGH VOLTAGE DC TRANSMISSION (3-0-0)

MODULE-I **(12 Lectures)**

HVDC Transmission: General Classes of Power Quality Problems, Transients, Long Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage Fluctuations, Power Frequency Variations, Power Quality Terms.

HVDC Converters: General Classes of Power Quality Problems, Transients, Long Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage Fluctuations, Power Frequency Variations, Power Quality Terms.

6-Pulse Converter Operation and Analysis: Sources of Sags and Interruptions, Estimating Voltage Sag Performance, Fundamental Principles of Protection, Solutions at the End-User Level, Evaluating the Economics of Different Ride-Through Alternatives, Motor Starting Sags, Utility System Fault-Clearing Issues.

(Chapter-1: 1.3 to 1.6 & 1.9 to 1.10, Chapter-2: 2.5 to 2.8 and Chapter-3: 3.2 to 3.6 & 3.8 to 3.11)

MODULE-II **(14 Lectures)**

Control of HVDC Converter and Systems: Mechanism of AC Power Transmission, Principle of Control, Necessity of Control in case of a DC link, Rectifier Control, Compounding of Rectifiers, Power Reversal in a DC Link, Voltage Dependent Current Order Limit (VDCOL)-Characteristics of the Converter, System Control Hierarchy and Basic Philosophy, Inverter Extinction Angle Control (EAG), Pulse Phase Control, Starting and Stopping of a DC Link, Constant Power Control, Control Systems for HVDC Converters, Inverter Operation Problems, Control of VSC Converters.

Harmonics in HVDC Systems: Importance of Harmonic Study, Generation of Harmonics by Converters, Characteristic Harmonics on the DC Side, Characteristic Current Harmonics, Characteristic variations of Harmonic Currents with Variation of α & μ, Effect of Control modes on Harmonics, Non-Characteristic Harmonics, Harmonics in VSC Converters.

(Chapter-4: 4.2 to 4.16 and Chapter-5: 5.2 to 5.9)

MODULE-III **(10 Lectures)**

Harmonic Suppression in HVDC System-Filters: Harmonic Model & Equivalent Circuit, Use of Filters, Filter Configurations, Design of a Band-Pass Filter, Design of High-Pass Filters, Protection of Filters, DC Filters.

Faults and Protection Schemes in HVDC Systems: Nature and Types of Faults, Faults on AC Side of Converter Stations, Converter Faults, Faults on DC Side of the System, Protection against Over Currents/ Over Voltages, Protection of Filter Units.

Multi-terminal HVDC Systems : Types of Multi-terminal (MTDC) Systems, Parallel Operation Aspects of MTDC, Paralleling (Disconnecting) of Units or Converter, Control of Power in MTDC, VSC-Multi-level DC Systems.

(Chapter-6: 6.2 to 6.5 & 6.7 to 6.8, 6.10, Chapter-8: 8.2 to 8.7 and Chapter-10: 10.2 to 10.6)

TEXT BOOK:

1. "***HVDC Transmission***" By S. Kamakshaiah & V. Kamaraju, TMH Education Private Ltd., 2011, New Delhi.

Reference Book:

1. HVDC Power Transmissions Systems: Technology & Systems Interaction, K.R.Padiyar, New Age Publication, 2005

INDUSTRIAL AUTOMATION AND CONTROL

(**Prerequisite: Control System Engineering – I**)

Module I: **(12 Hours)**

Process Control: Introduction: Process Definition, Feedback Control, PID Control, Multivariable Control. (Chapter 1 of Text Book 1)

PID Controller Tuning: Introduction, Zeigler-Nichols Tuning Method (Based on Ultimate Gain and Period, and Process Reaction Curve), Digital PID Controllers. (Chapter 13 of Text Book 2)

Module II: **(15 Hours)**

Special Control Structures: Cascade Control, Feedfroward Control, Feedfroward-Feedback Control Configuration, Ratio Control, Selective Control, Adaptive Control, Adaptive Control Configuration. (Chapter 10 and 11 of Text book 3)

Actuators: Introduction, Pneumatic Actuation, Hydraulic Actuation, Electric Actuation, Motor Actuators and Control Valves. (Chapter 8 of Text Book 1)

Module III: **(10 Hours)**

Industrial Automation: Programmable Logic Controllers: Introduction, Principles of operation, Architecture, Programming (Programming Languages, Ladder Diagram, Boolean Mnemonics) (Chapter 5 of Text Book 1)

Distributed Control: Distributed vs. Centralized, Advantages, Functional Requirements, System Architecture, Distributed Control Systems (DCS), Communication options in DCS. (Chapter 6 of Text Book 1)

Real-time Programming: Multi-tasking, Task Management, Inter-task Communication, Real-time Operating System. (Chapter 9 of Text Book 1)

Text Books:

1. Krishna Kant, “Computer-Based Industrial Control”, PHI, 2009.
2. M. Gopal, “Digital Control and State Variable Methods” Tata McGraw Hill, 2003.
3. Surekha Bhanot, Process Control: Principles and Applications, Oxford university Press, 2010

Reference Books:

1. Smith Carlos and Corripio, “Principles and Practice of Automatic Process Control”, John Wiley & Sons, 2006.
2. Jon Stenerson, “Industrial Automation and Process Control”, Prentice Hall, 2003.
3. C. Johnson, “Process Control Instrumentation Technology”, PHI, New Delhi
4. D.R. Coughnowr, “Process System analysis and Control”, McGraw Hill.

ADAPTIVE SIGNAL PROCESSING

Module – I(10 Hours)

Introduction: Adaptive Systems – Definition and characteristics, General properties, Open and Closed Loop Adaptations, Applications

The Adaptive Linear Combiner: Performance function, Gradient and Mean Square Error, Examples.

Module – II(14 Hours)

Theory of Adaptation with Stationary Signals: Properties of the Quadratic Performance Surface, Significance of eigen values, eigen vectors, coorelation matrix.

Searching the Proformance Surface: A simple gradient search algorithm, Stability and Rate of convergence, the learning curve

Gradient Estimation and its effects on Adoption: The performance penalty, Variance of the gradient estimate, Misadjustment.

Module – III(16 Hours)

Adaptive Algorithms and Structures: The LMS Algorithm, Convergence, learning Curve, Performanece analysis, Filtered X LMS algorithm,

Applications: Adaptive Modeling and System Identification using adaptive filter, Inverse Adaptive Modeling, Deconvolution, and equalization using adaptive filter, Adaptive Control Systems using Filtered X LMS Algorithm, Adaptive Noise Cancellation using Adaptive filter

Text Books :

1. Bernard Widrow and Samuel D. Stearns, *Adaptive Signal Processing*, Pearson Education, 2nd impression 2009.

Reference Book:

1. Simon Haykin, *Adaptive Filter Theory*, 4th Edn., Pearson Education.

ADVANCED CONTROL SYSTEMS

Module-I ***: (15 Hours) Discrete - Time Control Systems*** :

Introduction: Discrete Time Control Systems and Continuous Time Control Systems, Sampling Process.

Digital Control Systems: Sample and Hold, Analog to digital conversion, Digital to analog conversion.

The Z-transform: Discrete-Time Signals, **The Z-transform, Z-transform of Elementary functions, Important properties and Theorms of the Z-transform. The inverse Z-transform, Z-Transform method for solving Difference Equations.**

Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Reconstruction of Original signals from sampled signals: Sampling theorm, folding, aliasing. **Pulse Transfer function:** Starred Laplace Transform of the signal involving Both ordinary and starred Laplace Transforms; General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems. **Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane:** Stability analysis by use of the Bilinear Transformation and Routh stability critgion, Jury stability Test. **Book No. 1:** 1.1; 1.2; 1.4; 2.1; 2.2; 2.3; 2.4; 2.5; 2.6; 3.2; 3.4; 3.5; 4.2; 4.3.

Module -II : ***(15 Hours) State Variable Analysis & Design:***

Introduction: **Concepts of State, State Variables and State Model (of continuous time systems)**: State Model of Linear Systems, State Model for Single-Input-Single-Output Linear Systems, Linearization of the State Equation. **State Models for Linear Continuous – Time Systems**: State-Space Representation Using Physical Variables, State – space Representation Using Phase Variables, Phase variable formulations for transfer function with poles and zeros, State – space Representation using Canonical Variables, Derivation of Transfer Function for State Model. **Diagonalization**: Eigenvalues and Eigenvectors, Generalized Eigenvectors. **Solution of State Equations**: Properties of the State Transition Matrix, Computation of State Transition Matrix, Computation by Techniques Based on the Cayley-Hamilton Theorem, Sylvester's Expansion theorm. **Concepts of Controllability and Observability**: Controllability, Observability, Effect of Pole-zero Cancellation in Transfer Function. **Pole Placement by State Feedback**, **Observer Systems**. **State Variables and Linear Discrete – Time Systems:** State Models from Linear Difference Equations/z-transfer Functions, Solution of State Equations (Discrete Case), An Efficient Method of Discretization and Solution, Linear Transformation of State Vector (Discrete-Time Case), Derivation of z-Transfer Function from Discrete-Time State Model. **Book No. 2:** 12.1 to 12.9.

Module -III ***: (12 Hours) Nonlinear Systems :***

Introduction : Behaviour of Non linear Systems, Investigation of nonlinear systems.

Common Physical Non Linearities: Saturation, Friction, Backlash, Relay, Multivariable Nonlinearity.

The Phase Plane Method: Basic Concepts, Singular Points: Nodal Point, Saddle Point, Focus Point, Centre or Vortex Point, **Stability of Non Linear Systems:** Limit Cycles, **Construction of Phase Trajectories:** Construction by Analytical Method, Construction by Graphical Methods. **The Describing Function Method: Basic Concepts: Derivation of Describing Functions:** Dead-zone and Saturation, Relay with Dead-zone and Hysteresis, Backlash. **Stability Analysis by Describing Function Method:** Relay with Dead Zone, Relay with Hysteresis, Stability Analysis by Gain-phase Plots. **Jump Resonance. Liapunov's Stability Analysis: Introduction, Liapunov's Stability Critrion:** Basic Stability Theores, Liapunov Functions, Instability. **Direct Method of Liapunov & the Linear System:** Methods of constructing Liapunov functions for Non linear Systems.

Book No. 2: 13.1 to 13.4; 15.1 to 15.10.

Text :

1. Discrete-Time Control System, by K.Ogata, 2nd edition (2009), PHI.
2. Control Systems Engineering, by I.J. Nagrath and M.Gopal., 5th Edition (2007 / 2009), New Age International (P) Ltd. Publishers.

Reference :

1. Design of Feedback Control Systems by Stefani, Shahian, Savant, Hostetter, Fourth Edition (2009), Oxford University Press.
2. Modern Control Systems by K.Ogata, 5th Edition (2010), PHI.
3. Modern Control Systems by Richard C. Dorf. And Robert, H.Bishop, 11th Edition (2008), Pearson Education Inc. Publication.
4. Control Systems (Principles & Design) by M.Gopal, 3rd Edition (2008), Tata Mc.Graw Hill Publishing Company Ltd.
5. Control Systems Engineering by Norman S.Nise, 4th Edition (2008), Wiley India (P) Ltd.

HIGH VOLTAGE ENGINEERING (3-0-0)

MODULE-I **(10 Lectures)**

Conduction and Breakdown in Gases: Gases as Insulating Media, Collision Processes, Ionization Processes, Townsend's Current Growth Equation, Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-uniform Fields and Corona Discharges, Post-Breakdown Phenomena and Applications, Practical Considerations in using Gases and Gas Mixtures for Insulating Purposes Vacuum Insulation.
(Chapter-2: 2.1 to 2.4 and 2.6 to 2.15)

MODULE-II **(12 Lectures)**

Conduction and Breakdown in Liquid Dielectrics: Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids.

Breakdown in Solid Dielectrics: Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown, Breakdown of Solid Dielectrics in Practice, Breakdown in Composite Dielectrics, Solid Dielectrics used in Practice.

Generation of High Voltages and Currents: Generation of High Direct Current Voltages, Generation of High Alternating Voltages, Generation of Impulse Voltages, Generation of Impulse Currents.
(Chapter-3: 3.1 to 3.4, Chapter-4: 4.2 to 4.7 and Chapter-6: 6.1 to 6.4)

MODULE-III **(12 Lectures)**

Measurement of High Voltages and Currents: Measurement of High Direct Current Voltages, Measurement of High AC and Impulse Voltages, Measurement of High Currents-Direct, Alternating and Impulse.

Non-Destructive Testing of Materials & Electrical Apparatus: Measurement of Direct Current Resistivity, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.

High Voltage Testing of Electrical Apparatus: Testing of Insulators, Bushings, Isolators, Circuit Breakers, Cables, Transformers and Surge Arresters.
(Chapter-7: 7.1 to 7.3, Chapter-9: 9.2 to 9.4 and Chapter-10: 10.1 to 10.5)

TEXT BOOK: "***High Voltage Engineering***" By M.S.Naidu & V.Kamaraju, 4th Edition, TMH Publishing Company Ltd., New Delhi IEEE Press, Standard Publishers Distributors, New Delhi.

MECHATRONICS

Module – I:-

Sensors and Transduceers:- Sensors and transducers, Performance terminology, Displacement, position and proximitry, Velocity and motion, Force, Fluid pressure, Liquid flow, Liquid level, Temperature, Light sensors, Selection of sensors, Inputting data by switches.

Book – 1: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12.

Signal conditioning:- Signal conditioning, The operational amplifier, Protection, Filtering, Pulse modulation.

Book – 1: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6.

Digital Signals:- Digital signals, Analogue and digital signals, digital-to-analogue and analogue-to-digital converters, Multiplexers, Data acquisition, Digital signal processing.

Book – 1: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6.

Pneumatic and Hydraulic Actuation Systems:- Actuation systems, Pneumatic and hydraulic systems, Directional control valves, Pressure control valves, Cylinders, Servo and proportional control valves, process control valves, Rotary actuators.

Book – 1: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8.

Module – II:-

Mechanical Actuation Systems:- Mechanical systems, Types of motion, Kinematic chains, Cams, GTears, Belt and chain drives, bearings, Mechanical aspects of motor selection.

Book – 1: 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9.

Electrical Actuation Systems:- Electrical systems, Mechanical switches, Solid-state switches, Solenoids, D.C. motors, A.C. motors, Stepper motors.

Book – 1: 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7.

Basic System Models:- Mathematical models, Mechanical system building blocks, Electrical system building blocks, Electrical system building blocks, Fluid system building blocks, Thermal system building blocks.

Book – 1: 10.1, 10.2, 10.3, 10.4, 10.5.

Module – III:-

System Models:- Engineering systems, Rotational-translational systems, Electromechanical systems, Electromechanical systems, Linearity, Hydraulic-mechanical systems, Summary, Problems.

Book – 1: 11.1, 11.2, 11.3, 11.4, 11.5.

Closed-loop Controllers:- Continuous and discrete control processes, Terminology, Two-step mode, Proportional mode, Derivative control, Integral control, PID controller, Digital controllers, Control system performance, Controller tuning, Velocity control, Adaptive control, Summary, Problems.

Book – 1: 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 15.10, 15.11, 15.12.

Programmable Logic Controllers:- Introduction to PLCs, Basic Structure of a PLC, Principles of Operation, PLCs versus Computers, Introduction to Internal Architecture and Hardware Components, PLC Programming, Analog I/O, Selecting a PLC for the Application, Application of PLCs for Control.

Book – 2: 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 13.8, 13.9.

Text Books:

1. Mechatronics Electronic Control Systems in Mechanical and Electrical Engg. Pearson Publication, 4th Edition by William Bolton, 2010.
2. Mechatronics Integrated Mechanical Electronic Systems by K. P. Ramachandran, G. K. Vijayaraghavan, M. S. Balasundaram, Wiley India Edition, Printed on 2008.

Reference Books:

1. Mechatronics integrated Technologies for Intelligent Machines by A. Smaili, F.Mrad, Oxford University Press, Printed on 2009.

2. Mechatronic Sources Book, Cengage Learning India Edition by Newton C Braga, 2nd Edition, 2010.

BIOMEDICAL INSTRUMENTATION

Module – I (10 Hours)

Fundamentals of Biomedical Instrumentation: Sources of Biomedical Signals, Basic Medical Instrumentation System, Intelligent Medical Instrumentation Systems, PC Based Medical Instrumentation Systems, General Constraints & Regulations of Medical Devices

Biomedical Signals & Electrodes: Origin of Bioelectric Signals-Repolarization, Depolarization, Resting Potential Recording Electrodes – Ag-AgCl Electrodes, Electrodes for ECG, EEG, EMG, Microelectrodes, Skin Contact Impedance, Motion Artifacts

Module – II (13 Hours)

Physiological Transducers: Introduction to Physiological Transducers, Classification of Transducers, Pressure Transducers, Transducers for Body Temperature Measurement, Biosensors, Smart Sensors

Biomedical Recording Systems: Basic Recording Systems, General Considerations for Signal Conditioners, Biomedical Signal Analysis Techniques, Signal Processing Techniques, Writing Systems: Direct Writing Recorders, Inkjet Recorder, Potentiometric Recorders, Digital Recorders

Biomedical Recorders: Electrocardiograph (ECG), Phonocardiograph, Electroencephalograph (EEG), Electromayograph (EMG)

Module – III (14 Hours)

Patient Monitoring Systems: System Concepts, Measurement of Heart Rate, Blood Pressure Measurement, Measurement of Respiration Rate

Blood Flow meters: Electromagnetic Blood Flow meter, Ultrasonic Blood Flow meter, NMR Blood Flow meter, Laser-Doppler Blood Flow meter

Patient Safety: Electric Shock Hazards, Leakage Currents, Safety Codes for Biomedical Equipment

Text Books:

1. Hand Book of Biomedical Instrumentation-2nd Edition by R.S.Khandpur, Tata McGraw Hill 2003 (Chapters 1-6,11,18)
2. Biomedical Instrumentation and Measurements-2nd Edition by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, PHI learning Pvt Ltd 2nd Edition

Reference Books:

1. Introduction to Biomedical Equipment Technology-4th Edition by Joseph J. Carr, John M. Brown, Pearson Education 2007

Practical / Sessional

POWER SYSTEM LAB

Any 10 experiments out of which atleast 7 experiments from Group-A and 3 experiments from Group-B.

Group A: HARDWARE BASED

1. To determine negative and zero sequence synchronous reactance of an alternator.
2. To determine sub-transient direct axis and sub-transient quadrature axis synchronous reactance of a 3-ph salient pole alternator.
3. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation.
4. To study the IDMT over-current relay and with different plug setting and time setting multipliers and plot its time – current characteristics.
5. To determine the operating characteristics of biased different relay with different % of biasing.
6. To study the MHO and reactance type distance relays.
7. To determine A, B, C, D parameters of an artificial transmission line.
8. To compute series inductance and shunt capacitance per phase per km of a three phase line with flat horizontal spacing for single stranded and bundle conductor configuration.
9. To determine location of fault in a cable using cable fault locator.
10. To study the Ferranti Effect and voltage distribution in HV long transmission line using transmission line model.
11. Insulation test for Transformer oil.
12. a) Study of various types of Lightning arrestors.
    b) Study of layout of outdoor pole mounted & plinth mounted sub-stations.

Group B : SIMULATION BASED (USING MATLAB OR ANY OTHER SOFTWARE)

1. To obtain steady-state, transient and sub-transient short-circuit currents in an alternator.
2. To formulate the Y-Bus matrix and perform load flow analysis.
3. To compute voltage, current, power factor, regulation and efficiency at the receiving end of a three phase Transmission line when the voltage and power at the sending end are given. Use Π model.
4. To perform symmetrical fault analysis in a power system.
5. To perform unsymmetrical fault analysis in a power system.
6. Write a program in ‘C’ language to solve economic dispatch problem of a power system with only thermal units. Take production cost function as quadratic and neglect transmission loss.

TEXT BOOKS:

1. Hadi Sadat- Power System Analysis – TMH
2. T. K. Nagsarkar and M. S. Sukhija - Power System Analysis – Oxford University Press

8TH SEMESTER

POWER SYSTEM PROTECTION (3-0-0)

MODULE-I (10 Hours)

Introduction and Basic Principles: Basic Idea of relay protection, Nature and causes of faults, Zones of protection, Primary and back-up protection, Basic principle of operation of protective system, Methods of discrimination, Derivation of single phase quantity from three phase quantity, Components of Protection.

Relay (Principle, Construction and Characteristics): Relay classification, Principal Types of Electromagnetic relays, Theory of Induction relay torque, Relay design and construction, General Equations of Comparators and Electromagnetic Relays, Over Current relays, Directional relays, Distance relays, Differential relays.

Book-1: CH 1.1, 1.2, 1.5, 1.7, 1.8, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9.

MODULE-II (12 Hours)

Fault analysis using symmetrical components: Symmetrical & unsymmetrical faults.

3-Phase systems, Significance of positive, negative and zero sequence components, Average 3-phase power in terms of symmetrical components, sequence impedance, fault calculations, Single line to ground fault, Line to ground fault with Z_f, Faults in Power systems, Concept of short circuit capacity of a Bus

Book-3: CH 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 13.8, 13.10, 13.13.

Feeder Protection: Overcurrent, Distance and Pilot Protection Schemes.

Book-1: CH 5.2, 5.3, 5.4.

Apparatus Protection: Transformer Protection, Generator Protection, Motor Protection, Bus zone protection schemes.

Book-1: CH 6.2, 6.3, 6.4, 6.5.

MODULE-III (12 Hours)

Static Relays: Comparators and different relays.

Amplitude comparator, Phase Comparator, Coincidence type phase comparator, Basic elements of a static relay, OverCurrent Relays, Differential Protection, Static distance Protection

Book-1: CH 11.1, 11.2, 11.3 & CH 12.1, 12.2, 12.3, 12.4.

Numerical relays:

Block Diagram of Numerical Relay, Signal Sampling & Processing , Numerical Over-current protection, Numerical Transformer differential Protection, Numerical distance Protection of Transmission Line

Book-2: CH 11.2, 11.3, 11.7, 11.8, 11.9.

Switchgears: Autoreclosing fundamentals, Circuit breaker rating, Circuit constants and circuit conditions, Theory of Circuit interruption, Restriking voltage transients, characteristics of Restriking Voltage, Interaction between breaker and circuit, Current chopping, Automatic switch, Air-break circuit breakers, Oil circuit breakers, Air-blast circuit breakers, Vacuum circuit breakers, SF_6 circuit breakers, DC circuit breakings.

Book-1: CH 7.1, 7.2, 7.3, 7.4, CH 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 14.2,14.3, 14.4, 14.5, 14.6, 14.7, 15.1, 15.2, 15.3, 15.5, 16.2, 16.3, 16.4.

Text Book(s):

1. Power System Protection and Switchgear–B Ravindranath & M Chander–New Age International Publishers. (Book-1)
2. Fundamentals of Power system Protection – Y G Paithankar and S R Bhide, PHI Publication. (Book-2)
3. Electrical Power System by C L Wadhwa New Age International Publishers. (Fourth Edition). (Book-3)

Reference books:

1. Power System relaying by Horwitz, Phadke, Research Press.
2. Power System Protection & Switchgear by B.Oza, N.K Nair, R.Mehta,V.H.Makwana, TMH

INDUSTRIAL INSTRUMENTATION

Module 1 **18 Hours**

Introduction: Functional Units, Classification, Performance characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis, Reliability and Related Topics (Chapter 1 of Text book)

Instruments for Analysis: Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography (Chapter 8 of Text Book)

Module II: **10 Hours**

Telemetry: Introduction, Pneumatic Means, Electrical Means, Frequency Telemetring, Multiplexing, Modulation, Modulation of Digital Data, Transmission Channels, Briefing of a Telemetry System in Operation, Wireless I/O (Chapter 10 of Text Book)

Module III: **10 Hours**

Power Plant Instruments: Introduction, The Power Plant Scheme, Pressure, Temperature, Flow and Level, Vibration and Expansion, Analysis, Flue Gas Analysis (Chapter 12 of Text Book)

Hazard and Safety: Initial consideration, Enclosures, Intrinsic Safety, Prevention of Ignition, Methods of Production, Analysis Evaluation and Construction (Chapter 13 of Text Book)

Text Book:

1. Principles of Industrial Instrumentation, Third Edition, D Patranabis, Tata McGraw Hill Education Private Limited, New Delhi

Reference Books:

1. Process/Industrial Instruments and Controls Handbook, Gregory K. Mc Millian Editor-in-Chief, Douglas M. Considine Late Editor-in-Chief

ELECTRICAL POWER QUALITY (3-0-0)

MODULE-I **(12 Lectures)**

Terms & Definitions: General Classes of Power Quality Problems, Transients, Long Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage Fluctuations, Power Frequency Variations, Power Quality Terms.

Voltage Sags & Interruptions: Sources of Sags and Interruptions, Estimating Voltage Sag Performance, Fundamental Principles of Protection, Solutions at the End-User Level, Evaluating the Economics of Different Ride-Through Alternatives, Motor Starting Sags, Utility System Fault-Clearing Issues.

(Chapter-2: 2.2 to 2.10 and Chapter-3: 3.1 to 3.7)

MODULE-II **(12 Lectures)**

Transient Over Voltages: Sources of Transient Over Voltages, Principle of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor-Switching Transients, Utility System Lightning Protection, Managing Ferro-resonance, Switching Transient Problems with Loads, Computer Tools for Transient Analysis.

Fundamentals of Harmonics: Harmonic Distortion, Voltage Versus Current Distortion, Harmonics Versus Transients, Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Harmonic Sources from Commercial Loads, Locating Harmonic Sources, System Response Characteristics, Effects of Harmonic Distortion, Inter-harmonics.

(Chapter-4: 4.1 to 4.8 and Chapter-5: 5.1 to 5.11)

MODULE-III **(10 Lectures)**

Long Duration Voltage Variations: Principles of Regulating the Voltage, Devices for Voltage Regulation, Utility Voltage Regulator Application, Capacitors for Voltage Regulation, End-User Capacitor Application, Regulating Utility Voltage with Distributed resources, Flicker.

Power Quality Monitoring: Monitoring Considerations, Historical Perspective of Power Quality Measuring Instruments, Power Quality Measurement Equipments, Assessment of Power Quality Measurement Data, Application of Intelligent Systems, Power Quality Monitoring Standards.

(Chapter-7: 7.1 to 7.7 and Chapter-11: 11.1 to 11.6)

TEXT BOOK:

1."***Electrical Power Systems Quality***" By Roger C. Dugan, Mark F. Mcgranaghan, Surya Santoso & H.Wayne Beaty, 2nd Edition, TMH Education Private Ltd., New Delhi.

Reference Book:

1. Power System Quality Assesment, J.Arrilaga, N.R.Watson, S.Chen, John Wiley & Sons.
2. Understanding Power Quality Problems: Voltage Sags & Interruptions, M.H.J. Boller IEEE, 1999

OPTIMAL CONTROL

Module-I : ***(15 Hours)***

Performance Indices: Selection of Performance Index, **Calculus of variations:** Variation and its properties, Euler-Lagrange Equation.

Linear Quadratic Regulator: Formulation of Algebraic Riccati Equation (ARE), Solving the ARE using the Eigenvector Method, Optimal systems with prescribed poles, Linear Quadratic Regulator for Discrete Systems on an infinite Time Interval.

Book-1: 5.1, 5.2, 5.2.1, 5.2.2, 5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.5.

Module -II : ***(10 Hours)***

Dynamic Programming: Discrete Time Systems, Discrete Linear Quadratic Regulator Problem, Continous Minimum Time Regulator Problem, The Hamilton Jacobi Belman Equation.

Pontryagin's Minimum Principle: Optimal control with constraints on inputs.

Book-1: 5.4, 5.4.1, 5.4.2, 5.4.3, 5.4.4, 5.5, 5.5.1.

Module - III : ***(15 Hours)***

Optimal Observers-the Kalmanfilter: The linear Quadratic Gaussian (LQG) problem, **Loop Transfer Recovery (LTR). H_∞ Control:** H_∞ Control Solution, **Sub-optimal linear regulators:** Continuous Time Systems, Discrete Time Systems, **Introduction to Stochastic Optimal Linear Estimation and Control**.

Book-2: 10.3, 10.4, 10.6, 10.7, 10.7.1, 10.7.2, 10.7.3.

Book-3: 11.7, 12.1, 12.2.

Text Books:

1. Systems and Control by Stanislaw h.Zak, Oxford University Press, Publication (2003).
2. Design of Feedback Control Systems by Raymond T. Stefani, B.Shahian, Clement J.Savant, Jr. Gene H. Hostetter, 4th edition (2002), Oxford University Press Publication.
3. Modern Control System Theory by M.Gopal, Second edition (2000), New Age International (P) Ltd. Publishers.

Reference:

1. Linear Optimal Control by Jeffrey B.Burl, Prentice Hall Publication (1999).
2. Control Theory (Multivariable and Non linear Methods) by Torkel Glad and Lennart Ljung, Taylor & Francis Publications (2009).
3. Control Systems Theory (with Engineering Application) by Sergey, Edward Lysters (2006).

ADVANCED POWER ELECTRONICS (3-0-0)

Module I (12 Lectures)

Switched Mode Power Supply:

Isolated switched mode power supplies, Forward converter, Fly back converter,Half bridge converter, Bridge converter, Push pull converter, Cuk converter, resonant converter, Switched mode power supply with multiple outputs

(1.5, 1.7 SMPS Design and Construction by H W Whittington, Universities Press)

Multi output Boost Converter, Diode rectifier fed boost converter, State space analysis of regulators.

(5.10,5.11 and 5.13 Power Electronics, Circuits, Devices and Applications by M H Rashid,Pearson)

SMPS Control: Control requirements and technique, PWM controller, Isolation in the feed back loop, Power supplies with multiple outputs

(3.3 SMPS Design and Construction by H W Whittington, Universities Press)

Module II (12 Lectures)

Inverters:

Voltage Fed Converters:

Pulse width modulation techniques, Sinusoidal PWM, Selected harmonic elimination PWM, Space vector PWM, Hysteresis band current control PWM, Sigma delta modulation

Three level inverters, Resonant inverters, Soft switched inverters

Current Fed Converters:

Load commuted inverters, Forced commutated inverters, Inverters with self commutated devices

(5.5,5.6,5.7,5.8,5.9,6.3,6.4,6.7,6.7.2.2,6.8 Modern Power Electronics and AC Drives by Bimal K Bose, Eastern Economy Edition, PHI)

Module III (12 Lectures)

AC voltage controllers with PWM Control, Matrix Converter

(11.10,11.11 Power Electronics, Circuits, Devices and Applications by M H Rashid, Pearson)

Application: High Voltage DC Transmission, Interconnection of renewable energy sources and energy storage system to the utility grid, Active harmonic filter

(11.4, 17.2, 17.4 Power Electronics: Converters , Applications and Design by Mohan, Undeland and Robbin, Wiley India Edition)

Text Books:

1) Power Electronics: Circuits, Devices and Applications by M H Rashid, 3rd Edition, Pearson
2) Power Electronics: Converters , Applications and Design by Mohan, Undeland and Robbin, Wiley India Edition
3) Modern Power Electronics and AC Drives by Bimal K Bose, Eastern Economy Edition, PHI.
4) Switched Mode Power Supplies: Design and Construction by H W Whittington, B.W Flynn and D E Macpherson, 2nd Edition, Universities Press)

SATELLITE COMMUNICATION SYSTEMS

Module – I (12 Hours)

Introduction to state of satellite communication: Orbital mechanics and parameters, look angle determination, Launches and Lunch vehicle, Orbital effects in communication system performance. Attitude and orbit control system(AOCS), TT&C , Description of spacecraft System – Transponders,

Equipment reliability and space qualification.

Satellite Link Design: Basics of transmission theory, system noise temperature and G/T ratio, Uplink and Downlink design, design of satellite links for specified (C/N) performance.

Module – II (10 Hours)

Analog telephone and television transmission: Energy dispersal, digital transmission

Multiple Access: Multiplexing techniques for satellite links, Comprehensive study on FDMA, TDMA and CDMA. Spread Spectrum Transmission and Reception. Estimating Channel requirements, SPADE, Random access

Application of Satellite communication: Network distribution and direct broad casting TV, fundamentals of mobile communication satellite

Module – III (12 Hours)

Propagation on satellite: Earth paths and influence on link design: Quantifying attenuation and depolarization, hydrometric & non hydrometric effects, ionosphere effects, rain and ice effects

Satellite Antennas: Types of antenna and relationships , Basic Antennas Theory – linear, rectangular & circular aperture. Gain, pointing loss,

Earth station Technology: Earth station design, Design of large antennas – Cassegrain antennas, optimizing gain of large antenna, antenna temperature, feed system for large cassegrain antennas,

Design of small earth station antennas: Front fed paraboloid reflector antennas, offset fed antennas, beam steering, Global Beam Antenna, equipment for earth station

Text Books:

1. Satellite Communication by T. Pratt, C. Bostian. 2nd Edition, John Wiley Co.

Reference Books:

1. Digital Communication with Satellite and Fiber Optic Application, Harlod Kolimbins, PHI
2. Satellite Communication by Robert M. Gagliardi, CBS Publishers

DIGITAL IMAGE PROCESSING

Module: 1(12 hours)

Introduction: Digital Image fundamentals: Image sampling and quantization, relationship between pixels, Intensity transformations and spatial filtering, some basic intensity transformation functions, Histogram processing, spatial filters for smoothing and sharpening (Chapt: 2 & 3 of Text book 1)

Module: 2(12 hours)

Filtering in the Frequency Domain: preliminary concepts, 2D DFT and its properties, basic filtering in the frequency domain, image smoothing and sharpening (Chapt: 4 of Text book 1)

Image Restoration and Reconstruction: Image restoration/degradation model, noise models, restoration in the presence of noise only, estimating the degradation function (Chapt: 5 of Text Book 1)

Module: 3(12 hours)

Color Image Processing: color models, Color transformation (Chapt: 6 of Text book 1)

Wavelets and Multi-resolution Processing: multiresolution expansions, wavelet transforms in one and two dimension (Chapt: 7 of Text book 1)

Image Compression: Fundamentals, Some basic compression methods (Chapt: 8 of Text book 1)

Morphological Image Processing: Erosion and Dilation, opening and closing (Chapt: 9 of Text book 1)

Text Books:

1. R.C. Gonzalez, R.E. Woods, *Digital Image Processing*, 3rd Edition, Pearson Education
2. R C Gonzalez, Woods and Eddins, *Digital Image Processing using Matlab*, 2nd Edition, Tata McGraw Hill

Reference Books:

1. S.Sridhar, *Digital Image Processing*, Oxford University Press, 2011

EMBEDDED SYSTEMS

MODULE – I **10 Hours**

Embedded System: Understanding the Basic Concepts:

Introduction to Embedded System: Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification of Embedded Systems, Major Application Areas of Embedded Systems, Purpose of Embedded Systems, 'Smart' running shoes from Adidas – The Innovative bonding of Life Style with Embedded Technology.

The Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components, PCB and Passive Components.

Characteristics and Quality Attributes of Embedded System: Characteristics of Embedded System, Quality Attributes of Embedded System.

Embedded Systems – Application and Domain Specific: Washing Machine – Application Specific Embedded System, Automotive – Domain Specific Example for Embedded System.

Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language (UML), Hardware Software Trade-offs.

MODULE – II **12 Hours**

Design and Development of Embedded Product:

Embedded Hardware Design and Development: Analog Electronic Components, Digital Electronic Components, VLSI and Integrated Circuit Design, Electronic Design Automation (EDA) Tools.

Embedded Firmware Design and Development: Embedded firmware Design Approaches, Embedded firmware Development Languages, Programming in Embedded 'C'.

Real Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronisation, Device Drivers, How to choose an RTOS.

MODULE – III **14 Hours**

Design and Development of Embedded Systems:

An Introduction to Embedded System Design with VxWorks and MicroC/OS-II (μCOS-II) RTOS: VxWorks, MicroC/OS-II (μCOS-II).

Integration and Testing of Embedded Hardware and Firmware: Integration of Hardware & Firmware, Board Power up.

The Embedded System Development Environment: Integrated Development Environment (IDE), Types of files generated on cross-compilation, Disassembler/Decompiler, Simulators, Emulators & Debugging, Target Hardware Debugging, Boundary Scan.

Product Enclosure Design & Development: Product Enclosure Design Tools, Product Enclosure Development Techniques.

Embedded Product Development Life Cycle (EDLC): Definition and Objectives of EDLC, Different Phases of EDLC, EDLC Approaches (Modeling the EDLC).

Trends in the Embedded Industry: Processor Trends in Embedded System, Embedded OS Trends, Development Language Trends, Open standards, Frameworks and Alliances, Bottlenecks.

Text Book:

1. Shibu K.V., *Introduction to Embedded Systems*, TMH, New Delhi, 2009.

Reference Book:

1. Peter Marwedel, *Embedded System Design*, Springer, 2006 http://ls12-www.cs.uni-dortmund.de/~marwedel/kluwer-es-book/
2. Wayne Wolf, *Computers as Components*, Morgan Kaufmann, 2001 http://www.ee.princeton.edu/~wolf/embedded-book
3. G. De Micheli, Rolf Ernst and Wayne Wolf, eds, Readings in Hardware/Software Co-Design, Morgan Kaufmann, Systems-on-Silicon Series Embedded
4. Frank Vahid and Tony D. Givargis, System Design: A Unified Hardware/Software Introduction, Addison Wesley, 2002.
5. Michael Barr, Programming Embedded Systems in C and C++, O'Reilly, 1999.
6. David E. Simon, An Embedded Software Primer, Addison Wesley, 1999.
7. Jack Ganssle, The Art of Designing Embedded Systems, Newnes, 2000.
8. K. Short, *Embedded Microprocessor System Design*, Prentice Hall, 1998.
9. C. Baron, J. Geffroy and G. Motet, *Embedded System Applications*, Kluwer, 1997.
10. Raj Kamal, *Embedded Systems – Architecture, Programming and Design*, TMH, New Delhi,

ADAPTIVE CONTROL

Module-I : ***(10 Hours)***

Concept of adaptive control: **Adaptive Schemes:** Gain Scheduling, Model Reference Adaptive Systems (MRAS), Self tuning Regulators (STR), Dual Control. **Real time Parameter Estimation: Least squares and Regression Models**, Geometric Interpretation, Statistical Interpretation, **Estimating Parameters in Dynamical Systems**, Finite-Impulse Response (FIR) Models, Transfer Function Models, Closed loop Estimation.

Book-1: 1.1, 1.4, 2.1, 2.2, 2.3, 2.4, 2.5.

Module-II : ***(15 Hours)***

Deterministic Self Tuning Regulators (STR): Pole Placement: Process Model, Model-following, **Indirect Self-Tuning Regulators**, **Direct Self Tuning Regulators**. **Stochastic and Predictive Self-Tuning Regulators: Minimum-Variance and Moving-Average Controllers**, Linear Quadratic Gaussian Control (LQG). **Stochastic Self-tuning Regulators:** Direct Minimum-Variance and Moving-Average STR. **Adaptive Predictive Control, Model-Reference Adaptive Systems: The MIT Rule**, **Determination of the Adaptation Gain**, Kalman-Yaluebovich Lemma and its proof. **Feedback linearization of Nonlinear systems**, Adaptive feedback linearization.

Book-1: 3.2, 3.3, 3.5, 4.2, 4.3, 4.6, 5.2, 5.3, 5.6 (P-223), 5.10.

Module-III : ***(15 Hours)***

Properties of Adaptive Systems: Non linear dynamics, Analysis of a simple Discrete-Time system. **Adaptation of a feedforward Gain**. **Analysis of indirect descrete-time self tuners**, Identification in closed loop. **Averaging:** The averaged equations, **Application of averaging Techniques**, Analysis of a simple MRAS, **Averaging in stochastic Systems**, **Robust Adaptive Controllers**. **Stochastic Adaptive Control: The stochastic Adaptive Problem:** The Model, the criterion, Admissible control strategies, **Dual Control. Roubust and Self-Oscillating systems: Robust High-Gain Feedback Control**, Comparison between Robust and Adaptive Control, **Self-Oscillating Adaptive Systems**. **Introduction to Variable structure systems**.

Book-1: 6.1, 6.2, 6.3, 6.4 (P-288), 6.6, 6.7, 6.8, 6.9, 7.1, 7.3, 7.4, 10.1, 10.2, 10.3, 10.4.

Books :

Text : Adaptive control by Karl J.Astrom, Bjorn Wittenmark, Second Edition (2006) (low price) Pearson Education.

Reference :

(i) Applied Non linear Control by Jean-Jacques Slotine, Prentice Hall Publicatios (1991).

(ii) Control Systems by M. Srivastava, M.C. Srivastava and S. Bhatnagar, Tata Mc.Graw-Hill Publishing Co.(P) Ltd. (2009).

POWER STATION ENGINEERING AND ECONOMY

MODULE-1: **14 classes**

Introduction to different sources of energy and general discussion on their application to generation, Indian Energy Scenario. (Nag-1.5)

Load duration curves, Load Factor, Capacity Factor, Reserve Factor, Demand Factor, Diversity Factor, Plant Use Factor, Base Load, Intermediate Load and Peak Load Plants. (Nag-1.2)

ECONOMICS OF POWER GENERATION:

Construction costs, Fixed cost and Depreciation, Fuel cost, Economic scheduling principle, Annual Operating Costs, Effect of Load Factor on cost per kWh. (Vopat- 29.2-29.5, 29.13-29.22, Nag-1.4)

NUCLEAR POWER STATION:

Introduction to fission & fusion, reactor construction, controlled chain reaction, operational control of reactors, Brief study of various types of reactors (Boiling water, pressurized water, heavy water, breeder) , Location and layout of nuclear power plant (Nag- 9.5, 9.6, 9.13, 9.15 - 9.21

MODULE-2: **10 classes**

HYDEL POWER STATION:

Selection of site for hydro-electric power plant. (Nag-10.4)

Hydrology: Hydrological cycle, precipitation, run-off and its measurement, hydrograph, flow duration and mass curves, Estimation of amount stored by a dam across the river, Storage and Pondage. (Vopat- 25.2, 25.3, 25.5, Nag – 10.5 - 10.7)

Turbines: Operational principle of Kaplan and Francis Turbine and Pelton wheel, Speed and Pressure Regulation, Work done, efficiency (Vopat – Chapter-26, Nag- 10.10 – 10.15, 10.24 - 10.25)

Essential Elements of a Hydro-electric Power Plant: Catchment area, Reservoir, Dam, Head Gate, Spillways, Pen stock, Surge Tanks, Scroll case, Draft tubes and Tail Race, Power House, Classification of Hydroelectric Power Plants. (Vopat- 25.6 – 25.9, Nag-10.8, 10.9)

Governors, Plant auxiliaries (Nag – 10.21)

MODULE-3: **11 classes**

THERMAL POWER STATION:

Selection of site for thermal power plant. (Vopat-31.3, Nag-1.3)

Overall Block Diagram indicating the air circuit, coal and ash circuit, water and steam circuit, various types of steam turbines, ash and coal handling system, High Pressure and High capacity water tube boilers, Economizer, Superheaters, De-Superheater, Re-heater, Air Pre-heater. (Vopat – 7.4, Chap-8, Chap-10, Nag-2.15, 6.3.1, 6.3.2, 6.4-6.6, 6.8, 6.12 - 6.15)

Draft System: Natural, Induced Forced and Balance Draft, PA fan, FD fan, ID fan, Chimney. (Vopat – 9.1, 9.4, Nag- 4.14.1, 4.14.3, 4.15)

Condensers, Feed water heaters, Evaporators, Make-up water, Bleeding of steam, Cooling water system. (Vopat- 14.1, 14.6, 18.2, 18.13, Nag – 8.1- 8.6),

Electrostatic Precipitator: Basic working Principle and constructional details (Nag-6.10)

Governors, Plant auxiliaries (Vopat- 12.14)

TEXT BOOKS AND REFERENCES:

1. P. K. Nag, “Power Plant Engineering”, 3rd Edition, Tata McGraw Hill Publication
2. Bernhardt G. A. Skrotzki, William A. Vopat, ‘Power Station Engineering and Economy’, 2nd Edition, Tata McGraw Hill Publication
3. M. V. Deshpande, Elements of Electrical Power Station Design, PHI
4. Arora & Domkundwar, ‘A Course in Power Plant Engineering’, Dhanpat Rai and sons.
5. R. K. Rajput, ‘A Text Book of Power Plant Engineering’, 3rd Edition, Laxmi Publishing.

MARKETING MANAGEMENT (3-0-0)

Objective of the Course: The course aims at introducing the basic concepts of marketing to the undergraduate students in engineering. The learning shall help the students in better designing, manufacturing and selling product/ service packages keeping competitive market, customers and cost in view.

Module – I **(10 hours)**

Marketing Management: Concept, Process, Functions and relevance in the current context.

Marketing Environment: Elements of micro and macro environment

Competition Analysis: Factors contributing to competition, porter's five forces model, Identifying and analyzing competitors.

Marketing Planning : Exploring Opportunity, Product –market selection, Marketing Planning Process.

Market Research and Information Systems: Research Process, The Internet and World Wide Web based Information collection and processing, Database, Data Warehouses and Data Mining, Global Market Research.

Consumer Behavior: Factors influencing consumer behavior, consumer decision process. Organizational buying behavior.

Module II **(10 hours)**

Market Segmentation, Targeting and Positioning: Definition, Bases of segmenting consumer and Industrial markets. Target Market strategies: Market Positioning.

Market Demand Forecasting: Key Terms, Forecasting Tools: Short term tools: Moving average and Exponential smoothing methods, Long-term forecasting Tools: Time series analysis, Econometrics methods, Qualitative tools : Buying Intention Survey, Sales Force Opinion and Delphi Techniques.

Product Planning : Product Life Cycle, New Product Development Process, Branding Strategy, Positioning a Brand, Brand Equity, Packaging and Labeling, Product-mix and Product Line, Planned Obsolescence.

Module – III **(10 hours)**

Pricing Decision: Objectives and Factors influencing pricing, Pricing method and strategies.

Integrated Marketing Communication(IMC)- Concept of IMC, the marketing communication process, Promotion Mix, elements of promotion mix, Direct marketing.

Channels of Distributions: Types of intermediaries, functions of distribution channels, channel levels, Designing Distribution Channels, Physical Distribution, Supply Chain Management (Basic only).

Trends in Marketing: Green Marketing, Customer Relationship Management, E-marketing, Rural Marketing and Service Marketing (concepts only)

Books:

Text Book:

1. Etzel , Walker ,Stanton and Pandit, Marketing, 14/e, Tata McGraw Hill.

2. Saxena, "Marketing Management" Tata McGraw Hill, 4/e.

Reference

1. Grewal, Levy, 'Marketing' Tata McGraw Hill, special Indian edition.

2. Karunakaran "Marketing Management", Himalaya Publishing House, 2010/e.

3. Kotler, Keller,Koshy and Jha, "Marketing Management", 13/e, Pearson Education.

PRODUCTION & OPERATION MANAGEMENT

Objective : The course aims at acquainting all engineering graduates irrespective of their specializations the basic issues and tools of managing production and operations functions of an organization.

Module I

1. Operations Function in an Organization, Manufacturing Vrs Service Operations, System view of Operations, Strategic Role of Operations, Operations Strategies for Competitive Advantage, Operations Quality and Productivity Focus, Meeting Global Challenges of Production and Operations Imperatives. **(3 Hours)**

2. Designing Products, Services and Processes: New Product Design- Product Life Cycle, Product Development Process, Process Technology : Project, Jobshop, Batch, Assembly Line, Continuous Manufacturing; Process Technology Life Cycle, Process Technology Trends, FMS, CIM, CAD, CAM; Design for Services, Services Process Technology. **(4 Hours)**

3. Work Study: Methods Study- Techniques of Analysis, recording, improvement and standardization; Work Measurement : Work Measurement Principles using Stopwatch Time Study, Predetermined Motion Time Standards and Work Sampling, Standard Time Estimation. **(4 Hours)**

Module II

4. Location and Layout Planning : Factor Influencing Plant and Warehouse Locations, Impact of Location on cost and revenues. Facility Location Procedure and Models : Qualitative Models, Breakeven Analysis, location Model, centroid method.
Layout Planning: Layout Types : Process Layout, Product Layout, Fixed Position Layout Planning, block diagramming, line balancing, computerized layout planning- overview.
Group Technology **(4 Hours)**

5. Forecasting : Principles and Method, Moving Average, weighted Moving Average, Exponential Smoothing, Winter's Method for Seasonal Demand, Forecasting Error.**(4 Hours)**

6. Manufacturing Planning and Control : The Framework and Components : Aggregate Planning, Master Production Scheduling, Rough-cut-Capacity Planning, Material Requirements Planning, Capacity Requirements Planning. **(5 Hours)**

Module III

7. Sequencing and Scheduling : Single Machine Sequencing : Basics and Performance Evaluation Criteria, Methods for Minimizing Mean Flow Time, Parallel Machines : Minimization of Makespan, Flowshop sequencing : 2 and 3 machines cases : Johnson's Rule and Jobshop Scheduling : Priority dispatching Rules. **(3 Hours)**

8. Inventory Control : Relevant Costs, Basic EOQ Model, Model with Quantity discount, Economic Batch Quantity, Periodic and Continuous Review Systems, Safety Stock, Reorder Point and Order Quantity Calculations. ABC Analysis. **(4 Hours)**

9. Modern Trends in Manufacturing : Just in Time (JIT) System : Shop Floor Control By Kanbans, Total Quality Management, Total Productive Maintenance, ISO 9000, Quality Circle, Kaizen, Poka Yoke, Supply Chain Management. **(4 Hours)**

Reference Book:

1. S.N.Chary, "Production and Operations Management", Tata McGraw Hill.
2. R. Paneerselvam, "Production and Operations Management, Prentice Hall of India.
3. Aswathappa & Bhatt – Production & Operations Management, HPH.
4. Gaither & Frazier - Operations Management, Cengage Publication
5. Russell & Taylor - Operations Management, PHI Publication
6. Chase, Aquilanno, Jacob & Agarwal - Operations Management, TMH Publication.
7. E.E. Adam and R.J. Ebert "Production and Operations Management", Prentice Hall of India