

HM- 904A	Intellectual Property Rights for Technology Development & Management						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The objective of this course is to familiarize the students with the basic concepts of Intellectual Property Rights for technology development & management and new developments in the field of IPR						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand basics of Intellectual Property Rights and importance of IPR						
CO2	Understand law of copy rights and law of patents						
CO3	Learn about industrial designs & their protection law and trade marks						
CO4	Learn about Trade Secrets and new developments in the field of IPR						

UNIT- I

Introduction: Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

UNIT- II

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, Patent and kind of inventions protected by a patent, ownership rights and transfer. Case studies of patents.

UNIT- III

Industrial Designs: Introduction, need to protect industrial design, **industrial designs protection law.**

Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

UNIT IV

Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

New developments: New developments in trade mark law; copy right law, patent law, intellectual property audits. International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law.

Text Books/References:

1. P. Ganguli; Intellectual property right – Unleashing the knowledge economy, Tate McGraw Hill Publishing company Ltd.
2. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000.
3. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010
4. Deborah. E. Bouchoux; Intellectual property right, Cengage learning.
5. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India Ltd , 2006

EENP-401A	Industrial Electrical System						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To provide knowledge about various concepts of industrial electrical systems and their automation						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand residential and commercial electrical systems						
CO2	Understand various types of illumination systems and lighting schemes used for a residential and commercial premises						
CO3	Understand various concepts of industrial electrical systems						
CO4	Understand the concept related to industrial electrical system automation						

UNIT- I

Residential and Commercial Electrical Systems: Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components

UNIT- II

Illumination Systems: Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaires like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting

UNIT- III

Industrial Electrical Systems I : HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

UNIT IV

Industrial Electrical Systems II : DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks

Industrial Electrical System Automation: Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation

Text Books/References:

1. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
2. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
3. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997. Web site for IS Standards.
4. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008

EENP-403A		Digital Control System					
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To enable students to design and analyze discrete time (digital) control system						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Represent discrete time systems under the form of z-domain transfer functions and state-space models. Also able to obtain the model of discrete-time systems by pulse transfer function						
CO2	Analyze stability, transient response and steady state behaviour of linear discrete time systems, analytically and numerically using tools such as MATLAB and Simulink						
CO3	Design sampled data control systems.						
CO4	Describe Discrete state space model and test controllability and observability of systems						

UNIT- I

Introduction to digital control: Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction.

Modelling discrete-time systems by pulse transfer function

Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Pulse transfer function of closed loop system, Sampled signal flow graph

UNIT- II

Stability analysis of discrete time systems: Jury stability test, Stability analysis using bi-linear transformation, Time response of discrete systems, Transient and steady state responses, Time response parameters of a prototype second order system.

UNIT- III

Design of sampled data control systems: Root locus method, Controller design using root locus, Root locus-based controller design using MATLAB, Nyquist stability criteria, bode plot, Lead compensator design using Bode plot, Lag compensator design using Bode plot, Lag-lead compensator design in frequency domain.

UNIT IV

Discrete state space model: Introduction to state variable model, Various canonical forms, Characteristic equation, state transition matrix, Solution to discrete state equation. Controllability, observability and stability of discrete state space models: Controllability and observability, Stability, Lyapunov stability theorem.

Text Books/References:

1. B. C. Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, Indian Edition, 2007.
2. K. Ogata, Discrete Time Control Systems, Prentice Hall, 2nd Edition, 1995.
3. M. Gopal, Digital Control and State Variable Methods, McGraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D. Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998, Pearson Education, 3rd Edition.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3rd Edition, 1997.

EENP-405A	High Voltage Engineering
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Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To enable students to understand important concepts of high voltage engineering						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand the concept of electrostatic field and effect of high electrostatic field over Gases, Liquid and solid dielectric						
CO2	Understand the concept of generation of high voltages and currents in the system						
CO3	Measure high voltages and currents in the system						
CO4	Perform Non-destructive and high voltage testing on various components of power system						

UNIT I

Electrostatic Field and Field Stress Control: Electric field stresses, Numerical methods for Electric field computation, Finite Element Method, Charge simulation method.

Conduction and Break Down in Gases: Ionization processes, Townsend's criterion, breakdown in electronegative gases, time lags for breakdown, streamer theory, Paschen's law, break down in non-uniform field, and corona discharge

Break Down in Liquid Dielectrics: Conduction and breakdown in pure liquid and commercial liquid.

Break Down in Solid Dielectrics: Intrinsic breakdown, electromechanical breakdown breakdown of solid, dielectric and composite dielectrics.

UNIT II

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, tripping and control of impulse generators..

UNIT III

Measurement of High Voltages and Currents: Measurement of high direct current voltages, measurement of high alternating and impulse Voltages measurement of high direct, alternating and impulse currents, Cathode Ray Oscillographs for impulse voltage and current measurements.

Insulation Coordination in Electric Power Systems: Principle of Isolation Coordination in High-Voltage & Extra-High Voltage Power System.

UNIT IV

Non-Destructive Testing: Measurement of direct current resistively, measurement of dielectric constant and loss factor, partial discharge measurements

High Voltage Testing: Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, testing of transformers, testing of surge arresters, radio interference measurements.

Text Books/References :

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering, Tata Mc-Graw Hill.
2. C. L. Wadhwa, "High Voltage Engineering", Wiley Eastern Ltd.
3. E. Kuffel and W. S. Zaengal, "High Voltage Engineering", Pergamon Press.
4. M. P. Chaurasia, "High Voltage Engineering", Khanna Publishers
5. R. S. Jha, "High Voltage Engineering", Dhanpat Rai & sons
6. M. Khalifa, 'High Voltage Engineering Theory and Practice,' Marcel Dekker.
7. Subir Ray, 'An Introduction to High Voltage Engineering' Prentice Hall of India

EENP-407A	Electric Drives						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The main objective of the course is to impart the students with the knowledge of dynamics and controls of the electric drives.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand the basic fundamentals of electric drives						
CO2	Analyse the dynamics of electric drive during starting and breaking						
CO3	Understand the concepts of power electronic control of DC drives						
CO4	Understand the concepts of power electronic control of AC drives						

UNIT-1

Fundamentals of Electric Drive: Electric Drives and its parts, advantages of electric drives, Classification of electric drives, Speed torque conventions and multi-quadrant operations, Constant torque and constant power operation, Types of load, Load torque: components, nature and classification.

Dynamics of Electric Drive: Dynamics of motor-load combination, Steady state stability of Electric Drive, Transient stability of electric Drive

Selection of Motor Power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of

motor power rating for continuous duty, short time duty and intermittent duty., Load equalization

UNIT-2

Braking of drives: Purpose and types of electric braking, braking of dc, three phase induction and synchronous motors

Dynamics During Starting and Braking: Calculation of acceleration time and energy loss during starting of dc shunt and three phase induction motors, methods of reducing energy loss during starting. Energy relations during braking, dynamics during braking

UNIT-3

Power Electronic Control of DC Drives: Single phase and three phase-controlled converter fed separately excited dc motor drives (continuous conduction only), dual converter fed separately excited dc motor drive, rectifier control of dc series motor. Supply harmonics, power factor and ripples in motor current, Chopper control of separately excited dc motor and dc series motor.

UNIT-4

Power Electronic Control of AC Drives: Three Phase induction Motor Drive: Static Voltage control scheme, static frequency control scheme (VSI, CSI, and cyclo – converter based) static rotor resistance and slip power recovery control schemes.

Three Phase Synchronous motor: Self-controlled scheme

Special Drives: Switched Reluctance motor, Brushless dc motor. Selection of motor for particular applications

Text/Reference Books:

1. G.K. Dubey, "Fundamentals of Electric Drives", Narosa publishing House.
2. S.K.Pillai, "A First Course on Electric Drives", New Age International.
3. V Subrahmanyam, "Electric Drives", Mcgrawhill Education
4. M.Chilkin, "Electric Drives", Mir Publishers, Moscow.
5. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore.
6. N.K. De and Prashant K.Sen, "Electric Drives", Prentice Hall of India Ltd.
7. V.Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill.

CO4	The students will learn to define electric and magnetic fields, calculate electric and magnetic fields from stationary and dynamic charge and current distributions, solve simple electrostatic boundary problems, describe simple models for electromagnetic interaction with media, be able to choose adequate models and solution methods for specific problems, solve problems analytically and numerically, it also incorporates the understanding of method of moments and their applications.
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UNIT- I

Introduction to electromagnetic fields: review of vector analysis, electric and magnetic potentials, boundary conditions, Maxwell's equations, diffusion equation, Poynting vector, wave equation.

UNIT- II

Finite Difference Method (FDM): Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD) method

UNIT- III

Finite Element Method (FEM): Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations

UNIT- IV

Method of Moments (MOM): Integral formulation, Green's functions and numerical integration, other integral methods: boundary element method, charge simulation method Applications of these methods for EM simulation of waveguides, micro-striplines and other planar components, antennas, scatterers, radars.

Text Books / References:

1. M. V. K. Chari and S. J. Salon, Numerical methods in electromagnetism, Academic Press.
2. M. N. O. Sadiku, Numerical techniques in electro-magnetics, CRC Press.
3. N. Ida, Numerical modeling for electromagnetic non-destructive evaluation, Chapman and Hall.
4. S. R. H. Hoole, Computer aided analysis and design of electromagnetic devices, Elsevier Science Publishing Co.
5. J. Jin, The Finite Element Method in electromagnetics, 2nd Ed., John Wiley and Sons.
6. P. P. Silvester and R. L. Ferrari, Finite elements for electrical engineers, 3rd Ed., Cambridge University Press.

University 1888:

EENO-401A	Electronic Devices						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To familiarize the students with semiconductor technology and operation of various electronic devices.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand the basics of semiconductor and semiconductor technology.						
CO2	Know about various types of Semiconductor diodes						
CO3	Understand the concepts of bipolar transistor and field effect transistors.						
CO4	Know about special semiconductor devices and semiconductor power devices.						

UNIT 1

Semiconductors: Band structure of semiconductor, Electron & hole distribution, current transport in semiconductor & concept about mobility, Diffusion & recombination, the continuity equation & its solution and Hall effect.

Semiconductor technology : Introduction to technology of semiconductor devices , basic of ICs- Bipolar , MOS and CMOS type.

Unit-II

P-N Junction Diodes : Structures technology , V-I characteristics , charge control equation and transient response . Types of P-N junction diode: Tunnel , Zener , Shockley , schottky, varactor diode & circuit : rectifiers , clipping and clamping circuits.

Opto –Electronics : Basic of opto –Electronics , photo Diodes, photo transistor , P-N Junction solar cells , LED , laser and photovoltaic device .

Unit-III

Bipolar Transistor: Ebers-Mole model & charge control model, Transient behavior, small signal equivalent circuit Z parameter–h-parameter and hybrid – pai, switching and power transistor.

Field Effect Transistor: JFET operation and V-I characteristics, high frequency response , MOS capacitor theory , MOSFET types , MOSFET operation and V-I characteristics , equivalent circuit metal semiconductor junction and MOSFET.

Unit-IV

Special semiconductor Device : Metal semiconductor contact ,MIC structure surface charge transfer and charge coupled device and their applications.

Semiconductor power devices : Diodes, transistors, UJT, thyristor, DIAC, TRIAC, GTO, IGBT static characteristics. and principal of operation .

Text/Reference Books:

1. B.G. Streetman : Solid State Electronic Devices (PHI)
2. S.M. Sze: Physics of Semiconductor Devices (WILEY)
3. D. Nagchoudhari : Semiconductor Devices(TMH)
4. P.S. Bimbhra : Power Electronics(KP)
5. Dubey G.K. : Thyristorised Power Controllers (NAIL)

EENO-403A		Data Structure & Algorithms					
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The main objective of the course is to impart the students with the knowledge of data structure and various algorithms used in data structure operations. Data structure and algorithms help in understanding the nature of the problem at a deeper level and thereby a better understanding of the world.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand and analyze the time and space complexity of an algorithm						
CO2	Understand operations on Stack, Queue (i.e.Priority Queue , D-Queue etc.) and link lists.						
CO3	Discuss various algorithm design techniques for developing algorithms						
CO4	Discuss various searching, sorting and graph traversal algorithms						

UNIT-1

Introduction to data structure and Algorithms: Performance analysis of Algorithm, time complexity, Big-oh notation, Elementary data organization, data structure operations, Recurrences, Arrays, Operation on arrays, representation of arrays in memory, single dimensional and multidimensional arrays, sparse matrices, Character storing in C, String operations.

UNIT-2

Stack, Queue and Link List: Stack operation, PUSH and POP, Array representation of stacks, Operation associated with stacks Application of stacks, Recursion, Polish expression, Representation Queue, operation on Queue , Priority Queue , D-Queue , Singly and circularly linked list, Lists operations, Lists implementations

UNIT-3

Trees : Basic terminology, Binary Trees, Binary tree representation, Complete Binary Trees, Extended binary tree, representing binary trees in memory, linked representation of Binary trees, Traversing binary trees & Searching in binary trees, Inserting in binary search trees, Complexity of searching algorithm, Heaps, general trees, Threaded binary tree.

Graphs: Terminology & representations, Graphs & Multigraphs, Directed Graphs, Sequential representation of graphs, adjacency Matrices, Transversal, connected component and spanning trees, Minimum Cost spanning tree, Prims and Kruskal Algorithm, BFS, DFS, Shortest path and transitive closure, Activity networks, topological sort and critical paths.

UNIT-4

Searching and Sorting: Linear search, binary Search, Internal and External sorting, Bubble sorting, selection sort, Insertion sort, quick sort, Two way merge sort, Heap sort, sorting on different keys, practical consideration for internal sorting, External Sorting, Storage Devices : Magnetic tapes, Disk Storage, Sorting with disks and Indexing techniques, introduction to B tree and B+ tree, File organization and storage management, Introduction to hoisting.

Text / Reference Books:

1. Thomas H. Coreman, Charles E. Leiserson and Ronald L. Rivest, Introduction to Algorithms, PHI.
2. Horowitz and Sahani, "Fundamentals of Data Structures", Galgotia Publication.
3. Weiss, "Data Structure & Algorithm Analysis in C", Addison Wesley.
4. Basse, "computer Algorithms: Introduction to Design & Analysis", Addison Wesley.
5. Lipschutz, "Data structure, "Schaum series.
6. Aho, hopcroft, Ullman, "Data Structure & Algorithm", Addison Wesley.
7. Aho. Hopcraft. Ullman, "The Design and Analysis of Computer Algorithms" Pearson Education, 2008

EENO-405A	Signal and Image Processing						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective	The main objective of the course is to impart the students with the knowledge of various methods to convert an image or signal into digital form and perform some operations on						

(PO)	them, in order to get an enhanced image or signal to extract some useful information from them.
Course Outcomes (CO)	
After completion of course students will be able to	
CO1	Understand basic concepts of digital signal processing and its application.
CO2	Understand the concepts of frequency transformations and also learn about the structures of discrete time systems.
CO3	Understand fundamentals of digital image, image enhancement and compression
CO4	Understand basic concepts of digital image processing

UNIT 1

Introduction: Basic elements of DSP system, Advantages and disadvantage of DSP over analog processing, Application of Digital signal processing.

Z-Transform: Direct Z-Transform and importance of ROC, properties of Z-Transform, Inverse Z-transform methods, Rational Z-transform function representation, system function of LTI systems in Z-domain, one sided Z –Transform. Solution of difference equations. Analysis of LTI system in Z- domain, transient and steady- state response. Causality and stability. Pole- Zero Cancellations.

UNIT 2

FREQUENCY TRANSFORMATIONS : Introduction to DFT, Direct Computation of DFT ,Properties of DFT, Circular Convolution , Fast fourier Transform(FFT), decimation in time ,decimation in frequency algorithm, Use of FFT in Linear Filtering , Goetzel Algorithm, Chirp-Z Transform algorithm.

Structure of Discrete-Time Systems: Structure for FIR Systems-direct form, Linear Phase, Cascade form, Frequency-Sampling structures, Structures for IIR- Direct, Cascade, Parallel & transposed structure, signal flow graphs .

UNIT 3

Digital Image Fundamentals: Introduction, image model, sampling and Quantization, relationship between pixels, imaging geometry, photographic film, discrete, Fourier transform, properties of two dimensional Fourier transform.

Image Enhancement and Compression: Enhancement by point processing, spatial filtering and enhancement in the frequency domain, pseudo color image processing, image compression models, error free compression, image compression standards.

UNIT 4

Image Restorations: Degradation, models, diagonalizations of matrices, inverse filtering, interactive restorations, geometric transformations.

Image Segmentation: Detection of discontinuities, edge linking and boundary detection, thresholding, region orienting segmentation.

Representations and Recognition: Representations schemes, boundary descriptors, regional descriptors, morphology, recognition and interpretation, basics.

Text books / References:

1. Digital Signal Processing by J.G. Proakis and D.G. Manalakis-PHI
2. Digital Signal Processing by: A.V. Oppenheim and R.W. Schaffer-PHI
3. Digital Signal Processing by S. K. Mitra –TMH.
4. Digital Signal Processing by Rabinar, Gold-PHI
6. Barrie W. Jervis , “digital signal processing (Pearson education India)
7. Digital Signal Processing by S. Salivahanan- TMH
8. Rafael c. Gonzalez and Richard E. Woods, digital image processing, Addison Wesley publishing company
9. William K. Pratt, digital image processing, John Wiley and sons
10. Jain, Fundamentals of digital image processing, PHI

EENP-402A	Power Quality & FACTS						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The main objective of the course is to impart the students with the knowledge of various power quality issues, their effects on power system and mitigation techniques used to remove them from the system.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Familiarize with sources of power quality issues, power quality standards & regulations						
CO2	Familiarize with various power quality issues in electrical supply system						
CO3	Understand various causes of power system harmonics, harmonic effects in the system and mitigation techniques						
CO4	Understand the working of FACTS devices and custom power devices to mitigate power quality issues						

UNIT 1

Power Quality Problems & Monitoring : Overview and Definitions of power quality, sources of pollution, international power quality standards, and regulations.

UNIT 2

Power Quality Problems : Surges, voltage sag and swell, over voltage under voltage, outage voltage, and phase angle imbalance, electric noise, harmonics, frequency deviation monitoring,

UNIT 3

Power System Harmonics: Harmonic analysis, harmonic sources – the static converters, transformer magnetization and non-linear machines, arc furnaces, fluorescent lighting. Harmonic effect within the power system, interference with communication harmonic measurements, Harmonic Mitigation Techniques

UNIT 4

FACT Systems: Introduction – Terms & definition, Fact Controllers, Type of FACT devices i.e. SSC, SVC, TSC, SSS, TCSC, UPFC, Basic relationship for power flow control.

Introduction to Custom Power Devices-Network Reconfiguration devices; Load compensation and voltage regulation using DSTATCOM; protecting sensitive loads using DVR; Unified power Quality Conditioner. (UPQC), uninterruptible power suppliers

Text books/ References:

1. Roger C Dugan, McGrahan, Santoso&Beaty, "Electrical Power System Quality" McGraw Hill
2. Arinthom Ghosh & Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices" Kluwer Academic Publishers
3. C. Sankaran, "Power Quality" CRC Press
4. Narain G. Hingorani & Laszlo Gyugyi "Understanding FACTS: Concepts and Technology of Flexible

EENP-404A	Control System Design						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The course is useful for the students to get an idea of ideal practices in the field of control systems design. Students will get in touch with recent trends in the field of modern control engineering. Here importance of designing the control systems is emphasized.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Define fundamental control system design specifications and basic principles of controller design						
CO2	Design modern controllers based on the state space techniques and recognize the importance of observability and controllability for system design.						
CO3	Understand concept of optimal control and robust control techniques.						
CO4	Understand concept of Lyapunov's stability Criteria and optimal control						

UNIT 1

Design of Feedback Control Systems : Introduction, Approaches to System Design, Cascade Compensation Networks, Phase-Lead Design Using the Bode Diagram, Phase-Lead Design Using the Root Locus, System Design Using Integration Networks, Phase-Lag Design Using the Root Locus, Phase-Lag Design Using the Bode Diagram, Design on the Bode Diagram Using Analytical Methods, Systems with a Pre-filter, Design for Deadbeat Response; Design Examples.

UNIT 2

Design of State Variable Feedback Systems: Introduction, State space representation of physical systems, State space models of some common systems like R-L-C networks, DC motor, inverted pendulum etc., Controllable Canonical Form, Observable Canonical Form, Diagonal Canonical Form, State transition matrix, Solution of state equations, Controllability and Observability, Full-State Feedback Control Design; Observer Design; Integrated Full-State Feedback and Observer; Tracking Reference Inputs; Internal Model Design; Design Examples

UNIT 3

Introduction to Robust Control and optimal control : Robust control system and system sensitivities to parameter perturbations, analysis of robustness, systems with uncertain parameters, considerations in design of robust control system, robust PID controller.

UNIT 4

Lyapunov's stability and optimal control: Positive/negative definite, positive/negative semi-definite functions, Lyapunov stability criteria, introduction to optimal control, Riccati Equation, Linear Quadratic Regulator, Design Examples.

Text books / References:

1. Modern Control Engineering by K. Ogata, PHI.
2. Discrete Time Control Systems by K. Ogata, PHI.
3. Automatic Control Systems by B C Kuo, PHI.
4. Control Systems, Principles and Design by M. Gopal, MC Graw Hill, 2012.

EENP-406A	Electrical & Hybrid Vehicles						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To provide knowledge of Electrical and hybrid vehicles to the students.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	To learn about Electrical and Hybrid Vehicles.						
CO2	Understand about types of machinery used in Electric propulsion unit						
CO3	Understand about various methods of energy storage in Electric and hybrid vehicles						

CO4	Learn about sizing methodology of drive system and energy management strategies used in electric and hybrid vehicles
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UNIT 1

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles.

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 2

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 3

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.

UNIT 4

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

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.

Text / Reference Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004

EENP-408A	HVDC Transmission System						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The main objective of the course is to impart the students with the knowledge of high voltage direct current (HVDC) transmission system.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand about HVDC transmission systems, it's merits and demerits over EHVAC System.						
CO2	Understand about various control strategies of HVDC links, harmonics, it's effects & mitigation techniques.						
CO3	Understand about various types of faults in HVDC system and their protection schemes.						
CO4	Understand about MTDC systems, it's type, control & protection schemes.						

UNIT I

Merits and Demerits of HVDC over EHVAC, type of HVDC links, Analysis Of 3- phase bridge converter with grid control for $U \leq 60^\circ$ and $U > 60^\circ$, derivation of equivalent circuit of HVDC link.

UNIT II

Basic means of control of HVDC link, C.C.A., C.C. and C.E.A, Control Characteristics of a converter, Harmonics in HVDC Operation, types of filters used for harmonic elimination, characteristics harmonics, characteristic AC current harmonics, Non characteristic AC harmonics, harmful effects.

UNIT III

Protection aspects of a HVDC link, types of faults, over current protection, over voltage protection, ground and short circuit fault & their protection.

UNIT IV

	able to know about open loop dynamic performance of AC & DC drives.
CO4	Understand operations of various industrial drives. Students will also be able to acquire the knowledge of selection of drives as per practical operational industrial requirement.

UNIT I

Introduction: Definition of electric drive, type of drives; Speed torque characteristic of driven unit/loads, motors, joint speed-torque characteristic; Classification and components of load torque; Review of power converters used in drives, multi-quadrant operation of electric drive, example of hoist operation in four quadrant.

UNIT II

DC Motor Drive and its Operational Strategies: Dynamic model of machine with armature voltage control only and converters with continuous conduction only; Closed loop control using single (speed) and two loops (speed, current), Implementation using circulating current type three phase dual converter and four quadrant transistorized chopper, Closed loop control of solid state DC drives

UNIT III

AC Drives and its Operational Strategies: Induction Motor Drives. Starting & braking, VSI control, CSI control, Direct torque and flux control of induction motor, Variable frequency operation of three phase symmetrical induction machine, Scalar control methods for constant power and constant torque modes, Vector control of induction machine

Open-loop Dynamic Performance of AC & DC Drives: Starting & reversal time, Energy consumption & energy savings principle. Drives Application Engineering for Fan, Pump, Compressor, Lift-Elevator, Kiln, Winder-Un-Winder, Traction application. Synchronization and master-slave configuration.

UNIT IV

Self controlled synchronous motor drive, Vector control of synchronous motor, Switched reluctance motor drive, Brushless DC motor drive, Permanent magnet drives, Switched Reluctance Motors, performance characteristics, Stepper motor and switch reluctance motor drives, solar and battery powered drives

Suggested Text / Reference books:

1. G.K.Dubey, Power semi conductor controlled drives, Prentice Hall, January 1989
2. G.K.Dubey, Fundamentals of Electrical Drives, 2nd Revised edition, Alpha Science International Ltd, 15 October 2001
3. B.K. Bose, Power electronics and variable frequency drives, Wiley-Blackwell, 21 September 1996
4. Bose B.K., Modern Power Electronics & AC Drives, PHI Pvt. Ltd., (2001)
5. Mohan, N., Electric Drives: An Integrative Approach, MNPERE (2001).
6. Mohan, N., Advanced Electric Drives: Analysis, Control, and Modeling Using Simulink, MNPERE (2001).
7. Krishnan, R., Electric Motor & Drives: Modeling, Analysis & Control, PHI Pvt. Ltd. (2001).
8. Leonard, W., Control of Electric Drives, Springer-Verlag, New York, (1985)
9. Miller, T.J.E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science, Oxford (1989).

Course Outcomes (CO)**After completion of course students will be able to**

CO1	Understand the concept of continuous & discrete wavelet transform and orthogonal wavelet decomposition
CO2	Learn about MRA, Orthonormal wavelets and their relationship with filter banks
CO3	Understand the use of wavelets transform for Data compression & video coding
CO4	Understand the various applications of wavelets transform

UNIT 1

Continuous Wavelet Transform: Introduction, Definition of the CWT, the VWT as a Correlation, Constant-Factor Filtering Interpretation and Time-Frequency Resolution, the VWT as an Operator, Inverse CWT, Problems.

Introduction to Discrete Wavelet Transform and Orthogonal Wavelet Decomposition: Introduction, Approximation of Vectors in Nested Linear Vector Subspaces, Examples of an MRA, Problems.

UNIT 2

MRA, Orthonormal Wavelets, and their Relationship to Filter Banks: Introduction, Formal Definition of an MRA, Construction of General Orthonormal MRA, a wavelet Basic for the MRA, Digital Filtering Interpretation, Examples of Orthogonal Basic Generating Wavelets, Interpreting Orthonormal MRAs for Discrete-Time signals, Miscellaneous Issues Related to PRQME Filter Banks, generating Scaling Functions and wavelets from Filter Coefficient, Problems.

UNIT 3

Wavelet Transform and Data Compression: Introduction, Transform Coding, DTWT for Image Compression, Audio Compression, Video Coding Using Multi-resolution Techniques: a Brief Introduction.

UNIT 4

Applications of Wavelet Transforms: Introduction, Wavelet denoising speckles Removal, Edge Detection and Object Isolation, Image Fusion, Object Detection by Wavelet Transform of Projections, Communication application.

Text Books / References:

1. James S. Walker, "A Primer on Wavelets and their Scientific Applications", CRC Press, (1999).
2. Rao, "Wavelet Transforms", Pearson Education, Asia.
3. C. Sidney Burrus, Ramesh A. Gopinath, "Introduction to Wavelets and Wavelets Transforms", Prentice Hall, (1997).

EENO-406A	Embedded System						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To introduce the students to concepts of embedded systems. To offer them a level of confidence in microcontroller based system design. To introduce them to the concepts of ARM architectures and RTOS.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Understand various concepts of embedded system						
CO2	Learn about 8051 Microcontroller						
CO3	Understand the operating system of Embedded system and also learn about higher embedded system						
CO4	Learn about communication basics and interfacing of various devices to the microcontroller						

UNIT 1

Introduction to embedded system: Embedded System, Embedded versus external memory devices, CISC and RISC processors, Harvard and Von Neumann Architecture, Application of Embedded System, Embedded operating system, Design Parameters of embedded and its Significance, Design life cycle, Hardware fundamentals, Digital circuit parameter, O.C and Tristate outputs, I/O sink and Source, Custom single purpose processor Optimization, FSMD, data path & FSM, General purpose Processor and ASIP'S

UNIT 2

8051 Microcontrollers: 8051 microcontrollers-Assembly language, Architecture of 8051, Registers, Addressing Modes, Instruction Set, I/O ports, memory organization, Programs showing use of I/O Pins, Interrupts, Interrupt Programming, Timer and counters, Serial Communication, Programming of serial communication.

UNIT 3

Introduction to operating system and basics of higher embedded system: Introduction to RTOS, Tasks, Data, Semaphores and shared data, Operating system services, Message queues, Mailboxes, Advanced processor (Only architecture), 80386, 80486, Introduction to ARM, features, architecture, instruction set

UNIT 4

Communication basics and interfacing of various devices the microcontroller: Microprocessor interfacing I/O addressing, direct memory access (DMA), Arbitration, multilevel bus architecture, serial protocol, parallel protocols and wireless protocol, Real world interfacing: LCD, Stepping motor, ADC, DAC, LED, Pushbuttons, Keyboard, Latch connection, PPI

Text / Reference Books:

1. Embedded system Design-Frank Vahid/ Tony Givargis. John Willey
2. Microcontroller (Theory and applications) Ajay V Deshmukh, Tata , McGraw-Hill
3. An Embedded Software Primer-David E.Simon, Pearson Education
4. The 8051 Microcontroller and embedded systems-Muhammad Ali Mazidi and Janice Gillispie.
5. Microcontrollers (Architecture, Implementation & Programming) Kenneth Hinz, DanielTabak,Tata McGraw-Hill
6. 8051 Microcontrollers & Embedded Systems 2nd edition Sampath Kr. Katson books

EENO-408A	Mobile Communication & Networks						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To introduce the students to the concepts of Wireless & Mobile communication and networks. Study of this subject will also provide knowledge to students about various mobile telephony generations such as 1G, 2G, 3G, 4G systems etc. and their abilities and limitations.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Familiarize with fundamentals of mobile communication systems.						
CO2	Familiarize with the role of equalization in Mobile communication and also learn about different types of Equalizers. Students will also able to know about different types of multiplexing and multiple access techniques used in mobile communication system.						
CO3	To learn about the concept of GSM in real time applications (in mobile telecommunication)						
CO4	Familiarize with Wireless and Mobile Networks and higher generation cellular standards						

UNIT 1

Evolution of mobile radio communication fundamentals. General Model of Wireless Communication Link, Types of Signals, Cellular Infrastructure, Cellular System Components, Antennas for Cellular Systems, Operation of Cellular Systems, Channel Assignment, Frequency reuse, Channel Assignment strategies, Handoff Strategies Cellular Interferences, Sectorization; Wireless Channel and Radio Communication, Free Space Propagation Model, Channel Noise and Losses, Fading in Land Mobile Systems, Multipath Fading, Fading Effects on Signal and Frequency, Shadowing.

UNIT 2

Equalization Techniques: Transversal Filters, Adaptive Equalizers, Zero Forcing Equalizers, Decision Feedback Equalizers, and related algorithms.

Multiplexing and Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA, SCFDMA, IDMA Schemes and Hybrid Method of Multiple Access Schemes, RAKE Receiver; Multiple Access for Radio Packet Systems: Pure ALOHA, Slotted ALOHA, CSMA and their versions; Packet and Pooling Reservation Based Multiple Access Schemes.

UNIT 3

GSM system for mobile Telecommunication: General Packet Radio Service, Edge Technology; CDMA 2000, Wireless Local Loop, IMT 2000 and UMTS, Long Term Evolution (LTE), Mobile Satellite Communication, Introduction to Mobile Adhoc Networks, Li-Fi Communication, Ultra-Wideband Communication, Mobile data networks, Wireless Standards IMT 2000

UNIT 4

Wireless and Mobile Networks: Networks introduction, Network Coverage, Network topologies, Network Architecture, Network Technologies, Evolution of Cellular Networks (0G ~4G) , Wireless Area networks (WLANs) , Bluetooth and Personal Area networks (PANs), Adhoc networks

Higher Generation Cellular Standards: 3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, Introduction to 5G.

Text / Reference Books:

1. T.S. Rappaport, "Wireless Communication-Principles and practice", Pearson Publications, Second Edition.
2. Misra, Wireless Communication & Network: 3G & Beyond, McGraw Hill Education
3. Jaganathan, Principles of Modern Wireless Communication System, McGraw Hill Education

4. Upena Dalal, "Wireless Communication and Networks", Oxford Press Publications.
5. T L Singal, "Wireless Communications", McGraw Hill Education.
6. Andrea Goldsmith, "Wireless Communications", Cambridge University Press.
7. S. Haykin & M. Moher, "Modern wireless communication", Pearson, 2005.
8. "Mobile Communication", Jochen Schiller, Pearson Education, 2nd Edition
9. G.Sasibhushana Rao, "*Mobile Cellular Communication*", Pearson, 2013.
10. W.C.Y. Lee - Mobile Cellular Communications, 2nd Edition, MC Graw Hill, 1995.
11. Yi-Bing Lin - Wireless and Mobile Network Architectures, 2nd Edition, Wiley, 2008.

EENO-410A	Thermal and Fluid Engineering						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	The objective of this course is to familiarize the students with the basic concepts of Thermo dynamics and Fluid engineering.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	State the thermodynamic system, properties and equilibrium. Describe the ideal and real gas laws.						
CO2	Analyze and solve the first and second law of thermodynamics problems.						
CO3	Understand the basic concepts of fluid and learn about fluid statics.						
CO4	Understand the basic concepts of fluid kinematics and analyse the laws of fluid dynamics and its applications.						

UNIT-I

Basic Concepts: Thermodynamics: Macroscopic and Microscopic Approach, Thermodynamic Systems, Surrounding and Boundary, Thermodynamic Property – Intensive and Extensive, Thermodynamic Equilibrium, State, Path, Process and Cycle, Quasi-static, Reversible and Irreversible Processes, Working Substance. Concept of Thermodynamic Work and Heat, Equality of Temperature, Zeroth Law of Thermodynamic and its utility.

Ideal and Real Gases: Concept of an Ideal Gas, Basic Gas Laws, Characteristic Gas Equation, Avagadro's law and Universal Gas Constant, P-V-T surface of an Ideal Gas. Vander Waal's Equation of state, Reduced Co-ordinates, Compressibility factor and law of corresponding states. Mixture of Gases, Mass, Mole and Volume Fraction, Gibson Dalton's law, Gas Constant and specific Heats, Entropy for a mixture of Gases.

UNIT II

First Law of Thermodynamics: Energy and its Forms, Energy and 1st law of Thermodynamics, Internal Energy and Enthalpy, 1st Law Applied to Non-Flow Process, Steady Flow Process and Transient Flow Process, Throttling Process and Free Expansion Process. Numerical

Second Law of Thermodynamics: Limitations of First Law, Thermal Reservoir Heat Source and Heat Sink, Heat Engine, Refrigerator and Heat Pump, Kelvin- Planck and Clausius Statements and Their Equivalence, Perpetual Motion Machine of Second Kind. Carnot Cycle, Carnot Heat Engine and Carnot Heat Pump, Carnot's Theorem and its Corollaries, Thermodynamic Temperature Scale, Numerical

UNIT III

Fluid Properties: Concept of fluid and flow, ideal and real fluids, continuum concept, Properties of fluid: mass density, weight density, specific volume, specific gravity, viscosity, causes of viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus, Newtonian and non-Newtonian fluids.

Fluid Statics: Pressure, Pascal's law, hydrostatic law, pressure measurement, manometers, hydrostatic forces on submerged plane and curved surfaces, buoyancy, stability of floating and submerged bodies, liquids in relative equilibrium. Problems.

UNIT IV

Fluid Kinematics: Eulerian and Lagrangian description of fluid flow; types of fluid flows, stream, streak and path lines; acceleration of a fluid particle, flow rate and continuity equation, differential equation of continuity in cartesian and polar coordinates, rotation and vorticity, circulation, stream and potential functions, flow net.

Fluid Dynamics: Concept of system and control volume, Euler's equation, Bernoulli's equation and its practical applications, venturimeter, orificemeter, orifices, mouthpieces, Impulse momentum equation, kinetic energy and momentum correction factors.

Text / Reference Books:

1. Engineering Thermodynamics – C P Arora, Tata McGraw Hill
2. Engineering Thermodynamics – P K Nag, Tata McGraw Hill
3. Thermal Science and Engineering – D S Kumar, S K Kataria and Sons

4. Engineering Thermodynamics -Work and Heat transfer – G F C Rogers and Maghew Y. R. Longman
5. Introduction to Fluid Mechanics – R.W. Fox, Alan T. McDonald, P.J. Pritchard, Wiley Publications.
6. Fluid Mechanics – Frank M. White, McGraw Hill
7. Fluid Mechanics and Fluid Power Engineering – D.S. Kumar, S.K. Kataria and Sons
8. Fluid Mechanics – Streeter V L and Wylie E B, Mc Graw Hill
9. Introduction to Fluid Mechanics and Fluid Machines – S.K. Som and G. Biswas, Tata McGraw Hill.
10. Mechanics of Fluids – I H Shames, Mc Graw Hill
11. Fluid Mechanics: Fundamentals and Applications -YunusCengel and John Cimbala, McGraw Hill.
12. Fluid Mechanics: Pijush K. Kundu, Ira M. Cohen and David R. Rowling, Academic Press.

EENO-412A	Automobile Engineering						
Lecture	Tutorial	Practical	Credit	Major Test	Minor Test	Total	Time(Hrs)
3	0	0	3	75	25	100	3
Program Objective (PO)	To make aware the students with the study of engineering which teaches manufacturing and mechanical-mechanisms as well operations of automobiles. It is an introduction to vehicle engineering which deals with motorcycles, cars, buses trucks etc. It includes branch study of mechanical, electronic, and safety elements. Some of the engineering attributes and disciplines that are of importance to the automotive engineer.						
Course Outcomes (CO)							
After completion of course students will be able to							
CO1	Students will be able to Develop a strong base for understanding future developments in the automobile industry						
CO2	Students will be able to Explain the working of various parts like engine, transmission, gear box etc.						
CO3	Students will be able to Describe how the brakes and the suspension systems operate						
CO4	Students will be able to Understand the steering geometry and emission control system.						

UNIT I

Introduction: Brief history of automobiles, Main components of an automobile, Brief description of each component. Brief description of constructional details and working of a four stroke I.C. Engine (S.I. Engines and C.I. Engines) including lately developed overhead cam shaft, Multi-cylinder engines, Introduction to recent developments in I.C. Engines- Direct injection systems, Multi-point fuel injection systems, Introduction, Brief description of different components of Transmission System.

Clutch: Introduction to Clutch and its different types, Principle of Friction Clutch, Clutch Lining and friction materials used in

Friction Clutches, Torque transmitted, Brief description of Cone Clutch, Single Plate and Multiplate Clutches, Dry and wet clutches, Automatic clutch action, Centrifugal clutches, Electromagnetic clutches, Fluid Flywheel.

UNIT II

Gear Box: Gear Box Air resistance, gradient resistance and rolling resistance coming across a moving automobile, Tractive effort, Variation of tractive effort with speed, Performance curves (object and need of a gear box), Sliding mesh gear box, Control mechanism, Sliding type selector mechanism, Ball type selector mechanism, Steering column gear shift control, Constant mesh gear box, Synchromesh device, Automatic transmission in general, AP automatic gear box, Torque converter, Torque converter with direct drive, Lubrication of Gear Box.

Propeller Shaft: Functions and requirements of a propeller shaft, Universal joints, Constructional forms of universal joints, Flexible-ring joints, Rubber-bushed flexible joints. Constant-velocity joints. Differential : Principle of operation, Constructional details of a typical Differential unit, Traction control differentials, Multi-plate clutch type traction control device.

UNIT III

Brakes: Functions and methods of operation, Brake efficiency. Elementary theory of shoe brake, brake shoe adjustments, A modern rear-wheel brake, Disc brakes, Brake linkages, Leverage and adjustment of the brake linkage, Servo- and power operated brakes, Vacuum brake operation, Hydraulic Brakes-constructional details and working, Direct action vacuum servos, Power-operated brakes, A dual power air brake system,

Suspension system: Suspension principles, Road irregularities and human susceptibility, Suspension system, Damping, Double tube damper, Single tube damper, Lever arm type damper, Springs-Leaf springs, Coil and torsion springs, variable rate springs, Composite leaf springs, Rubber springs, Air springs, Adjustable and self-adjusting suspensions, Interconnected suspension system, Interconnected air and liquid suspensions, Independent suspension system, Different independent suspension layouts, McPherson strut type, Rear suspension-live axle, McPherson strut rear suspension.

UNIT IV

Steering Geometry: Castor, Camber, Kingpin inclination, Combined angle, Toe-in, Steering system-basic aims, Ackerman linkage, Steering linkages for independent suspension, Center point steering, Costarring or trailing action, Cornering power, Self-righting torque, Steering characteristics-over steer and under steer, Axle beam, Stub-axle construction, Steering column, Reversible and irreversible steering, Rack-and-pinion steering mechanism, Effect of toe-in on steering, Power steering, Vickers System. Recent trends in automobile engineering Multi fuel automobiles, Automobiles running on alternate sources of energy, Emission control through catalytic converter, Double catalytic converter, Aspects of pollution control in Automobiles.

Reference and Text Books:

1. The Motor Vehicle - By Newton, Steeds and Garretle Basic
2. Automobile Engineering - By Kirpal Singh
3. Automobile Engineering '*' -By K.M. Gupta, Umesh Publications