University of Pune

Faculty of Technology

Board of Studies in Mechanical and Materials Technology

Curriculum Structure

Sr. No	Course Title	Semester	Credits
01	**Materials Engineering**	I	5
02	**Finite Element Method**	I	5
03	**Mathematical Modeling and Analysis**	I	5
04	**Instrumentation & Experimental Techniques**	II	5
05	**Optimization Techniques**	II	5
06	Elective*	I	5
07	Elective*	II	5
08	Elective*	II	5
09	Open Elective**	I	5
10	Open Elective**	II	5
11	Seminar –I (Advanced Topic based on courses in semester I)	I	5
12	Seminar-II (Advanced Topic based on courses in semester II)	II	5
13	**Advanced Mathematics**	III	5
14	**Advanced Technologies in Materials and Mechanical Engineering**	III	5
15	**Research Methodologies**	III	5
16	Seminar-III on Literature Review of Research Problem)/ field works/assignments	III	5
17	Research Progress Seminar I and Report	IV	20
18	Research Progress Seminar II and Report	V	20
19	Research Progress Seminar III and Report	VI	20
20	Research Progress Seminar IV and Report	VII	20
21	Thesis Submission	VIII	--

*** Electives to be selected from following list**

MME1: Advanced Stress Analysis	MME7: Advanced Thermodynamics	MME13: Advanced Gas Dynamics
MME2: Vehicle Dynamics	MME8: Advanced Heat Transfer	MME14: Advanced Air conditioning and Heating and Ventilation
MME3: Engineering Fracture Mechanics	MME9: Advanced Fluid Mechanics	MME15: Internal Combustion Engines
MME4: Vibration & Noise Control	MME10: Computational Fluid Dynamics	MME16: Advanced Physical & Mechanical Metallurgy
MME5: Advanced Machine Design	MME11: Refrigeration Technology	MME17: Microcontrollers
MME6: Analysis & Synthesis of Mechanism	MME12: Industrial Automation	MME18: Drives & Actuators

****Open Elective**

The syllabi of open elective will be framed by supervisor of Ph. D. candidate in consultation with project sponsoring company. It has to be sent to concern Board of Studies for approval. The open elective should be relevant to the area of Ph. D. work.

Note

Candidates are required to perform minimum four (4) assignments for each core and elective course, and submit report as a bona fide document to supervisor/course instructor. The assignment may be in the form of modeling/ simulation/ programming/ experimental investigation/ fieldwork.

MMC1: Materials Engineering

Basics of material science – atomic structure, types of defects, microstructure, physical & mechanical properties, temperature and strain rate effects, characterization of materials

Effect of manufacturing (casting, forging, rolling, extrusion) and fabrication (welding) processes on material microstructure, properties and generation of residual stress, Heat Treatment of Nonferrous alloys, Heat Treatment of Tool steels

Overview of production methods, semiconducting nanostructures, carbon nanotubes, buckyballs, nanowires, semiconducting nanoparticles, metallic nanostructures, organic nanomaterials, nanometals

Introduction to corrosion and wear, stress corrosion cracking, surface cleaning and coating methods (viz. Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Ion Implantation, conducting polymers) and its applications to mechanical engineering, strengthening mechanisms, shot peening, shot blasting

Polymers, ceramics, composites, conducting polymers, shape memory alloys, nano materials, Orthodental materials, Bio material, Prosthetic materials, super conducting materials, sports materials

Transition behavior of material, stages of fatigue, damage estimation, methods of fatigue life estimation – stress life approach, strain life approach, cycle counting methods, critical plane approaches, Integration of Damage Differential (IDD) criteria, Smith Watson Topper (SWT) criteria, Dong criteria, elementary fracture mechanics, residual strength analysis

References

1. *R. A. Higgins, Engineering Metallurgy, Viva Books Pvt. Ltd.*
2. *H. Lawrence, Van Vlack, Elements of Material Science and Engineering, Addison- Wesley Publishing Company*
3. *William F. Smith, Principles of Material Science and Engineering, McGraw-Hill Book Co.*
4. *R. B. Gupta, Material Science, Satya Publications, New Delhi.*
5. *William D. Callister, Jr., Material Science and Engineering An Introduction, John Wiley and Sons Inc.*
6. *E. A. Brandes and G. B. Brook, Smithells Metals Reference Book, Butterworth Heinemann.*
7. *Donald L. Wise, Biomaterials and Bioengineering Handbook, Marcel Dekker Inc.*
8. *Philippe Boch and Jean-Claude Niepce, Ceramic materials*
9. *Donald Askeland and Pradeep Phule, The science and engineering of materials*
10. *Making, shaping & treating steels, American Institute of Iron & Steel Technology Handbook*
11. *George Dieter, Mechanical Metallurgy, TMH*

MMC2: Finite Element Method

Methods of weighted residual, weak formulation, piecewise continuous trial function, Galerkin's finite element formulation, variational formulation of the problem, Ritz method

Finite element solution to beam problem and plane frame, plates and shells, introduction to non-linear analysis, convergence criteria, stress stiffening, geometric and material non-linearity

Solution of eigen problems, transformation methods, Jacobi method, vector iteration methods, subspace iteration method, direct integration methods for dynamic analysis, Newmark method, mode superposition, change of basis to modal generalized displacements, effect of damping

Crack tip element, reduced integration, incompatible modes, shear locking and hour glass phenomenon, modelling of gap and contacts, adaptive mesh refinement

Introduction, Study State Heat transfer-1D and 2D Heat Conduction, Governing differential equation, Boundary Condition, Formulation of element

Type and size of element, mapped elements, quality checks-[aspect ratio, warp angle, skew, Jacobean, distortion, stretch, included angle, taper], boundary conditions, interpretation of results and design modification.

References

1. *Zienkiewicz O. C., Taylor, R. I., The Finite Element Method, Butterworth-Heinemann, Fifth Edition 2000.*
2. *Akin J.E., Finite Element Analysis with Error Estimators, Elsevier, 2005.*
3. *Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley & Sons Inc, 1995.*
4. *Liu G.R. and Quek S. S., The Finite Element Method – A Practical Course, Butterworth-Heinemann, 2003.*
5. *Kwon Y. W., Bang H., Finite Element Method using MATLAB, CRC Press, 1997.*
6. *Asghar Bhatti, Fundamental Finite Element Analysis and Applications, John Wiley & Sons Inc, 2005*
7. *Chandrupatla T.R. and Belegunda A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India.*

MMC3: Mathematical Modeling and Analysis

System, environment and variables, the state of a system, mathematical models of continuous line linear lumped parameter time invariant systems, discrete time systems, linear approximation of non-linear systems, topological models of system, block diagram representation, signal flow graph, Mason's rule

The principles of conservation and continuity, physical laws, mechanical systems, electrical and electro mechanical systems, fluid systems, thermal systems

The linear graph approach, linear graph terminology, formulation of system equations, systems with multi terminal components, linear graph models: skeletal structures, mass transfer processes

Discrete signal models, discrete time-convolution, response of linear discrete time systems, continuous (analogue) signal models, continuous time convolution, response of linear continuous time state equation - discrete time systems, computation of state transition matrix by canonical transformation, computation of state transition matrix by technique based on Caley-Hamilton theorem, the solution of state equation-continuous time systems

Numerical method for solution of continuous time state, ordinary differential equations: explicit and implicit techniques, adaptive step size control, adaptive RK method, numerical methods for partial differential equations

Application of Laplace transforms to differential equations, stability in s domain, linear system, Laplace transform analysis of causal periodic input to linear systems, relationship of the Z transform to the Fourier and Laplace transforms

Fourier spectra of power signals, Fourier transform of periodic functions- Fourier series, Fourier analysis of sampled signals, modulation, discrete Fourier transforms

The inverse Z-transform, Z-transform analysis of linear discrete time systems, nature of response of linear discrete-time systems, computation system, de-convolution

Multi resolution analysis and construction of wavelets, representation of functions by wavelets, the characterization of MRA wavelets

Introduction to simulation: digital and analogue simulation, analytic and Monte Carlo simulation, stochastic and deterministic simulation, random and pseudo random number generation, designing a simulation experiment, simulating basic stochastic models, simulator technology, applications

References

1. *Nicola Bellomo & Luigi Preziosi, Modeling Mathematical Methods & Scientific Computations, 1995, CRC Press.*
2. *I.J. Nagarath & M. Gopal, Systems Modeling & Analysis, Tata McGraw Hill, New Delhi.*
3. *Jan Willen Polderman, Jan C. Willems, Introduction to Mathematical Systems Theory- A behavioural approach, 1998, Springer.*
4. *J.L. Shearer, A.T. Murphy, H.H. Richardson, Introduction to System Dynamics, 1971, Addison & Wesley.*

5. *T.H. Glisson, Introduction to System Analysis, 1987, McGraw Hill.*
6. *W.J. Palm, Modeling Analysis and Control of Dynamic Systems, 2nd Ed., 1999, John Wiley.*
7. *Ernest O Doebelin, System Modeling and Response, theoretical and experimental approaches, 1980, Wiley.*
8. *Gray M. Sandquist, Introduction to System Science.*
9. *David K. Cheng, Analysis of Linear Systems.*
10. *James B. Reswick, Charles K Taff, Introduction to Dynamic Systems.*
11. *Robert L. Woods, Kent L. Lawrence, Modeling & Simulation of dynamic system.*
12. *Robert A. Gabel & Richard A. Roberts, Signals and Linear Systems.*
13. *Eugenio Hernandez, Guido Weiss, A First Course on Wavelets, 1996, CRC Press.*
14. *Alan V Oppenheim & Ronald W. Schafer, Digital Sigal Processing, Prentice Hall of India, Pvt. Ltd.*
15. *Richard E Blahut, Fast Algorithms for Digital Signal Processing, 1985, Addison-Wesley Publishing Co.*
16. *Dougllao F Elliott, K Ramamohan Rao, Fast Transforms Algorithms, Analysis and Applications, 1982, Academic Press Inc., Chapters 1, 2 & 3.*

MMC4: Instrumentation & Experimental Techniques

Basic concepts of measurement methods and planning and documenting experiments, typical sensors, transducers, and measurements system behavior, Data sampling and computerized data acquisition systems, statistical methods and uncertainty analysis applied to data reduction, laboratory experiments with measurement of selected material properties and solid mechanical and fluid/thermal quantities.

Static and dynamic characteristics of signals, review of electrical devices and signal processing, computerized data acquisition, temperature measurements, pressure and velocity measurements, fluid flow measurements, strain measurements, displacements and motion measurements.

Dynamics measurements and signal analysis.

Measurement of derived quantities, torque, power, thermo physical properties, radiation and surface properties, analytical methods and pollution monitoring, mass spectrometry, chromatography, spectroscopy.

Optical Methods - Optical Microscopy, Confocal Microscopy, X-ray Microscopy, UV/VIS Spectrometry, Infrared Spectrometry (FTIR), Terahertz Spectroscopy (THz), Raman Spectroscopy, Surface Enhanced Raman Spectroscopy (SERS).

Electron Microscopy - The Electron Optical System, Electron Range, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM)

X-ray Spectroscopy and diffraction, Atomic force microscope (AFM), Scanning tunneling microscopy (STM), Scanning Near-field optical microscopy (SNOM)

References

1. *E.O. Doeblin, Measurement Systems - Application and Design, McGraw-Hill.*
2. *J.P. Holman, Experimental Methods for Engineers, McGraw-Hill.*
3. *J. W. Dally, W. F. Riley, and K. G. McConnell, Instrumentation for Engineering Measurements, John Wiley & Sons.*

MMC5: Optimization Techniques

Basic Concepts, Functions of one variable, Unconstrained Functions of N Variables, Constrained Functions of N Variables: Linear Programming, Sequential Unconstrained Minimization Techniques, Direct Methods, Approximation Techniques, Duality

Discrete Variable Optimization and Multi-Objective Optimization, Structural Optimization, General Design Applications and Multidiscipline Design Optimization, Optimization Software

Sizing, Shape and Topology/ Topography Optimization, Design Sensitivity Analysis

Optimization by ANN and GA techniques

Optimization of Systems for specific application like acoustics, laminated composite materials etc.

References

1. *Raphael Haftka and Zafer Gurdal, Elements of Structural Optimization, Kluwer Academic Publishers*
2. *Jasbir Arora, Optimization of Structural and Mechanical Systems, World Scientific*
3. *Garret N Vanderplaats, Numerical optimization techniques for engineering design, Vanderplaats Research and Development, Inc*

MME1: Advanced Stress Analysis

Analysis of stress, Analysis of stain, Elasticity problems in two dimension and three dimensions, Mohr's circle for three dimensional stresses, stress tensor, Airy's stress function in rectangular & polar coordinates, energy method for analysis of stress, strain and deflection, the three theorem's -theorem of virtual work, theorem of least work, Castigliano's theorem, Rayleigh Ritz method, Galekin's method, Elastic behaviour of anisotropic materials like fiber reinforced composites

Torsion of prismatic bars of solid section and thin walled section, analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy, torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, torsion of noncircular shaft.

Concept of shear centre in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear centre for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section

Bending of plate to cylindrical surface, bending of a long uniformly loaded rectangular plate, pure bending in two perpendicular directions, bending of circular plates loaded symmetrically w. r. t. center, Bending of circular plates of variable thickness, circular plate with circular hole at center symmetrically loaded and load distributed along inner and outer edges

Governing equations, stress in thick walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength, plastic action in thick walled cylinders and rotating disc

Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area, introduction to analysis of low speed impact

Introduction to Linear Elastic Fracture Mechanics, modes of fractures, stress intensity factor, crack initiation and crack opening phenomenon, stress distribution around crack tip under various loading conditions, fracture toughness G_{Ic} plastic bending of elastic materials, post yield stress analysis, plastic flow process, shape factor, spring back effect

Dimensional analysis, analysis techniques strain gauges: configuration, instrumentation, characteristics of strain gauge measurement, theory of photo-elasticity and techniques used in photo elastic application

References

1. *Cook and Young, Advanced Mechanics of Materials, Prentice Hall*
2. *Richard G. Budynas, Advanced Strength and Applied Stress Analysis, McGraw Hill*
3. *Boresi, Schmidt, Sidebottom, Advanced Mechanics of Materials, Willey*
4. *Timoshenko and Goodier, Theory of Elasticity, McGraw Hill*
5. *Timoshenko, Advanced Strength of Materials, Vol. 1, 2, CBS*
6. *Den Harteg, Advanced Strength of Materials*
7. *Dally & Riley, Experimental Stress Analysis*

8. *Timoshenko, Theory of Plates and Shells, McGraw Hill*
9. *Hertzberg R. W., Deformation and Fracture Mechanics of Engineering Materials, 4th edition, John Wiley & Sons, Inc., 1996.*

MME2: Vehicle Dynamics

Tire forces and moments, rolling resistance of tires, tractive (braking) effort and longitudinal slip (skid), cornering properties of tires, slip angle and cornering force, slip angle and aligning torque, camber and camber thrust, characterization of cornering behavior of tires, performance of tires on wet surfaces, ride properties of tires

Equation of motion and maximum tractive effort, aerodynamic forces and moments, vehicle power plant and transmission characteristics, power plant characteristics, transmission characteristics, prediction of vehicle performance, acceleration time and distance, gradability, operating fuel economy, engine and transmission matching, braking performance, braking characteristics of a two-axle vehicle, braking efficiency and stopping distance, braking characteristics of a tractor-semitrailer, antilock brake systems, traction control systems.

Steering geometry, steady-state handling characteristics of a two-axle, vehicle, steady-state response to steering input, testing of handling characteristics, transient response characteristics, directional stability, criteria for directional stability, vehicle stability control, steady-state handling characteristics of a tractor-semitrailer.

Human response to vibration, vehicle ride models, two-degree-of-freedom vehicle model for sprung and unsprung mass, numerical methods for determining the response of a quarter-car model to irregular surface profile excitation, two-degree-of-freedom vehicle model for pitch and bounce, introduction to random vibration, surface elevation profile as a random function frequency response function, evaluation of vehicle vibration in relation to the ride comfort criterion, active and semi-active suspensions.

Motion resistance of a track, tractive effort and slip of a track, simplified analysis of the kinetics of skid-steering, kinematics of skid-steering, skid-steering at high speeds, a general theory for skid-steering on firm ground, shear displacement on the track-ground interface, kinetics in a steady-state turning maneuver, experimental substantiation, coefficient of lateral resistance, power consumption of skid-steering, steering mechanisms for tracked vehicles, clutch and brake steering system, controlled differential steering system, planetary gear steering system, articulated steering.

The multibody systems approach to vehicle dynamics

References

1. *Michael Blundell & Damian Harty, The Multibody Systems Approach to Vehicle Dynamics, Elsevier*
2. *Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, SAE*
3. *Ulrich W. Seiffert, Hans Hermann Braess, Handbook of Automotive Engineering, SAE*
4. *G. Genta, Motor Vehicle Dynamics: Modeling and Simulation, World Scientific*
5. *Homer Rahnejat, Multi-body dynamics: vehicles, machines and mechanisms, Professional Engineering Publications.*
6. *Homer Rahnejat, Multi-body dynamics: monitoring and simulation techniques-II, Steve Rothberg, Professional Engineering Publications*
7. *Homer Rahnejat, Multi-body dynamics: monitoring and simulation techniques-III, Steve Rothberg, Professional Engineering Publications*
8. *JY Wong, Theory of Ground vehicles, Wiley.*

MME3: Engineering Fracture Mechanics

Review of - Mechanical properties of solid materials, theory of elasticity stress and strain, plane stress, plane strain, stress function, theory of plasticity, yield stress, yield conditions (Mises & Tresca)

Macroscopic failure mode, ideal fracture strength, energy release rate, fracture Modes

Griffith criterion, Irwin's fracture criterion, stress intensity approach, stress intensity factor, crack tip plasticity, crack opening displacement, plastic constraint

Methods for evaluating fracture toughness, Numerical Methods Finite Elements (FE), Finite Differences (FD), Boundary Integral Equations (BIE),Experimental Methods, Compliance Method, Photoelasticity, Interferometry and Holography

Experimental evaluation of Fracture toughness: Plane strain fracture toughness, J– Integral, CTOD

Fatigue: S-N diagram, fatigue limit, fatigue crack growth rate, Paris law

Creep mechanics: creep deformation, creep strength, creep-fatigue interaction

References

1. *Anderson T.L., Fracture Mechanics, 2nd Edition, CRC Press, 1995*
2. *Hertzberg, R. W. Deformation and Fracture Mechanics of Engineering Materials. 4th ed. John Wiley & Sons, Inc., 1996.*
3. *ASTM standard E 1820*

MME4: Vibration & Noise Control

Multi degree freedom system, free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) flexibility coefficient, generalized coordinates, coordinate couplings, Langrange's equations matrix method eigen values eigen vector problems, modal analysis, forced vibrations of un-damped system and modal analysis

Multi degree system numerical methods, (i)Rayleigh's method, (ii)Rayleigh-Ritz method (iii) Holzer's method (iv)methods of matrix iterations (v) transfer matrix method, impulse response and frequency response functions

Continuous system, vibrations of string, bars, shafts and beams, free and forced vibration of continuous systems, transient vibrations, response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response functions

Vibration control, balancing of rotating machine, in-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation & vibration absorbers

Vibration measurement, FFT analyzer, vibration exciters, signal analysis, time domain & frequency domain analysis of signals, experimental modal analysis, machine conditioning and monitoring, fault diagnosis

Random vibrations, expected values auto and cross correlation function, spectral density, response of linear systems, and analysis of narrow band systems

Nonlinear vibrations, systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane technique, Duffing's equation, jump phenomenon, limit cycle, perturbation method

Noise and its measurement, sound waves, governing equation its propagation**,** fundamentals of noise, decibel, sound pressure level, sound intensity, sound fields, reflection, absorption and transmission, noise measurement, sound meter, allowed exposure levels and time limit by BIS, octave band analysis of sound, fundamentals of noise control, source control, path control, enclosures, noise absorbers, noise control at receiver

References

1. *W T Thomson, Theory of Vibrations with Applications, CBS Publishers Delhi*
2. *S S Rao, Mechanical Vibrations, Addison-Wesley Publishing Co.*
3. *Leonard Meirovitch, Fundamentals of Vibration, McGraw Hill International Edison.*
4. *Ashok Kumar Mallik, Principles of Vibration Control, Affiliated East- West Press.*
5. *A H Church, Mechanical Vibrations, John Wiley & Sons Inc*
6. *J P Den Hartog, Mechanical Vibrations, McGraw Hill.*
7. *Srinivasan,Mechanical Vibration Analysis, McGraw Hill.*
8. *G K Groover, Mechanical Vibrations*
9. *Kewal Pujara, Vibration and Noise for Engineers, Dhanpat Rai & co.*

MME5: Advanced Machine Design

Engineering statistics, analysis of variance (ANOVA), factorial design and regression analysis, reliability theory, design for reliability, Hazard analysis, fault tree analysis

Fatigue and creep, introduction, fatigue strength, factors affecting fatigue behavior, influence of super imposed static stress, cumulative fatigue damage, fatigue under complex stresses, fatigue strength after over stresses, true stress and true strength, mechanism of creep of material at high temperature, exponential creep law, hyperbolic sine creep law, stress relaxation, bending etc.

Optimization, introduction, multivariable search methods, linear & geometric programming, structural and shape optimization and simplex method

Composite materials, composite materials and structures, classical lamination theory, elastic stress analysis of composite material, fatigue strength improvement techniques, stresses, stress concentration around cutouts in composite laminates, stability of composite laminate plates and shells, hybrid materials, applications

Design for Materials and Process, Design for brittle fracture, design for fatigue failure, design for different machining process, assembly & safety etc.

Design of Mechanical components, a) gear design: involute gears, tooth thickness, interference, undercutting, rackshift etc., profile modification, S and So spur, helical gears etc. b) spring design: vibration and surging of helical springs, helical springs for maximum space efficiency, analysis of Belleville springs, ring spring, volute spring & rubber springs, design for spring suspension, c) design of miscellaneous components (to be detailed) cam shaft with valve opening mechanism, piston, cylinder, connecting rod etc.

References

1. *M.F. Spotts, Mechanical Design Analysis*
2. *Robert Norton, Machine Design*
3. *D.W. Dudley, Practical Gear design*
4. *R.C. Jhonson, Optimum design*
5. *A.M. Wahl, Mechanical Springs*
6. *D. Hull and T.W. Clyne, An introduction to composite materials*

MME6: Analysis and Synthesis of Mechanisms

Basic concepts: definitions and assumptions, planar and spatial mechanisms, kinematic pairs, degree of freedom

Kinematic analysis of complex mechanisms: velocity-acceleration analysis of complex mechanisms by the normal acceleration and auxiliary point methods

Dynamic analysis of planar mechanisms: inertia forces in linkages, kinetostatic analysis of mechanisms by matrix method. analysis of elastic mechanisms, beam element, displacement fields for beam element, element mass and stiffness matrices, system matrices, elastic linkage model, equations of motion

Curvature theory: fixed and moving centrodes, inflection circle, Euler- Savy equation, Bobillier constructions, cubic of stationary curvature, ball's point, applications in dwell mechanisms

Graphical synthesis of planar mechanisms: type, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, center point and circle point curves, Bermester points, synthesis for five accuracy points, branch and order defects, synthesis for path generation

Analytical synthesis of planar mechanisms:- analytical synthesis of four-bar and slider- crank mechanism, Freudenstein's equation, synthesis for four accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers. complex numbers method of synthesis, the dyad, center point and circle point circles, ground pivot specifications, three accuracy point synthesis using dyad method, Robert Chebychev theorem, cognates kinematic analysis of

Spatial mechanisms: Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

References

1. *A. Ghosh and A.K.Mallik, Theory of Machines and Mechanisms, Affiliated East- West Press.*
2. *R. S. Hartenberg and J. Denavit, Kinematic Synthesis of Linkages, McGraw-Hill.*
3. *A. G. Erdman and G. N. Sandor, Advanced Mechanism Design - Analysis and Synthesis (Vol.1 and 2), Prentice Hall of India.*
4. *J. E. Shigley and J. J. Uicker, Theory of Machines and Mechanisms, 2nd Ed., McGraw-Hill.*
5. *Robert L. Norton, Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Tata McGraw-Hill, 3rd Edition.*
6. *A.S. Hall, Kinematics and Linkage Design, Prentice Hall of India*

MME7: Advanced Thermodynamics

Equation of state, state postulate for simple system and equation of state, ideal gas equation, deviation from ideal gas, equation of state for real gases, generalized compressibility chart, law of corresponding states

Properties of pure substances, phase change process of pure substances, PVT surface, P-V & T - t diagrams, use of steam tables and charts in common use

Laws of thermodynamics, 2nd law analysis for engineering systems, entropy flow & entropy generation, increase of entropy principle, entropy change of pure sub, t-ds relations, entropy generation, thermo electricity, Onsager equation, exergy analysis of thermal systems, decrease of exergy principle and exergy destruction

Thermodynamic property relations, partial differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp, Joule Thomson coefficient, Δh, Δu, Δs of real gases

Chemical thermodynamics, chemical reaction - fuels and combustion, enthalpy of formation and enthalpy of combustion, first law analysis of reacting systems, adiabatic flame temperature
Chemical and phase equilibrium - criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about kp of ideal-gas mixtures, fugacity and activity, simultaneous relations, variation of kp with temperature, phase equilibrium, Gibb's phase rule, third law of thermodynamics, Nerst heat theorem and heat death of universe

Gas mixtures – mass & mole fractions, Dalton's law of partial pressure, Amagat's law, Kay's rule

Statistical thermodynamics- fundamentals, equilibrium distribution, significance of Lagrangian multipliers, partition function for canonical ensemble, partition function for an ideal monatomic gas, equipartition of energy, Bose Einstein statistics, Fermi- Dirac statistics

References

1. *Cengel, Thermodynamics, TMH*
2. *Howell & Dedcius: Fundamentals of engineering Thermodynamics, McGraw Hill, Inc, USA*
3. *Van Wylen & Sontag: thermodynamics, John Wiley & Sons, Inc., USA*
4. *Holman, Thermodynamics, 4th edition, McGraw Hill*
5. *Zimmansky & Dittman, Heat and Thermodynamics, 7th edition, TMH*
6. *Rao, Y.V.C., Postulational and Stastistical thermodynamics, Allied Pub. Inc.*
7. *Jones and Hawkings: engineering Thermodynamics, john Wiley & Sons, Inc. USA*
8. *Faires V. M. and Simmag: Thermodynamics. McMillan Pub. Co. Inc. USA*
9. *Turns, Thermodynamics- Concepts and Applications, Cambridge University Press*
10. *Wark, Advanced Thermodynamics, McGraw Hill*
11. *Nag P.K., Basic & Applied Thermodynamics, TMH, New Delhi.*
12. *Jones & Dugan, Advanced Thermodynamics, Prentice Hall Int.*
13. *Bejan, Advanced Thermodynamics, John Wiley, Inc.*

MME8: Advanced Heat Transfer

Overview of the subject of heat transfer with orientation to applications, the various boundary conditions, analytical solutions for temperature distribution, concept of thermal resistance, contact resistance, problems related to anisotropic materials, numerical methods for fin analysis

Transient conduction: lumped capacitance and its validity, general lumped capacitance analysis, spatial effects. Problems related with conventional geometries, principle of fluid flow and convective heat transfer

Concept of velocity and thermal boundary layers: laminar and turbulent flow, Navier-stokes equations and convection equation, boundary layer approximations and special conditions, boundary layer similarity, the normalized convection transfer equations, dimensionless parameters & physical significance, Reynolds analogy, Chilton-Colburn analogy

Forced convection (external flow) empirical method, flat plate in parallel flow, the Blasius solution (highlights only), local and average Nusselt number calculations, mixed boundary layer considerations

Forced convection (internal flow) laminar flow in a pipe, friction factor, thermal considerations, mean temperature, constant heat flux and constant wall temperature, thermal analysis and convection correlations for laminar flow in circular tubes, evaluation of Nusselt number, Marcos and Bergles correlation

Convection correlations: turbulent flow in circular tubes, for non-circular tubes, heat transfer enhancement, passive, active and compound techniques

Free convection: physical considerations, governing equations, similarity considerations. Laminar free convection on a vertical surface, effects of turbulence, empirical correlations for external free convection flows for various geometries and orientations, free convection within parallel plate channels, empirical correlations for enclosures, mixed convection, boiling and condensation boiling modes, the boiling curve, modes of pool boiling, correlations

Forced convection boiling, two phase flow, condensation: physical mechanisms, laminar film condensation on a vertical plate, turbulent film condensation, film condensation on radial systems, film condensation in horizontal tubes, on banks of tubes, dropwise condensation correlations

Thermal radiation fundamental concepts, radiation intensity: relation to emission, irradiation and radiosity, black body radiation and associated laws, spherical and hemispherical properties, environmental radiation, radiation exchange between surfaces, the view factor, black and gray surfaces, network method, reradiating surfaces, multimode heat transfer, gaseous emission and absorption

Cooling of electronic equipment introduction: manufacturing, chip carrier, PCN’s, the enclosure, cooling load of electronic equipment, thermal environment, electronics cooling in different applications, conduction cooling, conduction in chip carriers and PCB’s. Heat frames, air cooling, cooling of PC’s, liquid cooling, immersion cooling, ablative , transpiration and high speed cooling

References

1. *Incropera and Dewitt, Fundamentals of heat and mass transfer, John Wiley and sons.*
2. *Yunus Cengel, Heat transfer - a practical application, Tata McGraw Hill.*
3. *M.N. Ozisik, Heat transfer a basic approach, McGraw Hill Int.*
4. *A Bejan, Convective heat transfer, John Wiley and sons.*
5. *J.P. Holman- Heat transfer, McGraw Hill, Int.*
6. *S.P. Sukhatme, Heat transfer, University Press*

MME9: Advanced Fluid Mechanics

Governing equations: mass conservation in differential and integral forms, flow kinematics, and momentum equation: substantial derivative, differential and integral form, stress tensor, stress strain relations, ideal fluid flow concepts

Navier-Stokes equations: special forms: Euler equations, Bernoulli equation, stream function, vorticity

Exact solutions: fully developed flow in channel, pipe, flow between concentric rotating cylinders, Couette flow, stokes first problem (unsteady flow), creeping flow past a sphere, cylinder

Boundary layers: boundary layer assumptions, equations, flow over a flat plate, similarity (Blasius) solution, Falkner-Skan equation, momentum integral method, external flows: drag, lift, flow separation

Turbulent flow: introduction to hydrodynamic stability, characteristics of turbulence, governing equations, turbulent boundary layer, algebraic models (Prandtl's mixing length), velocity profile over a flat plate and in pipes.

Turbulent shear flows: equations for free shear layers: mixing layer, plane and axisymmetric jet, wake, turbulent energy equation, two equation model (k-epsilon), large eddy simulation, various turbulent models

Compressible flow: one-dimensional flow: speed of sound, variable cross-section flow, converging diverging nozzle, effect of friction and heat transfer, normal shock relations, introduction to oblique shocks, 2-dimensional flows(subsonic and supersonic) past slender bodies, compressible boundary layers.

References

1. *G. Biswas and K. Muralidhar, Advanced Fluid Mechanics*
2. *F. M. White, Viscous Fluid Flow*
3. *H. Schlichting, Boundary Layer Theory*
4. *Cengel, Fluid Mechanics, Tata McGraw Hill*

MME10: Computational Fluid Dynamics

Introduction to CFD, historical background, impact of CFD

The governing equations of fluid dynamics, derivation, discussion of physical meanings and presentation of forms particularly suitable to CFD

Mathematical behavior of partial differential equations: impact on CFD

Basic aspects of discretization: introduction to finite difference, finite elements and finite volume methods, detailed treatment of finite difference method, explicit and implicit methods, errors and stability analysis

Grids with appropriate transformations, adaptive grids and unstructured meshes

A Few CFD Techniques
The Lax-Wendroff Technique, MacCormack's technique, space marching, relaxation technique, numerical dissipation and dispersion, artificial viscosity, the ADI technique, pressure correction technique: application to incompressible viscous flow, the SIMPLE algorithm

Numerical solutions of quasi-one-dimensional nozzle flows

Numerical solution of a 2D supersonic flow, Prandtl-Meyer expansion wave

Incompressible Couette flow, solution by implicit method and the pressure correction method

Supersonic flow over a flat plate, numerical solution by solv*i*ng complete Navier Stokes equation

References

1. *John D. Anderson Jr, "Computational Fluid Dynamics-The Basics with Applications", Mcgraw Hill. Inc.,*
2. *Fletcher C.A.J. "Computational Techniques for Fluid Dynamics", Volumes I and II, Springer, Second Edition [2000]*
3. *C. Hirsch, "Numerical Computation of Internal and External Flows", Volumes I and II, John Wiley & Sons [2001]*

MME11: Refrigeration Technology

Vapour Compression refrigeration: Multi-evaporator system; Multi expansion system; Cascade systems; Study of P-h; T-s; h-s and T-h charts for various refrigerants, Concept of Heat Pump

Refrigerant: Designation, selection, desirable properties, refrigerant blends, secondary refrigerants, refrigerant recycling, reclaim and charging, alternative refrigerants, refrigerant-lubricant mixture behavior, ODP, GWP concepts

Vapour absorption refrigeration: Standard cycle and actual cycle, thermodynamic analysis, Li-Br-water, NH3-water systems, three fluid absorption systems, half effect, single effect, single-double effect, double effect, and triple effect system

Non-convention refrigeration system (Principle and thermodynamic analysis only): Thermoelectric refrigeration, thermo-acoustic refrigeration, adsorption refrigeration, steam jet refrigeration, vortex tube refrigeration, and magnetic refrigeration.

Compressor rating and selection- reciprocating, screw, Scroll and centrifugal compressors based on applications

Evaporators: types, thermal design, effect of lubricants accumulation, draining of lubricants, selection and capacity control

Condenser: types, thermal design, purging, selection and capacity control

Selection of expansion devices, Design of refrigerant piping refrigeration system controls and safety devices, Solenoid valves, suction and evaporator pressure regulators, Thermal Insulation

Motor selection: single phase, three phase, starters, constant speed and variable speed drive

Associated devices: high pressure receiver thermal design of low pressure receiver, accumulator, filters, driers, oil separators, relief valves, safety valves, high and low pressure cut out, thermostats, water regulators etc.

Case studies to be dealt with selection and design of various components for various Industrial refrigeration applications: Cold storage, Process applications - textile, pharmaceuticals, chemical, transport, etc.

(* Question Paper- 50% to 60% of maximum marks are kept for the questions asked on System Design and not any theory)

References

1. *R.J. Dossat, Principles of refrigeration, Pearson Education Asia*
2. *C.P. Arora, Refrigeration and Air-Conditioning*
3. *Stoecker and Jones, Refrigeration and Air-conditioning*
4. *Jordan and Priester, Refrigeration and Air-conditioning*
5. *A.R. Trott, Refrigeration and Air-conditioning, Butterworths*
6. *J.L. Threlkeld, Thermal Environmental Engineering, Prentice Hall*

7. *W.F. Stoecker, Industrial Refrigeration Handbook, McGraw-Hill*
8. *John A. Corinchock, Technician's guide to Refrigeration systems, McGraw-Hill*
9. *P.C. Koelet, Industrial Refrigeration: Principles, design and applications, Mcmillan*
10. *ASHRAE Handbook (i) Fundamentals (ii) Refrigeration*
11. *ISHRAE handbooks*
12. *ARI Standards*
13. *Refrigeration Handbook, Wang, Mc Graw Hill, Int.*

MME12: Advanced Gas Dynamics

Review of Elementary Principles, Mathematical Concepts, Thermodynamic Concepts for Control Mass Analysis

Control Volume Analysis, Flow Dimensionality and Average Velocity, Transformation of Material Derivative to a Control Volume Approach, Conservation of Mass, Conservation of Energy, Comments on Entropy, Pressure-Energy Equation, The Stagnation Concept, Stagnation Pressure-Energy Equation, Consequences of Constant Density

Introduction to Compressible Flow, Sonic Velocity and Mach Number, Wave Propagation, Equations for Perfect Gases in terms of Mach Number, h-s and T-s Diagrams

Varying Area Adiabatic Flow, General Fluid Flow without Losses, Perfect Gas Flow with Losses, The * reference concept, Isentropic Table, Nozzle operation and performance, Diffuser performance

Standing Normal Shocks, Shock analysis for a general fluid, Working equations for perfect gases, Normal Shock table, Shocks in Nozzles, Supersonic wind tunnel

Moving and Oblique Shocks, Normal velocity superposition: Moving normal shocks, tangential velocity superposition: Oblique shocks, oblique shock analysis of perfect gas, oblique shock table and charts, Boundary condition of flow direction, Boundary condition of pressure equilibrium, Conical shocks

Prandtl-Meyer Flow, Argument for isentropic turning flow, Analysis of Prandtl–Meyer flow, Prandtl-Meyer function, overexpanded and underexpanded nozzles, supersonic airfoils

Fanno Flow, Analysis for a General fluid, Working equations for perfect gases, reference state and Fanno table, applications, correlation with shocks, friction chocking

Rayleigh Flow, Analysis for a general fluid, Working equations for perfect gases, reference state and Rayleigh table, applications, correlation with shocks, thermal chocking due to heating

Real Gas Effects, Behavior of real gases, Equations of states and compressibility factors, semiperfect gas behavior

References

1. *Zucker R. D. and Biblarz Oscar, Introduction to Gas Dynamics, John Wiley and Sons. Inc., Second Edition, 2002*
2. *A. H. Shapiro, Dynamics and Thermodynamics of Compressible Fluid Flow, MIT Press.*
3. *Zucrow, Gas Dynamics, Vol I*

MME13: Advanced Air Conditioning, Heating and Ventilation

Applied Psychrometry, Psychrometric processes using chart

Load Estimation: solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations: Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design conditions

Air Distribution: Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers, etc. VAV

Sound Control: Definitions of various terms like level, pitch, attenuation, frequency, sources of noise in air conditioning plants, design procedure for noise prevention, noise and vibration study and elimination techniques (description only).

Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure

Direct and Indirect Evaporative Cooling: Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations, indirect evaporative cooling for tropical countries

Air Conditioning Equipments and Controls: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers, various types of filters, air washers, thermostat, humidistat, cycling and sequence controls, modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, BMS applications. Cooling Towers

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms (descriptive treatments only). VRF

Standards and Codes: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes
(* Question Paper- 50% to 60% of maximum marks are kept for the questions
asked on System Design and not any theory.)

References

1. *ASHRAE Handbooks*
2. *ISHRAE Handbook.*
3. *Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.*
4. *Trane air conditioning manual,*
5. *Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.*
6. *Norman C. Harris, Modern air conditioning*
7. *Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.*
8. *Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984*

9. *Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.*
10. *C P Arora, Refrigeration and Air conditioning, Tata McGraw Hill Publication, New Delhi.*
11. *McQuiston, Faye, Parker, Jerald, Spitler, Jeffrey, 2000, Heating, Ventilating and Air Conditioning-Analysis and Design, 5th ed. John Wiley & Sons*

MME14: Elective - Internal Combustion Engines

Measurement & Testing: Introduction, engine performance parameters, measurement and testing, engine operating characteristics, performance maps

Engine Materials: Various engine components, cylinder head, spark plug, gaskets, cylinder block, piston, piston rings, gudgeon pin, connecting rod, crankshaft, bearings, crankcase, fuel injector

Engine Design: Preliminary analysis, cylinder number, size and arrangement, experimental development
Electronic Injection System: Gasoline injection, EFI system, MPFI system, electronic control system, injection timing, electronic diesel injection system and control

Engine Emissions & Control: Air pollution due to IC engines, norms, engine emissions, HC, CO, NOx, particulates, other emissions, emission control methods, exhaust gas recirculation, modern methods, crankcase blow by

Simulation Technique: Application of simulation technique for engine tuning, engine selection parameters, recent trends in IC engines

References

1. *Charles Fayette Taylor, The Internal Combustion Engine- Theory and Practice, Vol. I & II, The MIT Press*
2. *V Ganesan, Internal Combustion Engines, 2nd edition, Tata McGraw Hill*
3. *Jack Erjavec, Automotive Technology, 3rd edition, Delmar Thomson Learning*
4. *Gordon P Blair, Design and Simulation of four stroke engines, SAE International*
5. *Gasoline Engine Management, Bosch handbook, 2nd edition, Professional Engineering Publication*
6. *C.R. Ferguson & A.R. Kirkpatrick, Internal Combustion Engines, Tata McGraw Hill, 2001*

MME15: Advanced Physical and Mechanical Metallurgy

Microstructure & Properties: solidification and solidification structures, interfaces, crystallographic texture, residual stress, structure-property relations.

Plasticity and work hardening: fundamentals, stress-strain behavior, fracture, creep & deformation mechanisms. Recovery, recrystallization, grain growth

Phase transformation: thermodynamic basics, nucleation and growth, spinoidal decomposition, martensitic transformations

References

1. *T.H. Courtney, Mechanical Behavior of Materials, McGraw-Hill, 2nd Ed., 2000.*
2. *R.W. Cahn, P. Haasen and E.J. Kramer, (Eds.), Materials Science and Technology: A Comprehensive Treatment, VCH, Weinheim, Germany, 1993.*
3. *R.E. Smallman and A.H.W. Ngan, Physical Metallurgy & Advanced Materials, 7th Ed., Elsevier, 2007.*
4. *J.W. Martin, R.D. Doherty and B. Cantor, Stability of Microstructures in Metallic Systems, 2nd Ed., Cambridge University Press, UK, 1997.*
5. *D.A. Porter. and K.E. Easterling, Phase Transformations in Metals and Alloys, Van Nostrand Reinhold, UK, 1986.*
6. *C.R. Calladine, Plasticity for Engineers – Theory and Applications, Horwood, Chichester, England, 2000.*
7. *B. Verlinden, J. Driver, I. Samajdar, R.D. Doherty, Thermo-Mechanical Processing of Metallic Materials, Pergamon Materials Series, Series Ed. R.W. Cahn, Elsevier, Amsterdam, 2007.*

MME16: Industrial Automation

Automation strategy, Plant wide control systems and Automation strategy, Evolution of instrumentation and control, Role of automation in industry, Benefits of automation, Introduction of automation tools PLC, DCS, SCADA, Hybrid DCS/PLC, Automation strategy evolution, control system audit, performance criteria, development of user requirement specification (URS) for automation, Functional design specifications (FDS) for automation tools

PLC, Advance applications of PLC, PLC programming methods as per IEC 61131 , PLC applications for batch process and Process using SEC, Analog control using PLC, PLC interfacing to SCADA/DCS using communications links ,Industrial Ethernet

Distributed control systems
Distributed control systems: DCS introduction, functions, advantages and limitations, DCS as an automation tool to support Enterprise resource planning, DCS component block diagram, Architecture of different makes, DCS Specifications, Latest trends and developments, performance criteria for DCS and other automation tools. SCADA specifications for different real time applications

Numerical control machines, fundamentals of numerical control including system concept, Design features of NC and CNC machines, Devices: drivers, servomechanism, tooling specifications, feedback components, positioning control, &countering pattern

CNC, CNC concepts, principle of operation of CNC, steps in manufacturing, construction features including drivers and structures, Advantages and limitations of CNC, axis of CNC machines, CNC programming using G codes, use of subroutines, computer aided part programming using APT programming, 2D and 3D integration and programming from CAD models and data banks. Multiple channel concepts, PLC selection, CNC selection guidelines Absolute and incremental encoders, Interface

Sourcing, sinking of PNP/ NPN digital input, outputs, PLC scan, synchronous & asynchronous events, fast acting I/O modules, sequence logic, step logic, FCs, FBs concept

References

1. *The management of control system Justification & Technical auditing,N E Britannica, ISA*
2. *S.K.Singh, Computer Aided process control, Prentice Hall of India*
3. *Webb & Ries, Programmable Logic controllers, Prentice Hall of India*
4. *Garry Dunning, Introduction of PLC, Thomas learning*
5. *Distributed control systems for Industrial Automation Popovik Bhatkar, Prentice Hall of India*
6. *Krishna Kant, Computer based process control, Prentice Hall of India*
7. *Ibrahim Zeid, CAD/ CAM- Theory and Practice*
8. *Ramamurthy V, Computer aided mechanical design & analysis*

MME17: Microcontrollers

Introduction to 8 bit architecture, memory and I/O interfacing, Introduction to software and hardware tools (Cross assembler, Logic analyzer, Emulator, Simulator)

8051 architecture, comparison with microprocessor, Pin diagram, clock and oscillator, flags, PSW, Stack, Internal Memory, External Memory, Idle mode, Power down mode, SFR counter, timer, timer mode, serial I/O, and interrupt structure

Programming, Instruction set, addressing mode and programming of 8051. Interfacing to external world, external RAM and ROM, Display (LED/LCD) and key board, ADC and DAC, memory Interfacing, Stepper motor, I^2C compatible, PIC Controllers

Architecture of PIC microcontrollers, features, interfacing of I/O devices with PIC controllers. PIC 16c6x, 16c7x. PIC memory organization

Introduction to ARM controllers, Comparison between RISC & CISC processor, Versions & variants of ARM processor, Register model of ARM processor, Modes of operation, Applications of ARM processor

Buses and protocols, RS 232 C, RS485, I2C, SPI, Modbus, Derivatives of microcontroller, Conceptual Study of various derivatives of 8051 microcontroller such as RD, OTP, AVR, containing PWM, RTC, Timer, EEPROM, in system programming

References

1. *Kennith Ayala, 8051 Microcontroller, Thomas Learning.*
2. *Predko, Programming and customizing 8051 microcontroller, TMH.*
3. *Peatman, Programming PIC microcontrollers, Pearson Education*
4. *A.V.Deshmukh, Microcontrollers Theory & Applications, McGraw Hill*
5. *Rajkamal, Microcontrollers, Architecture &Programming, Pearson Education*
6. *M.A.Mazidi & J.G.Mazidi, The 8051 Microcontroller & Embedded systems, PHI.*
7. *Arm Processor Hand book, Dominic Symens*

MME18: Drives & Actuators

Introduction to Electric motors, Solid state motors devices: SCR, TRIAC, MOSFET, IGBT and their characteristics. Introduction to converters, Inverters, Choppers, cycloconverters

Mechanical characteristics, constant torque and constant HP applications, four quadrant operation, rating of motors, selection of Drives

Single phase and three phase converters fed drives. DC Brushless (BLDC) conduction modes (continuous and discontinuous), Operation of drives, Gate drive circuits, performance parameters of converters, Chopper fed drives: Introduction, principle and modes of operation (four quadrant mode of operation), Types of chopper, closed loop drives. Self-tuning

Stator & rotor control Drives, V/F control: Principle of operation. VSI & CSI fed drives. Braking methods for induction drives. Rotor resistance control, Slip power recovery scheme, Comparison of induction motor with servo motor, DC motor to DC Brushless, commutation- physical versus Electronic, Pneumatic/ Hydraulic valves, control elements, Actuator and drive selection Intelligent drive.

Stepper motor- Driver circuit – control algorithm – PID Laws- self tuning strategies

Types of actuators, electromechanical actuators, rotary output actuators, Linear output actuators, Electro hydraulic actuators, smart actuators, Electro pneumatic actuators, solenoid valves, Features &selection criteria for actuators, spring/Diaphragm actuators, piston actuators.

Types of valves, Ball valve, butterfly valve, digital valves, valves applications, selection criteria for valves, valve sizing

The drive perspective, Hall Resolver, pulse coder

References

1. *Sen P.C., Thyristorised D.C. Drives, John Wiley & sons.*
2. *Murphy J.M.D. & Turnbull F.G., Thyristor control of AC Motors, Pergamon press.*
3. *B.K.Bose, Power Electronics & A.C. Drives, Prentice Hall Publication.*
4. *M.Rashid, Power Electronics, Tata Mc GRAW Hill Publications.*
5. *Dubey G.K., Power semiconductor Drives, Prentice Hall Publication.*
6. *N.K.De and P.K.Sen, Electric Drives , Prentice Hall Publication.*
7. *Liptak manual, Process Control*