MEPG 101: Advanced Engineering Mathematics [3-2-0]

Vector and Tensor Analysis (Cartesian and Curvilinear): Orthogonal coordinate systems, Transformation of coordinate systems.
Review of ODEs; Laplace & Fourier methods, series solutions, and orthogonal polynomials. Sturm-Liouville problem, Review of 1st and 2nd order PDEs. Similarity transformations for converting PDEs to ODEs.
Linear systems of algebraic equations, Gauss elimination, LU decomposition etc., Gram-Schmidt orthogonalization. Matrix inversion, ill-conditioned systems. Numerical eigen solution techniques (Power, Jacobi, Given, Householder, and QR methods).
Numerical solution of systems of nonlinear algebraic equations; Newton-Raphson method. Numerical integration: Newton-Cotes methods, error estimates, Gaussian quadrature, Numerical integration of ODEs: Euler, Adams, Runge-Kutta methods, and predictor-corrector procedures; stability of solutions; solution of stiff equations. Solution of PDEs: finite difference techniques.
Functions of Complex Variable: analytic functions and mapping.
Probability and Statistics – Probability Distribution, Bays Theorem, Random numbers, Parameter Estimation, Testing of Hypothesis, Goodness of Fit.

Books:

1. I.N. Sneddon, ***Elements of Partial Differential Equations***, McGraw-Hill, 1957.
2. F.B. Hilderbrand, ***Introduction to Numerical Analysis***, Tata McGraw-Hill, 1974.
3. W.E. Boyce and R.C. Diprima, ***Elementary Differential Equations and Boundary Value Problems***, Wilet, 1977.
4. E. Kreyzig, ***Advanced Engineering Mathematics***, New Age International, 1996.
5. M.K. Jain, S.R.K. Iyenger and R.K. Jain, ***Computational Methods for Partial Differential Equations***, New Age International, 1994.
6. R. Courant and D. Hilbert, Methods of Mathematical Physics, Wiley, 1989.
7. Louis A. Pipes and Lawrence R. Harvill, ***Applied Mathematics for Engineers and Physicists***, McGraw-Hill International Edition, 1970.
8. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, 'Numerical Methods for Scientific and Engineering Computation', 3rd edition, 1993, New Age International.
9. D. S. Watkins, 'Fundamentals of Matrix Computations', 1992, John Wiley.

MEPG 102: Advanced Engineering Thermodynamics [3-2-0]

Unit-I

Review of first and second law of thermodynamics, Maxwell equations, Joule-Thompson experiment, irreversibility and availability, exergy analysis, phase transition, types of equilibrium and stability, multi-component and multi-phase systems, equations of state, chemical thermodynamics, combustion. Third law of thermodynamics

Unit-II

Kinetic theory of gases- introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equipartition of energy, classical theory of specific heat capacity.

Unit-III

Transport phenomena-intermolecular forces, The Van der Waals equation of state, collision cross section, mean free path

Unit-IV

Statistical thermodynamics- introduction, energy states and energy levels, macro and microscales, thermodynamic probability, B-E, F-D, M-D statistics, distribution function, partition energy, statistical interpretation of entropy, application of statistics to gases-mono-atomic ideal gas, distribution of molecular velocity, ideal gas in a gravitational field.

Unit-V

Entropy flow and generation, Onsagar reciprocal relation, Phenomenological laws. Thermodynamic force, Verschaffelts superposition principles, Continuity equation of entropy, Entropy generation in control volume, in electrical energy flow, in heat and mass flow, in chemical reaction, total entropy generation.

References

1. F.W.Sears and G.L.Salinger, ***Thermodynamics, Kinetic Theory And Statistical Thermodynamics***, Narosa Publishing House, New Delhi.
2. Wylen, Sonntag and Borgnakke, ***Fundamentals of Classical Thermodynamics***, Wiley Eastern Limited, New Delhi.
3. M.J.Moran and H.N.Shapiro, ***Fundamentals Of Engineering Thermodynamics***, John Wiley and Sons.
4. Zemansky, ***Engineering Thermodynamics***, Mc Graw Hill.
5. Bejan, **Advanced Engineering Thermodynamics**, John Wiley and sons.

MEPG 103: Advanced Fluid Mechanics [3-2-2]

Fluid kinematics; Integral and differential forms of governing equations; Mass, momentum, and energy conservation equations; Navier-Stokes equations and its applications; Potential flow; Laminar boundary-layer; Free-shear flows: jet, wake, and mixing layer; Instability and transition; Turbulent flow; Compressible flow: Isentropic flow; flow with area change; flow with heat transfer; flow with friction.

Texts:

1. B.R.Munson, D.F.Young and T.H.Okiishi., **Fundamental of Fluid Mechanics,** John Wiley and Sons., 1994.
2. P.M.Gerhar, R.J.Gross and J.I.Hochstein., **Fundamentals of Fluid Mechanics,** Addison-Wesley Publishing Co., 1993
3. H.Schlichting, **Boundary Layer Theory**, Mc-Grawhill Series in Mechanical Engineering, 1979
4. F.M.White, **Fluid Mechanics,** Mc.Grawhill international editions., 1994.
5. F.M.White, **Viscous Fluid Flow,** Mc.Grawhill international editions., 1991

MEPG 104: FINITE ELEMENT METHODS [3-2-0]

Fundamental Concepts: The finite element analysis – Introduction, strain-displacement relations, Theory of stress and deformation, relation between stress-strain, temperature effects, Finite element analysis of an elastic continuum – displacement approach, plane stress and plane strain, generalization of finite concepts, Galerkin's – weighted Residual and variational approaches, Potential energy and equilibrium – the Rayleigh-Ritz methods.

Element Types: Triangular, Rectangular, CST, Quadrilateral, Isoperimetric elements, higher-order elements and Numerical integration.

One Dimensional Problem: Introduction, FEM modeling, Discretization, Co-Ordinates and shape functions, Assembly of the Global Stiffness Matrix and Load Vector.

Truss Problem: Introduction, Plane Truss (Determinate and Indeterminate), Local and Global co-ordinate system, Element stiffness matrix, stress calculations, Temperature effects.

FEM Applications: Steady state field problems – Heat Conduction, fluid flow, Finite elements in dynamics and vibration problems- Formulations using Hamilton's principle, Dynamic equation, Mass thickness and Damping, Axisymmetric Stress Analysis, Torsion problems, Brief introduction to 3D stress analysis.

Preprocessing and post-processing: Introduction, Mesh Generation.

Reference books:

1. The Finite Element Methods by O C Zienkiewicz, TMH Edition.
2. Finite Element Procedures for Engg. Analysis by K J Bathe, PHI, Eastern Economic Edition.
3. Introduction to Finite Element Methods by Abel and Desai, CBS Publishers.
4. Concepts and Applications of finite elements analysis by Robert Cook, J Wiley

MEPG 105: Material Characterization Techniques [3-0-3]

Unit-I

X-Ray Techniques: Elements of Crystallography, Principles of X-ray diffraction, X-ray equipment and data analysis; associated techniques in X-ray spectroscopy;

Unit-II

Fundamentals of elemental analysis. Optical/Electron Microscopy Techniques: Specimen preparation techniques for optical and electron microscopy in metallurgy. Elements of phase identification, grain size determination, inclusion analysis, Image analysis, etc. Electron diffraction, SEM, Failure analysis and fractography, EDAX / EPMA, data analysis.

Unit-III

Neutron Scattering Techniques: Diffraction, inelastic scattering and reflectometry.

Unit-IV

Thermal Analysis: Principles and applications of thermal analysis; DTA, DSC, TGA, TMA, DMA, etc.

Unit-V

Mechanical Property characterization: Principles and characterization techniques related to Tensile, compressive, hardness, fatigue, and fracture toughness properties. Deformation, Super-plasticity.

Texts:

1. **Materials characterization, Vol. 10**, ASM hand book, 1997 ,
2. B. D. Cullitey, **Elements of X-ray diffraction**, Addison-Wesley, 1968.
3. G. Dieter, **Mechanical Metallurgy**, Mc-Graw Hill, 1996.
4. **ASTM handbook**, vol. 3, 1997.
5. R.F. Speyer, **Thermal Analysis of Materials**, Marcel Decker, 1994

Syllabus

Subject: MEPG 312 - HEAT EXCHANGER DESIGN

1. **Classification of heat exchanger**: General classifications, Applications, Selection of heat exchangers.
2. **Basic design methods of heat exchangers**: Arrangement of flow path, basic equations of design, overall heat transfer coefficient, the LMTD method for heat exchanger analysis, the ε – NTU method for heat exchanger analysis, heat exchanger design calculation, variable overall heat transfer coefficient, heat exchanger design methodology.
3. **Forced convection correlations for single – phase side of heat exchangers**: Laminar forced convection, the effect of variable physical properties; Turbulent forced convection, turbulent flow in smooth straight non-circular ducts, effect of variable physical properties in turbulent forced convection, summary of forced convection in straight ducts, heat transfer from smooth – tube bundles, heat transfer in helical coils and spirals, heat transfer in bends.
4. **Heat Exchanger Pressure Drops and Pumping Power**: Tube – side pressure drop, pressure drop in tube bundles in cross-flow, pressure drop in helical and spiral coils, pressure drop in bends and fittings, pressure drop for abrupt contraction, expansion and momentum change, heat transfer and pumping power relationship.
5. **Fouling of Heat Transfer**: Basic considerations, effects of fouling, aspects of fouling, design of heat exchangers subject to fouling, operations of heat exchangers subject to fouling, techniques to control fouling.
6. **Double Pipe Heat Exchangers**: Thermal and hydraulic design of inner tube, thermal and hydraulic analysis of annulus, parallel and series arrangement of hair pins, total pressure drops, design and operational features.
7. **Design Correlations for Condensers and Evaporators:** Condensation, film condensation on a horizontal tube, film condensation on tube bundles, condensation inside tubes, flow boiling.
8. **Shell and Tube Heat Exchangers:** basic concepts, basic design procedure, shell side heat transfer and pressure.
9. **Compact Heat Exchangers:** Introduction, heat transfer and pressure drop.
10. **Gasketed Plate Heat Exchanger:** Mechanical features, operational characteristics, passes and flow arrangements, applications, heat transfer and pressure drop calculations, thermal performance.
11. **Condensers and Evaporators:** Shell and tube condensers – horizontal shell side, vertical shell side, vertical tube side and horizontal intube. Steam turbine exhaust condensers, plate condensers, air-cooled condensers, direct contact condensers. Thermal design of shell and tube condensers, design and operational conditions, Condensers for refrigeration and air-conditioning, Thermal analysis – Shah correlation, Kandilkar correlation, Gungor and Winterton correlation.

References:

1. Heat Exchangers – Selection, Rating and Thermal Design by S Kakaç, Hongtan Liu, CRC Press, Boca Raton.
2. Heat Exchanger design by
3. Heat and Mass Transfer – by Arora & Domkundwar

MEPG 106 Theory of Machining [4-2-1]

Chapter I: Machining, definition and objectives. Geometry of cutting tools; turning, milling and drilling - in different reference systems like machine reference system, tool reference system and work reference system. Sharpening and re-sharpening of cutting tools.

Chapter II: Mechanism of chip formation by single point tools, drills and milling cutters. Types of chips and their characteristics. Effective rake.

Chapter III: Mechanics of machining, theoretical estimation and experimental determination of cutting forces and power consumption. Dynamometers; types, design, construction and use.

Chapter IV: Thermodynamics of machining, sources of heat generation, cutting temperature modeling, measurement of cutting temperature. Cutting fluids; purpose, essential characteristics, selection and methods of application.

Chapter V: Cutting tools; methods of failure, mechanics of tool wear, essential properties, assessment of tool life and cutting tool materials.

Chapter VI: Economics of machining; principal objectives, main parameters and their role on cutting forces, cutting temperature, tool life and surface quality, selection of optimum combination of parameters.

Chapter VII: Causes of vibration and chatter in machining and their remedy.

Books & References

1. *Metal cutting: Theory & Practice* by Amitabha Bhattacharyya
2. *Manufacturing Science* by Ghosh and Mallik
3. *Metal cutting* by E. M. Trent
4. *Fundamentals of machining and machine tools*: Geoffrey Boothroyd