Structure of the Comprehensive Examination in the ME Department

For circulation to students

i. The exam will have a written and an oral part. The written exam will be conducted three times in a year.

ii. The dates of written examination will be announced by Convener, DPGC.

iii. The candidate has to opt for appearing in two subjects out of Mathematics, SMD, FTS, MFS, RA for which the syllabus is provided below.

Syllabi

Fluid Mechanics and Thermal Sciences

Engineering Thermodynamics (standard as per ESO201A):

Thermodynamics equilibrium, First law of thermodynamics, Steady state and steady flow process, Second law of thermodynamics, Availability, Power cycles, Refrigeration and air conditioning cycles. Pure substance, Ideal and real gas equation of state, Compressibility Chart, Combustion of fossil fuels, Adiabatic flame temperature, Chemical equilibrium.

Fluid Mechanics (standard as per ME231A and ME631A):

Basics of fluids mechanics and fluid properties, Continuum, Fluid deformation, Reynolds Transport Theorem, Integral form of continuity, Momentum and energy, Eulerian and Lagrangian view points, Constitutive relations, Navier Stokes equation, Exact solutions for simplified cases, Boundary layer theory. Separation and drag, Turbulent flow, Reynolds averaged equations, Flow in pipes and channels, Friction factor.

Heat and Mass Transfer (standard as per ME341A, ME641A and ME642A):

Conduction: 1D & 2D steady state conduction with and without heat sources, 1D & 2D transient conduction, Convection: Velocity, thermal and concentration boundary layers, Heat transfer in external flows, Heat transfer in internal flows, Turbulent heat transfer, Free convection, Heat Exchangers, Radiation: Black body radiation, Grey surface enclosure, Boiling and condensation

Textbooks:

Engineering Thermodynamics:

Fundamentals of Thermodynamics: Sonntag and Borgnakke

Fluid Mechanics:

Fluid Mechanics by F.M. White, 7th Edition, McGraw Hill Education India Private Limited
Viscous Fluid Flow by F.M. White, 3rd Edition, McGraw Hill Education India Private Limited

Heat Transfer:

Heat Transfer by P.S. Ghoshdastidar, Oxford University Press, 2nd Edition, 2012
Fundamentals of Heat and Mass Transfer by Incropera and DeWitt, Wiley, 6th Edition, 2010

Additional References:

Engineering Thermodynamics:

Thermodynamics: An Engineering Approach: Yunus A. Cengel, Michael A. Boles

An Introduction to Combustion: Concepts and Applications: Stephen R. Turns

Fluid Mechanics:

Fluid Mechanics, Streeter-Wylie, 9th Edition, Mcgraw Hill
Education, Fluid Mechanics, Kundu and Cohen, Elsevier, 5th Edition,
2012

Heat Transfer:

Heat Conduction: David W. Hahn, M. Necati Ozisik

Convection Heat Transfer: Adrian Bejan;

Radiative Heat Transfer: Michael F. Modest;

Manufacturing Sciences

Students can answer questions from any three areas out of the following four areas.

(1) Metal Casting: Solidification and cooling; Riser and gating design; Design considerations for casting processes; Solidification transport phenomena.

(2) Forming: Stress strain diagrams for engineering materials; Plastic deformation and yield criteria; Slab method for bulk (forging, rolling, drawing) and sheet (shearing, deep-drawing, bending) metal forming processes.

(3) Machining: Mechanics of machining; Cutting process using single and multi-point cutting tools; Tool geometry, tool life and tool wear; Thermal aspects of machining.

(4) Non-traditional Machining: Physics of the non-traditional processes (USM, ECM, EDM, JM).

Text books:

1. Advanced Machining Processes by V.K.Jain, Narosa Publishing House, New Delhi.
2. Introduction to Machining Science by G.K. Lal, New Age International.
3. Manufacturing Science by Amitabha Ghosh and Ashok Kumar Mallik-2nd Edition, East-West Press Pvt Ltd, 2010.
4. Fundamentals of Modern Manufacturing by M.P. Groover, John Wiley & Sons, 4th Edition.
5. Science and Engineering of Casting Solidification by D.M. Stefanescu, 2nd Edition.
6. Principles of Metal Casting by R.W. Heine, C.R. Loper and Rosenthal, Tata McGraw Hill, New Delhi.

Solid Mechanics and Design

Engineering Mechanics: Free body diagrams, equilibrium; kinematics and dynamics of rigid bodies in 3D,
energy methods.

Vibrations: Free and forced vibration of single and two degree of freedom systems; effect of damping; vibration isolation; resonance.

Solid Mechanics: Analysis of stress and strain in 3D, Stress equilibrium equations in 3D, strain compatibility, stress-strain relationship in 3D for isotropic materials; thin cylinders, bending of beams; torsion of circular shafts; Simple plane stress/strain problems (thick cylinder, rotating disc); strain energy methods; thermal stresses. Experimental measurement of strain and displacement.

Books:

Engineering Mechanics:

1. Engineering Mechanics-Statics: Merium & Kraige
2. Engineering Mechanics-Dynamics: Merium & Kraige
3. Classical Dynamics: D.T. Greenwood

Vibrations:

1. Fundamentals of Vibrations: Leonard Meirovitch
2. Theory of Vibrations with Applications: W. Thompson

Solid Mechanics:

1. Elasticity: Theory, Applications and Numerics- Martin H Sadd
2. Theory of Elasticity: Timoshenko and Goodier

Robotics and Automation

Dynamics and Vibrations: Free body diagrams, equilibrium; kinematics and dynamics of rigid bodies in 3D, energy methods. Free and forced vibration of single and two degree of freedom systems; effect of damping; vibration isolation; resonance.

Introduction to Robotics: Types of robots, spatial transformations and kinematics of open chain linkages, dynamics, singularity and workspace analysis, basic robot control, programming in VAL Il, trajectory planning, industrial automation.

Books:

Dynamics and Vibrations:

Engineering Mechanics-Statics: Merium & Kraige
Engineering Mechanics-Dynamics: Merium & Kraige
Classical Dynamics: D.T. Greenwood

Fundamentals of Vibrations: Leonard Meirovitch
Theory of Vibrations with Applications: W. Thompson

Introduction to Robotics:

Introduction to Robotics	by	Craig
Robotic Engineering	by	Klafter, Chmielewski and Negin
Fundamentals of Robotics	by	Schilling
Robotics	by	Fu, Gonzalez and Lee

Mathematics

Vector Calculus: Curves and surfaces; Gradient, divergence and curl, directional derivatives, vector identities: Line (Curve), surface and volume Integrals, Gauss (Divergence), Stokes and Green's theorems

Linear Algebra: Matrix algebra (symmetric, positive definite and orthogonal matrices, rank, inverse); System of linear algebraic equations (existence and uniqueness of solution, Gauss elimination, L-U decomposition and Gauss-Sidel iterative methods); Eigenvalues and eigenvectors (properties like multiplicities and linear independence, Eigenvalues of symmetric, positive definite and orthogonal matrices)

ODE: First order linear and non-linear ODE (separation of variables, integrating factor for reduction to exact form); Second order linear differential equations (homogeneous/non-homogeneous) with constant coefficients, Initial and boundary value problems, Euler-Cauchy equation; Laplace transform; Fourier Series

PDE: 1-D heat and wave equations and 2-D Laplace equation (in Cartesian coordinates): Solutions using separation of variables, D'Alembert's solution for wave equation, Laplace transform technique for heat equation

Numerical Methods: Numerical solution of a non-linear algebraic equation;

Integration by trapezoidal and Simpson's rule; Least square method (regression analysis) for curve-fitting; Finite difference and predictor-corrector (or multi-step methods) for ODE

Statistics: Random variables: Mean, median and standard deviation; normal, Poisson and binomial distributions

References

1. A$_{th}$dvanced Engineering Mathematics by E. Kreyszig, John Wiley and Sons, International 8 Revised Edition, 1999,
2. Applied Mathematical Methods by B. Dasgupta, Pearson Education, 2006.