

MT-620: Advanced Fluid Mechanics

Fluid as continuum, Lagrangian and Eulerian description, Velocity and stress field, Fluid statics, Fluid Kinematics. Governing Equations of Fluid Motion, Reynolds transport theorem, Integral and differential forms of governing equations, mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation. Exact solutions of Navier-Stokes Equations, Couette flows, Poiseuille flows, Fully developed flows in non-circular cross-sections, Unsteady flows, Creeping flows. Potential Flows, Revisit of fluid kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows, Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag. Laminar Boundary Layers, Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct. Elements of Stability Theory, Concept of small-disturbance stability, Orr-Sommerfeld equation, Inviscid stability theory, Boundary layer stability, Thermal instability, Transition to turbulence. Turbulent Flow, Fluctuations and time-averaging, General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows Compressible Flows, Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

Reference Books:

1. Frank M. White, Fluid Mechanics, Sixth Edition, 2008
2. Frank M. White, Viscous Fluid Flow, Third Edition, 2006