

ADVANCED FLUID MECHANICS**Course Code:** 13ME2301**L P C**
4 0 3**Course Outcomes:**

At the end of the course, the student will be able to

CO1 : Analyze and apply the concepts of potential flow and Navier-Stokes equations to solve the fluid flow problems.

CO2 : Explain the concepts of boundary layer separation and turbulent flows

CO3 : Classify the compressible fluid flows and discuss stagnation properties.

CO4 : Solve nozzle, diffuser, and shock wave problems of compressible fluids.

CO5 : Apply Prandtl, Rankine-Hugniot equations to solve oblique shock waves and discuss the Fanno curves.

UNIT-I

Rotational and irrotational flows – velocity potential – circulation – relationship between stream function and potential function – basic solutions of stream and potential functions for uniform flow, source or sink, doublet and vortex flow – stationary circular cylinder - cylinder with circulation.

Normal stresses – shear stresses - Navier-Stokes equations – flow through a parallel channel – very low Reynolds number flow – order of magnitude analysis, and approximation of N-S equations – boundary layer equations.

UNIT-II

Momentum integral equations – flow over a flat plate – displacement thickness – momentum thickness – boundary layer separation – drag – bluff bodies – aerofoils.

Laminar–turbulent transition – time mean and time dependent description – conservation of mass – momentum equations and Reynolds stresses – boundary layer equations – shear stress models, eddy viscosity, Prandtl's mixing length – laminar sub layer –turbulent boundary layer on a flat plate.

UNIT-III

Wave propagation in an elastic solid medium – propagation of sound waves – Mach number – Mach angle – equation of sound wave.

Energy equation – energy equation for non-flow and flow processes – adiabatic energy equation – stagnation enthalpy - stagnation temperature - stagnation pressure – stagnation velocity of sound – reference velocities – Bernoulli's equation – effect of Mach number on compressibility.

UNIT-IV

Comparison of isentropic and adiabatic processes – Mach Number variation - expansion in nozzles – compression in diffusers – stagnation and critical states – area ratio as a function of mach number – impulse function - mass flow rate, flow through nozzles - convergent nozzles – convergent-divergent nozzles – flow through diffusers.

Development of a shock wave – rarefaction wave – governing equations, Fanno line, Rayleigh line -Prandtl-Meyer relation – Mach number downstream of the shock wave – static pressure ratio across the shock - temperature ratio across the shock – density ratio across the shock - stagnation pressure ratio across the shock.

UNIT-V

Nature of flow through oblique shock waves – fundamental relations - Prandtl's equation – Rankine-Hugoniot equation.

The Fanno curves – Fanno flow equations – variation of flow parameters.

TEXT BOOKS:

1. A.K. Mohanty, "*Fluid Mechanics*", 2nd Edition, PHI Learning Private Limited, New Delhi, 2010.
2. S.M. Yahya, "*Fundamentals of Compressible Flow With Aircraft And Rocket Propulsion (SI UNITS)*", 3rd Edition, New Age International Publishers, New Delhi, 2003.

REFERENCES:

1. Som and Biswas, “*Introduction to Fluid Mechanics and Fluid Machines*”, 2nd Edition, Tata McGraw-Hill, 2004.
2. S.W. Yuan, “*Foundations of Fluid Mechanics*”, Prentice-Hall, 1967.
3. Patrick H. Oosthuizen and William E. Carscallen, “*Compressible Fluid Flow*”, McGraw-Hill Companies, Inc., New York, 1997.