ADVANCED FLUID MECHANICS

UNIT I:

Non – viscous flow of incompressible Fluids: Lagrangian and Eulerain Descriptions offluid motion- Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluidparticle, types of flows, Equations of three dimensional continuity equation- Stream andVelocitypotentialfunctions.

BasicLawsoffluidFlow: Conditionforirrotationality,circulation&vorticityAccelerationsinCartesystemsnormalandtangentialaccelerations,Euler's,Bernouliequationsin3D–ContinuityandMomentum Equations

UNIT2:

PrinciplesofViscousFlow: DerivationofNavier-Stoke'sEquationsforviscouscompressibleflow–Exactsolutions tocertainsimplecases: Plain Poisoulleflow-Coutteflowwithandwithoutpressuregradient-HagenPoisoulleflow-Blasiussolution.

UNIT3:

BoundaryLayerConcepts: Prandtl'scontributiontorealfluidflows–Prandtl'sboundarylayertheory-Boundarylayerthicknessforflowoveraflatplate–Approximatesolutions–Creepingmotion(Stokes)–Oseen'sapproximation-Von-Karman momentum integral equation for laminar boundary layer — Expressions for localandmeandragcoefficientsfor differentvelocityprofiles.

UNIT4:

Introduction to Turbulent Flow: Fundamental concept of turbulence – TimeAveragedEquations–Boundary LayerEquations-PrandtlMixingLengthModel-Universal Velocity Distribution Law: Van Driest Model –Approximate solutions for dragcoefficients–MoreRefinedTurbulenceModels–k-epsilon model-boundary layerseparation and form drag – Karman Vortex Trail, Boundary layer control, lift on circularcylinders

Internal Flow: Smooth and rough boundaries – Equations for Velocity Distribution andfrictionalResistanceinsmoothroughPipes–RoughnessofCommercialPipes–Moody'sdiagram.

UNIT5:

CompressibleFluidFlow–I: Thermodynamicbasics–Equationsofcontinuity,Momentum and Energy - Acoustic Velocity Derivation of Equation for Mach Number –FlowRegimes–MachAngle–MachCone–StagnationState

Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Machnumber, Nozzles, Diffusers – Fanno and Releigh Lines, Property Relations – IsothermalFlowinLongDucts–NormalCompressibleShock,ObliqueShock:ExpansionandCompressibleShocks–SupersonicWaveDrag.

TEXTBOOKS:

1. SchlichtingH–BoundaryLayerTheory(SpringerPublications).
2. ConvectiveHeatandMassTransfer–Oosthigen,McGrawhill
3. ConvectiveHeatandMassTransfer–W.M.Kays,M.E.Crawford,McGrawhill

REFERENCEBOOKS:

1. YumanS.W–FoundationsofFluidMechanics.
2. AnIntroductiontoCompressibleFlow–Pai.
3. Dynamics&TheoryandDynamicsofCompressibleFluidFlow –Shapiro.
4. FluidMechanicsandMachinery–D.RamaDurgaiah.(NewAgePub.)
5. FluidDynamics–WilliamF.Hughes&JohnA.Brighton(TataMcGraw-HillPub.)

MODEL QUESTION PAPER

ADVANCED FLUID MECHANICS

Time: 3 Hours **Max. Marks: 100**

Answer Any **FIVE** questions only

All Questions Carry Equal Marks

1	a) Briefly explain the Lagrangian and Eulerian methods of describing fluid flows	10
	b) Derive the three dimensional Bernouliequation?	10
2	a) State the assumptions of Hagen-Poisenelle equation for laminar flow	5
	b) Derive theNavier-Stoke'sEquationsforviscouscompressibleflow.	15
3	a) The velocity distribution in the boundary layer is given by $\frac{u}{u_0} = \frac{3}{2}(\frac{y}{\delta})$ - $\frac{1}{2}(\frac{y}{\delta})^3$ determine the expressions for boundary layer thickness, wall shear stress and coefficient of drag in terms of Reynold's number	10
	b) Derive the Von-Karman Integral momentum equation and reduce it to the case of flow over a flat plate	10
4	a) For turbulent flow in a pipe of 25 cm diameter, the centre line velocity is 2.25 m/s and the velocity at a point 8 cm from the centre as measured by a pitot tube is 1.95 m/s. Make calculations for (i) friction velocity and wall shearing stress, (ii) average velocity and discharge through the pipe, (iii) friction factor and (iv) pipe roughness.	15
	b) Explain TurbulenceModels?	5
5	a) A DC-10 aircraft cruises at 12 km altitude on a standard day. A pitot-static tube on the nose of the aircraft measures stagnation and static pressures of 29.6 kPa and 19.4 kPa.; Calculate (a) the flight Mach number of the aircraft, (b) the speed of the aircraft, and (c) the stagnation temperature that would be sensed by a probe on the aircraft	10
	b) Discuss about the Fanno and Releigh Lines ?	10
6	a) A paddle wheel of 100mm diameter rotates at 150 rpm inside a closed concentric vertical cylinder of 300 mm diameter completely filled with a water. i. Assuming a 2D flow in a horizontal plane, find the difference in pressure between cylinder surface and the center of the wheel. ii. If provision is made for an outward radial flow which has a velocity of 1 m/s at the periphery of the wheel, what is the resultant velocity at a radius of 100 mm and its inclination to the radial direction?	10
	b) The flow field of a fluid is given by $V=xyi+2yzj-(yz+z^2)k$, i. Show that it represents a possible 3-D steady incompressible continuous flow ii. Is the flow is rotation or irrotational? iii. Angular velocity iv. Vorticity	10
7	a) A passage is designed to expand air isentropically to atmospheric pressure from a large tank in which properties are held constant at 5°C and 304 kPa (abs). The desired flow rate is 1 kg/s. Assuming the passage is 5 m long, and that the Mach number increases linearly with position in the passage, plot the cross-sectional	10

area and pressure as functions of position

b) A diffuser for an incompressible, inviscid fluid of density p = 1000 kg/m^3 consists of a diverging section of pipe. At the inlet the diameter is D = 0.25 m, and at the outlet the diameter is D = 0.75 m. The diffuser length is L = 1 m, and the diameter increases linearly with distance x along the diffuser. Derive and plot the acceleration of a fluid particle, assuming uniform flow at each section, if the speed at the inlet is V = 5 m/s. Plot the pressure gradient through the diffuser, and find its maximum value. If the pressure gradient must be no greater than 25 kPa/m, how long would the diffuser have to be? 10

8 Explain the following: 20

a. Moody's diagram
b. Plane Couette flow
c. Boundary layer separation
d. Creeping motion