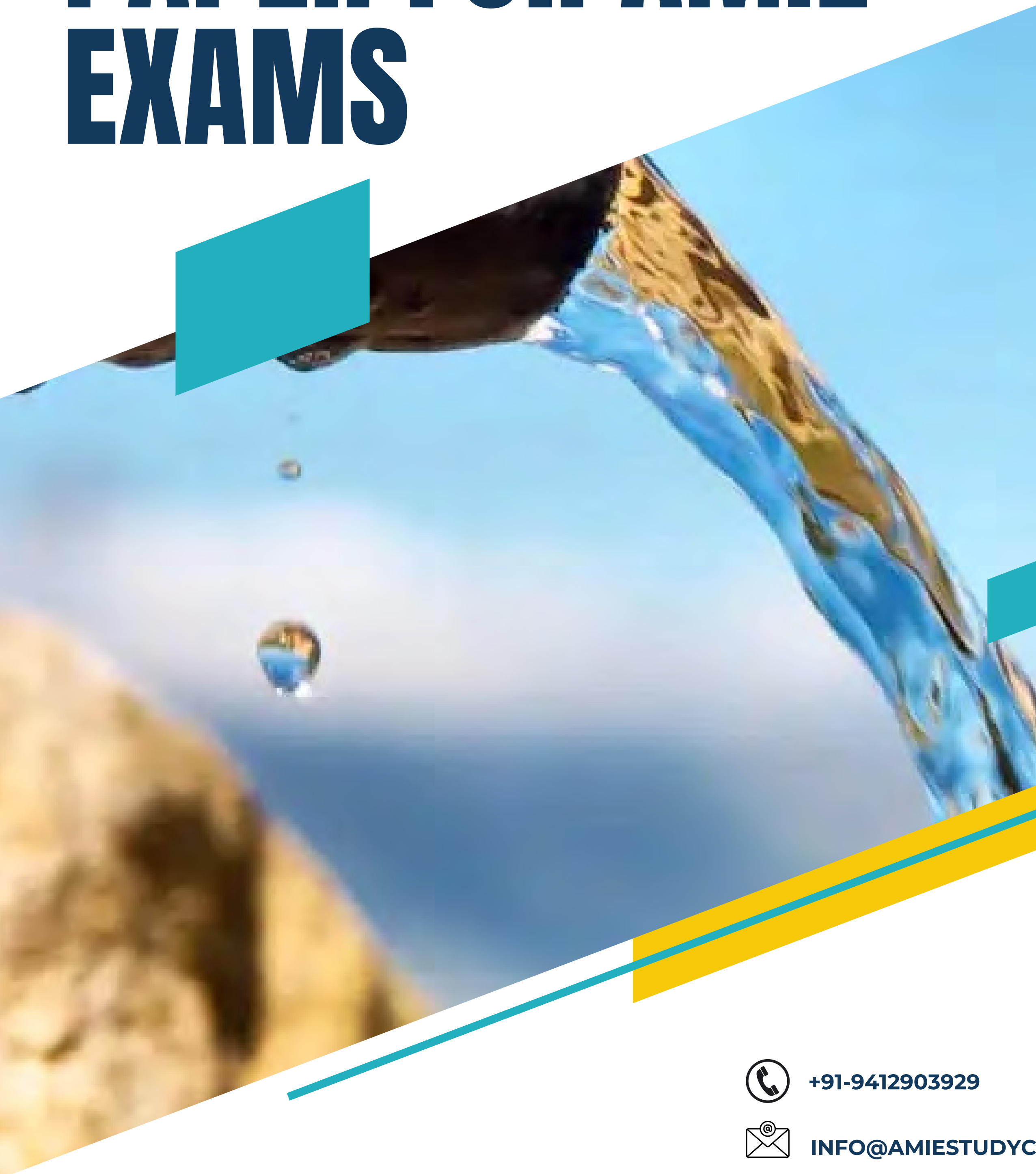
AMIE STUDY CIRCLE, ROORKEE

MODEL TEST PAPER FOR AMIE EXAMS



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MECHANICS OF FLUIDS

TEST PAPER 1

MECHANICS OF FLUIDS

***Time**: Three Hours*

***Maximum Marks**: 100*

Answer five questions, taking ANY TWO from Group A, any two from Group B and all from Group C.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (a) Define a fluid and distinguish between: (i) ideal and real fluids (ii) compressible and incompressible fluids (iii) Newtonian and non Newtonian fluids (iv) surface tension and capillarity (v) dynamic viscosity and kinematic viscosity. (vi) Specific weight and mass density 6

(b) With neat sketch, explain the condition of equilibrium of submerged bodies. 8

(c) Define (i) rotational and irrotational flow (ii) uniform and non uniform flow (iii) steady and non steady flow (iv) Compressible and incompressible flow (v) one, two and three dimensional flow (vi) laminar and turbulent flow 6

2. (a) Explain briefly the following : (i) velocity potential (ii) stream function. Describe relation these two. 6

(b) Derive Euler's equation of motion stating the assumptions. Obtain Bernoulli's equation from it. 8

(c) Derive the expression for the loss of head due to friction in pipe 6

$$h_f = 4flV^2 / 2gd$$

where h_f is the loss of head due to friction; L, the length of the pipes; f, the coeff. of friction; V, the velocity, and d, the diameter of pipe.

3. (a) Prove that the velocity distribution for viscous flow between two parallel 8

plates, when both plates are fixed across section is parabolic in nature. Also, prove that the maximum velocity is equal to one and a half times the average velocity.

(b) A laminar flow is taking place in a pipe of diameter 200 mm. The maximum velocity is 1.5 m/s. Find the mean velocity and the radius at which this occurs. Also, calculate the velocity at 4 cm from the wall of the pipe. 6

(c) Two parallel plates kept 0.01 m apart have a laminar flow of oil between them. Taking dynamic viscosity of oil to be 0.8 poise, determine the velocity distribution, discharge and shear stress on the upper plate that moves horizontally at relative velocity 1 m/s with respect to the lower plate which is stationary. Further, the pressure drops in the flow direction from 180 kPa to 100 kPa over a distance of 80 m. 6

4. (a) Explain with necessary sketch the following 6

(i) Laminar boundary layer

(ii) Turbulent boundary layer

(iii) Laminar sub-layer

(iv) Boundary layer thickness

(b) Starting with the Navier-Stokes equations of motion for two-dimensional incompressible flow, obtain the Prandtl's boundary layer equations. Give a brief outline of the Blasius solution of laminar boundary layer for flow over a flat plate. 8

(c) If a laminar boundary layer at zero pressure, gradient over a flat plate is described by the velocity profile. 6

$$V/V_0 = (3/2)\eta - \eta^3/2$$

in which η = (y/δ). Show that the boundary layer thickness, δ, wall shear stress τ_0 and coefficient of drag C_D are given by

$$\delta = \frac{4.65x}{\sqrt{\text{Re}_x}}; \tau_0 = \frac{0.322\rho V_0^2}{\sqrt{\text{Re}_x}}; C_D = 1.328\sqrt{\text{Re}_x}$$

Group B

5. (a) Explain the phenomenon of separation of boundary layer and formation of wake. Give a list of various methods of boundary layer control. 10

(b) A flat plate of 2 m width and 4 m length is kept parallel to air flowing at 5 m/s velocity at 15^0C. Determine the length of plate over which the boundary 10 layer is laminar, shear at the location where boundary layer ceases to be laminar, and total force on both sides on that portion of plate where the boundary layer is laminar. Take $\rho = 1.208$ kg/m^3, $\nu = 1.47 \times 10^{-5}$ m^2/s.

6. (a) A smooth pipe of diameter 80 mm and 800 m long carries water at the rate of 0.480 m^3/min. Calculate the loss of head, wall shearing stress, centre line velocity, velocity and shear stress at 30 mm from pipe wall. Also, calculate the thickness of laminar sub-layer. Take kinematic viscosity of water as 0.015 stokes. Take the value of coefficient of friction f from the relation $f = 0.0791/Re^{1/4}$ where Re = Reynold number. 10

(b) Obtain an expression for the sound wave in a compressible fluid in terms of change of pressure and change of density when the process is (i) isothermal (ii) adiabatic. 10

7. (a) Define (i) Mach number (ii) subsonic flow (iii) sonic flow (iv) supersonic flow. 10

(b) A tank contains air at a pressure 135 kPa and temperature 27^0C. The local barometric pressure is 100 kPa. Air discharges out of the tank and into atmosphere through a convergent nozzle. Determine the output flow velocity and the mass flow rate of air. The cross sectional area at the nozzle outlet is 500 m^2. 10

8. (a) Define an orificemeter. prove that the discharge through an orifice meter is given by 10

$$Q = C_d a_0 a_1 \sqrt{2gh} \,/\, \sqrt{a_1^2 - a_0^2}$$

where a_1 is area of pipe; a_0 is the area of orifice, and C_d is the coeff. of discharge.

(b) An orifice meter with diameter 15 cm is inserted in a pipe of 30 cm diameter. The pressure difference measured by a mercury oil differential manometer on two sides of the orifice meter gives a reading of 50 cm of mercury. Find the rate of flow of oil of specific gravity 0.9 when the coefficient of discharge of the meter is 0.64. 10

Group C

9. Answer the following in brief: 20

   (i) Hydraulic gradient line and total energy line

   (ii) Reynold transport theorem

   (iii) Momentum integral method

   (iv) Couette flow and Poiseuille flow

   (v) Prandtl mixing length theory

(Refer our course material for answers)