CBCS SCHEME

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21ME43

Fourth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Fluid Mechanics

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. Define the following terms :
(i) Absolute pressure
(ii) Gauge pressure
(iii) Differential manometers
(iv) Buoyancy
(v) Meta-centre. **(05 Marks)**

b. The left limb of a mercury U-tube manometer is open to atmosphere and the right limb is connected to a pipe carrying water under pressure. The centre of the pipe is at the level of the free surface of mercury. Find the difference in level of mercury limbs of U-tube, if the absolute pressure of water in the pipe is 14.5 m of water, atmospheric pressure is 760 mm of Hg. **(05 Marks)**

c. Derive an expression for the depth of centre of pressure from free surface of liquid of an inclined plane surface submerged in the liquid. **(10 Marks)**

OR

2 a. Define the equation of continuity. Derive the continuity equation for the three dimensional flow in Cartesian co-ordinates. **(10 Marks)**

b. If for a two-dimensional potential flow, the velocity potential is given by : $\phi = 4x(3y-4)$, determine the velocity at the point (2, 3). Determine also the value of stream function ψ at the point (2, 3). **(08 Marks)**

c. State Reynold's transport theorem. **(02 Marks)**

Module-2

3 a. Derive Euler's equation of motion along a stream line for an ideal fluid stating clearly the assumptions. Explain how this is integrated to get Bernoulli's equation along a stream line. **(10 Marks)**

b. A pipe 5 m long is inclined at an angle of 15° with the horizontal. The smaller section of the pipe which is at a lower level is of 80 mm diameter and the larger section of the pipe is of 240 mm diameter. Determine the difference of pressure between the two sections, if the pipe is uniformly tapering and the velocity of water at the smaller section is 1 m/s. **(06 Marks)**

c. A jet of water of diameter 100 mm strikes a curved plate at its centre with a velocity of 15 m/s. The curved plate is moving with a velocity of 7 m/s in the direction of the jet. The jet is deflected through an angle of 150°. Assuming the plate smooth find :
(i) Force exerted on the plate in the direction of the jet.
(ii) Power of the jet. **(04 Marks)**

OR

4 a. Define an orifice-meter. Prove that the discharge through an orifice-meter is given by the relation $Q = C_d \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$. **(10 Marks)**

b. Water flows over a rectangular notch 1 m wide with a head of 15 cm and afterwards passes through a triangular (V notch) of 90° . Taking C_d for the rectangular and V-notch as 0.62 and 0.59 respectively. Find the head over the triangular notch. **(06 Marks)**

c. With a neat sketch, explain Rota meter. **(04 Marks)**

Module-3

5 a. Prove that the maximum velocity in a circular pipe for viscous flow is equal to two times the average velocity of the flow. Also derive Hagen Poiseuille's formula. **(10 Marks)**

b. Determine :
(i) The pressure gradient,
(ii) The shear stress at the two horizontal plates.
(iii) The discharge per metre width for Laminar flow of oil, with a maximum velocity of 2 m/s between two plates which are 150 mm apart. Given $\mu = 2.5$ N-S/m^2. **(06 Marks)**

c. The external and internal diameters of a collar bearing are 200 mm and 150 mm respectively. Between the collar surface and the bearing, an oil film of thickness 0.25 mm and of viscosity 0.09 N-S/m^2 is maintained. Find the torque and the power lost in overcoming the viscous resistance of the oil when the shaft is running at 250 rpm. **(04 Marks)**

OR

6 a. Derive Darcy-Weisbach equation for loss of head due to friction in pipes. **(08 Marks)**

b. A horizontal pipe line 50 m long is connected to a reservoir at one end and discharges freely in to the atmosphere at the other end. For the first 25 m length from the reservoir the pipe has a diameter of 15 cm and it has a square entrance at the reservoir. The remaining 25 m length of pipe has a diameter of 30 cm. The junction of the two pipes is in the form of a sudden expansion. The 15 cm pipe has a gate valve (K = 0.2) in fully open condition. If the height of the water surface in the tank is 10 m above the center line of the pipe, estimate the discharge in the pipe by considering the Darcy-Weisbach friction factor f = 0.02 for both the pipes. (Include all minor losses in the calculations). **(08 Marks)**

c. Two tanks are connected with the help of two pipes in series. The lengths of the pipes are 1000 m and 800 m where as the diameters are 400 mm and 200 mm respectively. The co-efficient of friction for both the pipes is 0.008. The difference of water level in the two tanks is 15 m. Find the rate of flow of water through the pipes. Considering all losses. **(04 Marks)**

Module-4

7 a. Define the terms : (i) Lift (ii) Drag. **(04 Marks)**

b. Obtain an expression for the lift produced on a rotating cylinder placed in a uniform flow field such that the axis of the cylinder is perpendicular to the direction of flow. **(10 Marks)**

c. A Jet plane which weighs 19620 N has a wing area of 25 m^2. It is flying at a speed of 200 km/hour. When the engine develops 588.6 kW, 70% of this power is used to overcome the drag resistance of the wing. Calculate the co-efficient of lift and co-efficient of drag for the wing. Taken density of air as 1.25 kg/m^3. **(06 Marks)**

OR

8 a. Using Buckingham's π-theorem, show that the velocity through a circular orifice is given by $V = \sqrt{2gH}\phi\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$, where H is the head causing flow, D is the diameter of the orifice, μ is co-efficient of viscosity, ρ is the mass density and g is the acceleration due to gravity. **(10 Marks)**

b. Explain the different types of similarities that must exist between a prototype and its model. **(06 Marks)**

c. Define the following non-dimensiional numbers :
   (i) Reynold's number
   (ii) Mach's number.
   What are their significances for fluid flow problems? **(04 Marks)**

Module-5

9 a. Obtain an expression for velocity of the sound wave in a compressible fluid in terms of change of pressure and change of density. **(10 Marks)**

b. A projectile travels in air of pressure 8.829 N/cm^2 at $-10°$ C at a speed of 1200 km/hr. Find the mach number and mach angle. Take K = 1.4 and R = 287 J/kgK. **(05 Marks)**

c. Explain Normal and Oblique shocks. **(05 Marks)**

OR

10 a. Obtain an expression for stagnation pressure of a compressible fluid in terms of approaching mach number and pressure. **(10 Marks)**

b. Find the velocity of air flowing at the outlet of a nozzle, fitted to a large vessel which contains air at a pressure of 294.3 N/cm^2(abs.) and at a temperature of 30 °C. The pressure at the outlet of the nozzle is 137.34 N/cm^2(abs.). Take K = 1.4 and R = 287 J/kgK. **(04 Marks)**

c. Define computational fluid dynamics. Mention the applications and limitations of CFD. **(06 Marks)**

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