CBCS Scheme

USN **15ME44**

Fourth Semester B.E. Degree Examination, June/July 2017
Fluid Mechanics

Time: 3 hrs. Max. Marks: 80

Note: Answer FIVE full questions, choosing one full question from each module.

Module-1

1 a. Define compressibility of a fluid. Derive an expression for compressibility of a fluid undergoing isentropic compression. **(04 Marks)**

b. A thin horizontal plate of area A is placed midway in a gap of height 'h' between two horizontal plane surfaces. The gap is filled with a liquid of viscosity μ_1. The plate requires a force F to move with a constant velocity V. The gap is now filled with another liquid of viscosity μ_2 and the same plate is placed at a distance of h/4 from one wall and parallel to it. Experiments indicate that for the same velocity V, the force required was same. Prove that $\mu_2 = \frac{1}{3}\mu_1$ **(07 Marks)**

c. A U-tube manometer is used to measure the pressure of oil of specific gravity 0.85 flowing in a pipeline. Its left end is connected to the pipe and the right limb is open to the atmosphere. The centre of the pipe is 100 mm below the level of mercury in the right limb. If the difference of mercury level in the two limbs is 160 mm, determine the absolute pressure of oil in the pipe. Take atmospheric pressure = 100 kPa. **(05 Marks)**

OR

2 a. Derive an expression for the depth of centre of pressure from free surface of liquid of an inclined plane surface submerged in the liquid. **(08 Marks)**

b. A wooden cylinder of specific gravity 0.6 and circular in cross section is required to float in oil of specific gravity 0.9. Find the L/D ratio for the cylinder to float with its longitudinal axis vertical in oil, where L is the height of the cylinder and D is its diameter. **(08 Marks)**

Module-2

3 a. Derive the continuity equation in three dimensional Cartesian coordinates for a steady incompressible flow. **(06 Marks)**

b. Write the expressions for acceleration of a fluid in x, y and z directions. Differentiate between local and convective acceleration. **(05 Marks)**

c. The velocity potential function ϕ is given by an expression $\phi = 2\ln(x^2 + y^2)$. Show that it represents a possible case of fluid flow. **(05 Marks)**

OR

4 a. Derive an expression for discharge through a triangular notch. **(06 Marks)**

b. A pump has tapering pipe running full of water. The pipe is placed vertically with the diameter at the base and top being 1.2m and 0.6m respectively. The pressure at the upper end is 250 mm of Hg vacuum, while the pressure at the lower end is 15 kN/m². Assume the head loss to be 20% of the difference in the velocity head. Calculate the discharge. The flow is vertically upwards. The difference of elevation is 3.95 m. **(10 Marks)**

Module-3

5 a. Prove that the velocity distribution across a cross section of a circular pipe during viscous fluid flow is parabolic in nature. Also show that the maximum velocity is in the centre of the pipe and is equal to twice the average velocity. **(10 Marks)**

b. Water at 15°C flows between two parallel plates at a distance of 1.6 mm apart. Determine:
   - i) Maximum velocity
   - ii) Pressure loss per unit length
   - iii) Shear stress at the plate if the average velocity is 0.2 m/s. Viscosity of water at 15°C is 0.01 poise. Take unit width of the plate. **(06 Marks)**

OR

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

b. An oil of specific gravity 0.7 is flowing through a pipe of diameter 300 mm at the rate of 500 litres/s. Find the head loss due to friction and power required to maintain the flow for a length of 1000 m. Take kinematic viscosity of oil = 0.29 stokes. **(08 Marks)**

Module-4

7 a. What is the meaning of boundary layer separation? What is the effect of pressure gradient on boundary layer separation? **(08 Marks)**

b. Using Rayleigh's method, show that the power P developed by a hydraulic turbine is given by $P = \rho N^3 D^5 \phi\left(\frac{N^2 D^2}{gH}\right)$ where ρ = density of liquid, N = rotational speed of turbine in rpm, D = diameter of the runner, H = working head, g = gravitational acceleration. **(08 Marks)**

OR

8 a. The rate of discharge Q of a centrifugal pump is dependent upon density of the fluid ρ, pump speed N in rpm, diameter of the impeller D, pressure P, viscosity of the fluid μ. Using Buckingham's π - theorem method, show that $Q = ND^3 \phi\left[\frac{P}{\rho N^2 D^2}, \frac{\mu}{\rho N D^2}\right]$ **(08 Marks)**

b. A kite 0.8m × 0.8m weighing 3.924N assumes an angle of 12° to the horizontal. The string attached to the kite makes an angle of 45° to the horizontal. The pull on the string is 24.525 N when the wind is flowing at a speed of 30 km/hr. Find the corresponding coefficient of drag and lift. Take density of air = 1.25 kg/m³. **(08 Marks)**

Module-5

9 a. Show that the velocity of a sound wave in a compressible fluid medium is given by $C = \sqrt{\frac{K}{\rho}}$ where K and ρ are bulk modules of elasticity and density of the fluid respectively. **(08 Marks)**

b. Calculate the velocity and mach number of a supersonic aircraft flying at an altitude of 1000 m where the temperature is 280 K. Sound of the aircraft is heard 2.5 seconds after the passage of the aircraft on the head of an observer. Take γ = 1.41 and R = 287 J/kgK. **(08 Marks)**

OR

10 a. Define stagnation temperature of a fluid. Show that the stagnation temperature and static temperatures are related by $\frac{T_0}{T} = 1 + \frac{\gamma - 1}{2} M^2$ where γ = ratio of specific heats, M = mach number. **(08 Marks)**

b. Mention the applications and limitations of computational fluid dynamics. **(08 Marks)**