CBCS SCHEME

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18AE/AS35

Third Semester B.E. Degree Examination, June/July 2024
Mechanics of Fluid

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Define and derive the expression for capillary rise and capillary fall. **(10 Marks)**

b. A thin plate of very large area is placed in a gap of height h with oils of viscosities μ' and μ'' . On the two sides of the plate. The plate is pulled at a constant velocity V. Calculate the position of plate so that,

(i) The shear force on the two sides of the plate is equal.

(ii) The force required to drag the plate in minimum.

Assume viscous flow and neglect all end effects. **(10 Marks)**

OR

2 a. A manometer consists of an inclined glass tube which communicates with a metal cylinder standing upright ; liquid fills the apparatus to a fixed zero mark on the tube when both the cylinder and the tube are open to atmosphere. The upper end of the cylinder is then connected to a gas supply at a pressure P and Manometric liquid rises through a distance λ in the tube. Establish the relation :

$$h = S\ell\left[\sin\alpha + \left(\frac{d}{D}\right)^2\right]$$

For the pressure head h of water column in terms of inclination α of the tube, specific gravity S of the liquid, and ratio of diameter d of the tube to the diameter D of the cylinder. Also determine the value of $\left(\frac{D}{d}\right)$ so that the error due to disregarding the change in level in the cylinder will not exceed 0.1 percent when $\alpha = 25^\circ$ **(10 Marks)**

b. Derive the expression for the force exerted and centre of pressure for a completely submerged inclined plane surface. **(10 Marks)**

Module-2

3 a. Discuss plotting of stream lines and potential lines for source flow. **(10 Marks)**

b. Two discs are placed in a horizontal plane, one over the other. The water enters at the centre of the lower disc and flows radially outward from a source of strength 0.628 m^2/s. The pressure, at a radius 50 mm, is 200 kN/m^2. Find :

(i) Pressure in kN/m^2 at a radius of 500 mm and

(ii) Steam function at angles of 30° and 60° if $\psi = 0$ at $\theta = 0^\circ$ **(10 Marks)**

OR

4 a. For a finite control volume fixed in space derive energy equation in differential form. **(10 Marks)**

b. Derive the integral and differential form of momentum equation (Navier-Stokes equation) using control volume approach. **(10 Marks)**

Module-3

5 a. Express an expression for discharge through Orifice meter. **(10 Marks)**

b. A 30cm×15cm Venturimeter is provided in a vertical pipe line carrying oil of specific gravity 0.9, the flow being upwards. The difference in elevation of the throat section and entrance section of the Venturimeter is 30 cm. The differential U-tube mercury manometer shows a gauge deflection of 25 cm. Calculate

(i) The discharge of oil

(ii) The pressure difference between the entrance section and the throat section. Take the co-efficient of discharge as 0.98 and specific gravity of mercury as 13.6 **(10 Marks)**

OR

6 a. Using Buckingham's π-theorem, show that the discharge Q consumed by an oil ring is given by,

$$Q = Nd^3\phi\left[\frac{\mu}{\rho Nd^2}, \frac{\sigma}{\rho N^2 d^3}, \frac{w}{\rho N^2 d}\right]$$

where d is the internal diameter of the ring, N is rotational speed, ρ is density, μ is viscosity, σ is surface tension and w is the specific weight of oil. **(10 Marks)**

b. Define and derive an expression for the following :

(i) Reynold's number (R_e)

(ii) Fraude's number (F_e)

(iii) Euler's number (E_U)

(iv) Weber's number (W_C)

(v) Mach number (M) **(10 Marks)**

Module-4

7 a. Find the displacement thickness, the momentum thickness and energy thickness for the velocity distribution in the boundary layer given by $\frac{u}{U} = \frac{y}{\delta}$, where u is the velocity at a distance Y from the plate and u = U at y = δ, where δ = boundary layer thickness. Also calculate the value of $\frac{\delta^*}{\theta}$. **(10 Marks)**

b. Derive Von Karman momentum integral equation on a Flat plate due to boundary layer. **(10 Marks)**

OR

8 a. With a neat sketch, explain the airfoil aerodynamic characteristics for both symmetric and Cambered airfoil. **(10 Marks)**

b. Consider an NACA 2412 airfoil with a chord of 0.64 m in an airstream at standard sea level condition. The freestream velocity is 70 m/s. The lift per unit span is 1254 N/m. Calculate the angle of attack and the drag per unit span. Also calculate the moment per unit span about the aerodynamic center.

Assume $C_\alpha = 0.0068$, $\rho = 1.23\ kg/m^3$ **(10 Marks)**

Module-5

9 a. Define and derive stagnation pressure, stagnation density and stagnation temperature. **(15 Marks)**

b. Discuss Laminar and Turbulent boundary layers. **(05 Marks)**

OR

10 a. A gas is flowing through a horizontal pipe at a temperature of $4^\circ C$. The diameter of the pipe is 8 cm and at section 1 – 1 in the pipe, the pressure is 30.3 N/cm^2 (gauge). The diameter of the pipe charges from 8 cm to 4 cm at the section 2 – 2, where pressure is 20.3 N/cm^2 (gauge). Find the velocities of the gas at these sections assuming an isothermal process. Take R = 287.14 Nm/kgK and atmospheric pressure = 10 N/cm^2. **(12 Marks)**

b. A gas is flowing through a horizontal pipe which is having area of cross section as 40 cm^2, where pressure is 40 N/cm^2 (gauge) and temperature is $15^\circ C$. At another section the area of cross section is 20 cm^2 and pressure is 30 N/cm^2(gauge). If the mass rate of flow of gas through the pipe is 0.5 kg/s, find the velocities of the gas at these sections, assuming an isothermal change. Take R = 292 N-m/kg $^\circ K$ and atmospheric pressure = 10 N/cm^2. **(08 Marks)**

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