B.E/B.TECH. DEGREE EXAMINATION – NOV./DEC. 2014

Third Semester

Civil Engineering

CE 6303 – MECHANICS OF FLUIDS

(Common to Environmental Engineering)

(Regulation 2013)

Time: Three hours **Maximum: 100marks**

Any missing data can be assumed with justification.

Answer ALL questions

Part A - (10 × 2 = 20 Marks)

1. ***Define specific volume of a fluid and write its unit.***

Specific volume is defined as the volume of fluid occupied by unit mass.

$$\text{Specific volume, } v = \frac{\text{Volume}}{\text{Mass}} = \frac{V}{m} \text{ in } m^3/kg$$

2. ***Name the devices that are used to measure the pressure of a fluid.***

Manometers:

1) Piezometer
2) U-tube Manometer
3) Single column Manometer
4) U-tube differential Manometer
5) Inverted U-tube differential Manometers.

Pressure gauges:

1) Bourdon tube pressure gauge

2) Bellows pressure gauge

3) Diaphragm pressure gauge

4) Dead weight pressure gauge

3. *Define circulation and write its expression.*

Circulation is defined as the flow along a closed curve. Mathematically, the circulation is defined as the line integral of tangential velocity about a closed curve.

$$d\Gamma = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\Delta x\,\Delta y$$

4. *Write Euler's equation.*

$$\frac{dp}{\rho} + v\,dv + g.dz = 0$$

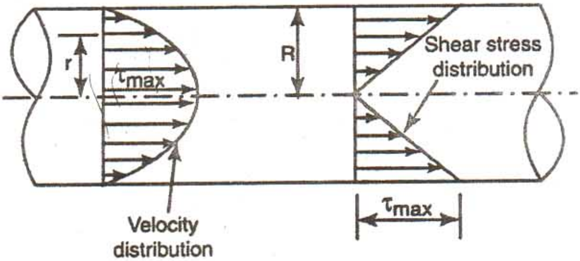
where

$$\frac{dp}{\rho} = \text{Pressure enery per unit specific weight}$$

$$v\,dv = \text{Kinetic enery per unit specific weight}$$

$$g.dz = \text{Datum enery per unit specific weight}$$

5. *Sketch the shear stress and velocity distribution for laminar flow across a pipe section.*



6. List the major and minor losses encountered in pipe flow.

1. Major losses

   The loss of energy is caused by friction.

2. Minor losses

   (i) Loss of energy due to sudden enlargement

   (ii) Loss of head due to sudden contraction

   (iii) Loss of energy at the entrance to the pipe

   (iv) Loss of energy at the exit from the pipe

   (v) Loss of energy due to gradual contraction or enlargement

   (vi) Loss of energy due to an obstruction in a pipe

   (vii) Loss of energy in bends

   (viii) Loss of energy in various pipes fittings.

7. What are the different methods of preventing the separation of boundary layers?

1. The streamlining of body shape reduces the separation. Due to stream lining the body, the point of separation shifts downstream, the wake region gets narrower and the drag gets reduced.

2. The motion of a solid boundary in the direction of flow will reduce the separation. Such a motion of the boundary may be achieved by rotating a circular cylinder lying in a stream of fluid.

3. The suction of slow moving fluid by a suction slot or through a porous surface.

4. Injecting fluid into the region of boundary layer from the interior of the body with the help of blower.

5. Providing slots near the leading edge.

6. Placing some disturbance near the boundary in the approach section.

7. Energizing the flow by introducing optimum amount of swirl in the incoming flow.

8. Providing guide or splitter vanes to guide the flow in a confined passage.

8. *Define the terms: Drag and Lift.*

The component of the total force in the direction parallel to the direction of motion is called *drag*. It means, the pulling force required to move any object in the horizontal direction.

The component of the total force in the direction perpendicular to the direction of motion is called *lift*. It means the upward force required to lift the any object to a certain height.

9. *Define Froude's number and write its expression.*

It is defined as the square root of the ratio of the inertia force of a flowing fluid to the gravity force.

$$F_r = \sqrt{\frac{\text{Inertia force}}{\text{Gravity force}}} = \sqrt{\frac{\rho L^2 v^2}{\rho L^3 g}} = \sqrt{\frac{v^2}{gL}}$$

10. *What are the merits of distorted models?*

(i) Accurate measurements can be possible.

(ii) Surface tension can be minimized as much as possible.

(iii) The operation is simplified due to small model size.

(iv) Reynolds number of flow is increased sufficiently.

Part B - (5 × 16 = 80 Marks)

11. (a) A liquid has a specific gravity of 0.72. Find its density, specific weight and also the weight per litre of the liquid. If the above liquid is used for lubrication between a shaft and a sleeve, find the power lost in liquid for a sleeve length of 100 mm. The diameter of the shaft is 0.5 m and the thickness of the liquid film is 1mm. Take the viscosity of fluid as 0.5N-s/m² and the speed of the shaft as 200 rpm.

Given data:

Specific gravity, $S = 0.72$

☺ ***Solution:***

1. Density of oil:

$$\text{Specific gravity, } S = \frac{\text{Density of liquid}}{\text{Density of water}}$$

$$0.72 = \frac{\rho_{\text{liquid}}}{1000}$$

$$\rho_{liquid} = 720\ kg/m^3$$

2. Specific weight of liquid:

Specific weight, $w = \rho \times g$

$$= 720 \times 9.81$$

$$= \mathbf{7063}\ N/m^3$$

3. Specific weight per litre of liquid:

$$W = \text{Weight of liquid} \times \text{Volume of liquid}$$

$$= 7063 \times 1$$

$$W = \mathbf{7063}\ N$$

The remaining procedure to calculate the power lost in liquid

Or

(b) A circular plate 1.2m diameter is placed vertically in water so that the centre of plate is 2m below the free surface. Determine the total pressure and the depth of centre of pressure. The above circular plate is taken out of water and made in to a solid cylindrical body which weighs 4.5N in water and 6N in oil of specific gravity 0.8. Find the volume and weight of the body. Find also the density and specific gravity of the material of the body.

[Ans.:- $P = 22.19\ kN$ & $\bar{h} = 2.045\ m$ from the free surface of water]

☺ ***Solution:***

Let V = Volume of metallic body in m^3

Specific gravity, $S = \dfrac{\text{Density of oil}}{\text{Density of water}}$

$$0.8 = \frac{\rho_{oil}}{1000}$$

$$\rho_{oil} = 800\ kg/m^3$$

At equilibrium,

$$\begin{pmatrix}\text{Weight of the}\\ \text{body in air}\end{pmatrix} - \begin{pmatrix}\text{Weight of water}\\ \text{displaced}\end{pmatrix} = \begin{pmatrix}\text{Weight of the}\\ \text{body in water}\end{pmatrix}$$

$$W_{body} - 1000 \times 9.81 \times V = 4.5 \qquad \ldots (1)$$

$$W_{body} - 800 \times 9.81 \times V = 6 \qquad \ldots (2)$$

Subtracting the equation (1) from (2),

$$1962\ V = 1.5$$

$\therefore$ Volume of water displaced,

$$V = 0.0007645\ m^3$$

It is known that

Volume of body = Volume of water displaced

$\therefore$ Volume of the metallic body,

$$\mathbf{V = 0.0007645\ m^3}$$

Substituting V in equation (1),

$$W_{body} - 1000 \times 9.81 \times 0.0007645 = 4.5$$

$$W_{body} = \mathbf{12\ N}$$

$$\text{Mass of the object} = \frac{12}{9.81} = 1.223kg$$

$$\text{Density of the body} = \frac{\text{Mass}}{\text{Volume}} = \frac{1.223}{0.0007645}$$

$$= \mathbf{1599.74 kg/m^3}$$

$$\text{Specific gravity, } S = \frac{1599.74}{1000} = \mathbf{1.6}$$

12. (a) If for a two-dimensional potential flow, the velocity potential function is given by $\phi = x(2y - 1)$, determine the velocity at the point P(4,5). Determine also the value of stream function ψ at the point P.

[Ans.: $u = -9 Units$, $v = -8 Units$,

$V = 12.04 m/s$ & $\psi = 36$]

Or

(b) A venturimeter of inlet diameter 300 mm and throat diameter 150 mm is inserted mercury manometer connected to the inlet and throat gives a reading of 200 mm. Find the discharge, if the co-efficient of discharge of meter is 0.98.

Given data:

$d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$x = 200mm = 0.2\ m$

$C_d = 0.98$

☺ ***Solution:***

Area at inlet section,

$$a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.3)^2 = 0.07m^2$$

Area at throat section,

$$a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.15)^2 = 0.017m^2$$

Head produced due to pressure difference,

$$h = x\left(\frac{S_m}{S_{water}} - 1\right) = 0.2\left(\frac{13.6}{1} - 1\right) = 2.52m$$

∴ The discharge through venturimeter,

$$Q = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$Q = 0.98 \times \frac{0.07 \times 0.017}{\sqrt{(0.07)^2 - (0.017)^2}} \times \sqrt{2 \times 9.81 \times 2.52}$$

∴ Discharge, $Q = 0.11207m^3/s$ =**112.07*lit/s***

13. (a)An oil of viscosity 1 N-s/m² flows between two parallel fixed plates which are kept at a distance of 50 mm apart. Find the discharge of oil between the plates. If the drop of pressure in a length of 1.2 m be 3 kN/m². The width of the plate is 200 mm.

[Ans.:- Discharge, Q = **5.2 *litres/s***]

Or

(b) A horizontal pipeline 40 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipe is 150 mm diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head which occur, determine the discharge. Take the Darcy's co-efficient of friction as0.01 for both sections of the pipe.

[Ans.:- Discharge, $Q = \mathbf{0.078}\ m^3/s$]

14. *(a) A flat plate 1.5 m× 1.5 m moves at 50 km/hour in stationary air of density 1.15 kg/m³. If the co-efficient of drag and lift are 0.15 and 0.75 respectively, determine the lift force, drag force, resultant force and the power required to keep the plate in motion.*

Given data

Area of the plate, $A = 1.5 \times 1.5 = 2.25\ m^2$

Velocity, $U = 50\ km/hr = \dfrac{50 \times 1000}{3600} = 13.89\ m/s$

$\rho_{air} = 1.15\ kg/m^3$

Coefficient of drag, $C_D = 0.15$

Coefficient of lift, $C_L = 0.75$

☻ ***Solution:***

(i) Lift force:

$$F_L = C_L A \frac{\rho U^2}{2}$$

$$F_L = 0.75 \times 2.25 \times \frac{1.15 \times 13.89^2}{2}$$

$$= \mathbf{187.2\ N}$$

(ii) Drag force:

$$F_D = C_D A \frac{\rho U^2}{2}$$

$$F_D = 0.15 \times 2.25 \times \frac{1.15 \times 13.89^2}{2}$$

$$= \mathbf{37.44\ N}$$

(iii) Resultant force,

$$F_R = \sqrt{(F_L)^2 + (F_D)^2}$$

$$= \sqrt{187.2^2 + 37.44^2}$$

$$= \mathbf{190.91\ N}$$

(iv) Power developed,

$$P = F_D U$$

$$P = 37.44 \times 13.89$$

$$= \mathbf{520.04\ W}$$

Or

(b) Find the displacement thickness and the momentum thickness for the velocity distribution in the boundary layer given by $u/U = y/\delta$, where u is the velocity at a distance y from the plate and $u = U$ at $y = \delta$ where δ is the boundary layer thickness.

15. (a) The efficiency η of a fan depends on density ρ, dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rotor and the discharge Q. Express η in terms of dimensionless parameters. Use Buckingham's π theorem.

Or

(b) Discuss briefly the types of forces acting in moving fluid and the importance of three types of similarities.

(i) Inertia force

(ii) Viscous force

(iii) Gravity force

(iv) Pressure force

(v) Surface tension force