S.E. Sem. III [CIVIL]

Fluid Mechanics - I

Time : 3 Hrs.] Prelim Question Paper **[Marks : 80**

Q.1(a) Define Total pressure and center of pressure. **[2]**

(A) **Total pressure :** The total pressure of the liquid on an immersed surface is defined as the force exerted by the liquid on the surface in contact with the liquid. The surface may be plane or curved. The force always acts normal to the surface.

Centre of pressure : A center of pressure is defined as a point on the immersed
surface at which the total pressure force of the liquid act.

The intensity of pressure acting on the body immersed in the liquid is directly proportional to its depth. Therefore the pressure is greater on lower portion of any immersed surface and hence the resultant of pressure acts at a point below the centre of gravity of the surface. It is expressed in terms of depth from the liquid surface.

Q.1(b) Write the classification of Orifice. **[2]**

(A) Based on

(i) Size : Small, Large.
(ii) Shape : Circular, Rectangular, triangular
(iii) Discharge condition : Free partially submerged, fully submerged.

Q.1(c) Define vorticity and circulation. **[2]**

(A) The flow among a closed curve is called the circulation. The flow among an element of the curve is defined as the product of the length element δs of the curve and the component of the velocity tangent to the curve, q cos α. Hence, the circulation Γ around a closed path C is

$$\Gamma = \int_C q \cos\alpha \, ds = \int_C q.\,ds$$

Vortex is the circulation around any closed path. The value of the circulation is the strength of the vortex.

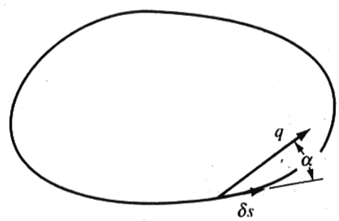
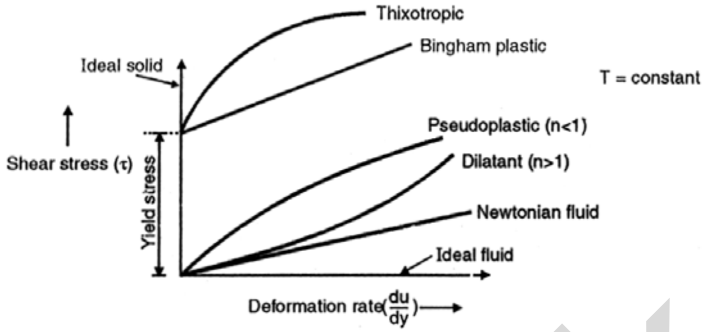
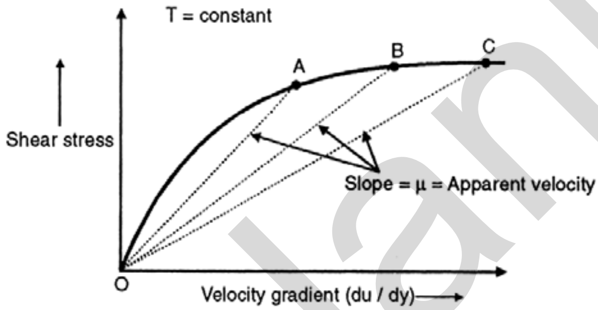


Fig.: Notation for the definition of circulation

Q.1(d) Write classification of fluids based on viscosity. [2]
(A)



1) Pseudoplastic Fluid or Shear Thinning Fluid :



- Fluid in which the apparent viscosity decreases with increasing deformation rate (n < 1) is called as Pseudoplastic fluid.
- Examples are slurries, mud, polymer solution, gums, blood, milk, colloidal suspensions, paper pulp in water, quick sand etc.

2) Dilatant Fluid or Shear Thickening Fluid :
Fluid in Which the apparent viscosity increases with increasing deformation rate (n>1) is called as dilatant fluids.
e.g. Suspension of sand, starch, butter, sugar solution.

3) Bingham Plastic Fluid or Ideal Plastic Fluid :
The Fluid which possess a definite yield stress but then the relationship between shear stress and angular deformation is linear is called as Bingham plastic fluid.
e.g. Sewage sludge, tooth paste, oil paint, jellies, applesauce, drilling mud.

4) Thixotrophic Fluid or Plastic Fluid :
The fluid which posses a definite yield stress but then the relationship between shear stress and angular deformation is non–linear are called as Thixotrophic fluid. e.g. Printer ink, lipstick.

5) Ideal Fluid :

The fluid which has zero viscosity or shear stress is always zero is called as ideal fluid, that's why ideal fluid is represented by the horizontal axis.

Q.1(e) State Bernoulli's theorem. **[2]**

(A) **Bernoulli's Theorem :** It states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is always constant.

∴ Total Energy = constant

Pressure energy + Kinetic energy + Potential energy = Constant

$$\frac{P}{\gamma} + \frac{V^2}{2g} + z = \text{constant}$$

where, $\frac{P}{\gamma}$ = pressure energy or pressure head per unit weight

$\frac{V^2}{2g}$ = Kinetic energy or kinetic head per unit weight

Z = Potential energy or datum energy or datum head per unit weight.

Q.1(f) Define source, sink. **[2]**

(A) A line normal to the xy plane, from which fluid is imagined to flow uniformly in all directions at right angles to it, is a source. It appears as a point in the customary two-dimensional flow diagram. The total flow per unit time and unit length of line is called the strength of the source.

$\phi = -\mu \ln r$

$\Psi = -\mu\theta$

A sink is a negative source, a line into which fluid is flowing.

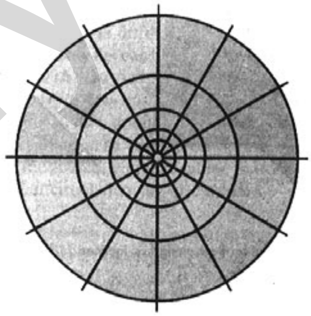


Fig. : Flow net for source or

Q.1(g) State Pascals law. **[2]**

(A) **Pascal's Law :**

Pascal law states, "The intensity of pressure at a point in a fluid at rest is same in all direction."

Q.1(h) Differentiate between pathline, streamline, streakline. [2]

(A) **Pathline :** The actual path followed by a fluid particle as it moves during a period of time is called as path line.

Streamline : The imaginary line drawn in the fluid in such a way that the tangent to any point gives the direction of motion at that point, is called as stream line.

Streakline : The curve that gives an instantaneous picture of the location of the fluid particles, which have passed through a given point, is called as streak line.

Q.1(i) Define notch and weir. [2]

(A) A notch may be defined as an opening provided in the side of a tank (or vessel) such that the liquid surface in the tank is below the top edge of the opening. Notches made of metallic plates are also provided in narrow channels (particularly in laboratory channels) in order to measure the rate of flow of liquid. As such in general notches are used for measuring the rate of flow of liquid from a tank or in a channel.

A weir is the same given to a concrete or masonry structure built across a river (or stream) in order to raise the level of water on the upstream side and to allow the excess water to flow over its entire length to the downstream side. Thus a weir is similar to a small dam constructed across a river, with the difference that whereas in the case of a dam excess water flows to the downstream side, only through a small portion called spillway, the same in the case of a weir flows over its entire length. Weirs may also be used for measuring the rate of flow of water in rivers or streams.

Q.1(j) Define nappe and sill. [2]

(A) The sheet of water flowing through a notch or a weir is known as the nappe (French term meaning sheet) or vein. The bottom edge of a notch or the top of a weir over which the water flows is known as the sill or crest, and its height above the bottom of the tank or channel is known as the crest height.

Q.2(a) Water in a container experiences a pressure increase a 820 KPa above atmospheric pressure. Find reduction in volume taking K_{water} = 2.2×10^9 Pa. [5]

(A) $K = 2.2 \times 10^9$ Pa

$dp = 820$ k Pa $= 820 \times 10^3$ Pa

$$K = -\frac{dp}{(\partial V/V)}$$

$$2.2 \times 10^9 = \frac{-820 \times 10^3}{(\partial V/V)}$$

$\therefore$ Reduction in volume $\frac{\partial V}{V}$ = 817.8×10^6 Am

Q.2(b) A stone weighs 400 KN in air and 225 KN when immersed in water. Calculate the volume of the stone and its relative density. **[5]**

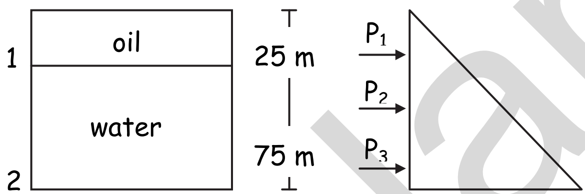
(A) Weight of water displaced = 400 − 225 = 175 kN

Volume of water displaced = $\frac{175}{9.81}$ = 17.83 m^3

$\therefore$ Density of stone = $\frac{400 \times 10^3}{17.83}$ = $22.4 \times 10^3 \text{ N/m}^3$

Q.2(c) A tank with vertical sides of 1 m is square in plan with side 1 m long. It contains oil of specific gravity 0.82 to a depth of 25 m floating on 75 m depth of water. Calculate the total pressure on one side of the tank. **[10]**

(A)



(i) Pressure at top = 0

(ii) Total pressure on side of the tank is

$$= (0.82 \times 9.81 \times 25) \times \left(\frac{1}{2} \times 1 \times 25\right) + (0.82 \times 9.81 \times 25) \times (75 \times 1) + (9.81 \times 75) \times \left(\frac{1}{2} \times 1 \times 75\right)$$

$$= (2.51 + 15.1 + 27.6) \times 10^3$$

$$= 45.2 \times 10^3 \text{ kN}$$

Q.3(a) Differentiate between simple and differential manometer. **[4]**

(A)

	Simple Manometer	Differential Manometer
(i)	It is used to measure +ve or −ve gauge pressure at a point in a pipe line.	It is used for measuring difference of pressure between two points in a pipeline or in two different pipes.
(ii)	One end of manometer is open to atmosphere and other end is connected to gauge point whose pressure is to be measured.	Two ends of manometer are connected to the two points whose pr. difference is to be measured.

(iii)	Simple manometer cannot be made inverted type.	Differential manometer can be made inverted type.
(iv)	Manometric fluid used is mercury.	Manometric fluid used may be heavy liquid or lighter liquid.

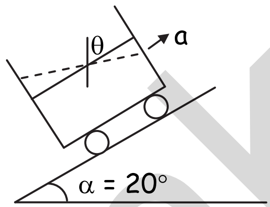
Q.3(b) A container having dimension 7m × 2m and 2.5 m deep contains water 1.25 m deep. The container moves with an acceleration 3 m/s² up to 20° inclined plane. Find the inclination of water surface with horizontal. **[6]**

(A) $a_x = 3 \cos 20$

$a_y = 3 \sin 20$

$\tan\theta = \dfrac{ax}{ay + g}$

$\therefore \quad \theta = 14.58°$ Am



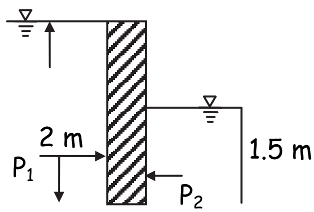
Q.3(c) A gate 3 m wide, 2 m high separates a liquid of specific gravity 1.5 and height 2 m on one side and water upto 1.5 m on other side of gate. Find the forces acting on the two sides of the gate and the resultant force acting on the gate and its location. **[10]**

(A) Area of gate = 3 × 2 = 6m²

$p = \Upsilon A\bar{h}$

$p_1 = 88.29$ kN

$P_2 = 44.15$ kN



Resultant force (R) = $P_1 - P_2 = 44.15$ kN Am

$h_P = \dfrac{I_a}{A\bar{h}} + \bar{h}$, $\quad I_a = \dfrac{1}{12} \times 3 \times 2^3 = 2m^3$

$\therefore \quad h_{P1} = 1.33, \qquad h_{P2} = 1.19$

$-R \cdot y = P_2 \times h_{P2} - p_1 \times h_{P1}$

$\therefore \quad y = 0.73$ m from top surface

Q.4(a) What do you understand by Langrangian and Eulerian method. **[4]**

(A) **Lagrangian Method :**

- In this method, the observer concentrates on the movement of single particle.
- Observer has to move with the particle movement.
- The path followed by the particle and changes in its velocity acceleration, density etc. are described. In this method, the observer moves with motion of fluid.

Eulerian method :

- In this method, observer concentrates on the fixed-point particles.
- Observer remains stationary and observes changes in the fluid parameters at the particular point only.

Q.4(b) The velocity components in 2 dimensional incompressible flow is given by : $U = y^3 + 6x - 3x^2y$

$V = 3xy^2 - 6y - x^3$

(i) Is the flow continuous? [4]

(ii) Find whether the flow is rotational or irrotational. [4]

(iii) Determine the potential function. [4]

(iv) Determine the stream function. [4]

(A) (i) $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 6 - 6xy + 6xy - 6$

$= 0$ Hence flow continuous.

(ii) $\nabla \times V = \begin{vmatrix} i & j & k \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ u & v & w \end{vmatrix} = 0$

Hence flow irrotational.

(iii) $\partial\phi = \frac{\partial\phi}{\partial x}\cdot\partial x + \frac{\partial\phi}{\partial y}\cdot\partial y = -u\,\partial x - v\,dy$

Integrating both side

Potential function $\phi = 2(x^3y - xy^3) + 3(y^2 - x^2) + C_1$

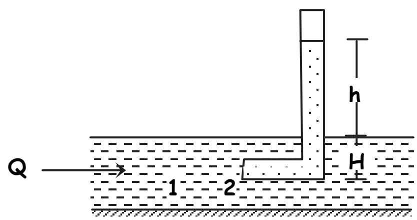
(iv) $\partial\psi = \frac{\partial\psi}{\partial x}\cdot\partial x + \frac{\partial\psi}{\partial y}\cdot\partial y = -v\,\partial x + u\,\partial y$

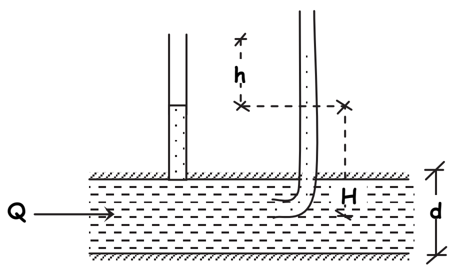
Integrating

$\psi = -3x^2y^2 + 12xy + \frac{1}{4}(x^4 + y^4)$

Q.5(a) Sketch a pitot tube and explain its working. [6]

(A) It is the device used for measuring the local velocity of flow at any point in a pipe or a channel. It's working principle is if velocity of flow at a point becomes zero, there is increase in pressure energy. In its simplest form, it is a glass tube sent at right angles.





Applying Bernoulli's equation at point (1) and (2)

$$\frac{p_1}{w}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{w}+\frac{V_2^2}{2g}+z_2 \qquad \text{... (1)}$$

Now

$$\therefore \quad \frac{p_1}{w} = H$$

$$\frac{p_2}{w} = H + h$$

$V_2 = 0$ and $z_1 = z_2$ put in equation (1)

$$\therefore \quad H+\frac{V_1^2}{2g} = H + h + 0$$

$$\therefore \quad V_1 = \sqrt{2gh}$$

$$\therefore \quad V_{actual} = C_v\sqrt{2gh}$$

where C_v = coefficient of velocity.

Q.5(b) Write on Cipolleti weir. **[4]**

(A) Cipolletti weir is particular type of trapezoidal weir, the sloping sides of which have an inclination of 1 horizontal to 4 vertical, $\left(\text{i.e.,}\frac{\theta}{2}=14^\circ\right)$. This weir was invented by an Italian engineer Cipolletti in 1887. As indicated below the slope of 1 in 4 provided for the sides of this weir results in making the decrease in the discharge over a rectangular weir due to two end contractions just equal to the increase in the discharge trough the two triangular portions. So that the discharge over a Cipolletti weir may be computed by using the formula for a suppressed rectangular weir.

As in the case of a trapezoidal weir, for a Cipolletti weir also the discharge is given by

$$Q = (Q_1 + Q_2)$$

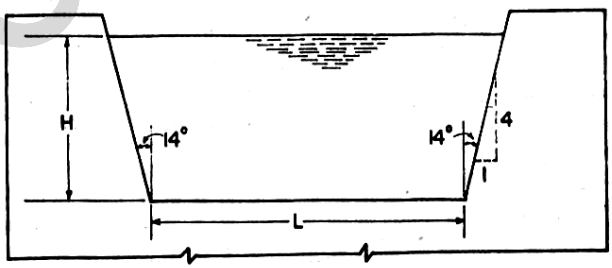


Fig. : Cipolletti weir

where Q_1 is the discharge through the rectangular portion and Q_2 is the discharge through the two triangular portions on either side.

Q.5(c) An oil of specify gravity of 0.90 is flowing through a venturimeter having inlet and throat diameter as 30 cm and 15 cm respectively. The oil mercury differential manometer shows a reading of 250 mm. The throat is 30 cm above inlet section. Find the discharge of oil through the venturimeter when it lies in horizontal plane. **[10]**

(A) Diameter = 30 cm^2, Area, $A_1 = 0.07\ m^2$ of pipe

diameter of throat = 15 cm, $A_2 = 0.0017\ m^2$

$y = 250\ mm = 0.25m$

$$h = y\left(\frac{Sm}{S} - 1\right) = 3.15\ m$$

$$Q = C_d \cdot \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} = 0.135\ m^3/s$$

Q.6(a) Water flow over a rectangular sharp crested weir of 1 m height, extends across a rectangular channel of 3 m width. If head of water over the weir is 0.4 m, determine the discharge. Consider the velocity of approach. Take C_d = 0.62. **[10]**

(A) $L = 3m$, $H = 0.4m$, $C_d = 0.62$

$$Q = \frac{2}{3} \cdot C_d \cdot L\sqrt{2g} \cdot H^{3/2}$$
$$= 1.389\ m^3/s$$

Approach velocity = $V_a = \dfrac{Q}{1 \times 3}$ = 0.46 m/s velocity head.

$$H_a = \frac{V_a^2}{2g} = 0.01\ m$$

$$Q = \frac{2}{3}C_d \cdot L\sqrt{2g}\left[(H + Ha)^{3/2} - HQ^{3/2}\right]$$
$$= 1.44\ m^3/s\ Am$$

Q.6(b) An external cylindrical mouthpiece of diameter 100 mm is discharging water under a constant head of 8 m. Determine the discharge and absolute pressure head of water at vena contracta. Take C_d = 0.855, C_c for vena contracta = 0.62 atmospheric pressure head = 10.3 m of water. **[10]**

(A) d.m.p. = 100 mm, $A = 0.00785m^2$

Head (H) = 8m, $C_C = 0.62$, $C_d = 0.85$

(i) Discharge = $Q = Cd \cdot A \cdot \sqrt{2gH}$

$= 0.085\ m^3/s$ (Am)

(ii) $H = 1.375\dfrac{V_1^2}{2g}$ $\quad\therefore\quad V_1 = 10.78$ m/s

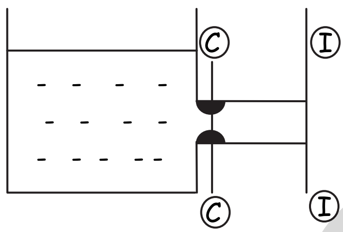
(iii) $C_C = \dfrac{V_1}{V_C}$ $\quad\therefore\quad V_C = 17.4$ m/s

(iv) $H + Ha = Hc + \dfrac{VC^2}{2g}$

$$8 + 10.3 = Hc + \frac{17.4^2}{2\times 9.81}$$

$\therefore\quad Hc = 3.09$ m

Absolute pressure head at vena contracta = 3.09 m



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