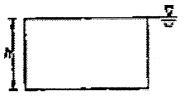
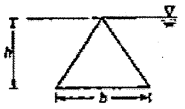
CHAPTER 3

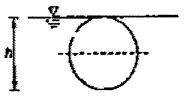
Hydrostatic Force on Surface

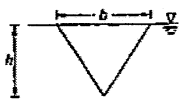
Q.1 Match Column-I with Column-II and select the correct answer using the codes given below:

Column-I (Surface)

A. 

B. 

C. 

D. 

Column-II (Centre of Pressure)

1. $\frac{5h}{8}$

2. $\frac{2h}{3}$

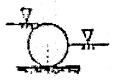
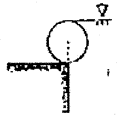
3. $\frac{h}{2}$

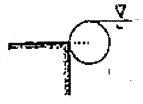
4. $\frac{3h}{4}$

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	3	1	4	2
(c)	2	4	1	3
(d)	2	1	4	3

Q.2 In which of the following arrangements will the vertical force in the cylinder due to water be maximum?

(a)  (b) 

(c)  (d) 

Q.3 A vertical rectangular plane surface is submerged in water such that its top and bottom surfaces are 1.5 m and 6.0 m respectively below the free surface. The position of centre of pressure below the free surface will be at a distance of

(a) 3.75 m (b) 4.0 m
(c) 4.2 m (d) 4.5 m

Q.4 A body weighs 30 N and 15 N when weighed under submerged conditions in liquids of relative densities 0.8 and 1.2 respectively. What is the volume of the body in liters?

(a) 12.55 (b) 3.83
(c) 16.78 (d) 75.53

Q.5 The total pressure on a plane surface inclined at an angle θ with the horizontal is equal to

(a) pA (b) $pA \sin\theta$
(c) $pA \cos\theta$ (d) $pA \tan\theta$

where p is pressure intensity at centroid of area with A is area of plane surface.

Q.6 Which of the following statements related to buoyancy in fluid statics is/are correct?

(a) Principle of buoyancy is applicable to both floating bodies and submerged bodies
(b) Archimedes formulated the first theory of buoyancy
(c) In a free body diagram of a floating body, summation of all horizontal forces is taken as zero
(d) All of these

Q.7 A vertical sluice gate, 5 m wide and weighing 2000 kg is held in position due to horizontal force of water on one side and associated friction force. When the water level drops down to 4 m above the bottom of the gate, the gate just starts sliding down. The coefficient of friction between the gate and the supporting structure is

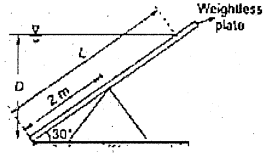
(a) 0.20 (b) 0.10
(c) 0.05 (d) 0.02

Q.8 **Assertion (A):** For a plane surface immersed vertically, the centre of pressure lies below the centroid of the surface area.

Reason (R): The pressure intensity increases with the increase in the depth of liquid.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.9 Find the depth of water at which the plate will topple.



(a) 6 m (b) 3 m
(c) 2 m (d) 1.5 m

Q.10 One end of a two dimensional water tank has the shape of a quadrant of a circle of radius 2 m. When the tank is full, the vertical component of the force per unit length on the curved surface will be

(a) 250 πkgf (b) 1000 πkgf
(c) 4000 kgf (d) 3000 πkgf

Q.11 An inclined plate 2 m long and 1 m wide lies with its length inclined at 45° to the surface of water and the nearest edge 1 m below it. If the specific weight of water is 1000 kg/m^3, then the total pressure on the plate (in kg) is approximately

(a) 2000 (b) 25000
(c) 3000 (d) 3420

Q.12 A triangular laminar is immersed in water with its apex downwards and base 1 meter below water surface. If its base width and height are 1.5 m and 1.8 m respectively, the total pressure on the triangle will be

(a) 21.189 kN (b) 42.30 kN
(c) 10.32 kN (d) 5.16 kN

Q.13 What is the vertical distance of the centre of pressure below the centroid of the plane area?

(a) $\frac{I_G}{A\bar{h}}$ (b) $\frac{I_G \sin\theta}{A\bar{h}}$

(c) $\frac{I_G \sin^2\theta}{A\bar{h}}$ (d) $\frac{I_G \sin^2\theta}{A\bar{h}^2}$

Q.14 For a vertical semicircular plate submerged in a homogeneous liquid with its diameter 'd' at the free surface, the depth of centre of pressure from the free surface is

(a) $\frac{3\pi d}{32}$ (b) $\frac{3d}{2\pi}$

(c) $\frac{4d}{3\pi}$ (d) $\frac{3\pi d}{16}$

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Answers Hydrostatic Force on Surface

1. (c) 2. (c) 3. (c) 4. (b) 5. (a) 6. (d) 7. (c) 8. (a) 9. (b) 10. (b)
11. (d) 12. (a) 13. (c) 14. (a)

Explanations Hydrostatic Force on Surface

2. (c)
Vertical force will be maximum when the cylinder is completely submerged in water.

3. (c)

$$\bar{h} = 1.5 + \frac{(6-1.5)}{2} = 3.75 \text{ m}$$

$$h' = 3.75 + \frac{b\times(4.5)^3}{12\times(b\times4.5)\times3.75} = 4.2 \text{ m}$$

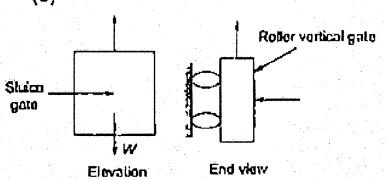
4. (b)

$$W - V\rho_1 g = 30 \quad ...(i)$$
$$W - V\rho_2 g = 15 \quad ...(ii)$$
$$\Rightarrow \frac{W - V(800)(9.8)}{W - V(1200)(9.8)} = 2$$
$$\Rightarrow W = 15680\ V$$

Putting the value of W in eq. (i)

$$15680\ V - V(800)(9.8) = 30$$
$$\Rightarrow V = 3.83 \times 10^{-3}\ m^3 = 3.83 \text{ litres}$$

7. (c)



Normal force (or) reaction force offered by rollers = Hydrostatic force

$$R_N = \rho g \bar{h} A$$
$$= 1000 \times g \times \frac{4}{2} \times (4\times5)$$
$$= 40000\ g \text{ (Newton)}$$

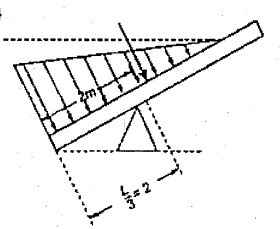
The vertical force provided externally is equal to frictional force offered by roller.

At equilibrium

Gate self weight = Frictional force

$$200 \times g = \mu \times 40000\ g$$
$$\mu = \frac{2000}{40000} = 0.05$$

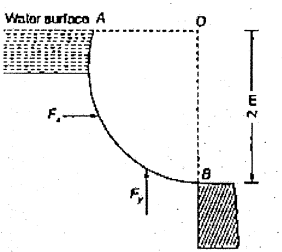
9. (b)



$$\frac{L}{3} = 2$$
$$\Rightarrow L = 6 \text{ m}$$
$$D = L \sin 30° = 6\times\frac{1}{2} = 3 \text{ m}$$

Toppling will just begin when the resultant force passes through the hinge.

10. (b)



Vertical component of force per unit length on the curved surface,

F_y = Weight of water supported by AB
= ρg × Area of AOB × 1
= $1000 \times 9.81 \times \pi/4 \times (2)^2 \times 1$N
= $9.81 \times 1000 \times \pi$ N = $1000\ \pi$ kgf

12. (a)

Total pressure = $\gamma A \bar{h}$

$$= 9810 \times \left(\frac{1}{2}\times1.5\times1.8\right)\times\left(\frac{1}{3}\times1.8+1\right)$$
$$= 21189.6 \text{ N} = 21.189 \text{ kN}$$

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