ANSWERS

1. B	**2.** D	**3.** C	**4.** C	**5.** A	**6.** D	**7.** A
8. B	**9.** C	**10.** C	**11.** A	**12.** A	**13.** B	**14.** A
15. B	**16.** D	**17.** A	**18.** B	**19.** A	**20.** A	**21.** A
22. C	**23.** A	**24.** A	**25.** D	**26.** C	**27.** C	**28.** B
29. C	**30.** A	**31.** A	**32.** A	**33.** C	**34.** C	**35.** B
36. C	**37.** D	**38.** C	**39.** A	**40.** D	**41.** C	**42.** C
43. A	**44.** A	**45.** A	**46.** D	**47.** D	**48.** C	**49.** B
50. D						

SOLUTIONS

1. $S = 0.9, \quad P_1 = 9818 N/m^2, \quad h = 3m$

$\therefore \quad P_2 = P_1 + {}^\circ gh$

$= 9810 + 0.9 \times 1000 \times 9.81 \times 3$

$= 36297 N/m^2 = 0.0363 N/mm^2$

2. $F = {}^\circ ghA = 1000 \times 10 \times 1 \times 2 = 2000N$

3. Specific weight = $\dfrac{\text{weight}}{\text{volume}} = \dfrac{47}{6} = 7.833\ KN/m^2$

4. $P = 3.924 \times 10^{+4} N/m^2$

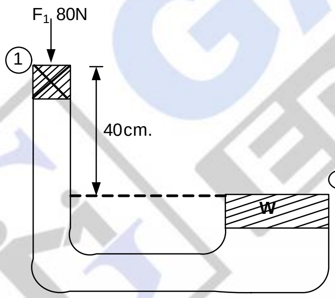
$h = P/{}^\circ g = \dfrac{3.924 \times 10^4}{10^3 \times 9.81} = 4m$

5. ${}^\circ{}_0 g z_0 + {}^\circ{}_w g z_w{}^1$

$= 0.9 \times 10^3 \times 9.81 \times 1 + 10^3 \times 9.81 \times 2$

$= 28.45 kN/m^2$

6.



Given data,

$D_1 = 3cm = 0.03m \qquad h_1 = 40cm = 0.40m$

$D_2 = 10cm = 0.10m \qquad F_1 = 80N$

$A_1 = \dfrac{®}{4}(D^2) = 7.069 \times 10^{-4} m^2$

$A_2 = \dfrac{®}{4}(D_2{}^2) = 7.854 \times 10^{-4} m^2$

$\therefore$ Pressure intercity at section 1-1 =Pressure Intercity at section 2-2

$\Rightarrow \dfrac{F_1}{A_1} + \text{Pressure Intercity due to} = \dfrac{W}{A_2}$

$\Rightarrow \dfrac{80}{7.069 \times 10^{-4}} + 1000 \times 9.81 \times 0.40 = \dfrac{W}{7.854 \times 10^{-3}}$

$\Rightarrow 117094.18 = \dfrac{W}{7.854 \times 10^{-3}}$

$\boxed{W = 919.657N}$

7. $aP = gh({}^\circ{}_w - {}^\circ{}_0) = 9.81 \times 0.4 (10^3 - 0.9 \times 10^3)$

$= 392.4 N/m^2$

8. $P_{abs} = P_{gauge} + P_{atm} = {}^\circ{}_l g h_l + {}^\circ{}_{hg} g h_{hg}$

$= 0.8 \times 10^3 \times 9.81 \times 2 + .760 \times 13.6 \times 10^3 \times 9.81$

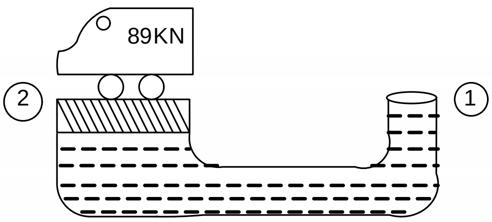
$= 117.1 kN/m^2$

9. Needle behaves like liquid Jet .

For liquid Jet, $F = 2±d = 2 \times 0.0728 \times 0.035$

$\therefore \quad F = 5.096 \times 10^{-3} = 5.1 \times 10^{-3} N$

10.



0020

$\therefore$ Pressure intensity at section (1)-(1) = Pressure intensity at section 2-2

$\Rightarrow P_1 = P_2$

$\Rightarrow P_1 = \dfrac{W}{A_2}$

$\Rightarrow \quad A_2 = \frac{W}{P_1} = \frac{89 \times 1000}{1.22 \times 106} = 0.07295 m^2$

$$\boxed{D = 305mm}$$

11. $\therefore$ Gauge Pressure at the top of tank

$= 276000 - 1000$
$\times 9.81(S_{Hg} \times h_{Hg} + S_w H_w + S_o H_o)$

$= 276000 - 1000 \times 9.81(13.6 \times 0.61 + 1 \times 1.524$
$+ 0.75 \times 2.438)$

$= 161728.215 Pa = 161.728 KPa$

12. Pressure intensity at one side = Pressure intensity at other side $^{\circ}{}_{oil} h_{oil} g = {}^{\circ}{}_{water} h_{water} g$

$$\frac{^{\circ}{}_{oil}}{^{\circ}{}_{water}} = \frac{h_{water}}{h_{oil}} = \frac{0.3}{0.35} = 0.86$$

13. $P_A - 9.80x - (0.8 \times 9.8)(0.7) + 9.8(x - 0.8) = P_B$

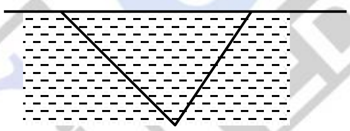
$\Rightarrow \quad P_A - P_B = 13.3 kPa$

14. Pressure head at centre

$\bar{h} = \frac{19.6 \times 10^4}{870 \times 9.81} = 22.99 m$

$F = {}^{\circ} g \bar{h} A = 870 \times 9.81 \times 22.99 \times \frac{®}{4} 4^2 = 2465 \times 10^3 N$

15. $\frac{I_G}{A\bar{h}} = \frac{Ad^2/16}{A\bar{h}} = \frac{d^2}{16\bar{h}} = \frac{4^2}{16 \times 22.99}$
$= 0.043 m$ below



16. Distance of centre of gravity from oil surface

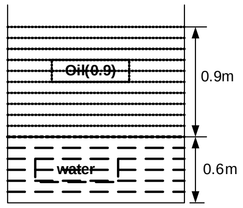
$\bar{h} = \frac{h}{3} = h/3 = 1.33 m$

$F = {}^{\circ} g \bar{h} A = 900 \times 9.81 \times 1.33 \times 8 = 93940.56 N$

17. $\bar{h} + \frac{I_G}{A\bar{h}} = 1.33 + \frac{7.11}{8 \times 1.33} = 1.99 m$

$I_G = \frac{bd^3}{36} = \frac{4.4^3}{36} = 7.11 m^4$

18.



$F_V = {}^{\circ}{}_o g \bar{h}_o A_o + {}^{\circ}{}_w g \bar{h}_w A_w$

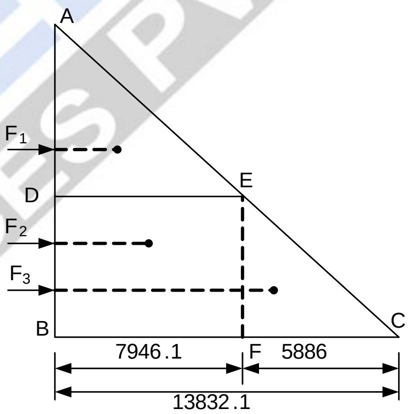
$\bar{h}_o = \frac{0.9}{2} = 0.45 m$

$\bar{h}_w = h_o \times S_o + \frac{0.6}{2} = 0.9 \times 0.9 + \frac{0.6}{2} = 1.11 m$

$\therefore \quad F_V = 0.9 \times 1000 \times 9.81 \times 45 \times 0.9 \times 1.5$
$+ 1000 \times 9.81 \times 1.11 \times 0.6 \times 1.5$

$= 1516.80 m$

19. Position of centre of pressure



F_1 = Area of triangle ADE $\times$ Width of tank

$= \left(\frac{1}{2} \times AD \times DE\right) 1.5 \quad (\because \quad$ Width = 1.5m)

$= \left(\frac{1}{2} \times 0.9 \times 7946.1\right) \times 1.5 N = 5363.6 N$

F_2 = Area of rectangle BDEF $\times$ Width of tank

$= (BD \times DE) \times 1.5 = (0.6 \times 7946.1) \times 1.5 = 7151.5$

F_3 = Area of triangle EFC $\times$ Width of tank

$\left(\frac{1}{2} \times EF \times FC\right) \times 1.5 = \left(\frac{1}{2} \times 0.6 \times 5886\right)$
$\times 1.5 = 2648.7 N$

Position of centre of pressure

Let the total force F is acting at a depth of h* from the free surface of liquid, i.e., from A.

Taking the moments of all forces about A, we get

$$F \times h^* = F_1 \times 0.6 + F_2 \times 1.2 + F_3 \times 1.3$$

$$h^* = \frac{F_1 \times 0.6 + F_2 \times 1.2 + F_3 \times 1.3}{F}$$

$$= \frac{5363.6 \times 0.6 + 7151.5 \times 1.2 + 2648.7 \times 1.3}{15163.8}$$

$= \mathbf{1.005\ m}$.

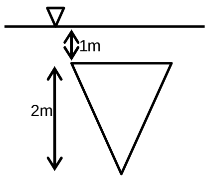
20. $P = \rho_w g h_w + \rho_S g h_S$

$$= 10^3 \times 9.81 \times 2 + 1.04 \times 10^3 \times 9.81 \times 4$$

$$= 60.4 \times 10^3 \text{Pa}$$

21.

$$P = \rho gh = 13.6 \times 10^3 \times 9.81 \times 0.2 = 26.7 \times 10^3 \text{Pa}$$



22. $P = \rho gh = 12.1 \times 10^6 \text{Pa}$

23. $\bar{h} = 1 + \frac{1}{3} \times 2 = 1.667\text{m}$

$$P = \rho gA\bar{h} = 10^3 \times 9.81 \times 1.5 \times 1.667 = 24530\text{N}$$

24. $\text{C.P.} = \bar{h} + \frac{I_G}{A\bar{h}} = 1.667 + \frac{.333}{1.5 \times 1.667}$
$= 1.8\text{m}$ from free surface

$$I_G = \frac{bh^3}{36} = \frac{1.5 \times 2^3}{36} = 0.333\text{m}^4$$

25. Volume of water displaced, V =
$$\frac{\text{displace weight}}{\text{water weight}} = \frac{5000 \times 10^3}{10^3} = 5000\text{m}^3$$

$$BM = \frac{I}{V} = \frac{1.5 \times 10^4}{5000} = 3\text{m}$$

Buoyancy centre = 2.5m

Meta centric height = 3-2.5=0.5m

26. $T = 2\pi\sqrt{\frac{k^2}{gh}} = 2\pi\sqrt{\frac{3.5^2}{9.81 \times 0.5}} = 9.93 \text{ sec}$

27. Pressure head

$$= \frac{p_1 - p_2}{\rho g} = \frac{\left(4 \times 10^4 - 1.5 \times 10^4\right)g}{10^3 \times g} = 25\text{m}$$

28. $T = 2\pi\sqrt{\frac{k^2}{gh}} = 2\pi\sqrt{\frac{10^2}{9.81 \times 1}} = 20 \text{ sec}$

29.

$$GM, h = \frac{I}{\forall} - BG \qquad \forall = \frac{\text{weight of ship}}{\text{weight of water}}$$

$$= \frac{10000}{3058.1} - 1.5 \qquad = \frac{30000 \times 10^3}{10^3 \times 9.81}$$

$$= 1.77\text{m} \qquad = 3058.1\text{m}^3$$

$$T = 2\pi\sqrt{\frac{k^2}{gh}}$$

$$10 = 2\pi \frac{k}{\sqrt{9.81 \times 1.77}}$$

$$k = 6.63\text{m}$$

30. Volume = $3 \times 2 \times 1 = 6\text{m}^3$

Weight of water displaced =

$$V \times 0.8 \times g \times \rho w = 6 \times 0.8 \times 9.81 \times 10^3$$
$$= 47088\text{N}$$

31. M.I., $I = \frac{bd^3}{12} = \frac{3 \times 2^3}{12} = 2\text{m}^4$

$$\forall = 6 \times 0.8 = 4.8\text{m}^3$$

$$\text{meta centric height} = \frac{2}{4.8} - 0.1 = 0.317\text{m}$$

32. $F = \rho g\bar{h}A = 10^3 \times 9.81 \times 4 \times \frac{\pi}{4} 3^2 = 277.3\text{kN}$

33. $\text{C.P.} = \frac{I_G}{A\bar{h}} + \bar{h}$

$$I_G = \frac{\pi d^4}{64} = \qquad A = \frac{\pi d^2}{4}$$

$$\text{C.P.} = \frac{d^2}{16\bar{h}} + \bar{h} = \frac{3^2}{16 \times 4} + 4 = 4.14\text{m}$$

34. The pressure at a point in a liquid is equal in all direction when fluid is at Rest .

35. $h_w = S_o h_o = 0.9 \times 40 = 36\text{mm}$ of water

36. $h_1 = 25\text{cm}, \quad h_2 = 45\text{cm},$

$$\rho_1 = 0.8 \times 1000 = 800\text{kg/m}^3$$

$\circ_2 = 13.6 \times 1000 = 13600 kg/m^3$

$P_A = \frac{a}{A} h_2 (\circ_2 g - \circ_1 g) + h_2 \circ_2 g - h_1 \circ_1 g$

$\Rightarrow \quad 7.25 \times 10^4 = \frac{a}{A}(0.45)(13600 - 800)9.81$
$+0.45 \times 13600 \times 9.81 - 0.25 \times 800 \times 9.81$

$\frac{a}{A} = \frac{\text{Area of tube}}{\text{Area of reservoir}} = 0.2552$

$\therefore \quad \frac{A}{a} = 3.91$

37. $P_A = h_2 \circ_2 g - h_1 \circ_1 g$
as the first term will be neglected as A>>a

$P_A = 58.467\ kN/m^2$

38. Pressure at B = Pressure at C

P_A + Pressure due to 15cm of oil = P_D + Pressure due to 15cm of mercury

$P_D = 0$

$P_A = \circ_1 gh - \circ_2 gh$

$P_A = gh(\circ_1 - \circ_2) = 17.06 kPa$

39.

A

Due to decrease of pressure, mercury in left limb will go up and hence mercury in right limb will go down by same level as total volume is constant.

Pressure at E = Pressure at G

$P_A + \frac{(15-x)}{100} \circ_2 g = P_D + \frac{(15-2x)}{100} \circ_1 g$

$P_A = 10 \times 10^3 Pa, \qquad P_D = 0$

$\therefore \quad 10 \times 10^3 = \frac{(15-2x)}{100} \circ_1 g - \frac{(15-x)}{100} \circ_2 g$

$\therefore \quad x = 2.85 cm$

40. New difference of mercury level = 15-2x = 9.3cm

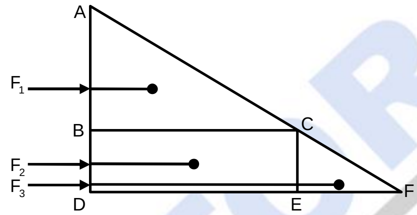
41. Applying Pascal's law at X-X

$P_A + 13.6 \times 1000 \times 9.81 \times .2$
$+5 \times 1000 \times 9.81 \times 1.75$

$= P_B + 2.2 \times 1000 \times 9.81 \times 0.8$

$P_A = 100 \times 10^3 Pa$

$\therefore \quad P_B = 195.225$ kpa



42

Total pressure is calculated using pressure diagram

Intensity of pressure on top, P_A = 0

Intensity of pressure on B or (BC)

$= \circ_1 gh_1 = 25751.25 N/m^2$

Intensity of pressure on D or (DE)

$= \circ_1 gh_1 + \circ_2 gh_2 = 44145 N/m^2$

From pressure diagram,

F_1 = Area of a ABC x width of tank

$= \frac{1}{2} \times AB \times BC \times 2 = 38626.875 N$

F_2 = Area of rectangle BCED x width of tank

$= BD \times DE \times 2 = 38626.875 N$

F_3 = Area of a CEF x width of tank

$= \frac{1}{2} \times CE \times EF \times 2 = 13795.31 N$

Total pressure, F

$= F_1 + F_2 + F_3 = 91.04 \times 10^3 Pa$

42. (C)

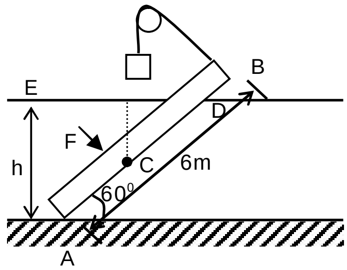
43. Let total pressure F is acting at a distance of h* from top

Taking moments about A

$F \times h^* = F_1 \times \frac{2}{3} \times AB + F_2 \left(AB + \frac{BD}{2} \right)$
$+F_3 \left(AB + \frac{BD}{3} \right)$

$h^* = 1.484$ from top

44. (A), **45.** (A)



Let h be the height of water over the gate.

AE = h

$$AD = \frac{AE}{\sin 60^0} = \frac{2h}{\sqrt{3}}$$

Area of gate immersed in water $= \frac{2h}{\sqrt{3}} \times 3 = 2\sqrt{3}hm^2$

Depth of C.G. of the immersed area = $\bar{h} = \frac{h}{0.2} = 0.5h$

$$\text{Total force } F = = \rho g 2\sqrt{3}h \times \frac{h}{2} = \sqrt{3}\rho gh^2 N$$

Centre of pressure of immersed area $h = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$

$$I_G = \text{M.O.I.} = \frac{1}{12} \times b \times (AD)^3 = \frac{1}{12} \times 3 \times \frac{8h^3}{3\sqrt{3}} = \frac{2h^3}{3\sqrt{3}}$$

$$h^* = CH = \frac{2h^3 \times \sin^2 60^0 \times 2}{3\sqrt{3} \times 2\sqrt{3}h \times h} + \frac{h}{2} = \frac{h}{6} \times \frac{h}{2} = \frac{2h}{3}$$

Now, $CD = \frac{CH}{\sin 60^0} = \frac{2h \times 2}{3 \times \sqrt{3}} = \frac{4h}{3\sqrt{3}}$

$$AC = AD - CD = \frac{2h}{\sqrt{3}} - \frac{4h}{3\sqrt{3}} = \frac{2h}{3\sqrt{3}}$$

taking moments about A

$$W \times 6 = F \times \frac{2h}{3\sqrt{3}}$$

$$60 \times 10^3 \times 6 = \rho g\sqrt{3} \times h^2 \times \frac{2h}{3\sqrt{3}}$$

h ≈ 3.8m

Total force, $F = \sqrt{3}\rho gh^2 =$ **245.35kN**

46. – (D) **47. –** (D) **48.–**(C)

Forces acting on the left side of cylinder

$F_{x1} = \rho gA\bar{h}$, A = Area of projected surface on vertical

$F_{x1} = 706.32kN,\ A = 6 \times 4 = AC \times width = 24m^2$

$$\bar{h} = \frac{1}{2} \times AC = 3m$$

F_{y1} = Weight of water enclosed by ABCOA

$$= 1000 \times 9.81 \times \left[\frac{\pi}{2} \times R^2\right] \times 4 = 554.74kN$$

Forces acting on right side of cylinder

$F_{x2} = \rho gA'\bar{h},\ A'$ = Area of projected surface

$= CO \times 2 = 3 \times 2 = 6m^2 = 88.29kN$

$$\bar{h} = \frac{3}{2} = 1.5m$$

F_{y2} = weight of water enclosed by DOCD

$$= 1000 \times 9.81 \times \left[\frac{\pi}{4} \times R^2\right] \times 4 = 277.37kN$$

Total horizontal force, $F_x = F_{x1} - F_{x2} = 618.03kN$

Total vertical force, $F_y = F_{y1} + F_{y2} = 832.11kN$

∴ Magnitude pf resultant force, $F = \sqrt{F_x^2 + F_y^2}$

≈ **1036.51kN**

∴ direction, $\theta = \tan^{-1}\frac{F_y}{F_x}$

$=$ **53.39^0**

The weight of the cylinder should not be less than the net upward force

$m \times g = F_y = 832.11$, **m ≈ 84.82 × 10^3 kg**

49. (B)

50. (D)

•••●•••