Fluid Mechanics Test I

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. When pressure is increased, the bulk modulus of elasticity 'K'+
(A) decreases
(B) increases
(C) remains same
(D) decreases then increase

2. The viscosity of water and the viscosity of air with increase in temperature
(A) decrease and increases
(B) increases and decreases
(C) decreases and decreases
(D) decreases and remains same

3. Pascal's law for a fluid is not valid if
(A) fluid is at rest
(B) fluid is at constant rotational velocity in a container
(C) fluid is at constant linear acceleration
(D) None of the above

4. An inverted U tube manometer is more sensitive than an upright manometric because
(A) the height of levels is greater
(B) the manometric fluids are heavier than working fluids
(C) the manometric fluids are lighter than working fluids
(D) None of the above

5. A vertical wall is holding a liquid of specific weight 'w' and height 'h' on one side. The total pressure on the wall per unit length is
(A) wh (B) $wh/2$
(C) $\frac{wh^2}{2}$ (D) $\frac{2}{3}wh$

6. If the surface of liquid is concave, then cohesive pressure is
(A) increased
(B) decreased
(C) absent
(D) negligible or doesn't matter

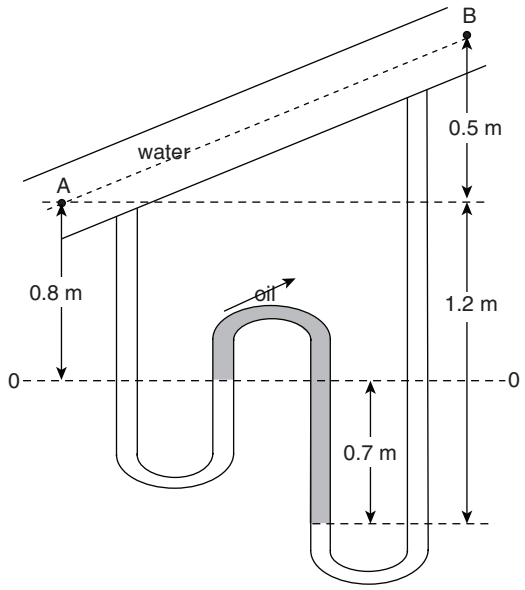
7. A body weight 4 kg in air was found to weigh 3.5 kg when submerged in water. Its specific gravity
(A) 1 (B) 3
(C) 6 (D) 8

8. If density of liquid $\rho = 1000$ kg/m^3 and area $A = 1$ m^2. Then flow rate Q at $t = 0$, (x, y) is (0, 1)
(A) 100 (B) 1000
(C) 0 (D) Can't be known

9. Surface Tension is
(A) also known as capillarity
(B) is a function of curvature of interface
(C) decreases with fall in temperature
(D) acts in a plane of interface normal to any line in the surface

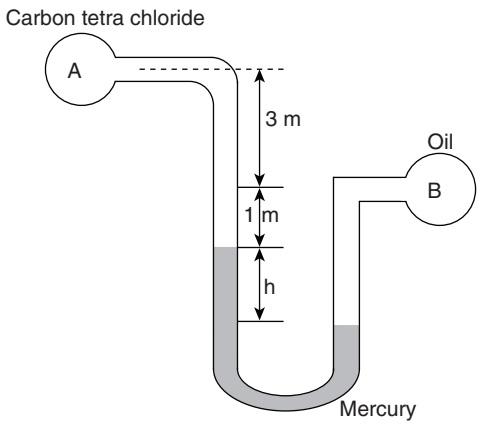
10. For stability of a floating body
(A) the meta centre 'M' should lie between the centre of gravity 'C' and centre of buoyancy 'B'
(B) M should lie above B and C
(C) M should coincide with B and C
(D) M should lie below B and C

11. An inverted U – tube differential manometer is used to measure pressure difference in an inclined water pipe as shown in figure. The manometer fluid is oil of specific gravity 0.75



Pressure difference between points A and B in N/m^2 is
(A) 1792 (B) 2882
(C) 3679 (D) 4216

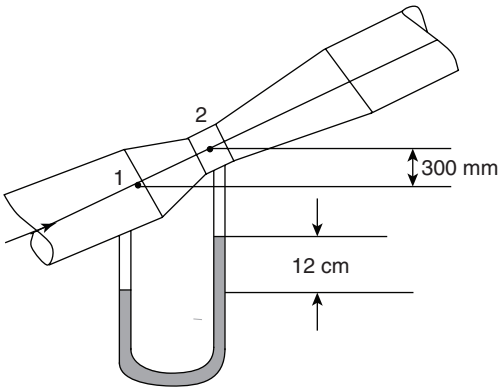
12.



Referring to the figure, pipe *A* contains carbon tetrachloride of sp gravity 1.59 under a pressure of 105 kN/m^2 and pipe *B* contains oil of sp gravity 0.8 under pressure 170 kN/m^2. Level difference h shown by the manometric fluid mercury is

(A) 72 mm (B) 83 mm
(C) 95 mm (D) 115 mm

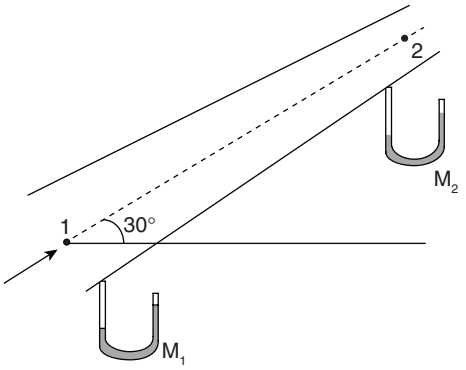
13. Water flows through an inclined venturimeter as shown in figure. Inlet and throat diameters are 100 mm and 50 mm respectively. Inlet and throat sections have a level difference of 300 mm. The differential mercury manometer connected across inlet and throat indicates 12 cm of mercury level difference at a given flow rate. Coefficient of discharge is 0.99.



The rate of flow in litres/s is

(A) 14.76 (B) 12.85
(C) 10.91 (D) 8.86

14.



Water flows through a tapering pipe inclined at 30° to the horizontal. At points 1 and 2 manometers are connected. Point 1 is at an elevation of 1 m from ground level and 2 is 3 m from ground level. Diameter at section 1 and 2 are 15 cm and 10 cm respectively. Velocity at 1 is 6 m/s. If manometer M_2 reads 10 cm of mercury, the reading shown by manometer M_1 in cm of mercury is

(A) 79.5 (B) 65.6
(C) 58.3 (D) 49.4

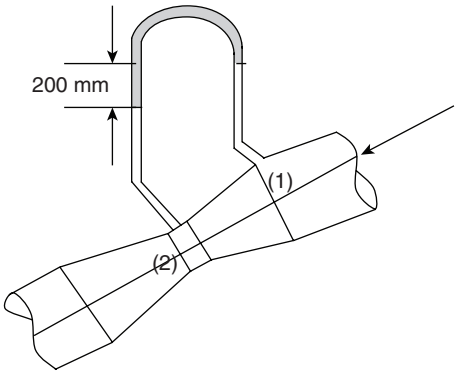
15. Mass flow rate of the oil in kg/s is

(A) 2.82 (B) 2.64
(C) 2.41 (D) 2.22

16. Power required to pump oil per 100 m length of pipe is

(A) 6.12 kw (B) 6.34 kw
(C) 6.63 kw (D) 6.82 kw

17. Water flows through an inclined pipe in which a venturimeter is installed for discharge measurement. The inlet and throat sections of the venturimeter have areas of cross sections 0.07 m^2 and 0.0177 m^2 respectively. An inverted U-tube manometer is used for measurement of differential pressure head. A liquid of specific gravity 0.7 is used in the manometer, which gives a reading of 250 mm. Inlet and throat sections have a level difference of 400 mm



Neglecting frictional losses the rate of flow through the pipe in m^3/s is

(A) 0.028 (B) 0.022
(C) 0.019 (D) 0.016

18. Vertical distance between the two orifices is

(A) 3.16 m (B) 2.82 m
(C) 2.25 m (D) 2.06 m

19. Vertical distance of point of intersection of the jets from the water level in the tank is

(A) 9.32 m (B) 10.25 m
(C) 10.78 m (D) 11.16 m

20. Velocity of kerosene at point *B* is

(A) 7.8 m/s (B) 6.7 m/s
(C) 5.6 m/s (D) 4.2 m/s

21. Pressure of kerosene at point *B* is

(A) –29.32 kPa (B) – 21.97 kPa
(C) –18.14 kPa (D) – 12.82 kPa

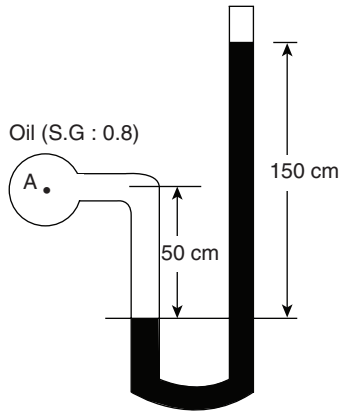
22. Match List – I with List – II and select the correct answer

	List – I (Forces)		**List – II (Dimensionless number)**
a.	Gravity force	1.	Weber number
b.	Pressure force	2.	Mach number
c.	Surface tension	3.	Froude's Number
d.	Elastic force	4.	Euler's number

Codes:

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

23. A U-tube mercury manometer is used to measure pressure of oil flowing through a pipe at a point. Specific gravity of oil is 0.8 and the level of mercury is as shown in the figure. The pressure in kPa is



(A) 196.20 (B) 147.15
(C) 110.36 (D) 73.58

24. Match List – I with List – II and select the correct answer

	List – I (condition of floating bodies)		List – II (Result)
a.	M below G	1.	Floating body
b.	M above G	2.	Unstable equilibrium
c.	M and G coincides	3.	Stable equilibrium
d.	B below G	4.	Neutral equilibrium

[M - Meta centre
G - Centre of gravity
B - centre of buoyancy]

Codes:

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

25. A glass tube of 3.7 mm diameter is dipped in water. If the contact angle at the meniscus is 0° and surface tension is 0.074 N/m determine the capillary effect in mm. (Take specific weight of water as 10000 N/m^2)

(A) 4 mm(dep) (B) 4 mm(rise)
(C) 8 mm(dep) (D) 8 mm (rise)

Answer Keys

1. A	**2.** A	**3.** D	**4.** C	**5.** C	**6.** B	**7.** D	**8.** B	**9.** C	**10.** B
11. C	**12.** B	**13.** C	**14.** A	**15.** A	**16.** C	**17.** B	**18.** C	**19.** B	**20.** D
21. B	**22.** C	**23.** A	**24.** B	**25.** D					

Hints and Explanations

7. $E_b g = 4\text{kg}\ (\rho_b - \rho_w)\ g = 3.5$ kg
$E_w g = 0.5$ kg

Specific gravity $= \dfrac{\rho_b}{\rho_w} = 8$ Choice (D)

8. $Q = \rho AV$
$V = (6xt + 3y^2)\ i + (3t + y^2)\ j = j$
$Q = 1000 \times 1 \times 1 = 1000$ kg/s. Choice (B)

11. Considering pressure balance on the horizontal plane 0 – 0

$p_A + 0.8 \times 9810 = p_B + (0.5 + 1.2) \times 9810 - 0.7 \times 0.75 \times 9810$

$p_A - p_B = 9810[(0.5 + 1.2) - 0.7 \times 0.75 - 0.8]$
$= 9810 \times 0.375 = 3679$ N/m^2. Choice (C)

12. Starting from pipe A the manometric equation is

$p_A + 4 \times 1.59 \times 9810 + h \times 13.6 \times 9810 - (h + 1) \times 0.8 \times 9810 = p_B$

$\dfrac{4fL}{D} \times \dfrac{v^2}{2g} = 6.36 + h \times 13.6 - 0.8h - 0.8$

$= 12.8\ h + 5.56$

$\dfrac{7}{40}\delta = 12.8h + 5.56$

$h = 0.083$ m $= 83$ mm. Choice (B)

13. For manometer,

$$\left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) - \left(\frac{s_m}{s_w} - 1\right) h_m = h$$

where h_m = the manometric level difference
Applying Bernoulli's equation,

$$\left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) = \frac{v_2^2 - v_1^2}{2g}$$

$$\frac{v_2^2 - v_1^2}{2g} = h$$

Also $A_1 v_1 = A_2 v_2$

The discharge equation for venturimeter

$Q = \dfrac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$ is derived from the above

∴ Irrespective of inclination h corresponding to manometric reading can be directly used in the above equation

$$h = h_m\left(\frac{s_m}{s_m}-1\right) = 0.12\left(\frac{13.6}{1}-1\right) = 1.512 \text{ m}$$

$C_d = 0.99$

$$A_1 = \frac{\pi}{4}(0.1)^2 = 7.85\times10^{-3}$$

$$A_2 = \frac{\pi}{4}(0.05)^2 = 1.96\times10^{-3}$$

$$Q = \frac{0.99\times7.85\times1.96\times10^{-6}}{10^{-3}\sqrt{7.58^2-1.96^2}}\times\sqrt{2\times9.31\times1.512}$$

$= 0.01091 \text{ m}^3/\text{s} = 10.91 \ \ell/\text{s}.$ Choice (C)

14. $d_1 = 15$ cm: $z_1 = 1$ m; $v_1 = 6$ m/s; $d_2 = 10$ cm; $z = 3$ m

$$v_2 = \frac{A_1}{A_2}v_1 = \left(\frac{d_1}{d_2}\right)^2 v_1 = \left(\frac{15}{10}\right)^2\times6 = 13.5 \text{ m/s}$$

Applying Bernoulli's theorem

$$\frac{p_1}{w}+\frac{v_1^2}{2g}+z_1 = \frac{p_2}{w}+\frac{v_2^2}{2g}+z_2$$

$$\frac{p_1}{w} = \frac{v_2^2-v_1^2}{2g}+(z_2-z_1)+\frac{p_2}{w}$$

$$= \frac{13.5^2-6^2}{2\times9.81}+(3-1)+(0.1\times13.6)$$

$$= 7.45 + 2 + 1.36 = 10.81 \text{ m of water} = \frac{10.81}{13.6}$$

$= 0.795$ m of mercury $= 79.5$ cm of mercury.

Choice (A)

15. $\mu = 1.2$ poise

$= 0.12 \text{ Ns/m}^2$

sp. gravity $= 0.85$

$\rho = 850 \text{ kg/m}^3$ $D = 0.03$ m

Pressure drop/m $= 20 \text{ kN/m}^2$

$$\Delta p = \frac{32\mu\bar{u}L}{D^2}$$

$$20\times10^3 = \frac{32\times0.12\times\bar{u}\times1}{(0.03)^2}$$

$\bar{u} = 4.6875$ m/s

$$\text{mass flow rate} = \rho A\ \bar{u} = (850)\times\frac{\pi}{4}\times(0.03)^2\times4.6825$$

$= 2.816$ kg/s. Choice (A)

16. Power required per metre

$p = w\,Q\,h_f = g(\rho Q)\,h_f$

where $\rho Q = \rho A\ \bar{u}$ = mass /s = 2.816

$$h_f = \frac{p_2-p_1}{\rho g} = \frac{20\times1000}{850\times9.81} = 2.4 \text{ m of oil}$$

∴ $P = 9.81\times2.816\times2.4 = 66.26$ W

power required per 100 m

$= 6626$ W $= 6.626$ kW. Choice (C)

17. Differential pressure head

$$h = h_1\left(1-\frac{s_l}{s_w}\right) = 0.25\left(1-\frac{0.7}{1.0}\right) = 0.075 \text{ m of water}$$

$$Q = \frac{A_1A_2}{\sqrt{A_1^2-A_2^2}}\sqrt{2gh}$$

$$= \frac{0.07\times0.0177\sqrt{2\times9.81\times0.075}}{\sqrt{0.07^2-0.0177^2}}$$

$= 0.022 \text{ m}^3/\text{s}.$ Choice (B)

18. horizontal distance $x = ut$

vertical distance $z = \frac{1}{2}gt^2$

$$u = \sqrt{2gH}$$

From the above,

$$z = \frac{x^2}{4H}$$

where H = height of water level above orifice

For the upper orifice,

$$z_1 = -\frac{x^2}{4\times4} = \frac{x^2}{16} = \frac{100}{16} = 6.25$$

For the lower orifice,

$$z_2 = \frac{100}{4(4+h)} = \frac{100}{4(4+h)} = \frac{25}{(4+h)}$$

$$z_1 - z_2 = h = 6.25 - \frac{25}{(4+h)} \text{ or}$$

$$h+\frac{25}{(4+h)} = 6.25$$

$(4 + h)\,h + 25 = 6.25\,(4 + h)$

$4h + h^2 + 25 = 25 + 6.25\,h$

$h^2 + 4h - 6.25\,h = 0$

$h - 2.25 = 0$

$h = 2.25$ m. Choice (C)

19. $$z_2 = \frac{25}{(4+h)} = \frac{25}{4+2.25} = 4$$

Vertical distance of water level from point of intersection of jets

$L = 4 + h + z_2 = 4 + 2.25 + 4 = 10.25$ m. Choice (B)

20 Velocity of kerosene at point B = velocity at C

Applying Bernoulli's theorem, between oil surface in the tank and pipe outlet

$$\frac{p_1}{w}+\frac{v_1^2}{2g}+z_1 = \frac{p_2}{w}+\frac{v_2^2}{2g}+z_2+h_{f(1-2)}$$

$$0+0+4=0+\frac{v_2^2}{2g}+1.5+(0.4+1.2)$$

$$\frac{v_2^2}{2g}=4-1.5-1.6\ =0.9\text{ m}$$

$$v_2^2=0.9\times 2\times 9.81$$

$v_2=4.2$ m/s $=v_B$. Choice (D)

21. Applying Bernoulli's equation at points 1 and B

$$0+0+4=\frac{p_B}{w}+\frac{(4.2)^2}{2g}+5.5+0.4$$

$$\frac{p_B}{w}=4-5.9-\frac{4.2^2}{2\times 9.81}\ =-2.8\text{ m}$$

$p_B=-2.8\times(9810\times 0.8)$

$=-21967$ N/m^2

$=-21.97$ kPa. Choice (B)

23. Equating pressure heads above the line passing through A

$$h_A+\frac{50}{100}\times 0.8=\frac{150}{100}\times 13.6$$

$\therefore\quad h_A+0.4=20.4$

$\Rightarrow\quad h_A=20$ m of water

Pressure $p_A=wh_A=9810\times 20$ N/m^2

$=9.81\times 20$ kN/m$^2=196.2$ kN/m^2

$=196.2$ kPa. Choice (A)

25. Capillary effect $h=\dfrac{4\sigma\cos\theta}{wd}$

where σ = surface tension, θ = contact angle

w = specific weight

$$=\frac{4\times 0.074\times\cos 0^\circ}{10000\times 3.7\times 10^{-3}}=8\text{ mm(rise).}$$ Choice (D)