CHAPTER - 08
MECHANICAL PROPERTIES OF SOLIDS & FLUIDS

SYNOPSIS

A. ELASTICITY

Elasticity is the property of the materials to regain the original state on the removal of the deforming forces. (Quartz is almost perfectly elastic)

Hooke's law

With in the limits of elasticity, stress is α strain. Then, $\frac{\text{stress}}{\text{strain}} = E$ is called Modulus of elasticity

Stress = F/A, Unit = N/m^2, Unit of E is also N/m^2 Since **strain** $\left(=\frac{\text{change in dimension}}{\text{original dimension}}\right)$ has no unit

When a wire (or body) is stretched by a force F, a restoring force equal to F but opposite in direction is developed in the wire. This restoring force/unit area is called tensile stress (=F/A, where A is the area of cross section of the wire)

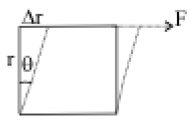
The corresponding strain $\left(\frac{\Delta\ell}{\ell}\right)$ produced is called longitudinal strain or linear strain

Then, $\frac{\text{tensile stress}}{\text{longitudinal strain}} = \frac{F/A}{\Delta\ell/\ell} = Y$ is called the **Young's modulus** of the material of the wire. $\therefore \mathbf{Y = \frac{F}{A}\frac{\ell}{\Delta\ell}}$

The normal stress acting on a body of volume V producing volume change ΔV is usually taken as the pressure P and the modulus involved is called **Bulk modulus**

Then, Bulk modulus $B = \frac{\text{normal stress (or Pr)}}{\text{volume strain}} = \frac{F/A}{\Delta V/V}$ ie. $\mathbf{B = \frac{F}{A}\frac{V}{\Delta V}}$

If two equal an opposite forces are applied parallel to the cross sectional area of a body, there is relative displacement between the opposite faces of the body. The restoring force then, developed per unit area of the surface is called tangential stress or shearing stress.



The shearing stress can change only the shape of the body. The strain, thus produced is called the shearing strain and is the ratio of relative displacement Δr to the distance between the faces r ie; $\frac{\Delta r}{r} = \theta$.

The ratio of shearing stress to the corresponding shearing strain is called shear modulus or modulus of rigidity and is represented by G or n.

Then shear modulus $G = \frac{\text{shearing stress}}{\text{shearing strain}} = \frac{F/A}{\Delta r/r}$ ie. $\mathbf{G = \frac{F}{A}\frac{r}{\Delta r}}$

Thus Young's modulus $Y = \frac{F}{A}\frac{\ell}{\Delta\ell}$

Bulk modulus $B = \frac{F}{A}\frac{V}{\Delta V}$

Shear modulus $G = \frac{F}{A}\frac{r}{\Delta r}$

Gases and liquids have volume elasticity only. Then $B = \frac{F}{A}\frac{V}{\Delta V} = P\frac{V}{\Delta V} = E$

E is called modulus of elasticity of the liquid or the gas. Also $E = -P\frac{V}{\Delta V}$

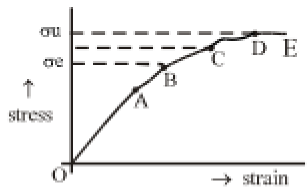
–ve sign indicates than as P increases V decreases.

Compressibility e in the reciprocal of Bulk modulus B ie; $C = \frac{1}{B} = \frac{1}{P}\frac{\Delta V}{V}$. It is the fractional change in volume per unit increase in pressure.

unit of C is $\frac{1}{Nm^{-2}}$ ie; $N^{-1}m^2$

Gases have isothermal elasticity $E_I = P$, and adiabatic elasticity $E_A = \gamma P$

Stretching a wire under increasing weights



σ_e - limiting stress B is elastic limit or yield point; σ_u - tensile strength or ultimate strength ; along OA - Hooke's law is obeyed

Poissons' ratio

When a wire is extended its diameter decreases. Then the Poissons' ratio

$$\sigma = \frac{\text{lateral strain}}{\text{longitudinal strain}} = \frac{\Delta r}{r}\Big/\frac{\Delta l}{l}$$

Theoretical limits - 1 to $\frac{1}{2}$. Practical limits 0 to $\frac{1}{2}$

Work done in stretching

W = $\frac{1}{2}$ load $\times$ extension = $\frac{1}{2}Fx$; This is the PE stored in the stretched wire. ie; $\mathbf{W = \frac{1}{2}Fx}$ = PE stored

Word done /unit volume = Energy stored per unit volume = $\frac{1}{2}$ stress $\times$ strain = $\frac{1}{2}\frac{\text{stress}^2}{Y} = \frac{Y}{2}\text{strain}^2$

B. HYDROSTATICS

Density = Mass/Volume

Relative Density $= \dfrac{\text{Density of the substance}}{\text{Density of water (at } 4^0\text{C)}}$

Thrust = Normal force acting on a surface is Thrust. Unit ⟶ N

Pressure $= \dfrac{\text{Thrust}}{\text{area}}$. Unit - N/m^2, or Pascal (Pa). Dimensions - $ML^{-1}T^{-2}$

Pressure due to a fluid column of height h

$$P = h\rho g \quad \text{Unit } Nm^{-2} \text{ or Pa}$$

Atmospheric Pressure P_0 is the pressure exerted by the earth's atmosphere. $P_0 = H\sigma g$ where H is the height of the atmosphere. σ is the average density of air

At sea level P_0 = 76 cm of Hg

ie, $P_0 = 0.76 \times 13.6 \times 10^3 \times 9.8 = 1.01325 \times 10^5\,\text{Pa}$ This is the standard atmospheric pressure.

$P_0 \cong 10^5\,\text{Pa}$ is called one atmosphere or one Bar.

Gauge Pressure : The pressure measured in excess of atmospheric pressure is the gauge pressure. If P is the actual pressure of a gas in a vessel and h is the manometer level difference $P = P_o + h\rho g$. Here $P - P_o = h\rho g$ is called gauge Pressure.

Pascal's Law:- (1) Pr. applied at any point in a liquid is equally transmitted to all other points in the liquid in all direction.

(2) In a communicating column of liquid, pressure is same at all points in a horizontal plane.

Buoyancy:- A body immersed fully or partially in a fluid experiences an upthrust called buoyancy. It is acting through the C.G of the displaced fluid - the centre of Buoyancy (C.B). For a floating body, *wt. of the floating body = wt. of the liquid displaced by it.* For the equilibrium of the floating body, centre of mass and centre of buoyancy must be along the same vertical line. For stable equilibrium CG lies below CB and for unstable equilibrium CG lies above CB.

Archimedis principle: When a body is fully immersed in a liquid, the body experiences a loss of wt. Then,

Apparent wt = wt in air – upthrust

Loss of wt = wt of displaced liquid = upthrust

R.D of a body $= \dfrac{\text{Wt. in air}}{\text{Loss of wt. in water}}$

R.D of a liquid $= \dfrac{\text{loss of wt. of a body in liquid}}{\text{loss of wt. of the body in water}}$

C. SURFACE TENSION

It is the property of a liquid surface to acquire minimum surface area. It is acting tangential to the surface and is perpendicular to any line imagined to be drawn on the surface. Surface tension $T = \dfrac{F}{l}$.

Unit N/m. Dimension MT^{-2}

Molecules on the surface of a liquid have greater P.E. Work has to be done in increasing the surface area. This work done will be stored in the surface in the form of P.E. Surface tension is numerically equal to work done to increase surface area by unity.

S.T = $\frac{\text{work}}{\text{area}}$ $\sigma = \frac{W}{A}$, Energy = Area × S.T

Cohesive force is the force between molecules of same substances.

Adhesive force is the force between molecules of diff.substances.

Angle of contact θ is the angle between the tangent to the liquid meniscus and the solid surface in liquid.

i) If θ < 90, the liquid surface will be concave. Adhesive force > Cohesive force. Eg. water in glass

ii) If θ > 90 the liquid surface will be convex, adhesive force < cohesive force; eg. Hg in glass

iii) If θ = 90, the liquid surface will be horizontal adhesive force = $\frac{\text{cohesive force}}{\sqrt{2}}$.

eg:- water in silver capillary

Applications :-

1. Capillary rise:-

$h = \frac{2T\cos\theta}{rdg}$; r is the radius of the capillary tube. If θ = 0 $h = \frac{2T}{r\rho g}$ $h \alpha \frac{1}{r}$ for a given liquid. graph between h and r is a rectangular hyperbola. ST in general decreases with increase of temp. ST = 0, at boiling point and also at critical temp. ST increases with temp for molten cadmium and copper.

2. Excess of Pressure:-

Pressure on the concave side of a surface is greater than that on the convex side. This pressure difference is called excess of pressure. The excess pressure inside a spherical bubble of radius r is given by.

$P = \frac{4T}{r}$. A drop has only one surface, Therefore, the excess of presure inside a spherical drop $P = \frac{2T}{r}$

For a cylindrical drop, the excess of pressure $P = \frac{T}{r}$

Radius of curvature of the interface of two bubbles of radii r_1 and r_2 ($r_1 < r_2$)

$r = \frac{r_1 r_2}{r_2 - r_1}$

In case of a thin liquid layer between two glass plates, the excess pressure over the concave surface.

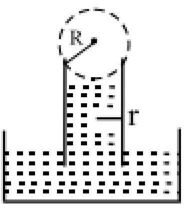
$P = \frac{2T}{d}$; d is the separation between the plates. So force required to separate the plates $F = \frac{2T}{d}A$.

Detergents decreases S.T.

Notes:

(1) In case of capillarity, the excess pressure is balanced by the hydrostatic pressure

ie, $\frac{2T}{R} = h\rho g$



Where R is the radius of curvature of the surface.

But $R = \frac{r}{\cos\theta}$ where θ is the angle of contact. r is the radius of capillary tube.

$\therefore \frac{2T\cos\theta}{r} = h\rho g$ or, $h = \frac{2T\cos\theta}{r\rho g}$

When $\theta = 0$ R= r

$\therefore \frac{2T}{r} = h\rho g \quad h = \frac{2T}{r\rho g}$

(2) In the case of capillaries of insufficient length (l < h), there will be no overflow. At the upper end radius of the meniscus increases such that hR = $l\, r_1$ where, r_1 is the radius of curvature of the surface at the top.

D. VISCOSITY

Viscosity is the internal friction between successive layers of a fluid when it is in stream line motion or it is the property of fluid to oppose the relative motion between successive layers. The force developed is called Viscous force or Viscous drag, and is given by,

$$F = \eta A \frac{dv}{dx}, \quad \therefore \eta = \frac{F}{A\frac{dv}{dx}} \quad ;$$

$\eta = F \quad \text{when } A = 1, \ \frac{dv}{dx} = 1$

η is called the coefficient of viscosity. Its unit is poiseuille (Pl) in SI and poise in CGS system.

1 Pl = 1 N/m^2/ unit velocity gradient = Nm^{-2}s or, kg m^{-1} s^{-1}

Dimensions ML^{-1}T^{-1}

1 Poise = 1 dyne / cm^2 / unit velocity gradient

1 Pl = 10 poise (1 deca poise)

Stoke's formula:-

When a spherical body of radius r and density d is moving down through a liquid of density ρ, its weight is acting in the downward direction. At the same time, the force due to buoyancy and the force due to viscosity are acting in the upward direction. When the down ward and upward forces become equal, the body attains a constant velocity called the terminal velocity v. At this condition,

wt. of the body = upthrust + viscos force

The viscos force is given by Stoke's formula as $F = 6\pi r\eta v$

$\therefore Vdg = V\rho g + 6\pi r\eta v$ Here $V = \frac{4}{3}\pi r^3$ the volume of the body.

Substituting and simplyfing, the terminal velocity $v = \frac{2}{9}\frac{r^2}{\eta}(d - \rho)g$

E. HYDRODYNAMICS

When a liquid is flowing through a pipe of varying area of cross section, the mass of liquid crossing each section, must be a constant inorder to maintain continous flow

ie; $a_1v_1\rho_1 = a_2v_2\rho_2$ Since the liquids are incompressible, $\rho_1 = \rho_2$; $a_1v_1 = a_2v_2$

Bernoulli's Theorem:-

Total energy of a small amount of liquid flowing from one point to another along a stream line is a constant. ie, Potential energy + Pressure energy + Kinetic energy = a constant.

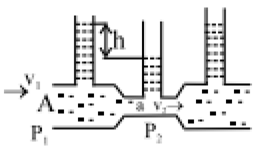
For unit mass, $gh + \frac{P}{\rho} + \frac{1}{2}v^2 = \text{a constant}$ or $h + \frac{P}{\rho g} + \frac{v^2}{2g} = \text{a constant}$ h is gravitational head, $\frac{P}{\rho g}$ is the pressure head and $\frac{v^2}{2g}$ is the velocity head.

For horizontal flow h is constant, $\frac{P}{\rho g} + \frac{v^2}{2g} = \text{a constant}$ or $\frac{P}{\rho} + \frac{v^2}{2} = \text{a constant}$.

As velocity increases pressure decreases.

Applications:-

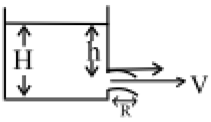
1. Venturimeter:-



$P_1 - P_2 = h\rho g$; Rate of flow of water = $Av_1 = av_2 = Aa\sqrt{\frac{2(P_1 - P_2)}{\rho(A^2 - a^2)}} = Aa\sqrt{\frac{2gh}{A^2 - a^2}}$

Atomiser - Principle: As velocity increases pressure decreases

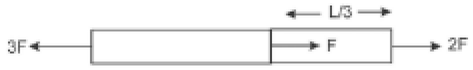
Velocity of Efflux is the velocity with which a liquid comes out of an orifice. This velocity is equal to velocity acquired by a body falling freely from a height equal to the height of liquid above the orifice $v = \sqrt{2gh}$



Range $R = 2\sqrt{h(H-h)}$; R is max. when h = H/2.

Part - 1 Jee main
Section 1 - Straight objective type questions

1. A uniform cylindrical rod of length L, cross sectional area A and Young's modulus Y is acted upon by the forces shown in the figure. The elongation of the rod is



A) $\frac{3FL}{5AY}$

B) $\frac{2FL}{5AY}$

C) $\frac{3FL}{8AY}$

D) $\frac{8FL}{3AY}$

2. Two wire of same material and length but diameters in the ratio 1:2 are stretched by the same force. The ratio of the potential energy per unit volume for the two wires when stretched will be

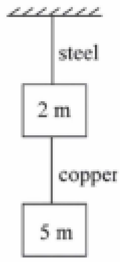
A) 1:1

B) 2:1

C) 16:1

D) 1:4

3. If the ratio of diameters, lengths and Young's modulus of steel and copper wires shown in the figure are p, q and s respectively, then the corresponding ratio of increase in their lengths would be



A) $\frac{7q}{5p^2s}$

B) $\frac{5q}{7sp^2}$

C) $\frac{7sp^2}{5q}$

D) $\frac{2q}{5sp}$

4. Sixty four spherical rain drops of equal size are falling vertically through air with a terminal velocity 1.5m/s. If these drops coalese to form a big spherical drop, then terminal velocity of the big drop will be

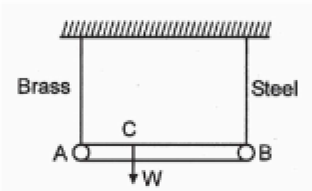
A) 24m/s

B) 16 m/s

C) 8 m/s

D) 32 m/s

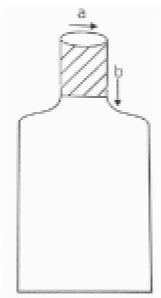
5. A 2m long light metal rod AB is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends. One wire is of brass and has cross-sectional area of 0.2×10^{-4} m^2 and the other is of steel with 0.1×10^{-4} m^2 cross-sectional area in order to have equal stresses in the two wires, a weight W is hung from the rod. The position of the weight along the rod from end A should be:



A) 66.6 cm B) 133 cm

C) 44.4 cm D) 155.6 cm

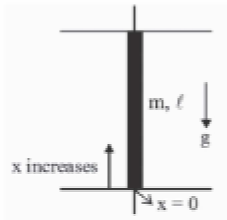
6. A bottle has an opening of radius and length b. A cork of length b and radius $(a+\Delta a)$ where $(\Delta a << a)$ is compressed to fit into the opening completely (see figure). If the bulk modulus of cork is B and the frictional coefficient between the bottle and cork is μ then the force needed to push the cork into the bottle is:

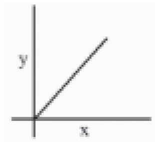


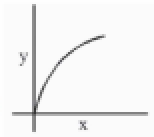
A) $(2\pi\mu Bb)\Delta a$ B) $(\pi\mu Bb)a$

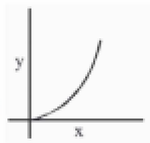
C) $(\pi\mu Bb)\Delta a$ D) $(4\pi\mu Bb)\Delta a$

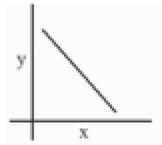
7. A uniform dense rod with non uniform young's modulus is hanging from ceiling under gravity. If elastic energy density at every point is same then young's modulus with x will change as which of the shown graph?



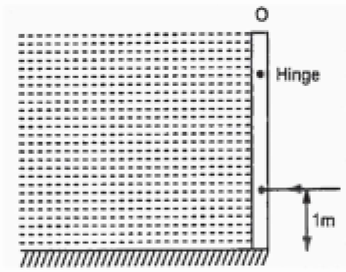
A) 

B) 

C) 

D) 

8. A square gate of size of 4m × 4m is hinged at topmost point. A fluid of density ρ fills the space left of it. The force which acting 1 m from lowest point can hold the gate stationary is:



A) $\frac{256}{3}\rho g$ B) $\frac{256}{9}\rho g$

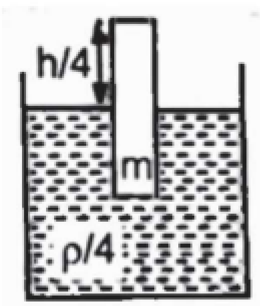
C) $\frac{128}{9}\rho g$ D) $\frac{128}{3}\rho g$

9. A hollow spherical shell at outer radius R floats just submerged under the water surface. The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t. water, the value of r is:

A) $\frac{8}{9}R$ B) $\frac{4}{9}R$

C) $\frac{2}{3}R$ D) $\frac{1}{3}R$

10. A soild cylinder of height h and mass m floats in a liquid of density ρ as shown in figure. Now the cylinder is released inside a liquid of density ρ/4, contained in a downward accelerated vessel. Determine the magnitude of acceleration of vessel, A, for which cylinder sinks with relative acceleration A/3 with respect to vessel. Neglect any dissipative force:



A) $\frac{2}{3}g$ B) $\frac{4}{3}g$

C) $\frac{3}{4}g$ D) $\frac{1}{3}g$

11. A cube of ice of edge 4cm is placed in an empty cylidrical glass of inner diamtere 6cm. Assume that the ice melts uniformly from each side so that it always retains its cubical shape. Remembering that ice is lighter than water, find the length of the edge of the ice cube at the instant it just leaves the contact with the bottom of the glass.

A) 2.26 B) 12.26

C) 20.26 D) 10.26

12. A large block of ice 5m thick has a vertical hole drilled through it and is floating in the middle of a lake. What is the minimum length of the rope required to scoop up a bucket full of water through the hole? (Relative density of ice = 0.9)

A) 0.5 m B) 0.6 m

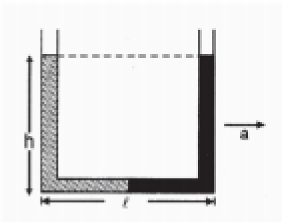
C) 1.5 m D) 2.5 m

13. A small steel ball falls through a syrup at constant speed of 10 cm/s. If the steel ball is pulled upwards. With a force equal to twice its effective weight, how fast will it move upwards?

A) 20 cm/s B) 10 cm/s

C) 5 cm/s D) -5 cm/s

14. A U-tube of base length "l" filled with same volume of two liquids of densities ρ and 2ρ is moving with an acceleration "a" on the horizontal plane as shown in the figure. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by



A) $\frac{a}{2g}\ell$

B) $\frac{3a}{2g}\ell$

C) $\frac{a}{g}\ell$

D) $\frac{2a}{3g}\ell$

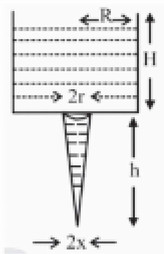
15. A wire forming a loop is dipped in to soap solution and taken out so that a film of soap solution is formed. A loop of ℓ long thread

is gently put on the film and the film is pricked with a needle inside the loop. The thread loop takes the shape of a circle. Find the tension in the thread. Surface tension of soap solution is T.

A) $\frac{T\ell}{2\pi}$ B) $\frac{T\ell}{\pi}$

C) $\frac{T\ell}{3\pi}$ D) $\frac{T\ell}{4\pi}$

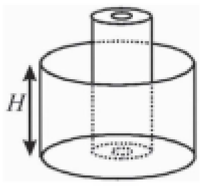
16. Consider a water jar of radius R that has water filled up to height H and is kept on a stand of height h (see figure). Through a hole of radius r (r <<R) at its bottom, the water leaks out and the stream of water coming down towards the ground has a shape like a funnel as shown in the figure. If the radius of the cross-section of water stream when it hits the ground is x. Then:



A) $x = r\left(\frac{H}{H+h}\right)^{1/4}$ B) $x = r\left(\frac{H}{H+h}\right)$

C) $x = r\left(\frac{H}{H+h}\right)^{2}$ D) $x = r\left(\frac{H}{H+h}\right)^{1/2}$

17. A hollow wooden cylinder of height h, inner radius R and outer radius 2R is placed in a cylindrical container of radius 3R. When water is poured into the container, the minimum height H of the container for which cylinder can float inside freely is



A) $\frac{h\rho_{water}}{\rho_{water}+\rho_{wood}}$

B) $\frac{h\rho_{wood}}{\rho_{water}}$

C) h

D) $\frac{h^2}{R}$

18. A lower end of a glass capillary tube is dipped in water. Water rises to a height of 8cm. The tube is then broken at a height of 6cm. The height of water column and angle of contact will be

A) $6\text{cm}, \cos^{-1}\left(\frac{2}{3}\right)$

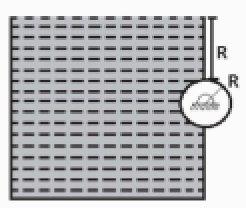
B) $6\text{cm}, \cos^{-1}\left(\frac{3}{4}\right)$

C) $6\text{cm}, \sin^{-1}\left(\frac{3}{4}\right)$

D) $6\text{cm}, \tan^{-1}\left(\frac{3}{4}\right)$

19. A cylinder of radius R is kept embedded along the wall of a dam as shown. Take density of water as ρ. Take length as L.

The net torque exerted by liquid on the cylinder is



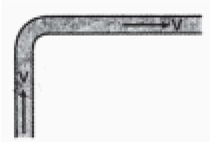
A) $\frac{2\rho R^3 Lg}{3}$

B) $\frac{\rho R^3 Lg}{3}$

C) $\frac{\rho R^3 Lg}{2}$

D) Zero

20. A fire hydrant (as shown in the figure) delivers water of density ρ at a volume rate L. The water travels vertically upward through the hydrant and then does 90° turn to emerge horizontally at speed V. The pipe and nozzle have uniform cross-section throughout. The force exerted by the water on the corner of the hydrant is:



A) ρVL B) zero

C) 2ρVL D) $\sqrt{2}\rho VL$

21. A small spherical droplet of density d is floating exactly half immersed in a liquid of density ρ and surface tension T. The radius of the droplet is (take note that the surface tension applied an upward force on the droplet):

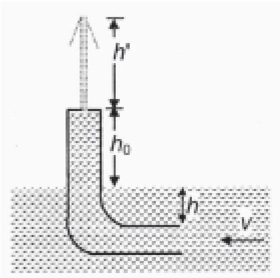
A) $r = \sqrt{\frac{2T}{3(d+\rho)g}}$ B) $r = \sqrt{\frac{T}{(d-\rho)g}}$

C) $r = \sqrt{\frac{T}{(d+\rho)g}}$ D) $r = \sqrt{\frac{3T}{(2d-\rho)g}}$

Section 2 - Numerical type

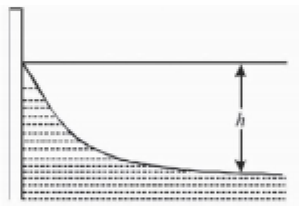
22. A wooden plank of length 1m and cross section is hinged at one end to the bottom of a tank. (S.G plank = 0.5) Plank makes an angle 45° with vertical in equilibrium position. Find the height of water filled

23. A bent tube is lowered into a stream of water as shown in figure. the velocity of stream V is 2 m/s. The closed upper end of the tube is at a height h_0 = 10 cm from the surface of water in the stream and has an orifice. To what height h' will the water jet from the orifice spurt ? (g = 10 m/s^2) (in cm)



Section 3 - Jee Advanced

24. Water of density ρ in a clean aquarium forms a meniscus, as illustrated in the figure. Calculate the difference in height h between the centre and the edge of the meniscus. The surface tension of water is γ.



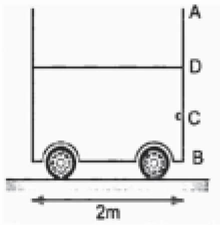
A) $\sqrt{\frac{2\gamma}{\rho g}}$

B) $\sqrt{\frac{\gamma}{\rho g}}$

C) $\frac{1}{2}\sqrt{\frac{\gamma}{\rho g}}$

D) $2\sqrt{\frac{\gamma}{\rho g}}$

25. A cubical container with side 2m has a small hole with a cap at point C as shown. The water level is upto point D. (BC = 0.5m and BD = 1.5m)



If container is given an acceleration of 8m/s^2 and the hole is opened simultaneously. The amount of water that will spill out of the container is:

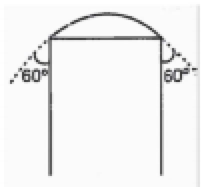
A) 1200 litre

B) 200 litre

C) 600 litre

D) 800 litre

26. A soap bubble is being blow on a tube of radius 1cm. The surface tension of the soap solution is 0.05 N/m and the bubble makes an angle of 60° with the tube as shown. The excess of pressure over the atmospheric pressure in the tube is:



A) 5 Pa

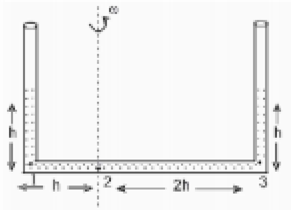
B) 1 Pa

C) 10 Pa

D) 20 Pa

Section 4 - More than option correct type

27. A vertical U-tube has a liquid upto a height h. The tube is slowly rotated to an angular speed $\omega = \sqrt{\frac{g}{h}}$



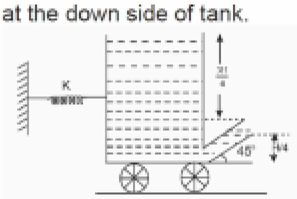
A) height of liquid column above point $1 = \frac{h}{4}$

B) height of liquid column above point $3 = \frac{7h}{4}$

C) point 2; pressure $= \rho_0 + \frac{h\rho g}{4}$

D) $\Delta\rho$ between 3 and 2 = ρgh

28. A tank fitted with smooth wheels is filled with fluid of density 'ρ' upto a height h. Tank spring system is in equilibrium at an instant shown. A nozzle of cross sectional area 'a' is located at the down side of tank.



A) For equilibrium, spring is compressed

B) Compression/elongation of spring for equilibrium $= \frac{3\rho agh}{2\sqrt{2}K}$

C) Elongation/compression of spring = $= \frac{\rho agh}{2\sqrt{2k}}$

D) Maximum height from the base of the tank attained by liquid coming out of nozzle is $\frac{5H}{8}$

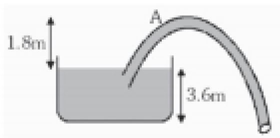
29. A cappillary tube of radius 'r' is lowered in to water whose surface tension is 'α' and density 'd'. The liquid rises to a height. Assume that the contact angle is zero. Choose the correct statement(s)

A) Magnitude of work done by force of surface tension is $\frac{4\pi\alpha^2}{dg}$

B) Magnitude of work done by force of surface tension is $\frac{2\pi\alpha^2}{dg}$

D) Potential energy acquired by the water is $\frac{2\pi\alpha^2}{dg}$

30. A siphon has a uniform circular base of diameter $\frac{8}{\sqrt{\pi}}$ cm with its crest A, 1.8m above water level as in figure. Then (Given that density of water is 1000 kg/m³) [Use $P_0 = 10^5$ N/m² & g=10 m/s²]



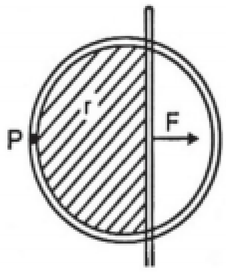
A) Velocity of flow $= 6\sqrt{2}$ m/sec

B) Discharge rate of flow is $= 9.6\sqrt{2} \times 10^{-3} m^3 / sec$

C) Absolute pressure at the crest level A is $=4.6\times10^4$ N/m²

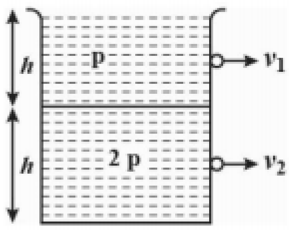
D) Speed of flow will decrease with time

31. A circular wire, 10cm in diameter, with a slider wire on it, is in a horizontal plane. A liquid film is formed, bounded by the wires, on the left side of the slider, as shown. The surface tension of the liquid is 0.1N/m. An applied force 16 mN, perpendicular to the slider, maintains the film is equilibrium. Ignore the sag in the film. What can be the distance between point P and slider?



A) 8cm
B) 2 cm
C) 5 cm
D) slider cannot be in equilibrium

32. Equal volumes of two immiscible liquids of densities ρ and 2ρ are filled in a vessel as shown in figure. Two small holes are punched at depths h/2 and 3h/2 from the surface of lighter liquid. If v_1 and v_2 are the velocities of efflux at these two holes, then $\frac{v_1}{v_2}$ is:



A) $\frac{1}{2\sqrt{2}}$
B) $\frac{1}{2}$
C) $\frac{1}{4}$
D) $\frac{1}{\sqrt{2}}$

Section 5- Numerical type

33. A thin uniform metallic rod of length 0.5m and radius 0.1m rotates with an angular velocity 400rad/s in a horizontal plane about a vertical axis passing through one of its end the elongation of rod is $\frac{1}{n}\times10^{-3}$ m [$\rho=10^4$ kg/m^3, $y=2\times10^{11}$ N/m^2] Find n?

34. Figure shows a cubical block of side 10cm and relative density 1.5 suspended by a wire of cross sectional area 10^{-6}m^2. The breaking stress of the wire is 7×10^6 N/m^2. The block is placed in a beaker of base area 200cm^2 and initially i.e, at t=0, the top surface of water and the block coincide. There is pump at the bottom corner which ejects 2cm^3 of water per s. Find the time at which the wire will break.