## DPP – 5

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/82

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Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/20

Q 1. What is the height to which a liquid rises between two long parallel plates, a distance d apart? (Surface tension of liquid is T and density is ρ)

(a) $\frac{4T}{\rho dg}$ (b) $\frac{2T}{\rho dg}$ (c) $\frac{T}{\rho dg}$ (d) $\frac{T}{2\rho dg}$

Q 2. A metallic cylindrical wire of density ρ floats horizontal in water. The maximum radius of the wire so that the wire may not sink will be: (surface tension of water = T and angle of contact = π )

(a) $\sqrt{\frac{2T}{\pi\rho g}}$ (b) $\sqrt{\frac{2T}{\rho g}}$ (c) $\sqrt{\frac{T}{\pi\rho g}}$ (d) $\sqrt{\frac{T\rho}{\pi g}}$

Q 3. What is the radius of a steel sphere that will float on water with exactly half the sphere submerged? Density of steel is 7.9 × $10^3$ kg/$m^3$ and surface tension of water is 7 × $10^{-2}$ N.

(a) 2.6 cm (b) 4.6 mm (c) 1.2 mm (d) 6.5 mm

Q 4. A capillary is clipped in water vessel kept on a freely falling lift, then:

(a) water will not rise in the tube
(b) water will rise to the maximum available height of the tube
(c) water will rise to the height observed under normal condition
(d) water will rise to the height below that observed under normal condition

Q 5. A solid ball of density $\rho_1$ and radius r falls vertically through a liquid of density $\rho_2$ . Assume that the viscous force acting on the ball is F = krv, where k is a constant and v its velocity. What is the terminal velocity of the ball?

(a) $\frac{4\pi g r^2(\rho_1-\rho_2)}{3K}$ (b) $\frac{2\pi r\,(\rho_1-\rho_2)}{3gK}$
(b) $\frac{2\pi g\,(\rho_1+\rho_2)}{3gr^2K}$ (d) None of these

Q 6. A capillary tube of radius r is immersed in water and water rises in it to a height h. The mass of the water in the capillary tube is m. Another capillary of radius 2r is immersed in water. The mass of water that will rise in this tube is:

(a) m/2 (b) m (c) 2 m (d) 4 m

Q 7. A small steel ball falls through a syrup with terminal speed 1.0 m/s. If the steel ball is pulled upwards with a force equal to twice its effective weight, its terminal speed will be

(a) 1.0 m/s (b) 2.0 m/s (c) 0.5 m/s (d) zero

Q 8. A flat plate of area 20 $cm^2$ is placed on a horizontal surface coated with a layer of glycerine 1 mm thick. What force must be applied to the plate to keep it moving with a speed of 1 cm/s over the horizontal surface? (Coefficient of viscosity of glycerine =2.0 kg/m-s)

(a) $2.0 \times 10^{-3}$ N (b) 2.0 N (c) $1.0 \times 10^{-4}$N (d) $4.0 \times 10^{-2}$N

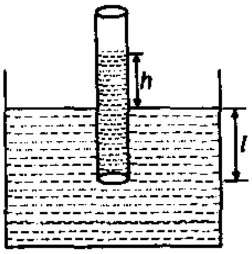
Q 9. A vertical capillary is brought in contact with the water surface (surface tension = T). The radius of the capillary is r and the contact angle $\theta = 0^o$. The increase in potential energy of the water (density = ρ) is:

(a) independent of ρ (b) independent of r
(c) independent of T (d) zero

Q 10. A glass rod of radius 1 mm is inserted symmetrically into a glass capillary tube with inside radius 2 mm. Then the whole arrangement is brought in contact of the surface of water. Surface tension of water is 0.7 N/m. To what height will the water rise in the capillary: (contact angle is zero.)

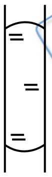
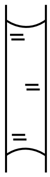
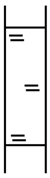
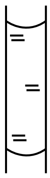
(a) 14 cm (b) 4.2 cm (c) 2.1 cm (d) 6.8 cm

Q 11. A capillary tube is dipped in water to a depth and the water rises to height $h(< l)$ in the capillary tube. The lower end of the tube is closed in water by putting a thumb over it. The tube is now taken out and the thumb is removed from the lower end and it is kept open. The length of liquid column in the tube will be:




(a) l (b) l + h (c) h (d) 2h

Q 12. A vertical glass capillary tube, open at both ends, contains some water. Which of the following shapes may be taken by the water in the tube ?

(a) 
(b) 
(c) 
(d) 

Q 13. A spherical steel ball released at the top of a long column of glycerine of length l, falls through a distance l/2 with accelerated motion and the remaining distance l/2 with uniform velocity. Let $t_1$ and $t_2$ denote the times taken to cover the first and second half and $W_1$ and $W_2$ the work done against gravity in the two halves, then:

(a) $t_1 < t_2$, $W_1 > W_2$ (b) $t_1 > t_2$, $W_1 < W_2$

(c) $t_1 = t_2$, $W_1 = W_2$ (d) $t_1 > t_2$, $W_1 = W_2$

Q 14. A ball of density ρ is released from deep inside of a liquid of density 2ρ. It will move up:
(a) with an increasing acceleration
(b) with a decreasing acceleration
(c) with a constant acceleration
(d) with zero acceleration

Q 15. The terminal velocity of a ball in air is v, where acceleration due to gravity is g. Now the same ball is taken in a gravity free space where all other conditions are same. The ball is now pushed at a speed v, then: (Given that density of the ball = 2 times the density of air )
(a) the terminal velocity of the ball will be v/2
(b) the ball Will move with a constant velocity
(c) the initial acceleration of the ball is 2g in opposite direction of the bail's velocity
(d) the ball will finally stop

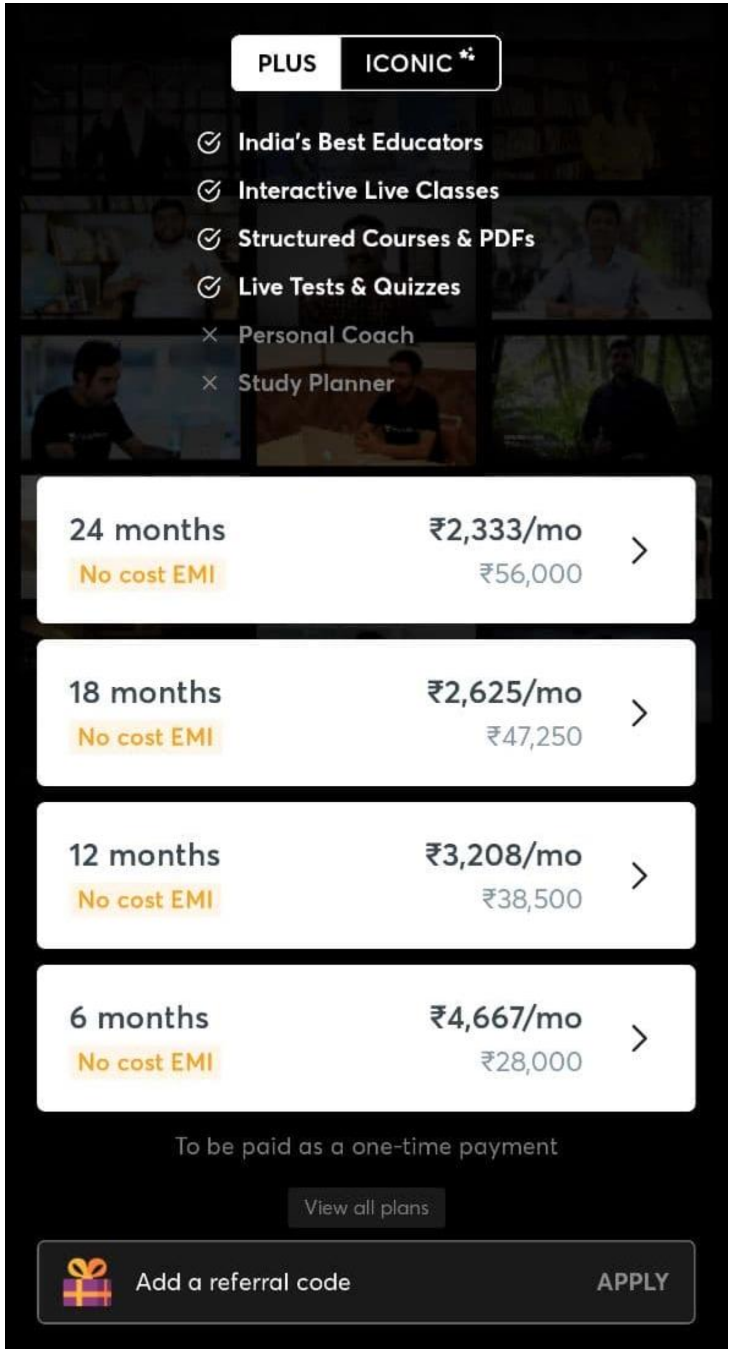
Q 16. An oil drop falls through air with a terminal velocity of $5 \times 10^{-4}$ m/s. Viscosity of oil is $1.8 \times 10^{-5}$ N-s/m$^2$ and density of oil is 900 kg/m$^3$. Neglecting density of air as compared to that of the oil:
(a) radius of the drop is $6.20 \times 10^{-2}$ m
(b) radius of the drop is $2.14 \times 10^{-6}$ m
(c) terminal 'velocity of the drop at half of this radius is $1.25 \times 10^{-4}$ m/s
(d) terminal velocity of the drop at half of this radius is $2.5 \times 10^{-4}$ m/s

Q 17. A raindrop reaching the ground with terminal velocity has momentum P. Another drop of twice the radius, also reaching the ground with terminal velocity, will have momentum–
(a) 4P (b) 8P (c) 16P (d) 32P



# Answer Key

| | | | | |
|---|---|---|---|---|
| **Q.1 b** | **Q.2 a** | **Q.3 c** | **Q.4 b** | **Q.5 a** |
| **Q.6 c** | **Q.7 a** | **Q.8 d** | **Q.9 b** | **Q.10 a** |
| **Q.11 d** | **Q.12 b, d** | **Q.13 d** | **Q.14 b** | **Q.15 d** |
| **Q.16 b, c** | **Q.17 d** | | | |

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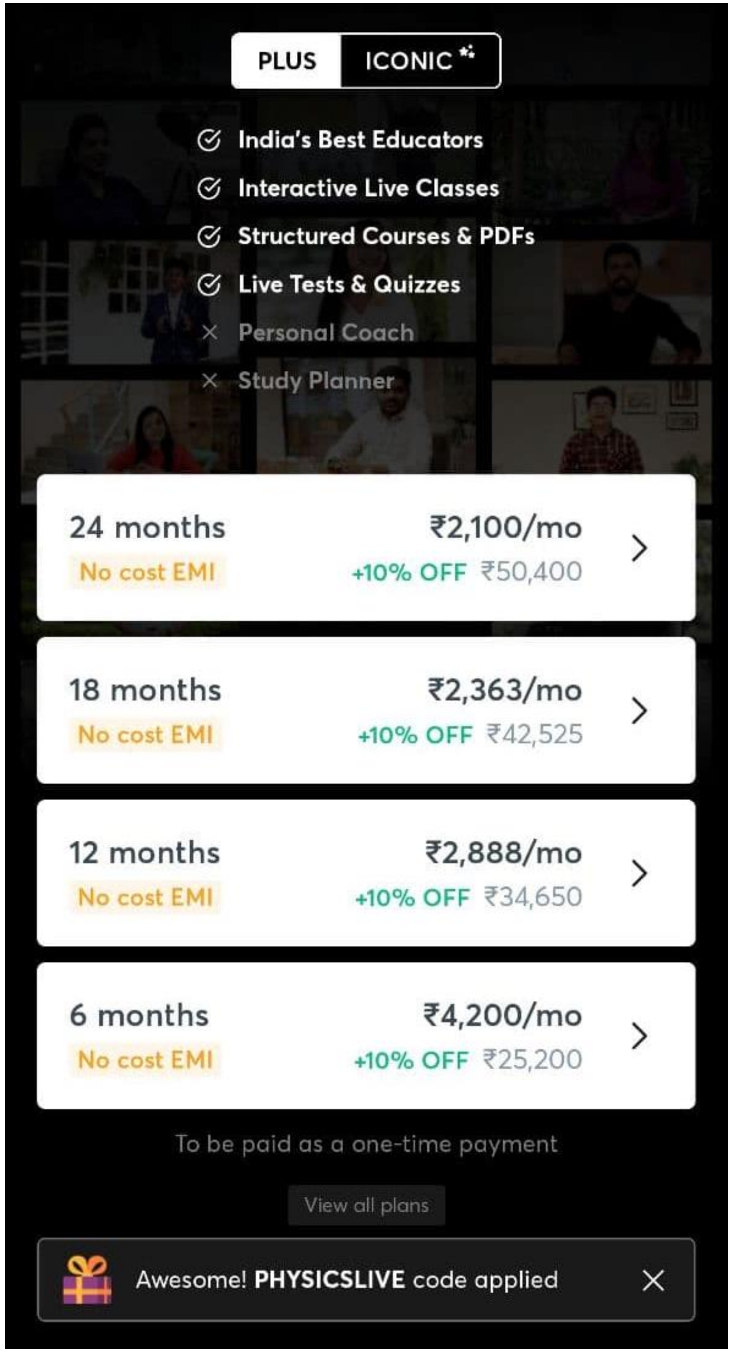


# JEE Main & Advanced, NSEP, INPhO, IPhO
# Physics DPP – Written Solution

## DPP- 5 Fluid : Capillary Rise , Viscosity, Terminal Velocity

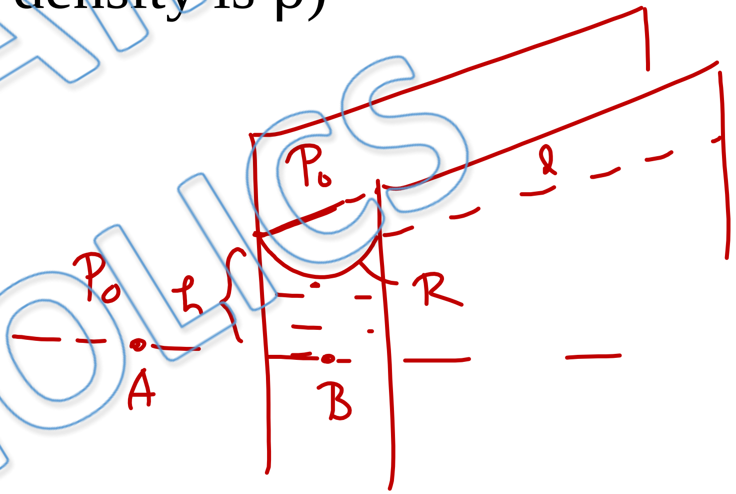

# By Physicsaholics Team

Q1) What is the height to which a liquid rises between two long parallel plates, a distance d apart? (Surface tension of liquid is T and density is ρ)

$$P_A = P_B$$

$$\Rightarrow P_0 = P_0 - \frac{T}{R} + \rho g h$$

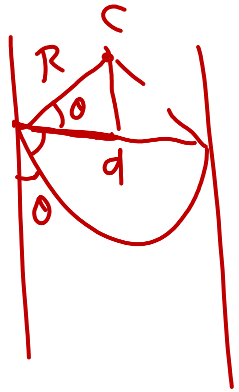
$$\Rightarrow h = \frac{T}{\rho g R} = \frac{2T\cos\theta}{\rho g d}$$




(a) $\frac{4T}{\rho d g}$ (b) $\frac{2T}{\rho d g}$ (c) $\frac{T}{\rho d g}$ (d) $\frac{T}{2\rho d g}$

If $\theta = 0$

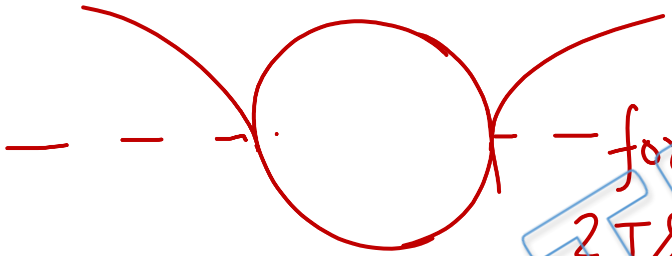
$$h = \frac{2T}{\rho g d}$$

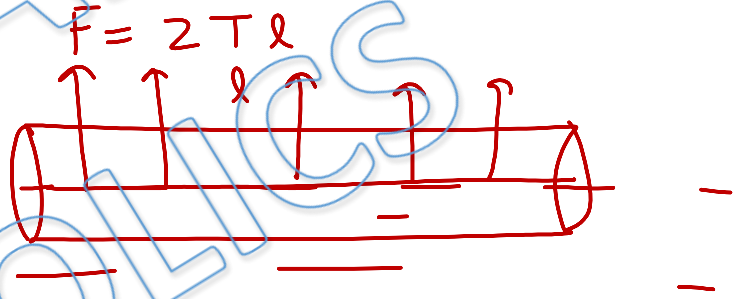



$$\cos\theta = \frac{d}{2R}$$

$$R = \frac{d}{2\cos\theta}$$

Q2) A metallic cylindrical wire of density ρ floats horizontal in water. The maximum radius of the wire so that the wire may not sink will be: (surface tension of water = T and angle of contact = π )






for floatation i.e.

$2T\ell > \rho(\pi r^2 \ell)g$

(a) $\sqrt{\frac{2T}{\pi\rho g}}$ (b) $\sqrt{\frac{2T}{\rho g}}$ (c) $\sqrt{\frac{T}{\pi\rho g}}$ (d) $\sqrt{\frac{T\rho}{\pi g}}$

$r^2 < \frac{2T}{\rho g \pi}$

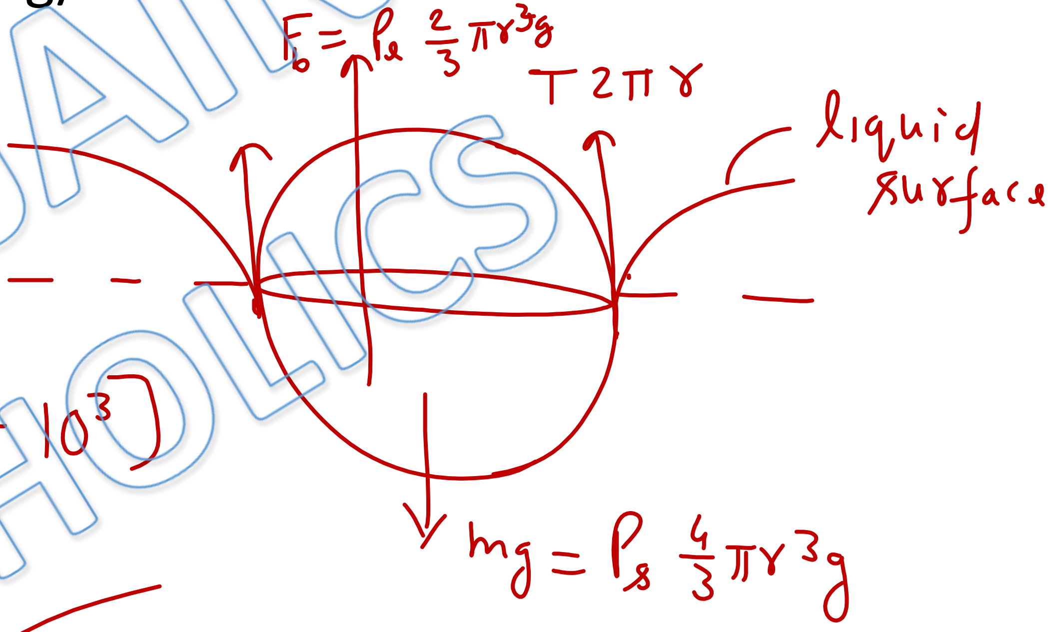
$r < \sqrt{\frac{2T}{\rho g \pi}}$

Q3) What is the radius of a steel sphere that will float on water with exactly half the sphere submerged? Density of steel is $7.9 \times 10^3$ kg/m$^3$ and surface tension of water is $7 \times 10^{-2}$ N.

$$T\,2\pi r + \frac{2}{3}\pi r^3 g \rho_l = \frac{4}{3}\pi r^3 g \rho_s$$

$$T\,2\pi r = \frac{2}{3}\pi r^3 g\left[2\rho_s - \rho_l\right]$$

$$7\times10^{-2} = \frac{10}{3}\times r^2\left[2\times7.9\times10^3 - 10^3\right]$$

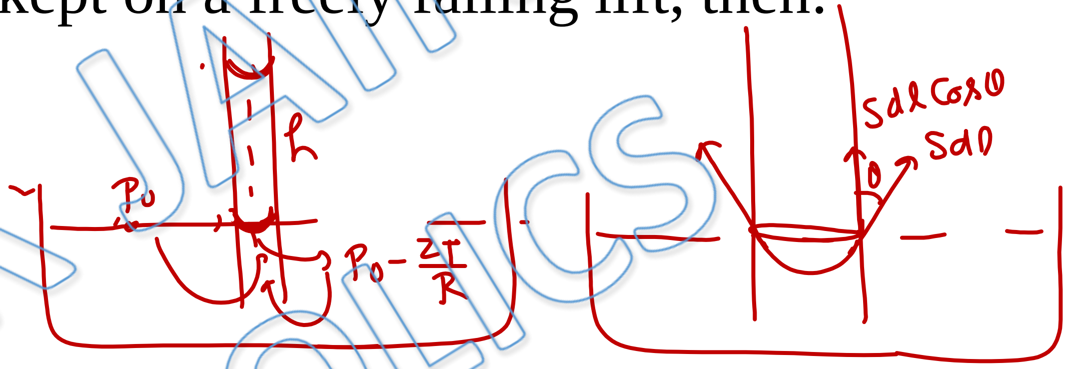



(a) 2.6 cm (b) 4.6 mm (c) 1.2 mm (d) 6.5 mm

$$r^2 = \frac{21\times10^{-3}}{148\times10^3} = \frac{21}{148}\times10^{-6}$$

$$r = \sqrt{\frac{21}{14.8}}\times10^{-3}\text{ meter} = \sqrt{\frac{21}{148}}\text{ mm}$$

Q4) A capillary is clipped in water vessel kept on a freely falling lift, then:




(a) water will not rise in the tube

(b) water will rise to the maximum available height of the tube

(c) water will rise to the height observed under normal condition

(d) water will rise to the height below that observed under normal condition

Q5) A solid ball of density $\rho_1$ and radius r falls vertically through a liquid of density $\rho_2$ . Assume that the viscous force acting on the ball is F = krv, where k is a constant and v its velocity. What is the terminal velocity of the ball?

Q5) A solid ball of density $\rho_1$ and radius r falls vertically through a liquid of density $\rho_2$ . Assume that the viscous force acting on the ball is F = krv, where k is a constant and v its velocity. What is the terminal velocity of the ball?

$F = Krv$

$V_T = \frac{2}{9}\frac{r^2 g}{\eta}(\rho - \sigma)$

$F = 6\pi\eta r v$, $\eta \to K$

(a) $\frac{4\pi g r^2(\rho_1-\rho_2)}{3K}$ ✓

(b) $\frac{2\pi r\,(\rho_1-\rho_2)}{3gK}$

$= \frac{2}{9}\frac{r^2 g}{K}6\pi(\rho_1-\rho_2)$

(b) $\frac{2\pi g\,(\rho_1+\rho_2)}{3gr^2K}$

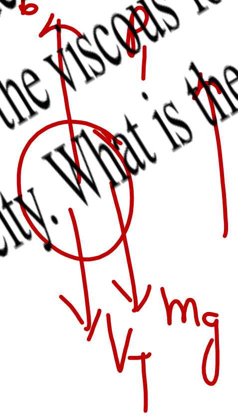
(d) None of these

at $V = V_T$

$F_{net} = 0$

$F_b = mg\frac{\rho_2}{\rho_1}$

$F_v = KrV_T$

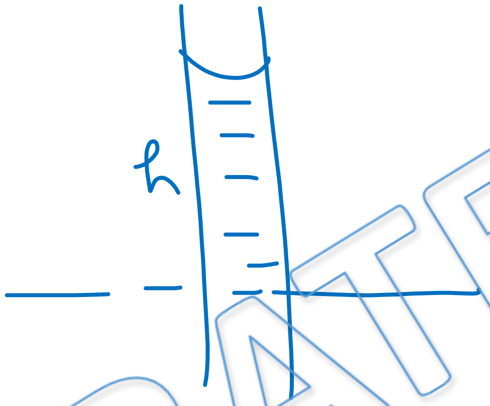



$KrV_T = mg\left(1-\frac{\rho_2}{\rho_1}\right)$

$KrV_T = \frac{4}{3}\pi r^3\rho_1 g\left(1-\frac{\rho_2}{\rho_1}\right)$

$V_T = \frac{4\pi r^2 g(\rho_1-\rho_2)}{3K}$

Q6) A capillary tube of radius r is immersed in water and water rises in it to a height h. The mass of the water in the capillary tube is m. Another capillary of radius 2r is immersed in water. The mass of water that will rise in this tube is:

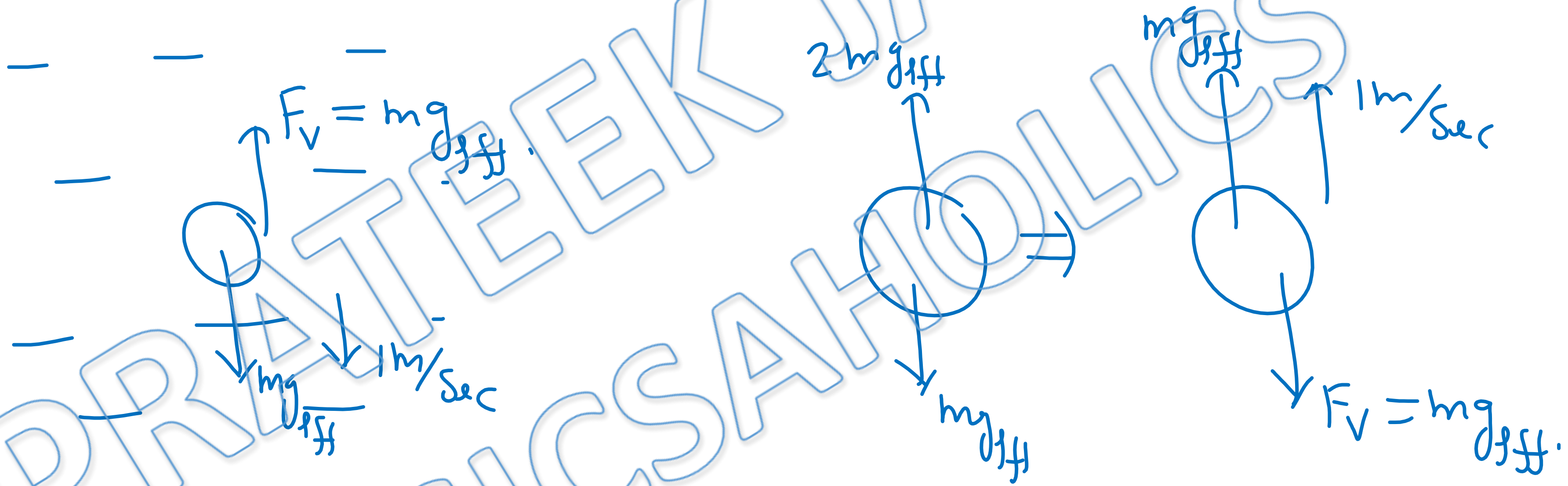



$m = \pi r^2 h \rho = \pi r^2 \rho \dfrac{2T\cos\theta}{\rho g r} \propto r$

2 times → 2 times

(a) m/2 (b) m (c) 2 m (d) 4 m

Q7) A small steel ball falls through a syrup with terminal speed 1.0 m/s. If the steel ball is pulled upwards with a force equal to twice its effective weight, its terminal speed will be

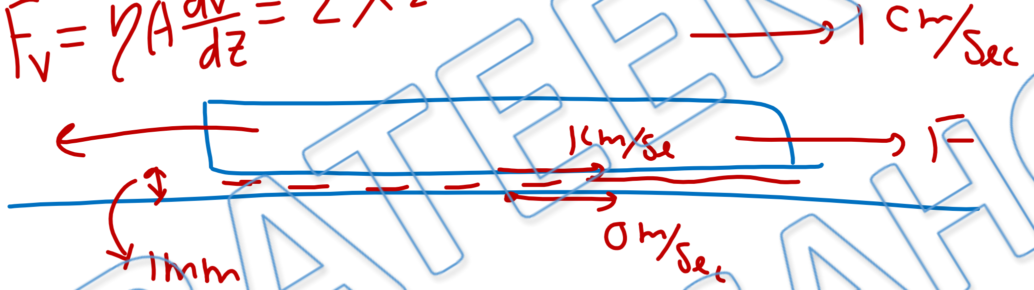



(a) 1.0 m/s (b) 2.0 m/s (c) 0.5 m/s (d) zero

Q8) A flat plate of area 20 $cm^2$ is placed on a horizontal surface coated with a layer of glycerine 1 mm thick. What force must be applied to the plate to keep it moving with a speed of 1 cm/s over the horizontal surface ? (Coefficient of viscosity of glycerine =2.0 kg/m-s)

$$F_v = \eta A \frac{dv}{dz} = 2 \times 20 \times 10^{-4} \times 10$$

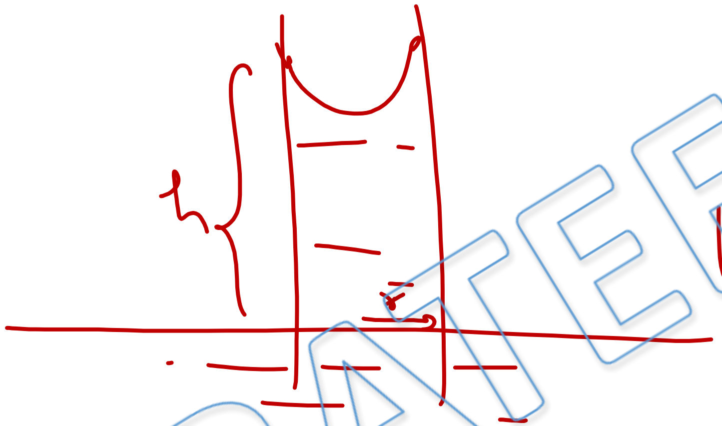
$$\frac{dv}{dz} = \frac{dv}{dz} = \frac{1\ cm/sec}{1\ mm} = 10/sec$$




(a) $2.0 \times 10^{-3}$ N (b) 2.0 N (c) $1.0 \times 10^{-4}$N (d) $4.0 \times 10^{-2}$N ✓

$$F = F_v = 400 \times 10^{-4}\ N$$
$$= 4 \times 10^{-2}\ N$$

Q9) A vertical capillary is brought in contact with the water surface (surface tension = T). The radius of the capillary is r and the contact angle $\theta = 0^o$. The increase in potential energy of the water (density = ρ) is:




$$m = \pi r^2 h \rho = \pi r^2 \rho \frac{2T}{\rho g r} = \frac{2\pi T r}{g}$$

$$U = mg h_{cm} = \frac{2\pi T r}{g} \times \frac{h}{2} = \frac{2\pi T r}{2g} \times \frac{2T}{\rho g r}$$

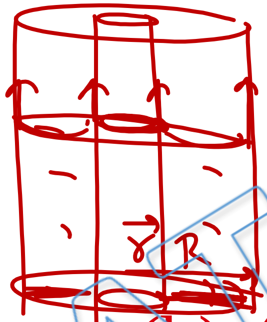
(a) independent of ρ

(b) independent of r

(c) independent of T

(d) zero

Q10) A glass rod of radius 1 mm is inserted symmetrically into a glass capillary tube with inside radius 2 mm. Then the whole arrangement is brought in contact of the surface of water. Surface tension of water is 0.7 N/m. To what height will the water rise in the capillary : (contact angle is zero.)




net upward force due to surface tension = weight of liquid column

$$T(2\pi r + 2\pi R) = \pi(R^2 - r^2) h \rho g$$

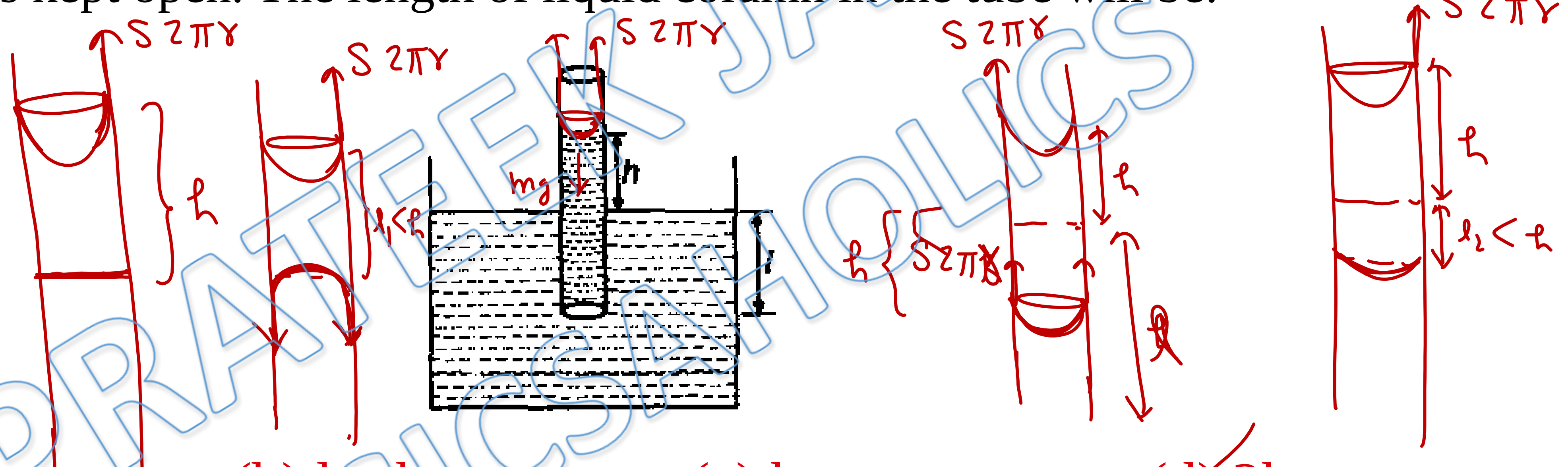
(a) 14 cm (b) 4.2 cm (c) 2.1 cm (d) 6.8 cm

$$2T = (R - r)\rho g h$$

$$h = \frac{2T}{(R-r)\rho g} = \frac{2 \times .7}{10^{-3} \times 10^3 \times 10} = .14 \text{ m}$$

$= 14$ cm

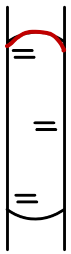
Q11) A capillary tube is dipped in water to a depth and the water rises to height $h(< l)$ in the capillary tube. The lower end of the tube is closed in water by putting a thumb over it. The tube is now taken out and the thumb is removed from the lower end and it is kept open. The length of liquid column in the tube will be:



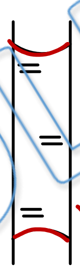

(a) l (b) l + h (c) h (d) 2h

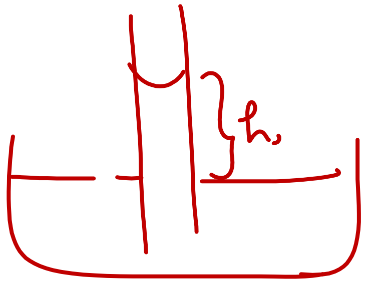
Q12) A vertical glass capillary tube, open at both ends, contains some water. Which of the following shapes may be taken by the water in the tube ?

(a)

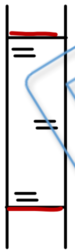


(b)

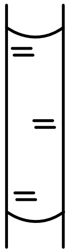




(c)



(d)



Q13) A spherical steel ball released at the top of a long column of glycerine of length l, falls through a distance l/2 with accelerated motion and the remaining distance l/2 with uniform velocity. Let $t_1$ and $t_2$ denote the times taken to cover the first and second half and $W_1$ and $W_2$ the work done against gravity in the two halves, then:


(a) $t_1 < t_2$, $W_1 > W_2$

(b) $t_1 > t_2$, $W_1 < W_2$

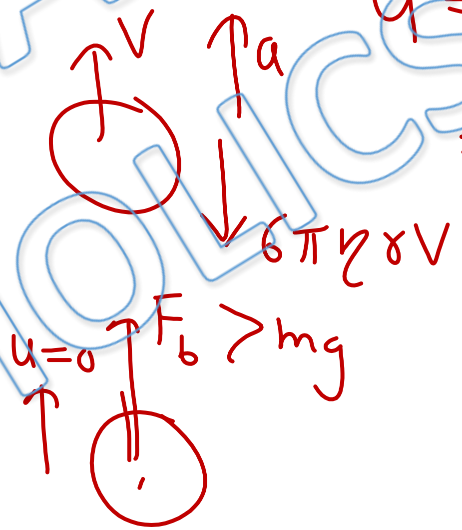
(c) $t_1 = t_2$, $W_1 = W_2$

(d) $t_1 > t_2$, $W_1 = W_2$

Q14) A ball of density ρ is released from deep inside of a liquid of density 2ρ. It will move up:

$$F_b = \frac{mg\,2\rho}{\rho} = 2mg$$

$$a = \frac{F_b - mg - 6\pi\eta r v}{m} = \frac{mg - 6\pi\eta r v}{m}$$




(a) with an increasing acceleration

(b) with a decreasing acceleration

(c) with a constant acceleration

(d) with zero acceleration

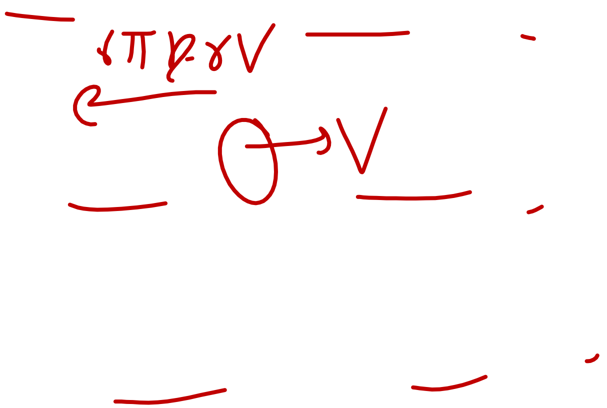
Q15) The terminal velocity of a ball in air is v, where acceleration due to gravity is g. Now the same ball is taken in a gravity free space where all other conditions are same. The ball is now pushed at a speed v, then: (Given that density of the ball = 2 times the density of air )

(a) the terminal velocity of the ball will be v/2

(b) the ball Will move with a constant velocity

(c) the initial acceleration of the ball is 2g in opposite direction of the bail's velocity

(d) the ball will finally stop



Q16) An oil drop falls through air with a terminal velocity of 5 × $10^{-4}$ m/s. Viscosity of oil is 1.8 × $10^{-5}$ N-s/$m^2$ and density of oil is 900 kg/$m^3$. Neglecting density of air as compared to that of the oil:

$V_T \propto r^2$ ; $V_T \rightarrow \frac{1}{4}$ times, $r \rightarrow \frac{1}{2}$ times

$V_T = \frac{2}{9}\frac{r^2}{\eta} g(\rho)$

$5 \times 10^{-4} = \frac{2}{9} \times \frac{r^2 \times 10 \times 900}{1.8 \times 10^{-5}}$

$r^2 = \frac{9 \times 10^{-12}}{2}\ m \Rightarrow r = \frac{3}{1.4} \times 10^{-6}\ m$

(a) radius of the drop is 6.20 × $10^{-2}$ m

(b) radius of the drop is 2.14 × $10^{-6}$ m ✓

(c) terminal ‘velocity of the drop at half of this radius is 1.25× $10^{-4}$ m/s ✓

(d) terminal velocity of the drop at half of this radius is 2.5 x $10^{-4}$ m/s

Q17) A raindrop reaching the ground with terminal velocity has momentum P. Another drop of twice the radius, also reaching the ground with terminal velocity, will have momentum–

$P = m V_T$

$= \frac{4}{3}\pi r^3 \rho \cdot \frac{2}{9}\frac{r^2 g}{\eta}(\rho - \sigma)$

$P \propto r^5$

32 times ← 2 times

(a) 4P

(b) 8P

(c) 16P

(d) 32P ✓

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