

# Applied Physics 1

## Chapter: Properties of Matter

### Exercise Set 4: Numerical Problems with Solutions

This set has only numerical problems of the chapter **Properties of Matter**, each solved step by step. All problems are new and do not repeat Sets 1, 2 or 3. They are grouped as Elasticity, Surface Tension, Viscosity and Hydrodynamics.

**Method for every numerical:** write the given data in SI units, write the formula, substitute the values, calculate step by step and give the answer with its unit. Take  $g = 9.8 \text{ m/s}^2$  and  $\pi = 3.14$  unless stated otherwise.

### Formulas Used in this Set

| Topic           | Formulas                                                                                                                                                                            |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Elasticity      | Stress = $F/A$ ; strain = $\Delta L/L$ ; $Y = FL / (A\Delta L)$ ; $K = PV / \Delta V$ ; $G = (F/A) / \theta$ , $\theta = x/h$ ; factor of safety = breaking stress / working stress |
| Surface tension | $T = F/l = W/\Delta A$ ; capillary rise $h = 2T \cos\theta / (r \rho g)$                                                                                                            |
| Viscosity       | Stokes' drag $F = 6\pi \eta r v$ ; terminal velocity $v = 2 r^2 (\rho - \sigma) g / (9 \eta)$                                                                                       |
| Hydrodynamics   | $Re = \rho v D / \eta$ ; $v_c = Re_c \eta / (\rho D)$ ; $A_1 v_1 = A_2 v_2$ ; $Q = A v$ ; $P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$                                     |

### A. Elasticity

**N1. An aluminium wire of length 2.5 m and diameter 1.2 mm carries a mass of 6 kg. Find the elongation of the wire. ( $Y = 7 \times 10^{10} \text{ N/m}^2$ )**

**Given:**  $L = 2.5 \text{ m}$ ,  $r = 0.6 \times 10^{-3} \text{ m}$ ,  $m = 6 \text{ kg}$ ,  $Y = 7 \times 10^{10} \text{ N/m}^2$

**Formula:**  $\Delta L = F L / (A Y)$

**Solution:**

- $F = mg = 6 \times 9.8 = 58.8 \text{ N}$
- $A = 3.14 \times (0.6 \times 10^{-3})^2 = 1.13 \times 10^{-6} \text{ m}^2$
- $\Delta L = (58.8 \times 2.5) / (1.13 \times 10^{-6} \times 7 \times 10^{10}) = 147 / 7.91 \times 10^4$
- $\Delta L = 1.86 \times 10^{-3} \text{ m}$

**Answer:** Elongation = 1.86 mm.

**N2. A steel wire and a copper wire of the same length and cross-section carry the same load. Find the ratio of their extensions. ( $Y_{\text{steel}} = 2 \times 10^{11} \text{ N/m}^2$ ,  $Y_{\text{copper}} = 1.2 \times 10^{11} \text{ N/m}^2$ )**

**Given:** Same  $L$ ,  $A$  and  $F$ ;  $Y_s = 2 \times 10^{11}$ ,  $Y_c = 1.2 \times 10^{11} \text{ N/m}^2$

**Formula:**  $\Delta L = F L / (A Y)$ , so  $\Delta L \propto 1 / Y$

**Solution:**

- $\Delta L_s / \Delta L_c = Y_c / Y_s$
- $= 1.2 \times 10^{11} / 2 \times 10^{11} = 0.6 = 3 / 5$

**Answer:**  $\Delta L_{\text{steel}} : \Delta L_{\text{copper}} = 3 : 5$  (steel stretches less, so it is stiffer).

**N3. What force is needed to double the length of a steel wire of cross-section  $2 \text{ mm}^2$ , if it remained elastic? ( $Y = 2 \times 10^{11} \text{ N/m}^2$ )**

**Given:**  $A = 2 \times 10^{-6} \text{ m}^2$ ,  $Y = 2 \times 10^{11} \text{ N/m}^2$ ,  $\Delta L = L$  (length doubles)

**Formula:**  $Y = (F/A) / (\Delta L/L)$ , so  $F = Y A (\Delta L / L)$

**Solution:**

- $\Delta L / L = 1$
- $F = 2 \times 10^{11} \times 2 \times 10^{-6} \times 1 = 4 \times 10^5 \text{ N}$

**Answer:**  $F = 4 \times 10^5 \text{ N}$ . (In practice the wire would break long before this, because it crosses the elastic limit.)

**N4. A steel sphere of volume  $0.02 \text{ m}^3$  is lowered to a depth of 3 km in sea water of density  $1030 \text{ kg/m}^3$ . Find the decrease in its volume. ( $K$  for steel =  $1.6 \times 10^{11} \text{ N/m}^2$ )**

**Given:**  $V = 0.02 \text{ m}^3$ ,  $h = 3000 \text{ m}$ ,  $\rho = 1030 \text{ kg/m}^3$ ,  $K = 1.6 \times 10^{11} \text{ N/m}^2$

**Formula:**  $P = \rho g h$ ;  $\Delta V = P V / K$

**Solution:**

- $P = 1030 \times 9.8 \times 3000 = 3.03 \times 10^7 \text{ N/m}^2$
- $\Delta V = (3.03 \times 10^7 \times 0.02) / (1.6 \times 10^{11}) = 6.06 \times 10^5 / 1.6 \times 10^{11}$
- $\Delta V = 3.79 \times 10^{-6} \text{ m}^3$

**Answer:** Decrease in volume =  $3.79 \times 10^{-6} \text{ m}^3$  ( $3.79 \text{ cm}^3$ ).

**N5. A steel rope of cross-section  $2 \text{ cm}^2$  has a breaking stress of  $5 \times 10^8 \text{ N/m}^2$ . Find the safe load if the factor of safety is 5.**

**Given:**  $A = 2 \times 10^{-4} \text{ m}^2$ , breaking stress =  $5 \times 10^8 \text{ N/m}^2$ , factor of safety = 5

**Formula:** Working stress = breaking stress / factor of safety; safe load = working stress  $\times$  A

**Solution:**

- Working stress =  $5 \times 10^8 / 5 = 1 \times 10^8 \text{ N/m}^2$
- Safe load =  $1 \times 10^8 \times 2 \times 10^{-4} = 2 \times 10^4 \text{ N}$
- Mass =  $2 \times 10^4 / 9.8 = 2041 \text{ kg}$

**Answer:** Safe load =  $2 \times 10^4 \text{ N}$  (about 2041 kg).

**N6. A tangential force of  $5.2 \times 10^4 \text{ N}$  is applied on the top face of an aluminium cube of side 6 cm. Find the displacement of the top face. ( $G = 2.6 \times 10^{10} \text{ N/m}^2$ )**

**Given:**  $F = 5.2 \times 10^4 \text{ N}$ ,  $h = 0.06 \text{ m}$ ,  $G = 2.6 \times 10^{10} \text{ N/m}^2$

**Formula:**  $G = (F/A) / \theta$ ;  $\theta = x / h$

**Solution:**

- $A = (0.06)^2 = 3.6 \times 10^{-3} \text{ m}^2$
- Shear stress =  $5.2 \times 10^4 / 3.6 \times 10^{-3} = 1.44 \times 10^7 \text{ N/m}^2$
- $\theta = 1.44 \times 10^7 / 2.6 \times 10^{10} = 5.56 \times 10^{-4}$
- $x = \theta h = 5.56 \times 10^{-4} \times 0.06 = 3.33 \times 10^{-5} \text{ m}$

**Answer:** Displacement of the top face =  $3.33 \times 10^{-5} \text{ m}$  (0.033 mm).

## B. Surface Tension

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**N7. A soap film is formed on a rectangular frame with a movable wire of length 4 cm. The surface tension of the soap solution is 0.025 N/m. Find the force on the wire and the work done in pulling it through 3 cm.**

**Given:**  $l = 0.04$  m,  $x = 0.03$  m,  $T = 0.025$  N/m; the film has two surfaces

**Formula:**  $F = 2 T l$ ;  $W = F \times x$

**Solution:**

- $F = 2 \times 0.025 \times 0.04 = 2 \times 10^{-3}$  N
- $W = 2 \times 10^{-3} \times 0.03 = 6 \times 10^{-5}$  J
- Check: increase in area  $= 2 \times 0.04 \times 0.03 = 2.4 \times 10^{-3}$  m<sup>2</sup>, and  $T \times \Delta A = 0.025 \times 2.4 \times 10^{-3} = 6 \times 10^{-5}$  J

**Answer:** Force  $= 2 \times 10^{-3}$  N; work done  $= 6 \times 10^{-5}$  J.

**N8. Find the work done in increasing the radius of a soap bubble from 1 cm to 3 cm. ( $T = 0.04$  N/m)**

**Given:**  $r_1 = 0.01$  m,  $r_2 = 0.03$  m,  $T = 0.04$  N/m; two surfaces

**Formula:**  $W = T \times 2 \times 4\pi (r_2^2 - r_1^2)$

**Solution:**

- $r_2^2 - r_1^2 = 9 \times 10^{-4} - 1 \times 10^{-4} = 8 \times 10^{-4}$  m<sup>2</sup>
- Increase in area  $= 2 \times 4 \times 3.14 \times 8 \times 10^{-4} = 2.01 \times 10^{-2}$  m<sup>2</sup>
- $W = 0.04 \times 2.01 \times 10^{-2} = 8.04 \times 10^{-4}$  J

**Answer:**  $W = 8.04 \times 10^{-4}$  J.

**N9. A mercury drop of radius 4 mm splits into 64 identical droplets. Find the work done against surface tension. ( $T = 0.465$  N/m)**

**Given:**  $R = 4 \times 10^{-3}$  m,  $n = 64$ ,  $T = 0.465$  N/m

**Formula:** Equal volume:  $R^3 = 64 r^3$ ;  $W = T \times \text{increase in area}$

**Solution:**

- $r = R / 4 = 1 \times 10^{-3}$  m
- Increase in area  $= 64 \times 4\pi r^2 - 4\pi R^2 = 4\pi (64 \times 10^{-6} - 16 \times 10^{-6})$
- $= 12.56 \times 48 \times 10^{-6} = 6.03 \times 10^{-4}$  m<sup>2</sup>
- $W = 0.465 \times 6.03 \times 10^{-4} = 2.80 \times 10^{-4}$  J

**Answer:**  $W = 2.80 \times 10^{-4}$  J.

**N10. A capillary tube of radius 0.3 mm is dipped in water and inclined at 60° to the vertical. Find the vertical height to which water rises and the length of the water column along the tube. ( $T = 0.072$  N/m,  $\theta = 0^\circ$ ,  $\rho = 1000$  kg/m<sup>3</sup>)**

**Given:**  $r = 0.3 \times 10^{-3}$  m,  $T = 0.072$  N/m,  $\alpha = 60^\circ$ ,  $\cos 60^\circ = 0.5$

**Formula:**  $h = 2T \cos \theta / (r \rho g)$ ; length along the tube  $l = h / \cos \alpha$

**Solution:**

- $h = (2 \times 0.072) / (0.3 \times 10^{-3} \times 1000 \times 9.8) = 0.144 / 2.94 = 0.0490$  m
- The vertical height stays the same when the tube is inclined.
- $l = h / \cos 60^\circ = 0.0490 / 0.5 = 0.098$  m

**Answer:** Vertical height  $= 4.90$  cm; length of column along the tube  $= 9.8$  cm.

**N11. Find the depression of mercury in a glass capillary of radius 0.5 mm if the angle of contact is 140°. (T = 0.47 N/m,  $\rho = 13600 \text{ kg/m}^3$ ,  $\cos 140^\circ = -0.766$ )**

**Given:**  $r = 0.5 \times 10^{-3} \text{ m}$ ,  $T = 0.47 \text{ N/m}$ ,  $\theta = 140^\circ$ ,  $\rho = 13600 \text{ kg/m}^3$

**Formula:**  $h = 2T \cos \theta / (r \rho g)$

**Solution:**

- Numerator =  $2 \times 0.47 \times (-0.766) = -0.720$
- Denominator =  $0.5 \times 10^{-3} \times 13600 \times 9.8 = 66.64$
- $h = -0.720 / 66.64 = -1.08 \times 10^{-2} \text{ m}$

**Answer:** The negative sign shows a fall: mercury is depressed by 1.08 cm.

**N12. A liquid of surface tension 0.06 N/m and density 1100 kg/m<sup>3</sup> rises 2.5 cm in a capillary tube of radius 0.4 mm. Find the angle of contact.**

**Given:**  $T = 0.06 \text{ N/m}$ ,  $\rho = 1100 \text{ kg/m}^3$ ,  $h = 0.025 \text{ m}$ ,  $r = 0.4 \times 10^{-3} \text{ m}$

**Formula:**  $h = 2T \cos \theta / (r \rho g)$ , so  $\cos \theta = h r \rho g / (2T)$

**Solution:**

- $\cos \theta = (0.025 \times 0.4 \times 10^{-3} \times 1100 \times 9.8) / (2 \times 0.06)$
- $\cos \theta = 0.1078 / 0.12 = 0.898$
- $\theta = \cos^{-1}(0.898) = 26^\circ$

**Answer:** Angle of contact =  $26^\circ$  (acute, so the liquid wets the glass).

## C. Viscosity

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**N13. A steel ball of radius 2.5 mm falls through castor oil of density 950 kg/m<sup>3</sup> and viscosity 0.99 Pa·s. Find the terminal velocity. ( $\rho_{\text{steel}} = 7800 \text{ kg/m}^3$ )**

**Given:**  $r = 2.5 \times 10^{-3} \text{ m}$ ,  $\rho = 7800 \text{ kg/m}^3$ ,  $\sigma = 950 \text{ kg/m}^3$ ,  $\eta = 0.99 \text{ Pa·s}$

**Formula:**  $v = 2 r^2 (\rho - \sigma) g / (9 \eta)$

**Solution:**

- $\rho - \sigma = 7800 - 950 = 6850 \text{ kg/m}^3$
- $v = (2 \times 6.25 \times 10^{-6} \times 6850 \times 9.8) / (9 \times 0.99) = 0.839 / 8.91$
- $v = 9.42 \times 10^{-2} \text{ m/s}$

**Answer:** Terminal velocity =  $9.42 \times 10^{-2} \text{ m/s}$  (9.42 cm/s).

**N14. A steel ball of radius 0.5 mm falls through 40 cm of glycerine at its terminal velocity. Find the time taken. ( $\eta = 0.83 \text{ Pa·s}$ ,  $\rho_{\text{steel}} = 7800 \text{ kg/m}^3$ ,  $\sigma_{\text{glycerine}} = 1260 \text{ kg/m}^3$ )**

**Given:**  $r = 0.5 \times 10^{-3} \text{ m}$ ,  $d = 0.4 \text{ m}$ ,  $\eta = 0.83 \text{ Pa·s}$ ,  $\rho = 7800$ ,  $\sigma = 1260 \text{ kg/m}^3$

**Formula:**  $v = 2 r^2 (\rho - \sigma) g / (9 \eta)$ ;  $t = d / v$

**Solution:**

- $v = (2 \times 2.5 \times 10^{-7} \times 6540 \times 9.8) / (9 \times 0.83) = 3.20 \times 10^{-2} / 7.47$
- $v = 4.29 \times 10^{-3} \text{ m/s}$
- $t = 0.4 / 4.29 \times 10^{-3} = 93.2 \text{ s}$

**Answer:** Time taken = 93 s (about 1.5 minutes).

**N15. A sphere moving at 0.05 m/s in oil of viscosity 0.6 Pa·s experiences a viscous drag of  $5.65 \times 10^{-3}$  N. Find the radius of the sphere.**

**Given:**  $v = 0.05$  m/s,  $\eta = 0.6$  Pa·s,  $F = 5.65 \times 10^{-3}$  N

**Formula:**  $F = 6\pi \eta r v$ , so  $r = F / (6\pi \eta v)$

**Solution:**

- $6\pi \eta v = 6 \times 3.14 \times 0.6 \times 0.05 = 0.565$
- $r = 5.65 \times 10^{-3} / 0.565 = 1 \times 10^{-2}$  m

**Answer:** Radius = 1 cm.

**N16. Two spheres of the same radius, one of density  $7800 \text{ kg/m}^3$  and the other of density  $2700 \text{ kg/m}^3$ , fall through the same liquid of density  $1000 \text{ kg/m}^3$ . Find the ratio of their terminal velocities.**

**Given:**  $\rho_1 = 7800$ ,  $\rho_2 = 2700$ ,  $\sigma = 1000 \text{ kg/m}^3$ ; same  $r$  and  $\eta$

**Formula:**  $v \propto (\rho - \sigma)$

**Solution:**

- $v_1 / v_2 = (7800 - 1000) / (2700 - 1000)$
- $= 6800 / 1700 = 4$

**Answer:**  $v_1 : v_2 = 4 : 1$ .

**N17. The viscosity of water is  $1.0 \times 10^{-3}$  Pa·s at  $20^\circ\text{C}$  and  $0.35 \times 10^{-3}$  Pa·s at  $80^\circ\text{C}$ . By what factor does the terminal velocity of the same small ball change when the water is heated from  $20^\circ\text{C}$  to  $80^\circ\text{C}$ ? (Neglect the change in density.)**

**Given:**  $\eta_{20} = 1.0 \times 10^{-3}$  Pa·s,  $\eta_{80} = 0.35 \times 10^{-3}$  Pa·s; same  $r$ ,  $\rho$ ,  $\sigma$

**Formula:**  $v \propto 1 / \eta$

**Solution:**

- $v_{80} / v_{20} = \eta_{20} / \eta_{80}$
- $= 1.0 \times 10^{-3} / 0.35 \times 10^{-3} = 2.86$

**Answer:** Terminal velocity becomes about 2.86 times larger, because the viscosity of a liquid decreases with temperature.

**N18. An oil drop of radius 0.05 mm and density  $900 \text{ kg/m}^3$  falls in air. Find its terminal velocity. ( $\eta_{\text{air}} = 1.8 \times 10^{-5}$  Pa·s, density of air =  $1.2 \text{ kg/m}^3$ )**

**Given:**  $r = 0.05 \times 10^{-3}$  m,  $\rho = 900 \text{ kg/m}^3$ ,  $\sigma = 1.2 \text{ kg/m}^3$ ,  $\eta = 1.8 \times 10^{-5}$  Pa·s

**Formula:**  $v = \frac{2}{9} r^2 (\rho - \sigma) g / \eta$

**Solution:**

- $\rho - \sigma = 900 - 1.2 = 898.8 \text{ kg/m}^3$
- $v = (2 \times 2.5 \times 10^{-9} \times 898.8 \times 9.8) / (9 \times 1.8 \times 10^{-5}) = 4.40 \times 10^{-5} / 1.62 \times 10^{-4}$
- $v = 0.272$  m/s

**Answer:** Terminal velocity = 0.27 m/s.

## D. Hydrodynamics

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**N19. Water ( $\rho = 1000 \text{ kg/m}^3$ ,  $\eta = 10^{-3} \text{ Pa}\cdot\text{s}$ ) flows at 2 m/s through a garden hose of diameter 1.6 cm. Find the Reynolds number and the type of flow.**

**Given:**  $\rho = 1000 \text{ kg/m}^3$ ,  $\eta = 10^{-3} \text{ Pa}\cdot\text{s}$ ,  $v = 2 \text{ m/s}$ ,  $D = 0.016 \text{ m}$

**Formula:**  $Re = \rho v D / \eta$

**Solution:**

- $Re = (1000 \times 2 \times 0.016) / 10^{-3} = 32 / 10^{-3}$
- $Re = 3.2 \times 10^4$

**Answer:**  $Re = 32000$ , which is much greater than 3000, so the flow is turbulent.

**N20. Find the critical velocity for glycerine ( $\rho = 1260 \text{ kg/m}^3$ ,  $\eta = 0.83 \text{ Pa}\cdot\text{s}$ ) flowing in a pipe of diameter 2 cm. Take  $Re_c = 2000$ .**

**Given:**  $\rho = 1260 \text{ kg/m}^3$ ,  $\eta = 0.83 \text{ Pa}\cdot\text{s}$ ,  $D = 0.02 \text{ m}$ ,  $Re_c = 2000$

**Formula:**  $v_c = Re_c \eta / (\rho D)$

**Solution:**

- $v_c = (2000 \times 0.83) / (1260 \times 0.02) = 1660 / 25.2$
- $v_c = 65.9 \text{ m/s}$

**Answer:** Critical velocity = 65.9 m/s. Because glycerine is so viscous, its flow stays streamline up to a very high speed.

**N21. Water flows at 1.2 m/s through a pipe of diameter 8 cm into an empty tank of capacity 2000 litres. Find the time taken to fill the tank.**

**Given:**  $D = 0.08 \text{ m}$  so  $r = 0.04 \text{ m}$ ,  $v = 1.2 \text{ m/s}$ ,  $V = 2000 \text{ litres} = 2 \text{ m}^3$

**Formula:**  $Q = A v$ ;  $t = V / Q$

**Solution:**

- $A = 3.14 \times (0.04)^2 = 5.02 \times 10^{-3} \text{ m}^2$
- $Q = 5.02 \times 10^{-3} \times 1.2 = 6.03 \times 10^{-3} \text{ m}^3/\text{s}$
- $t = 2 / 6.03 \times 10^{-3} = 332 \text{ s}$

**Answer:** Time taken = 332 s (about 5.5 minutes).

**N22. A river 40 m wide and 3 m deep flows at 1.5 m/s. At a narrow place its width becomes 25 m and its depth 4 m. Find the speed of the river there.**

**Given:** Section 1: width 40 m, depth 3 m,  $v_1 = 1.5 \text{ m/s}$ . Section 2: width 25 m, depth 4 m

**Formula:**  $A_1 v_1 = A_2 v_2$

**Solution:**

- $A_1 = 40 \times 3 = 120 \text{ m}^2$ ;  $A_2 = 25 \times 4 = 100 \text{ m}^2$
- $Q = A_1 v_1 = 120 \times 1.5 = 180 \text{ m}^3/\text{s}$
- $v_2 = Q / A_2 = 180 / 100 = 1.8 \text{ m/s}$

**Answer:** Speed at the narrow place = 1.8 m/s.

**N23. In a horizontal pipe, water flows at 0.5 m/s at a pressure of  $1.8 \times 10^5 \text{ N/m}^2$ . At a narrow section its speed is 4.5 m/s. Find the pressure there.**

**Given:**  $v_1 = 0.5 \text{ m/s}$ ,  $P_1 = 1.8 \times 10^5 \text{ N/m}^2$ ,  $v_2 = 4.5 \text{ m/s}$ ,  $\rho = 1000 \text{ kg/m}^3$

**Formula:**  $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$  (horizontal pipe)

**Solution:**

- $P_1 - P_2 = \frac{1}{2} \times 1000 \times (4.5^2 - 0.5^2) = 500 \times (20.25 - 0.25) = 10000 \text{ N/m}^2$
- $P_2 = 1.8 \times 10^5 - 0.1 \times 10^5 = 1.7 \times 10^5 \text{ N/m}^2$

**Answer:**  $P_2 = 1.7 \times 10^5 \text{ N/m}^2$ .

**N24. The water tank on the roof of a building is 20 m above a tap. Find the gauge pressure at the tap when it is closed, and the speed of water when the tap is opened (neglect friction).**

**Given:**  $h = 20 \text{ m}$ ,  $\rho = 1000 \text{ kg/m}^3$

**Formula:** Gauge pressure  $P = \rho g h$ ; speed  $v = \sqrt{2 g h}$  from Bernoulli's equation

**Solution:**

- $P = 1000 \times 9.8 \times 20 = 1.96 \times 10^5 \text{ N/m}^2$
- $v = \sqrt{2 \times 9.8 \times 20} = \sqrt{392} = 19.8 \text{ m/s}$

**Answer:** Gauge pressure =  $1.96 \times 10^5 \text{ N/m}^2$ ; speed of water = 19.8 m/s.

**N25. A small hole of area  $2 \text{ cm}^2$  is made in the side of a large open tank, 1.25 m below the water surface. Find the volume of water flowing out per second.**

**Given:**  $a = 2 \times 10^{-4} \text{ m}^2$ ,  $h = 1.25 \text{ m}$

**Formula:**  $v = \sqrt{2 g h}$ ;  $Q = a v$

**Solution:**

- $v = \sqrt{2 \times 9.8 \times 1.25} = \sqrt{24.5} = 4.95 \text{ m/s}$
- $Q = 2 \times 10^{-4} \times 4.95 = 9.9 \times 10^{-4} \text{ m}^3/\text{s}$

**Answer:**  $Q = 9.9 \times 10^{-4} \text{ m}^3/\text{s}$  (about 0.99 litre/s).

**N26. A Pitot tube measures a pressure difference of  $600 \text{ N/m}^2$  between the stagnation point and the static point in air. Find the speed of the air. (Density of air =  $1.2 \text{ kg/m}^3$ )**

**Given:**  $\Delta P = 600 \text{ N/m}^2$ ,  $\rho = 1.2 \text{ kg/m}^3$

**Formula:**  $\Delta P = \frac{1}{2} \rho v^2$ , so  $v = \sqrt{2 \Delta P / \rho}$

**Solution:**

- $v = \sqrt{2 \times 600 / 1.2} = \sqrt{1000}$
- $v = 31.6 \text{ m/s}$

**Answer:** Speed of air = 31.6 m/s.

**N27. In a sprayer, air blows at 40 m/s across the top of a vertical tube dipped in oil of density  $900 \text{ kg/m}^3$ . Find the pressure reduction at the top of the tube and the height to which the oil can rise in the tube. (Density of air =  $1.2 \text{ kg/m}^3$ )**

**Given:**  $v = 40 \text{ m/s}$ ,  $\rho_{\text{air}} = 1.2 \text{ kg/m}^3$ ,  $\rho_{\text{oil}} = 900 \text{ kg/m}^3$

**Formula:**  $\Delta P = \frac{1}{2} \rho_{\text{air}} v^2$ ;  $h = \Delta P / (\rho_{\text{oil}} g)$

**Solution:**

- $\Delta P = \frac{1}{2} \times 1.2 \times (40)^2 = 0.6 \times 1600 = 960 \text{ N/m}^2$
- $h = 960 / (900 \times 9.8) = 960 / 8820 = 0.109 \text{ m}$

**Answer:** Pressure reduction =  $960 \text{ N/m}^2$ ; oil rises about 10.9 cm in the tube.