

## Numerical Problems

**7.1 A wooden block measuring 40 cm x 10 cm x 5 cm has a mass 850 g. Find the density of 3 wood.**

**(425 kgm<sup>-3</sup>)**

**Solution:** volume of wooden block =  $V = 40 \text{ cm} \times 10 \text{ cm} \times 5 \text{ cm} = 2000 \text{ cm}^3$

$$= 2000 \times \frac{1}{100} \times \frac{1}{100} \times \frac{1}{100} \text{ m}^3$$

$$= 0.002 \text{ m}^3$$

$$\text{Mass} = m = 850 \text{ g} = \frac{850}{1000} = 0.85 \text{ kg}$$

Density of wood =  $\rho = ?$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{0.85}{0.002} = 425 \text{ kg}^{-3}$$

**7.2 How much would be the volume of ice formed by freezing 1 litre of water?**

**(1.09 litre)**

**Solution:** Volume of water = 1 litre

Volume of ice = ?

1 litre of water = 1 kg mass and density =  $1000 \text{ kg}^{-3}$

Since density of ice is 0.92 times of the liquid water therefore,

$$\text{Volume of ice} = \frac{\text{Mass}}{\text{Density}}$$

$$= \frac{1000}{920}$$

Volume of ice = 1.09 litre

### 7.3 Calculate the volume of the following objects:

(i) An iron sphere of mass 5 kg, the density of iron is  $8200 \text{ kgm}^{-3}$ .

$$(6.1 \times 10^{-4} \text{ m}^3)$$

(ii) 200 g of lead shot having density  $11300 \text{ kgm}^{-3}$ .

$$(1.77 \times 10^{-5} \text{ m}^3)$$

(iii) A gold bar of mass 0.2 kg. The density of gold is  $19300 \text{ kgm}^{-3}$ .

$$(1.04 \times 10^{-5} \text{ m}^3)$$

**Solution:** Mass of iron sphere =  $m = 5 \text{ kg}$

Density of iron =  $\rho = 8200 \text{ kgm}^{-3}$

Volume of iron sphere =  $V = ?$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$\text{Volume} = \frac{5}{8200}$$

$$= 0.00060975 = 6.0975 \times 10^{-4}$$

$$\text{Volume} = 6.1 \times 10^{-4} \text{ m}^3$$

(ii) Mass of lead shot =  $m = 200 \text{ g} = \frac{200}{1000} \text{ kg} = 0.2 \text{ kg}$

Density of lead =  $\rho = 11300 \text{ kgm}^{-3}$

Volume of lead shot =  $V = ?$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$\text{Volume} = \frac{0.2}{11300}$$

$$= 0.000017699 = 1.76699 \times 10^{-5}$$

$$\text{Volume} = 1.77 \times 10^{-5} \text{m}^3$$

(iii) Mass of gold bar =  $m = 0.2 \text{ kg}$

Density of gold =  $\rho = 19300 \text{ kgm}^{-3}$

Volume of gold bar =  $V = ?$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$\text{Volume} = \frac{0.2}{19300}$$

$$= 0.000010362 = 1.0362 \times 10^{-5}$$

$$\text{Volume} = 1.04 \times 10^{-5} \text{m}^3$$

**7.4 The density of air is  $1.3 \text{ kgm}^{-3}$ . Find the mass of air in a room measuring  $8\text{m} \times 5\text{m} \times 4\text{m}$ .**

**(208 kg)**

**Solution:** Density of air =  $\rho = 1.3 \text{ kgm}^{-3}$

Volume of room =  $v = 8 \text{ m} \times 5 \text{ m} \times 4 \text{ m} = 160 \text{ m}^3$

Mass of air =  $m = ?$

Mass of air = Density of air  $\times$  volume of room

Mass of air =  $1.3 \times 160$

Mass of air = 208 kg

**7.5 A student presses her palm by her thumb with a force of 75 N. How much would be the pressure under her thumb having contact area 1.5 cm<sup>2</sup> ?**

**(5 × 10<sup>5</sup> Nm<sup>-2</sup>)**

**Solution:** Force = F = 75 N

$$\text{Contact Area } A = 1.5 \text{ cm}^2 = 1.5 \times \frac{1}{100} \times \frac{1}{100} \text{ m}^2 = 1.5 \times 10^{-4} \text{ m}^2$$

Pressure under the thumb = P = ?

$$P = \frac{F}{A}$$

$$P = \frac{75}{1.5 \times 10^{-4}} = \frac{75}{1.5} \times 10^4 = 5 \times 10^5 \text{ Nm}^{-2}$$

**7.6 The head of a pin is a square of side 10 mm. Find the pressure on it due to a force of 20 N.**

**(2 × 10<sup>5</sup> Nm<sup>-2</sup>)**

**Solution:** Force = F = 20 N

$$\begin{aligned} \text{Area of head of a pin } A &= 10 \text{ mm} \times 10 \text{ mm} = \frac{10}{10} \text{ cm} \times \frac{10}{10} \text{ cm} = \\ &= \frac{1}{100} \text{ m} \times \frac{1}{100} \text{ m} \\ &= 10^{-4} \text{ m}^2 \end{aligned}$$

Pressure under the thumb = P = ?

$$P = \frac{F}{A}$$

$$P = \frac{20}{1 \times 10^{-4}} = 2 \times 10^5 \text{ Nm}^{-2}$$

**7.7** A uniform rectangular block of wood 20 cm x 7.5 cm x 7.5 cm and of mass 1000g stands on a horizontal surface with its longest edge vertical. Find

- (i) The pressure exerted by the block on the surface  
 (ii) Density of the wood.

(1778 Nm<sup>-2</sup> , 889 kgm<sup>-3</sup>)

**Solution:** Length of the smallest side of the block = 7.5 cm

Mass of the block  $m = 1000\text{g} = 1\text{kg}$

- (i) Pressure exerted by the block  $P = ?$   
 (ii) Density of wood  $\rho = ?$

**Calculations:** (i) since the smallest edge of the block is rested on the horizontal surface. Therefore, area of the block will be:

$$\text{Area} = A = 7.5 \text{ cm} \times 7.5 \text{ cm} = 56.25 \text{ cm}^2$$

$$= 56.25 \times \frac{1}{100} \times \frac{1}{100} \text{ m}^2 = 56.25 \times 10^{-4} \text{ m}^2$$

Pressure under the thumb =  $P = ?$

$$P = \frac{F}{A} = \frac{mg}{A}$$

$$P = \frac{1 \times 10}{56.25 \times 10^{-4}} = 0.1778 \times 10^4 = 1778 \text{ Nm}^{-2}$$

- (ii) Volume =  $V = 20 \text{ cm} \times 7.5 \text{ cm} \times 7.5 \text{ cm} = 1125 \text{ cm}^3$

$$= 1125 \times \frac{1}{100} \text{ m} \times \frac{1}{100} \text{ m} \times \frac{1}{100} \text{ m} = 1125 \times 10^{-6} \text{ m}^3$$

Or  $V = 1.125 \times 10^{-3} \text{ m}^3$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{1}{1.125 \times 10^{-3}} = 0.8888 \times 10^3 = 888.8 \text{ kgm}^{-3}$$

$$\text{Density} = 889 \text{ kgm}^{-3}$$

**7.8 A cube of glass of 5 cm side and mass 306 g, has a cavity inside it. If the density of glass is  $2.55 \text{ gcm}^{-3}$ . Find the volume of the cavity.**

**(5 cm<sup>3</sup>)**

**Solution:** Size of the cube = 7.5 cm

Mass of the cube = m = 306 g

Density of glass =  $\rho = 2.55 \text{ kgm}^{-3}$

Volume of the cavity = V = ?

Volume of the whole cube = 5 cm x 5 cm x 5 cm = 125 cm<sup>3</sup>

Volume of the glass =  $\frac{\text{Mass}}{\text{Density}}$

$$\text{Volume} = \frac{306}{2.55} = 120 \text{ cm}^3$$

Volume of the cavity = 125 cm<sup>3</sup> – 120 cm<sup>3</sup> = 5 cm<sup>3</sup>

**7.9 An object has weight 18 N in air. Its weight is found to be 11.4 N when immersed in water. Calculate its density. Can you guess the material of the object?**

**(2727 kgm<sup>-3</sup>, Aluminium)**

**Solution:** weight of object in air =  $w_1 = 18 \text{ N}$

Weight of object immersed in water =  $w_2 = 11.4 \text{ N}$

Density of glass =  $\rho = 1000 \text{ kgm}^{-3}$

(i) Density of the object =  $D = ?$

(ii) Nature of the material = ?

(i) 
$$D = \frac{w_1}{w_1 - w_2} \times \rho$$

$$D = \frac{18}{18 - 11.4} \times 1000$$

$$= \frac{18}{6.6} \times 1000 = 2.727 \times 10^3 = 2727 \text{ kgm}^{-3}$$

(ii) The density of aluminum is  $2700 \text{ kgm}^{-3}$ , the above calculated value of density is  $2727 \text{ kgm}^{-3}$  nearest to the density of aluminum, so the material of the object is aluminum.

**7.10 A solid block of wood of density  $0.6 \text{ gcm}^{-3}$  weighs  $3.06 \text{ N}$  in air. Determine (a) volume of the block (b) the volume of the block immersed when placed freely in a liquid of density  $0.9 \text{ gcm}^{-3}$ ?**

**(510 cm<sup>3</sup>, 340 cm<sup>3</sup>)**

**Solution:** Density of wood =  $D = 0.6 \text{ gcm}^{-3}$

Weight of the wooden block =  $w = 3.06 \text{ N}$

Since  $w = mg$  or  $m = \frac{w}{g} = \frac{3.06}{10} = 0.306 \text{ kg} = 306 \text{ g}$

Density of liquid  $D = 0.9 \text{ gcm}^{-3}$

(i) Volume of the block  $V = ?$

(ii) Volume of the block immersed in a liquid  $V = ?$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$V = \frac{306}{0.6} = 510 \text{ cm}^3$$

(b) 
$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$V = \frac{306}{0.9} = 340 \text{ cm}^3$$

**7.11 The diameter of the piston of a hydraulic press is 30 cm. How much force is required to lift a car weighing 20 000 N on its piston if the diameter of the piston of the pump is 3 cm? (200 N)**

**Solution:** Diameter =  $D = 30 \text{ cm}$

$$\text{Radius of the piston} = R = \frac{D}{2} = \frac{30 \text{ cm}}{2} = 15 \text{ cm} = \frac{15}{100} \text{ m} = 0.15 \text{ m}$$

$$\text{Area of the piston} = A = 2\pi R^2 = 2 \times 3.14 \times (0.15)^2$$

$$A = 0.1413 \text{ m}^2$$

$$\text{Weight of the car} \quad w = F_2 = 20000 \text{ N}$$

$$\text{Diameter of the piston} \quad d = 3 \text{ cm}$$

$$\text{Radius of the piston} = R = \frac{D}{2} = \frac{3 \text{ cm}}{2} = 1.5 \text{ cm} = \frac{1.5}{100} \text{ m} = 0.015 \text{ m}$$

$$\text{Area of the piston} = A = 2\pi R^2 = 2 \times 3.14 \times (0.015)^2$$

$$A = 1.413 \times 10^{-3} \text{ m}^2$$

$$\text{Force} = F_1 = ?$$

$$\frac{F_1}{a} = \frac{F_2}{A}$$

$$F_1 = F_2 \times \frac{a}{A}$$

$$F_1 = 200000 \text{ N} \times \frac{1.413 \times 10^{-3}}{0.1413}$$

$$= 200000 \text{ N} \times 0.01$$

$$F_1 = 200 \text{ N}$$

7.12 A steel wire of cross-sectional area  $2 \times 10^{-5} \text{ m}^2$  is stretched through 2 mm by a force of 4000 N. Find the Young's modulus of the wire. The length of the wire is 2 m.

**( $2 \times 10^{11} \text{ Nm}^{-2}$ )**

**Solution:** Cross-sectional area =  $A = 2 \times 10^{-5} \text{ m}^2$

$$\text{Extension} = \Delta L = 2 \text{ mm} = 2 \times \frac{1}{1000} \text{ m} = 0.002 \text{ m}$$

$$\text{Force} = F = 4000 \text{ N}$$

$$\text{Length of the wire} = L = 2 \text{ m}$$

$$Y = \frac{FL}{A\Delta L}$$

$$Y = \frac{4000 \times 2}{2 \times 10^{-5} \times 0.002} = \frac{8000}{0.004 \times 10^{-5}}$$

$$Y = \frac{800}{0.004} \times 10^{-5}$$

$$Y = 2,000,000 \times 10^{-5} = 2 \times 10^{11} \text{ Nm}^{-2}$$

