Unit 7: Properties of Matter

Problems

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

Given Data

Volume of wooden block = v = 40 cm x 10 cm x 5 cm = 2000 cm^3 = 2 x 10^{-3} m^3

Mass of wooden block = m = 850 g = 0.85 kg

Required

Density of wooden block = d = ?

Solution

As we know that

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

By putting the values, we have

$$\text{Density} = \frac{0.85}{2 \times 10^{-3}}$$

Density = 0.425 x 10^3 kg m^{-3}

OR Density = 425 kg m^{-3}

Result

Density of wooden block = d = 425 kgm^{-3}

7.2 How much would be the volume of the ice formed by freezing 1 liter of water?
(LHR 2014)

Given Data

Volume of water = V_1 = 1 litre

Required

Volume of ice on freezing = V_2 = ?

Solution

As we know that

$$\frac{\text{Volume of ice}}{\text{volume of water}} = \frac{\text{density of water}}{\text{density of ice}}$$

So $$\text{volume of ice} = \left(\frac{\text{density of water}}{\text{density of ice}}\right) \times \text{volume of water}$$

Putting values, we have

Volume of ice = (1000/920) x 1

Volume of ice = 1.09 litres

Result

Volume of ice on freezing = V_2 = 1.09 litres

7.3 (i) Calculate the volume of the following objects.

(i) An iron sphere of mass 5 kg, the density of iron is 8200 kgm^{-3}.
(ii) 200 g of lead shot having density 11300 kgm^{-3}.
(iii)A gold bar of mass 0.2 kg. the density of gold is 19300 kgm^{-3}.

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

Given Data

Mass of iron sphere = m = 5 kg
Density of iron = d = 8200 kgm^{-3}

Required

Volume of iron sphere = V = ?

Solution

As we know that

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

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

By putting the values, we have

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

Volume = 0.00069 m^3
OR Volume = 6.9×10^{-4} m^3

Result

Volume of iron sphere = V = 6.9×10^{-4} m^3

7.3 (ii) 200 g of lead shot having density 11300 kgm^{-3}. **(LHR 2013)**

Given Data

Mass of lead shot = m = 200 g = 0.2 kg
Density of lead = d = 11300 kgm^{-3}

Required

Volume of lead shot = v = ?

Solution

As we know that

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

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

By putting the values, we have

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

Volume = 0.000017699 m^3
OR Volume = 1.77×10^{-5} m^3

Result

Volume of lead shot = v = 1.77×10^{-5} m^3

7.3 (iii) A gold bar of mass 0.2 kg. the density of gold is 19300 kgm^{-3}. **(LHR 2016)**

Given Data

Mass of gold bar = m = 0.2 kg
Density of gold = d = 19300 kgm^{-3}

Required

Volume of gold bar = v = ?

Solution

As we know that

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

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

By putting the values, we have

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

$$\text{Volume} = 0.00001036 \text{ m}^3$$

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

Result

Volume of gold bar = v = 1.04×10^{-5} m^3

7.4 The density of air is 1.3 kgm^{-3}. Find the mass of air in room measuring 8 m x 5 m x 4 m. (GRW 2016)

Given Data

Density of air = d = 1.3 kgm^{-3}

Volume of air = v = 8 m x 5 m x 4 m = 160 m^3

Required

Mass of air = m = ?

Solution

As we know that

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

So Mass = density x volume

By putting the values, we have

Mass = 1.3 x 160

Mass = 208 kg

Result

Mass of air = m = 208 kg

7.5 A student passes 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^2?

Given Data

Force exerted by student = F = 75 N

Contact area = A = 1.5 cm^2 = 1.5×10^{-4} m^2

Required

Pressure under the thumb = P = ?

Solution

As we know that

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

By putting the values, we have

$$P = \frac{75}{1.5 \times 10^{-4}}$$

$P = 50 \times 10^4 \text{ Nm}^{-2}$

$P = 5 \times 10^5\ Nm^{-2}$

Result

Pressure under the thumb = $P = 5 \times 10^5\ Nm^{-2}$

7.6 The head of the pin is a square of side 10 mm. find the pressure on it due to a force of 20 N. (GRW 2014)

Given Data

Force applied = F = 20 N

Side of head of pin = L = 10 mm = 10×10^{-3} m

Area of head of pin = A = L x L = 10×10^{-3} m x 10×10^{-3} m

= $100 \times 10^{-6}\ m^2 = 1 \times 10^{-4}\ m^2$

Required

Pressure exerted by head of pin = P = ?

Solution

As we know that

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

By putting the values, we have

$$P = \frac{20}{1 \times 10^{-4}}$$

$P = 20 \times 10^4\ Nm^{-2}$

$P = 2 \times 10^5\ Nm^{-2}$

Result

Pressure exerted by head of pin = $P = 2 \times 10^5\ Nm^{-2}$

7.7 A uniform rectangular block of wood 20 cm x 7.5 cm x 7.5 cm and of mass 1000 g 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

Given Data

Mass of wooden block = m = 1000 g = 1 kg

Volume of wooden block = V = 20 cm x 7.5 cm x 7.5 cm

= $0.001125\ m^3$ or 1.125×10^{-3}

Area of wooden block = A = 7.5 cm x 7.5 cm

= $0.005625\ m^2$ or $5.625 \times 10^{-3}\ m^2$

Required

(i) The pressure exerted by the block on the surface = P = ?

(ii) Density of wood = d =?

Solution

As we know that

V = L x W x H

By putting the values, we have

V = 20 cm x 7.5 cm x 7.5 cm = $1125\ cm^3 = 0.001125\ m^3$

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

By putting the values, we have

$$\text{Density} = \frac{1}{0.001125}$$

$$\text{Density} = 888.89 \text{ kgm}^{-3} = 889 \text{ kgm}^{-3}$$

As we know that

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

By putting the values, we have

$$P = \frac{10}{0.005625}$$

$$P = 1778 \text{ Nm}^{-2}$$

Result

(i) The pressure exerted by the block on the surface = P = 1778 Nm^{-2}

(ii) Density of wood = d = 889 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 the glass is 2.55 gcm^{-3}. Find the volume of the cavity.

Given Data

Length of side of glass cube = L = 5 cm

Volume of glass cube = $v = L^3 = (5 \text{ cm})^3 = 125 \text{ cm}^3$

$= 125 \times 10^{-6} \text{ m}^3 = 1.25 \times 10^{-4} \text{ m}^3$

Mass of cube = m = 306 g = 0.306 kg = 3.06×10^{-1} kg

Density of glass = d = 2.25 gcm^{-3} = $2.55 \times 10^3 kg\, m^{-3}$

Required

Volume of cavity inside the glass cube = V = ?

Solution

Volume without cavity = $1.25 \times 10^{-4} \text{ m}^3$

Volume with cavity = mass/density

$= (3.06 \times 10^{-1})/(2.55 \times 10^3)$

$= 1.20 \times 10^{-4} \text{ m}^3$

Volume of cavity = volume without cavity – volume with cavity

$= 1.25 \times 10^{-4} \text{ m}^3 - 1.20 \times 10^{-4} \text{ m}^3$

$= 0.05 \times 10^{-4} \text{ m}^3$

$= 5 \times 10^{-6} \text{ m}^3$ or 5 cm^3

Result

Volume of cavity inside the glass cube = v = 5 cm^3

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? (GRW 2014)

Given Data

Weight of object in air = w_1 = 18 N

Weight of object in water = w_2 = 11.4 N

Density of water = ρ_w = 1000 kgm^{-3}

Gravitational acceleration = g = 10 ms^{-2}

Weight of equal volume of water = $w = w_1 - w_2$ = 18 N – 11.4 N = 6.6 N

Required

Density of material = D_m = ?

Name of material = ?

Solution

As we know that

$$\frac{D}{\rho} = \frac{w_1}{w}$$

By putting the value, we have

$$\frac{D}{1000} = \frac{18}{6.6}$$

$$D = \frac{18000}{6.6}$$

$$D = 2727\,Kgm^{-3}$$

Result

Density of material = D_m = 2727 Kgm^{-3}

As we know that density of aluminum is approximately equal to the density found in the numerical. So, the material is aluminum.

7.10 A solid block of wood of density 0.6 gcm^{-3} weighs 3.06 N in air. Determine,

(i) Volume of the block

(ii) The volume of block immersed when placed freely in liquid of density 0.9 gcm-3.

Given Data

Density of wooden block = $d = 0.6\ gcm^{-3}$

Weight of the wooden block = $w = 3.06$ N

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

Required

Volume of the wooden block = $V_1 = ?$

Volume of block when immersed in liquid = $V_2 = ?$

Solution

As we know that

Volume = mass/ density

$V_1 = 0.306/(0.6 \times 10^3)$ $= 0.51 \times 10^{-3}\ m^3$ or $510 cm^3$

As we also know that

Upward thrust = weight of the liquid displaced

Weight = 10 x volume x density

$3.06 = 10 \times \text{volume} \times 0.9 \times 10^3$

Volume $= 3.06/(9 \times 10^3)$

$V_2 = 0.00034\ m^3$ or $34\ cm^3$

Result

Volume of the wooden block = V_1 = 510 cm^3

Volume of block when immersed in liquid = V_2 = 34 cm^3

7.11 The diameter of the piston of hydraulic press is 30 cm. How much force is required a car weighing 20000 N on its piston, if the diameter of the piston of the pump is 3 cm. (GRW 2016)

Given Data

Diameter of the piston of hydraulic press = D = 30 cm = 0.3 m

Diameter of the piston of pump = d = 3 cm = 0.03 m

Weight of the car lifted by hydraulic press = w = F_2 = 20000 N

Required

Force applied on piston of pump = $F_1 = ?$

Solution

As we know that

$$A = \frac{\pi D^2}{4}$$

(i) Larger piston

By putting the values, we have

$$A = \frac{3.14 \times (3 \times 10^{-1})^2}{4}$$

$$A = \frac{3.14 \times 9 \times 10^{-2}}{4}$$

$$A = \frac{28.26 \times 10^{-2}}{4}$$

$$A = 7.065 \times 10^{-2}\ m^2$$

(ii) Smaller piston

By putting the value, we have

$$a = \frac{3.14 \times (3 \times 10^{-2})^2}{4}$$

$$a = \frac{3.14 \times 9 \times 10^{-4}}{4}$$

$$a = \frac{28.26 \times 10^{-4}}{4}$$

$$a = 7.065 \times 10^{-4}\ m^2$$

From Pascal's law, we have

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

By putting the values, we have

$$\frac{F_1}{7.065 \times 10^{-4}} = \frac{20000}{7.065 \times 10^{-2}}$$

$$F_1 = \frac{20000 \times 7.065 \times 10^{-4}}{7.065 \times 10^{-2}}$$

$$F_1 = \frac{20000}{100}$$

$$F_1 = 200\ N$$

Result

Force applied on piston of pump = F_1 = 200 N

7.12 A steel wire of cross-sectional area 2 x 10^{-5} 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 2m.

Given Data

Length of the wire = L_o = 2 m

Area of steel wire = A = 2 x 10^{-5} m^2

Increase in length of wire = ΔL = 2 mm = 2 x 10^{-3} m

Force applied = F = 4000 N

Required

Young's modulus of wire = Y = ?

Solution

As we know that

$$Y = \frac{F \times L}{A \times \Delta L}$$

By putting the values, we have

$$Y = \frac{4000 \times 2}{2 \times 10^{-5} \times 2 \times 10^{-3}}$$

$$Y = \frac{2000}{10^{-5} \times 10^{-3}}$$

$Y = 2000 \text{ x } 10^{8} \text{ Nm}^{-2} = 2 \text{ x } 10^{3} \text{ x } 10^{8} \text{ Nm}^{-2}$

$Y = 2 \text{ x } 10^{11} \text{ Nm}^{-2}$

Result

Young's modulus of wire = $Y = 2 \text{ x } 10^{11} \text{ Nm}^{-2}$