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 $^{-3}$)

Solution: volume of wooden block = V = 40 cm x 10 cm x 5cm = 2000 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 = ρ = ?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{0.85}{0.02} = 425 \text{ kg}^{-3}$$

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 kg $^{-3}$

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

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

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

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 kgm $^{-3}$.

(6.1x10 $^{-4}$ m^3)

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

(1.77x10 $^{-5}$ m^3)

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

1.3 Calculate the volume of the following objects:

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(1.77×10^{-5} m^3)

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

(1.04×10^{-5} m^3)

Solution: Mass of iron sphere = m = 5 kg

Density of iron = ρ = 8200 kgm $^{-3}$

Volume of iron sphere = V =?

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

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

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

Volume = 6.1×10^{-4} m^3

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

Density of lead = ρ = 11300 kgm $^{-3}$

Volume of lead shot = V =?

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

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

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

Volume = 1.77×10^{-5} m^3

(iii) Mass of gold bar = m = 0.2 kg

Density of gold = ρ = 19300 kgm $^{-3}$

Volume of gold bar = V =?

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

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

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

Volume = 1.04×10^{-5} m^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 gcm $^{-3}$. Find the volume of the cavity.

(5 cm^3)

Solution: Size of the cube = 7.5 cm

Mass of the cube = m = 306 g

Density of glass = ρ = 2.55 kgm $^{-3}$

Volume of the cavity = V =?

Volume of the whole cube = 5 cm x 5 cm x 5 cm = 125 cm^3

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

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

Volume of the cavity = 125 cm^3 – 120 cm^3 = 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?

(2727 kgm $^{-3}$, Aluminium)

Solution: weight of object in air = w_1 = 18 N

Weight of object immersed in water = w_2 = 11.4 N

Density of glass = ρ = 1000 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 kgm $^{-3}$, the above calculated value of density is 2727 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 gcm $^{-3}$ weighs 3.06 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 gcm $^{-3}$?

(510 cm^3 , 340 cm^3)

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

Weight of the wooden block = w= 3.06 N

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

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

(i) Volume of the block V = ?

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

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^{-2} , 889 kgm^{-3})

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

Mass of the block m = 1000g = 1kg

(i) Pressure exerted by the block P = ?
(ii) Density of wood ρ = ?

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

Area = A = 7.5 cm x 7.5 cm = 56.25 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 cm x 7.5 cm x 7.5 cm = 1125 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 x 10^{-3} m^3

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

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

Density = 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 glass is 2.55 gcm^{-3}. Find the volume of the cavity.

(5 cm^3)

Solution: Size of the cube = 7.5 cm

Mass of the cube = m = 306 g

Density of glass = ρ = 2.55 kgm^{-3}

Volume of the cavity = V =?

Volume of the whole cube = 5 cm x 5 cm x 5 cm = 125 cm^3

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

(208 kg)

Solution: Density of air = ρ = 1.3 kgm $^{-3}$

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

Mass of air = m = ?

Mass of air = Density of air x volume of room

Mass of air = 1.3 x 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 cm² ?

(5x10^5 Nm $^{-2}$)

Solution: Force = F = 75 N

Contact Area A = 1.5 cm² = 1.5 x $\frac{1}{100}$ x $\frac{1}{100}$ m² = 1.5 x 10 $^{-4}$ m²

Pressure under the thumb = P = ?

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

$P = \frac{75}{1.5 \times 10^{-4}} = \frac{75}{1.5}$ x 10^4 = 5 x 10^5 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.

(2x10^5 Nm $^{-2}$)

Solution: Force = F = 20 N

Area of head of a pin A = 10mm x 10mm = $\frac{10}{10}$ cm x $\frac{10}{10}$ cm =

= $\frac{1}{100}$ m x $\frac{1}{100}$ m

= 10 $^{-4}$ m²

Pressure under the thumb = P = ?

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

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

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

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

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 cm

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

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

$A = 0.1413\ m^2$

Weight of the car $w = F_2 = 20000\ N$

Diameter of the piston $d = 3\ cm$

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

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

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

Force = F_1 = ?

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

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

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

$$= 200000\ N \times 0.01$$

$F_1 = 200\ N$

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

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

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

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

Force = F = 4000 N

Length of the wire = L = 1m

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

$$Y = \frac{4000 \times 2}{2 \times 10^{-3} \times 0.002} = \frac{8000}{0.004 \times 10^{-5}}$$

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