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UNITS AND MEASUREMENT

1.1 (a) Side of cube = 1 cm

Volume of cube = $(\text{side})^3$

$1 \times 1 \times 1\ cm^3$

$= 1 cm^3$

$1 \times 1 \times 1 cm^3 = \left(\frac{1}{100}\right)^3 m^3$ $\quad 1 cm = \frac{1}{100} m$

$= (10^{-2})^3$

$= 10^{-6} m^3$

(b). $r = 2.0$ cm $= 2.0 \times 10 = 20 mm$

$h = 10.0$ cm $= 10.0 \times 10 = 100$ mm

Surface area of solid cylinder =

$= 2\pi r^2 + 2\pi r h$

$= 2\pi r(r+h)$

$= 2 \times \frac{22}{7} \times 20 (20 + 100)\ mm^2$

$= \frac{40 \times 22 \times 100}{7}$

$= \frac{1056}{7} \times 100$

$= 150.85 \times 100$

$\cancel{= 15085\ mm^2}$ $= 150.85 \times 10^2$

$= 1.5 \times 10^4\ mm^2$

(C). Speed $= 18$ km/hr.

$= 18 \times \frac{5}{18} = 5 m/s$

or

$= 5 ms^{-1}$

d). Relative density of lead = 11.3

Relative density = $\dfrac{\text{density of substance}}{\text{density of water}}$

$11.3 = \dfrac{\text{density of lead}}{1}$

density of lead = $11.3\ g/cm^3$

In MKS system,

$= 11.3 \times \dfrac{1}{1000} \times (100)^3$ $\left[\begin{array}{l} \because 1cm = \frac{1}{100} m \\ \because 1gm = \frac{1}{1000} kg \end{array}\right]$

$= 11.3 \times 10^{-3} \times 10^{6}$

$= 11.3 \times 10^{3}\ kg\, m^{-3}$

$= 1.13 \times 10^{4}\ kg\, m^{-3}$

1.2 Fill in the blanks :-

(a) $1\ kg\, m^2 s^{-2} = 1 \times (1000 g) \times (100 cm)^2 \times s^{-2}$

$= 10^3 g \times 10^4 cm^2 \times s^{-2}$

$= 10^7\ g\, cm^2 s^{-2}$

(b). 1 light year = 9.46×10^{15} m

or $1 m = \dfrac{1 \text{ light year}}{9.46 \times 10^{15}}$

$1m = \dfrac{1}{9.46 \times 10^{15}}$

$= \dfrac{1 \times 10^{-15}}{9.46}$

$= \dfrac{10 \times 10^{-16}}{9.46}$

$= \dfrac{1000}{946} \times 10^{-16}$

$\therefore$ $1m = 1.057 \times 10^{-16}$ ly.

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(c) $3.0\ m/s^2 = 3\ m/s^2$

$3 \times \frac{1}{1000}\ km \times (60 \times 60)^2\ hrs$

$= \frac{3 \times 360\cancel{0} \times 360\cancel{0}}{1\cancel{000}}$

$= 3 \times 360 \times 36$

$= 38880\ km\ H^{-2}$

$\approx 3.9 \times 10^4\ km\ H^{-2}$

(d). $G = 6.67 \times 10^{-11}\ N m^2 kg^{-2}$

$1N = 10^5$ dyne $\quad 1m = 100\ cm \quad 1kg = 1000\ g$

$= 6.67 \times 10^{-11} \times 10^5$ dyne $\times (100cm)^2 \times (1000g)^{-2}$

$= 6.67 \times 10^{-11} \times 10^5 \times 10^4 \times 10^{-6}$ dyne $cm^2 g^{-2}$

$= 6.67 \times 10^{-8}$ dyne $cm^2 g^{-2}$.

1.3. $1\ cal = 4.2\ J$

New system of unit =

Dimensional formula of Energy $[ML^2T^{-2}]$

$\therefore a = 1,\ b = 2,\ c = -2$.

Here,

$[M_1] = 1\ kg,\ [L_1] = 1m,\ [T_1] = 1\ sec$

$[M_2]\ \alpha\ m,\ [L_2]\ \beta\ m,\ [T_2]\ \gamma\ s$

$n_1 = 4.2,\quad n_2 = ?$

We have formula,

$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$

$= 4.2 \left[\frac{1\ \cancel{kg}}{\alpha\ \cancel{kg}}\right]^1 \left[\frac{1\ \cancel{m}}{\beta\ \cancel{m}}\right]^2 \left[\frac{1\ \cancel{s}}{\gamma\ \cancel{s}}\right]^{-2}$

$= 4.2 \times \frac{1}{\alpha} \times \frac{1}{\beta^2} \times \frac{1}{\gamma^{-2}}$

$= 4.2\ \alpha^{-1} \beta^{-2} \gamma^2$ new units

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1.5 Given that speed of light in vacuum is unity in new system of units

$$c = \frac{1 \text{ new unit of length}}{\text{sec}}$$

Time taken by light to reach earth = 8 min 20 sec
= 500 sec.

$\therefore$ Speed = $\frac{\text{distance}}{\text{time}}$

distance = speed × time
= 1 × 500
= 500 units (new units)

1.6 (c) The least count of an optical instrument is very ~~low~~ less in comparison to vernier ~~cap~~ callipers and screw gauge. Therefore optical instrument is most precise.
(c)

1.7 Linear magnification = $\frac{\text{Observed width}}{\text{Real width}}$

$$100 = \frac{3.5}{\text{Real width}}$$

$$= \frac{3.5}{100}$$

Real width of hair = 0.035 mm

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1.8.

(a) Wrap the thread on the metre scale with no gap between the threads. Measure the length l which contains n turns.

Diameter of thread,

$$d = \frac{l}{n}$$

(b). We know that,

$$\text{least count} = \frac{\text{Pitch}}{\text{no. of divisions on the circular scale}}$$

If we increase no. of division, least count will decreases and accuracy increases but only to a certain limit as the resolution becomes low.

(c). We know, to reduce random errors more or large no. of observations are taken. Therefore the set of 100 measurement is more reliable the set of 5

1.9 If A = area and L = length then,

$$\frac{A_1}{A_2} = \frac{L_2^2}{L_1^2}$$

or

$$\frac{L_2}{L_1} = \sqrt{\frac{A_2}{A_1}}$$

here, $A_1 = 1.75\ cm^2 = 1.75 \times 10^{-4}\ m^2$

and $A_2 = 1.55\ m^2$

$$\frac{L_2}{L_1} = \sqrt{\frac{1155}{1175 \times 10^{-4}}} = \sqrt{\frac{155}{175 \times 10^{-4}}}$$

$$= \sqrt{\frac{155 \times 10^4}{175}}$$

$$= \sqrt{0.8857} \times 10^2$$

$$= 0.9411 \times 10^2$$

$$= 94.11 \rightarrow 94.1$$

Hence the linear magnification is 94.1

1.10 (a) $0.007\ m^2 = 1$

(b) 2.64×10^{24} kg $= 3$

(c) $0.2370\ g\ cm^{-3} = 4$

(d) $6.320\ J = 4$

(e) $6.032\ N m^{-2} = 4$

(f). $0.0006032\ m^2 = 4$

1.11 $l = 4.234\ m$ $b = 1.005\ m$

$t = 2.01\ cm = 0.0201\ m$

Area of metal sheet,

$A = 2(lb + bh + hl)$

$= 2\ [(4.234 \times 1.005) + (1.005 \times 0.0201) + (0.0201 \times 4.234)]$

$= 2\ [4.25517 + 0.0202005 + 0.0851034]$

$= 2 \times 4.3604739$

$= 8.720947\ m^2$

or $8.72\ m^2$

Now,

Volume $= l \times b \times t$

$= 4.234 \times 1.005 \times 0.0201$

$= 0.0855289$

$= 0.0855 \ m^3$

1.12. Mass of grocer's box = 2.300 kg
Mass of gold piece 1 = 20.15 g
Mass of gold piece 2 = 20.17 g
= 0.02017 kg

(a). Total mass of the box with gold pieces

$= 2.3 + 0.02015 + 0.02017$

$= 2.34032.$

or $= 2.3$ kg

(b). Difference in masses of gold pieces

$= 20.17 - 20.15$

$= 0.02$ g

1.13 The boy writes the relation as,

$$m = \frac{m_0}{(1-v^2)^{1/2}},$$

$m \rightarrow$ moving mass
$m_0 \rightarrow$ rest mass
$v \rightarrow$ velocity

Check the correctness of formula,

$$[M] = \frac{[M]}{[LT^{-1}]}$$

LHS $\neq$ RHS
Hence, the formula is incorrect

for correction we need to put c^2 in division of v^2, then the denominator will become dimension-less and both sides will be of same dimension. i.e,

$$m = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}}.$$

1.14. The size of hydrogen atom = 0.5 Å

i.e $r = 0.5 A^\circ$

$= 0.5 \times 10^{-10} m$

Volume of hydrogen atom,

$\frac{4}{3} \pi r^3 = \frac{4}{3} \times 3.14 \times (0.5 \times 10^{-10})^3$

$= \frac{4}{3} \times 3.14 \times \cancel{0.0}\ 0.125 \times 10^{-30}$

$= \frac{3.14 \times 0.5}{3} \times 10^{-30}$

$= 0.523 \times 10^{-30} m^3$

Now volume of one mole of hydrogen atom,

$= 6.023 \times 10^{23} \times 0.523 \times 10^{-30}$

[$\because$ 1 mole = 6.023×10^{23} atoms]

$= 3.15 \times 10^{-7}\ m^3.$

$\cong 3 \times 10^{-7} m^3$

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1.15 radius of the hydrogen molecule =

$r = 1\mathring{A} = 1 \times 10^{-10} m$

volume of hydrogen molecule,

$V = \frac{4}{3} \pi r^3$

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

$= \frac{12.56}{3} \times 10^{-30}$

$= 4.189 \times 10^{-30} m^3$

Now,

we know, $N_A = 6.023 \times 10^{23}$ atom

Atomic volume $= 4.189 \times 10^{-30} \times 6.023 \times 10^{23}$

$= 25.23 \times 10^{-7} m^3$

Molar volume $= 22.4\ l$

$= 22.4 \times 10^{-3} m$

$[1 l = \frac{1}{1000} m]$

Ratio,

$\frac{\text{Molar volume}}{\text{Atomic volume}} = \frac{22.4 \times 10^{-3}}{25.23 \times 10^{-7}}$

$= 0.89 \times 10^{4} \simeq 10^{4}$

The ratio is very large because the size of a gas molecule is very small in comparison with the volume of the gas.

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1.16 The direction of line of sight changes very rapidly for nearby objects like trees, houses etc. therefore, they appear moving fast. However, line of sight does not change much for distant object like hills, stars, moon etc. therefore they appear stationary.

1.17 Given,

Mass of sun = 2×10^{30} kg

Radius of sun = 7×10^{8} m

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

$$= \frac{\cancel{2} \times 10^{30}}{2\,\frac{\cancel{4}}{3} \times \pi \times (7 \times 10^{8})^3}$$

$$= \frac{3 \times 10^{30}}{2 \times \pi \times 7 \times 7 \times 7 \times 10^{24}}$$

$$= \frac{3 \times 10^{30}}{2 \times \frac{22}{\cancel{7}} \times \cancel{7} \times 49 \times 10^{24}}$$

$$= \frac{3 \times 10^{6}}{2156}$$

$$= \frac{3 \times 10^{3}}{2.156}$$

$$= 1.38 \times 10^{3}$$

density $= 1.4 \times 10^{3}$ kg/m^3.