

Maharashtra State Board 11th Physics Solutions Chapter 1 Units and Measurements

1. Choose the correct option.

Question 1.

[L¹M¹T⁻²] is the dimensional formula for

- (A) Velocity
- (B) Acceleration
- (C) Force
- (D) Work

Answer:

- (C) Force

Question 2.

The error in the measurement of the sides of a rectangle is 1%. The error in the measurement of its area is

- (A) 1%
- (B) 12%
- (C) 2%
- (D) None of the above.

Answer:

- (C) 2%

Question 3.

Light year is a unit of

- (A) Time
- (B) Mass
- (C) Distance
- (D) Luminosity

Answer:

- (C) Distance

Question 4.

Dimensions of kinetic energy are the same as that of

- (A) Force
- (B) Acceleration
- (C) Work
- (D) Pressure

Answer:

- (C) Work

Question 5.

Which of the following is not a fundamental unit?

- (A) cm
- (B) kg
- (C) centigrade
- (D) volt

Answer:

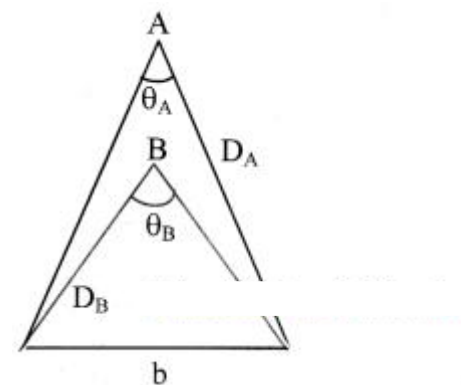
- (D) volt

2. Answer the following questions.

Question 1.

Star A is farther than star B. Which star will have a large parallax angle?

Answer:



i). 'b' is constant for the two stars

$$\therefore \theta \propto \frac{1}{D}$$

ii) As star A is farther i.e., $D_A > D_B$

$\Rightarrow \theta_A < \theta_B$

Hence, star B will have larger parallax angle than star A.

Question 2.

What are the dimensions of the quantity $\sqrt{l/g}$, l being the length and g the acceleration due to gravity?

Answer:

$$\text{Quantity} = l \times \sqrt{\frac{l}{g}} \quad \dots(i)$$

$$\text{gravitational acceleration, } g = \frac{\text{velocity}}{\text{time}}$$

$$\therefore g = \frac{\text{distance}}{\text{time} \times \text{time}}$$

Substituting in equation (i),

$$\text{Quantity} = l \times \sqrt{\frac{l \times \text{time}^2}{\text{distance}}}$$

\therefore Dimensional formula of quantity

$$= [L] \times \frac{[L^{1/2}][T^{2 \times 1/2}]}{[L^{1/2}]} = [L] \times [T^1] = [L^1 T^1]$$

[Note: When power of symbol expressing fundamental quantity appearing in the dimensional formula is not given, it is taken as 1.]

Question 3.

Define absolute error, mean absolute error, relative error and percentage error.

Answer:

Absolute error:

a. For a given set of measurements of a quantity, the magnitude of the difference between mean value (Most probable value) and each individual value is called absolute error (Δa) in the measurement of that quantity.

b. absolute error = |mean value – measured value|

$$\Delta a_1 = |a_{\text{mean}} - a_1|$$

$$\text{Similarly, } \Delta a_2 = |a_{\text{mean}} - a_2|$$

....

....

....

$$\Delta a_n = |a_{\text{mean}} - a_n|$$

Mean absolute error:

For a given set of measurements of a same quantity the arithmetic mean of all the absolute errors is called mean absolute error in the measurement of that physical quantity.

$$\Delta a_{\text{mean}} = \frac{\Delta a_1 + \Delta a_2 + \dots + \Delta a_n}{n} = \frac{1}{n} \sum_{i=1}^n \Delta a_i$$

Relative error:

The ratio of the mean absolute error in the measurement of a physical quantity to its arithmetic mean value is called relative error.

$$\text{Relative error} = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}}$$

Percentage error:

The relative error represented by percentage (i.e., multiplied by 100) is called the percentage error.

$$\text{Percentage error} = \Delta a_{\text{mean}} / a_{\text{mean}} \times 100\%$$

[Note: Considering conceptual conventions question is modified to define percentage error and not mean percentage error.]

Question 4.

Describe what is meant by significant figures and order of magnitude.

Answer:

Significant figures:

- Significant figures in the measured value of a physical quantity is the sum of reliable digits and the first uncertain digit.
OR
The number of digits in a measurement about which we are certain, plus one additional digit, the first one about which we are not certain is known as significant figures or significant digits.
- Larger the number of significant figures obtained in a measurement, greater is the accuracy of the measurement. The reverse is also true.
- If one uses the instrument of smaller least count, the number of significant digits increases.

Rules for determining significant figures:

- All the non-zero digits are significant, for example if the volume of an object is 178.43 cm³, there are five significant digits which are 1, 7, 8, 4 and 3.

2. All the zeros between two nonzero digits are significant, eg., $m = 165.02$ g has 5 significant digits.
3. If the number is less than 1, the zero/zeros on the right of the decimal point and to the left of the first nonzero digit are not significant e.g. in 0.001405 , significant. Thus the above number has four significant digits.
4. The zeroes on the right hand side of the last nonzero number are significant (but for this, the number must be written with a decimal point), e.g. 1.500 or 0.01500 both have 4 significant figures each.

On the contrary, if a measurement yields length L given as $L = 125 \text{ m} = 12500 \text{ cm} = 125000 \text{ mm}$, it has only three significant digits.

Order of magnitude:

The magnitude of any physical quantity can be expressed as $A \times 10^n$ where 'A' is a number such that $0.5 \leq A < 5$ then, 'n' is an integer called the order of magnitude.

Examples:

1. Speed of light in air $= 3 \times 10^8 \text{ m/s}$
 \therefore order of magnitude $= 8$
2. Mass of an electron $= 9.1 \times 10^{-31} \text{ kg}$
 $= 0.91 \times 10^{-30} \text{ kg}$
 \therefore order of magnitude $= -30$

Question 5.

If the measured values of two quantities are $A \pm \Delta A$ and $B \pm \Delta B$, ΔA and ΔB being the mean absolute errors. What is the maximum possible error in $A \pm B$? Show that if $Z = AB$

$$\Delta ZZ = \Delta AA + \Delta BB$$

Answer:

Maximum possible error in $(A \pm B)$ is $(\Delta A + \Delta B)$.

Errors in divisions:

i) A

Suppose, $Z = AB$ and measured values of A and B are $(A \pm \Delta A)$ and $(B \pm \Delta B)$ then,

$$Z \pm \Delta Z = \frac{A \pm \Delta A}{B \pm \Delta B}$$

$$\therefore Z \left(1 \pm \frac{\Delta Z}{Z} \right) = \frac{A \left[1 \pm \left(\frac{\Delta A}{A} \right) \right]}{B \left[1 \pm \left(\frac{\Delta B}{B} \right) \right]}$$

$$= \frac{A}{B} \times \frac{1 \pm \left(\frac{\Delta A}{A} \right)}{1 \pm \left(\frac{\Delta B}{B} \right)}$$

As, $\frac{\Delta B}{B} \ll 1$, expanding using Binomial theorem,

$$Z \left(1 \pm \frac{\Delta Z}{Z} \right) = Z \times \left(1 \pm \frac{\Delta A}{A} \right) \times \left(1 \mp \frac{\Delta B}{B} \right)$$

$$\dots \left(\because \frac{A}{B} = Z \right)$$

$$\therefore 1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B} \pm \frac{\Delta A}{A} \times \frac{\Delta B}{B}$$

$$\text{Ignoring term } \frac{\Delta A}{A} \times \frac{\Delta B}{B}, \frac{\Delta Z}{Z} = \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B}$$

This gives four possible values of $\frac{\Delta Z}{Z}$ as

$$\left(+\frac{\Delta A}{A} - \frac{\Delta B}{B} \right), \left(+\frac{\Delta A}{A} + \frac{\Delta B}{B} \right), \left(-\frac{\Delta A}{A} - \frac{\Delta B}{B} \right) \text{ and } \left(-\frac{\Delta A}{A} + \frac{\Delta B}{B} \right)$$

$$\therefore \text{Maximum relative error of } \Delta ZZ = \pm (\Delta AA + \Delta BB)$$

ii) Thus, when two quantities are divided, the maximum relative error in the result is the sum of relative errors in each quantity.

Question 6.

Derive the formula for kinetic energy of a particle having mass m and velocity v using dimensional analysis

Answer:

Kinetic energy of a body depends upon mass (m) and velocity (v) of the body.

Let K.E. $\propto m^x v^y$

$$\therefore \text{K.E.} = km^x v^y \dots \dots (1)$$

where,

k = dimensionless constant of proportionality. Taking dimensions on both sides of equation (1),

$$[L^2 M^1 T^{-2}] = [L^0 M^1 T^0]^x [L^1 M^0 T^{-1}]^y$$

$$= [L^0 M^x T^0] [L^y M^0 T^{-y}]$$

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$$= [L^0 + y M^x + 0 T^{0-y}]$$

$$[L^2 M^1 T^2] = [L^y M^x T^{-y}] \dots\dots\dots (2)$$

Equating dimensions of L, M, T on both sides of equation (2),

$$x = 1 \text{ and } y = 2,$$

Substituting x, y in equation (1), we have

$$K.E. = \frac{1}{2} m v^2$$

3. Solve numerical examples.

Question 1.

The masses of two bodies are measured to be 15.7 ± 0.2 kg and 27.3 ± 0.3 kg. What is the total mass of the two and the error in it?

Answer:

Given: $A \pm \Delta A = 15.7 \pm 0.2$ kg and

$B \pm \Delta B = 27.3 \pm 0.3$ kg.

To find: Total mass (Z), and total error (ΔZ)

Formulae: i. $Z = A + B$

$$\text{ii) } \pm \Delta Z = \pm \Delta A \pm \Delta B$$

Calculation: From formula (i),

$$Z = 15.7 + 27.3 = 43 \text{ kg}$$

From formula (ii),

$$\pm \Delta Z (\pm 0.2) + (\pm 0.3)$$

$$= \pm (0.2 + 0.3)$$

$$= \pm 0.5 \text{ kg}$$

Total mass is 43 kg and total error is ± 0.5 kg.

Question 2.

The distance travelled by an object in time (100 ± 1) s is (5.2 ± 0.1) m. What is the speed and its relative error?

Answer:

Given: Distance $(D \pm \Delta D) = (5.2 \pm 0.1)$ m,

time $(t \pm \Delta t) = (100 \pm 1)$ s.

To find: Speed (v), maximum relative error ($\Delta v/v$)

Formulae: i. $v = D/t$

$$\text{ii. } \Delta v/v = \pm (\Delta D/D + \Delta t/t)$$

Calculation: From formula (i),

$$v = \frac{5.2}{100} = 0.052 \text{ m/s}$$

From formula (ii),

$$\Delta v/v = \pm \left(\frac{0.1}{5.2} + \frac{1}{100} \right)$$

$$= \pm \left(\frac{1}{52} + \frac{1}{100} \right) = \pm \frac{146}{5200}$$

$$= \pm 0.029 \text{ m/s}$$

The speed is 0.052 m/s and its maximum relative error is ± 0.029 m/s.

[Note: Framing of numerical is modified to make it specific and meaningful.]

Question 3.

An electron with charge e enters a uniform magnetic field \vec{B} with a velocity \vec{v} . The velocity is perpendicular to the magnetic field. The force on the charge e is given by

$$|\vec{F}| = Bev \text{ Obtain the dimensions of } \vec{B}.$$

Answer:

$$\text{Given: } |\vec{F}| = B e v$$

Considering only magnitude, given equation is simplified to,

$$F = B e v$$

$$\therefore B = \frac{F}{ev}$$

$$\text{but, } F = ma = m \times \frac{\text{distance}}{\text{time}^2}$$

$$\therefore [F] = [M^1] \times \left[\frac{L^1}{T^2} \right]$$

$$= [L^1 M^1 T^{-2}]$$

Electric charge, e = current \times time

$$\therefore [e] = [I^1 T^1]$$

$$\text{Velocity } v = \frac{\text{distance}}{\text{time}}$$

$$\therefore [v] = \left[\frac{L}{T} \right] = [L^1 T^{-1}]$$

$$\text{Now, } [B] = \left[\frac{F}{ev} \right]$$

$$= \frac{[L^1 M^1 T^{-2}]}{[T^1 I^1][L^1 T^{-1}]}$$

$$\therefore B = [L^0 M^1 T^{-2} I^{-1}]$$

[Note: The answer given above is calculated in accordance with textual method considering the given data.]

Question 4.

A large ball 2 m in radius is made up of a rope of square cross section with edge length 4 mm. Neglecting the air gaps in the ball, what is the total length of the rope to the nearest order of magnitude?

Answer:

Volume of ball = Volume enclosed by rope.

$$\frac{4}{3} \pi (\text{radius})^3 = \text{Area of cross-section of rope} \times \text{length of rope.}$$

$$\therefore \text{length of rope } l = \frac{4}{3} \pi r^3 A$$

Given:

$$r = 2 \text{ m and}$$

$$\text{Area} = A = 4 \times 4 = 16 \text{ mm}^2$$

$$= 16 \times 10^{-6} \text{ m}^2$$

$$\therefore l = \frac{4 \times 3.142 \times 2^3 \times 16 \times 10^{-6}}{3}$$

$$= 3.142 \times 2^3 \times 10^{-6} \text{ m}$$

$$\approx 2 \times 10^6 \text{ m.}$$

$$\text{Total length of rope to the nearest order of magnitude} = 10^6 \text{ m} = 10^3 \text{ km}$$

Question 5.

Nuclear radius R has a dependence on the mass number (A) as $R = 1.3 \times 10^{-16} A^{1/3} \text{ m}$. For a nucleus of mass number A=125, obtain the order of magnitude of R expressed in metre.

Answer:

$$R = 1.3 \times 10^{-16} \times A^{1/3} \text{ m}$$

$$\text{For } A = 125$$

$$R = 1.3 \times 10^{-16} \times (125)^{1/3}$$

$$= 1.3 \times 10^{-16} \times 5$$

$$= 6.5 \times 10^{-16}$$

$$= 0.65 \times 10^{-15} \text{ m}$$

$$\therefore \text{Order of magnitude} = -15$$

[Note: Taking the standard value of nuclear radius $R = 1.3 \times 10^{-15} \text{ m}$, the order of magnitude comes to be 10^{-14} m .]

Question 6.

In a workshop a worker measures the length of a steel plate with a Vernier callipers having a least count 0.01 cm. Four such measurements of the length yielded the following values: 3.11 cm, 3.13 cm, 3.14 cm, 3.14 cm. Find the mean length, the mean absolute error and the percentage error in the measured value of the length.

Answer:

$$\text{Given: } a_1 = 3.11 \text{ cm, } a_2 = 3.13 \text{ cm,}$$

$$a_3 = 3.14 \text{ cm. } a_4 = 3.14 \text{ cm}$$

$$\text{Least count L.C.} = 0.01 \text{ cm.}$$

To find.

i. Mean length (a_{mean})

ii. Mean absolute error (Δa_{mean})

iii. Percentage error.

$$\text{Formulae: i. } a_{\text{mean}} = \frac{a_1 + a_2 + a_3 + a_4}{4}$$

$$\text{ii. } \Delta a_n = |a_{\text{mean}} - a_n|$$

$$\text{iii. } \Delta a_{\text{mean}} = \frac{\Delta a_1 + \Delta a_2 + \Delta a_3 + \Delta a_4}{4}$$

$$\text{iv. Percentage error} = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$$

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Calculation: From formula (i),

$$a_{\text{mean}} = \frac{3.11 + 3.13 + 3.14 + 3.14}{4}$$

$$= 3.13 \text{ cm}$$

From formula (ii),

$$\Delta a_1 = |3.13 - 3.11| = 0.02 \text{ cm}$$

$$\Delta a_2 = |3.13 - 3.13| = 0$$

$$\Delta a_3 = |3.13 - 3.14| = 0.01 \text{ cm}$$

$$\Delta a_4 = |3.13 - 3.14| = 0.01 \text{ cm}$$

From formula (iii),

$$\Delta a_{\text{mean}} = \frac{0.02 + 0 + 0.01 + 0.01}{4} = 0.01 \text{ cm}$$

From formula (iii).

$$\% \text{ error} = \frac{0.01}{3.13} \times 100$$

$$= 13.13$$

$$= 0.3196$$

.....(using reciprocal table)

$$= 0.32\%$$

i. Mean length is 3.13 cm.

ii. Mean absolute error is 0.01 cm.

iii. Percentage error is 0.32 %.

[Note: As per given data of numerical, percentage error calculation upon rounding off yields percentage error as 0.32%]

Question 7.

Find the percentage error in kinetic energy of a body having mass $60.0 \pm 0.3 \text{ g}$ moving with a velocity $25.0 \pm 0.1 \text{ cm/s}$.

Answer:

Given: $m = 60.0 \text{ g}$, $v = 25.0 \text{ cm/s}$.

$$\Delta m = 0.3 \text{ g}, \Delta v = 0.1 \text{ cm/s}$$

To find: Percentage error in E

Formula: Percentage error in E

$$\left(\frac{\Delta m}{m} + 2 \frac{\Delta v}{v} \right) \times 100\%$$

Calculation: From formula,

Percentage error in E

$$= \left(\frac{0.3}{60.0} + 2 \times \frac{0.1}{25.0} \right) \times 100\%$$

$$= 1.3\%$$

The percentage error in energy is 1.3%.

Question 8.

In Ohm's experiments, the values of the unknown resistances were found to be 6.12Ω , 6.09Ω , 6.22Ω , 6.15Ω . Calculate the mean absolute error, relative error and percentage error in these measurements.

Answer:

Given: $a_1 = 6.12 \Omega$, $a_2 = 6.09 \Omega$, $a_3 = 6.22 \Omega$, $a_4 = 6.15 \Omega$,

To find:

i) Absolute error (Δa_{mean})

ii) Relative error

iii) Percentage error

Formulae:

$$\text{i) } a_{\text{mean}} = \frac{a_1 + a_2 + a_3 + a_4}{4}$$

$$\text{ii) } \Delta a_n = |a_{\text{mean}} - a_n|$$

$$\text{iii) } \Delta a_{\text{mean}} = \frac{\Delta a_1 + \Delta a_2 + \Delta a_3 + \Delta a_4}{4}$$

$$\text{iv) Percentage error} = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$$

From formula (ii),

$$\Delta a_1 = |6.145 - 6.12| = 0.025$$

$$\Delta a_2 = |6.145 - 6.09| = 0.055$$

$$\Delta a_3 = |6.145 - 6.22| = 0.075$$

$$\Delta a_4 = |6.145 - 6.15| = 0.005$$

From formula (iii),

$$\Delta a_{\text{mean}} = \frac{0.025 + 0.055 + 0.075 + 0.005}{4} = 0.1604$$

$$= 0.04 \Omega$$

From formula (iv),

$$\text{Relative error} = \frac{0.04}{6.145} = 0.0065 \Omega$$

From formula (v).

$$\text{Percentage error} = 0.0065 \times \frac{100}{6.145} = 0.65\%$$

i. The mean absolute error is 0.04Ω .

ii. The relative error is 0.0065Ω .

iii. The percentage error is 0.65% .

[Note: Framing of numerical is modified to reach the answer given to the numerical.]

Question 9.

An object is falling freely under the gravitational force. Its velocity after travelling a distance h is v . If v depends upon gravitational acceleration g and distance, prove with dimensional analysis that $v = k\sqrt{gh}$ where k is a constant.

Answer:

Given $v = k\sqrt{gh}$

Quantity	Formula	Dimension
Velocity (v)	$\frac{\text{Distance}}{\text{Time}}$	$\left[\frac{L}{T}\right] = [L^1 T^{-1}]$
Height (h)	Distance	$[L^1]$
Gravitational acceleration (g)	$\frac{\text{Distance}}{(\text{Time})^2}$	$\left[\frac{L}{T^2}\right] = [L^1 T^{-2}]$

k being constant is assumed to be dimensionless.

Dimensions of L.H.S. = $[v] = [L^1 T^{-1}]$

Dimension of R.H.S. = $[\sqrt{gh}]$

$= [L^1 T^{-2}]^{1/2} \times [L^1]^{1/2}$

$= [L^1 T^{-1}]$

$= [L^1 T^{-1}]$

As, [L.H.S.] = [R.H.S.],

$\Rightarrow v = k\sqrt{gh}$ is dimensionally correct equation.

Question 10.

$v = at + bt^2 + v_0$ is a dimensionally valid equation. Obtain the dimensional formula for a , b and c where v is velocity, t is time and v_0 is initial velocity.

Answer:

Solution: Given: $y = at + bt^2 + v_0$

As only dimensionally identical quantities can be added together or subtracted from each other, each term on R.H.S. has dimensions of L.H.S. i.e., dimensions of velocity.

$\therefore [L.H.S.] = [v] = [L^1 T^{-1}]$

This means, $[at] = [v] = [L^1 T^{-1}]$

Given, t = time has dimension $[T^1]$

$\therefore [a] = [L^1 T^{-1}][t] = [L^1 T^{-1}][T^1] = [L^1 T^{-2}] = [L^1 M^0 T^{-2}]$

Similarly, $[c] = [t] = [T^1] = [L^0 M^0 T^1]$

$\therefore [b][T^1] = [v] = [L^1 T^{-1}]$

$\therefore [b] = [L^1 T^{-1}] \times [T^1] = [L^1] = [L^1 M^0 T^0]$

Question 11.

The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.

Answer:

Given: $l = 4.234$ m, $b = 1.005$ m,

$t = 2.01$ cm = 2.01×10^{-2} m = 0.0201 m

To find:

i) Area of sheet to correct significant figures (A)

ii) Volume of sheet to correct significant figures (V)

Formulae: i. $A = 2(lb + bt + tl)$

iii) $V = l \times b \times t$

Calculation: From formula (i),

$A = 2(4.234 \times 1.005 + 1.005 \times 0.0201 + 0.0201 \times 4.234)$

$= 2 \{ \text{antilog}(\log 4.234 + \log 1.005) + \text{antilog}(\log 1.005 + \log 0.0201) + \text{antilog}(\log 0.0201 + \log 4.234) \}$

$= 2 \{ \text{antilog}(0.6267 + 0.0021) + \text{antilog}(0.0021 + 2^{-.3010}) + \text{antilog}(2^{-.3010} + 0.6267) \}$

$= 2 \{ \text{antilog}(0.6288) + \text{antilog}(2^{-.3031}) + \text{antilog}(2^{-.9277}) \}$

$= 2 [4.254 + 0.02009 + 0.08467]$

$= 2 [4.35876]$

$= 8.71752 \text{ m}^2$

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In correct significant figure,

A = 8.72 m² From formula (ii),

V = 4.234 × 1.005 × 0.0201

= antilog [log (4.234) + log (1.005) + log (0.0201)]

= antilog [0.6269 – 0.0021 – 2.3032]

= antilog [0.6288 – 2.3032]

= antilog [2.9320]

= 8.551 × 10⁻²

= 0.08551 m³

In correct significant figure (rounding off),

V = 0.086 m³

i.) Area of sheet to correct significant figures is 8.72 m².

ii) Volume of sheet to correct significant figures is 0.086 m³.

[Note: The given solution is arrived to by considering a rectangular sheet.]

Question 12.

If the length of a cylinder is l = (4.00 ± 0.001) cm, radius r = (0.0250 ± 0.001) cm and mass m = (6.25 ± 0.01) gm. Calculate the percentage error in the determination of density.

Answer:

Given: l = (4.00 ± 0.001) cm,

In order to have same precision, we use, (4.000 ± 0.001),

r = (0.0250 ± 0.001) cm,

In order to have same precision, we use, (0.025 ± 0.001)

m = (6.25 ± 0.01) g

To find: percentage error in density

Formulae:

i) Relative error in volume, $\frac{\Delta V}{V} = 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$

....(∵ Volume of cylinder, V = πr²l)

ii) Relative error $\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta V}{V}$

....[∵ Density (ρ) = $\frac{\text{mass}(m)}{\text{volume}(V)}$]

iii) Percentage error = Relative error × 100%

Calculation.

From formulae (i) and (ii),

∴ $\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$

= $\frac{0.01}{6.25} + 2\frac{0.001}{0.025} + \frac{0.001}{4.000}$

= 0.0016 + 0.08 + 0.00025

= 0.08185

From formula (iii).

% error in density = $\frac{\Delta \rho}{\rho} \times 100$

= 0.08185 × 100

= 8.185%

Percentage error in density is 8.185%.

Question 13.

When the planet Jupiter is at a distance of 824.7 million kilometers from the Earth, its angular diameter is measured to be 35.72" of arc.

Calculate the diameter of the Jupiter.

Answer:

Given: Angular diameter (α) = 35.72"

= 35.72" × 4.847 × 10⁻⁶ rad

1.73 × 10⁻⁴ rad

Distance from Earth (D)

= 824.7 million km

= 824.7 × 10⁶ km

= 824.7 × 10⁹ m.

To find: Diameter of Jupiter (d)

Formula: d = α D

Calculation: From formula,

d = 1.73 × 10⁻⁴ × 824.7 × 10⁹

= 1.428 × 10⁸ m

$$= 1.428 \times 10^5 \text{ km}$$

Diameter of Jupiter is $1.428 \times 10^5 \text{ km}$.

Question 14.

If the formula for a physical quantity is $X = a^4 b^3 c^{1/3} d^{1/2}$ and if the percentage error in the measurements of a, b, c and d are 2%, 3%, 3% and 4% respectively. Calculate percentage error in X.

Answer:

$$\text{Given } X = a^4 b^3 c^{1/3} d^{1/2}$$

Percentage error in a, b, c, d is respectively 2%, 3%, 3% and 4%.

Now, Percentage error in X

$$\begin{aligned} &= \left(4 \frac{\Delta a}{a} + 3 \frac{\Delta b}{b} + \frac{1}{3} \frac{\Delta c}{c} + \frac{1}{2} \frac{\Delta d}{d} \right) \times 100\% \\ &= \left[(4 \times 2) + (3 \times 3) + \left(\frac{1}{3} \times 3 \right) + \left(\frac{1}{2} \times 4 \right) \right] \times 100\% \\ &= [8 + 9 + 1 + 2] \times 100\% = \mathbf{20\%} \end{aligned}$$

Question 15.

Write down the number of significant figures in the following: 0.003 m^2 , 0.1250 g cm^{-2} , $6.4 \times 10^6 \text{ m}$, $1.6 \times 10^{-19} \text{ C}$, $9.1 \times 10^{-31} \text{ kg}$.

Answer:

Number	No. of significant figures	Reason
0.003 m^2	1	Rule no. iii.
0.1250 g cm^{-2}	4	Rule no. iv.
$6.4 \times 10^6 \text{ m}$	2	Rule no. i.
$1.6 \times 10^{-19} \text{ C}$	2	Rule no. i.
$9.1 \times 10^{-31} \text{ kg}$	2	Rule no. i.

Question 16.

The diameter of a sphere is 2.14 cm . Calculate the volume of the sphere to the correct number of significant figures.

Answer:

$$\text{Volume of sphere} = \frac{4}{3} \pi r^3$$

$$= \frac{4}{3} \times 3.142 \times (2.14/2)^3 \dots\dots\dots (\because r = d/2)$$

$$= \frac{4}{3} \times 3.142 \times (1.07)^3$$

$$= 1.333 \times 3.142 \times (1.07)^3$$

$$= \{\text{antilog} [\log(1.333) + \log(3.142) + 3 \log(1.07)]\}$$

$$= \{\text{antilog} [0.1249 + 0.4972 + 3(0.0294)]\}$$

$$= \{\text{antilog} [0.6221 + 0.0882]\}$$

$$= \{\text{antilog} [0.7103]\}$$

$$= 5.133 \text{ cm}^3$$

In multiplication or division, the final result should retain as many significant figures as there are in the original number with the least significant figures.

Volume in correct significant figures

$$\therefore 5.13 \text{ cm}^3$$

11th Physics Digest Chapter 1 Units and Measurements Intext Questions and Answers

[Can you recall \(Textbook Page No. 1\)](#)

Question 1.

i) What is a unit?

ii) Which units have you used in the laboratory for measuring

a. length

b. mass

c. time

d. temperature?

iii. Which system of units have you used?

Answer:

- The standard measure of any quantity is called the unit of that quantity.

Physical quantity	Length	Mass	Time	Temperature
Units	millimetre, centimetre, metre	gram, kilogram	seconds, minutes	Degree celsius, degree fahrenheit

-

- MKS or SI system is used mostly. At times, even CGS system is used.

[Can you tell? \(Textbook Page No. 8\)](#)

Question 1.

If ten students are asked to measure the length of a piece of cloth upto a mm, using a metre scale, do you think their answers will be identical? Give reasons.

Answer:

Answers of the students are likely to be different. Length of cloth needs to be measured up to a millimetre (mm) length. Hence, to obtain accurate and precise reading one must use measuring instrument having least count smaller than 1 mm.

But least count of metre scale is 1 mm. As a result, even smallest uncertainty in reading would vary reading significantly. Also, skill of students doing measurement may also introduce uncertainty in observation. Hence, their answers are likely to be different.

Activity (Textbook Page No. 10)

Perform an experiment using a Vernier callipers of least count 0.01cm to measure the external diameter of a hollow cylinder. Take 3 readings at different positions on the cylinder and find (i) the mean diameter (ii) the absolute mean error and (iii) the percentage error in the measurement of diameter.

Answer:

Given: L.C. = 0.01 cm

To measure external diameter of hollow cylinder readings are taken as follows:

Reading	Main Scale Reading (M.S.R.) cm	Vernier Scale Reading (VSR) (Coinciding div \times L.C.) cm	Observed reading (MSR+VSR) cm	Mean Reading (cm)
1.	_____	_____	a_1	a_{mean}
2.	_____	_____	a_2	
3.	_____	_____	a_3	

i. The mean diameter $= a_{\text{mean}} = \frac{a_1 + a_2 + a_3}{3}$

ii. Absolute mean error $\Delta a_{\text{mean}} = \frac{\Delta a_1 + \Delta a_2 + \Delta a_3}{3}$

$$\Delta a_{\text{mean}} = \frac{|a_{\text{mean}} - a_1| + |a_{\text{mean}} - a_2| + |a_{\text{mean}} - a_3|}{3}$$

iii. Percentage error $= \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100$

[Note: The above table is made assuming zero error in Vernier callipers. If calliper has positive or negative zero error, the zero error correction needs to be introduced into observed reading.]

Types of zero error	Corrected reading
Negative: The instrument possesses -ve zero error when zero mark on Vernier scale is ahead of the main scale zero.	Original/observed reading + zero error.
Positive: The instrument possesses +ve zero error when zero mark on Vernier scale is behind the main scale zero.	Original/observed reading - zero error.

Internet my friend (Textbook Page No. 12)

i. ideolectures.net/mit801f99_lewin_lec0/

ii. [hyperphysics.phy-astr.gsu.edu u/libase/hfra me. html](http://hyperphysics.phy-astr.gsu.edu/libase/hfra me.html)

[Students can use links given above as reference and collect information about units and measurements]