

Units and Measurements — Assignment 2

Class 11 Physics · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
 (2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
 (3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

SI Base Units and Standards

1. Convert $1 \text{ kg m}^2 \text{ s}^{-2}$ into $\text{g cm}^2 \text{ s}^{-2}$.
2. A body moves at 90 km h^{-1} . Express this speed in m s^{-1} and in cm s^{-1} .
3. Distinguish between base units and derived units, and list the seven SI base quantities with their units.

Dimensions and Dimensional Analysis

1. Write the dimensional formulae of force, work and pressure.
2. The viscous force on a sphere is $F = 6\pi\eta rv$. Find the dimensions of η .
3. Using dimensions, check whether the equation $v^2 = u^2 + 2as$ is correct.

Accuracy, Precision and Errors

1. Six readings of a time interval (in s) are 1.23, 1.24, 1.23, 1.25, 1.24 and 1.23. Find the mean, mean absolute error and percentage error.
2. Two readings of a length are 3.24 m and 3.28 m. Find the mean and the absolute errors.
3. Explain, with sources, the difference between systematic and random errors and how each is reduced.

Propagation of Errors

1. A quantity $X = a^2b^3/c$. If the percentage errors in a , b and c are 1%, 2% and 3%, find the percentage error in X .
2. $A = 5.00 \pm 0.02 \text{ m}$ and $B = 3.00 \pm 0.03 \text{ m}$. Find $A + B$ and $A - B$ with their errors.
3. The period of a simple pendulum is $T = 2\pi\sqrt{l/g}$. If the relative errors in l and g are e_l and e_g , find the relative error in T .

Significant Figures

1. State the number of significant figures in (a) 0.007 m^2 (b) $2.64 \times 10^{24} \text{ kg}$ (c) 6.320 J .
2. The length, breadth and thickness of a metal sheet are 4.234 m, 1.005 m and 2.01 cm. Give the area and volume to the correct number of significant figures.
3. Add 2.15 m and 1.3 m, and multiply 2.5 by 3.25, giving each result to the correct number of significant figures.

Part B — Integrated problems (multi-topic)

1. The speed of light in vacuum is $3 \times 10^8 \text{ m s}^{-1}$. A new unit of length is chosen so that the speed of light is unity. If light takes 8 min 20 s to reach the Earth from the Sun, find the Earth–Sun distance in the new unit.

2. A student measures the thickness of a human hair using a microscope of magnification 100. Over 20 observations the average width in the field of view is 3.5 mm. Estimate the thickness of the hair in metres and state the number of significant figures in the result.
3. The mass of a box measured by a grocer's balance is 2.30 kg. Two gold pieces of masses 20.15 g and 20.17 g are added. Find (a) the total mass of the box and (b) the difference in the masses of the pieces, each to the appropriate number of significant figures.
4. One mole of an ideal gas at STP occupies 22.4 L. Taking the size of a hydrogen molecule to be about $1 \text{ \AA}$, find the ratio of the molar volume to the atomic volume of a mole of hydrogen, and explain why this ratio is so large.
5. The density of a material in the CGS system is 8.9 g cm^{-3} . In a system of units in which the unit of length is 10 cm and the unit of mass is 100 g, find the numerical value of the density.

Answer Key

SI Base Units and Standards

Base units are independent (metre, kilogram, second, ampere, kelvin, mole, candela); derived units are combinations (newton, joule, watt). $1 \text{ kg m}^2 \text{ s}^{-2} = 10^7 \text{ g cm}^2 \text{ s}^{-2}$. $90 \text{ km h}^{-1} = 25 \text{ m s}^{-1} = 2500 \text{ cm s}^{-1}$.

Dimensions and Dimensional Analysis

Force $[\text{M L T}^{-2}]$; work $[\text{M L}^2 \text{ T}^{-2}]$; pressure $[\text{M L}^{-1} \text{ T}^{-2}]$. η has dimensions $[\text{M L}^{-1} \text{ T}^{-1}]$. $v^2 = u^2 + 2as$ is dimensionally correct (all terms have $[\text{L}^2 \text{ T}^{-2}]$).

Accuracy, Precision and Errors

Mean = 1.237 s; mean absolute error $\approx 0.007 \text{ s}$; percentage error $\approx 0.5\%$. Mean of 3.24 and 3.28 = 3.26 m with absolute errors 0.02 m each. Systematic errors are repeatable (instrument/method defects); random errors reduce by averaging many readings.

Propagation of Errors

X: $2 \times 1 + 3 \times 2 + 3 = 11\%$. $A + B = 8.00 \pm 0.05 \text{ m}$; $A - B = 2.00 \pm 0.05 \text{ m}$. For T, $\Delta T/T = \frac{1}{2}(\Delta l/l + \Delta g/g) = \frac{1}{2}(e_l + e_g)$.

Significant Figures

(a) 1 (b) 3 and 6.320 J has 4. Area = 4.255 m^2 ; volume = $8.55 \times 10^{-2} \text{ m}^3$. $2.15 + 1.3 = 3.5 \text{ m}$ (one decimal place); $2.5 \times 3.25 = 8.1$ (two significant figures).

Integrated problems

1: Light travels 1 new unit per second, so distance = 500 new units. 2: Width = $3.5/100 \text{ mm}$... thickness $\approx 0.035 \text{ mm} = 3.5 \times 10^{-5} \text{ m}$ (2 significant figures). 3: (a) 2.30 kg (to 0.01 kg) (b) 0.02 g. 4: Molar volume/atomic volume $\approx 7 \times 10^4$; gases are mostly empty space. 5: $8.9 \text{ g cm}^{-3} = 8.9 \times 10^{-3}$... numerical value in the new units = 0.89.