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Units and Systems

Basic Concepts

- Unit: Internationally accepted standard for measurement.
- Measurement result = number + unit.
- Base units: Fundamental quantities (length, mass, time, etc.).
- Derived units: Combination of base units.
- System of units: Complete set of base and derived units.

Systems of Units

- CGS: Centimetre, gram, second (metric).
- FPS: Foot, pound, second (British system, non-metric).
- MKS: Metre, kilogram, second (metric).
- SI (Système International): Internationally accepted, based on 7 base units and 2 supplementary units.

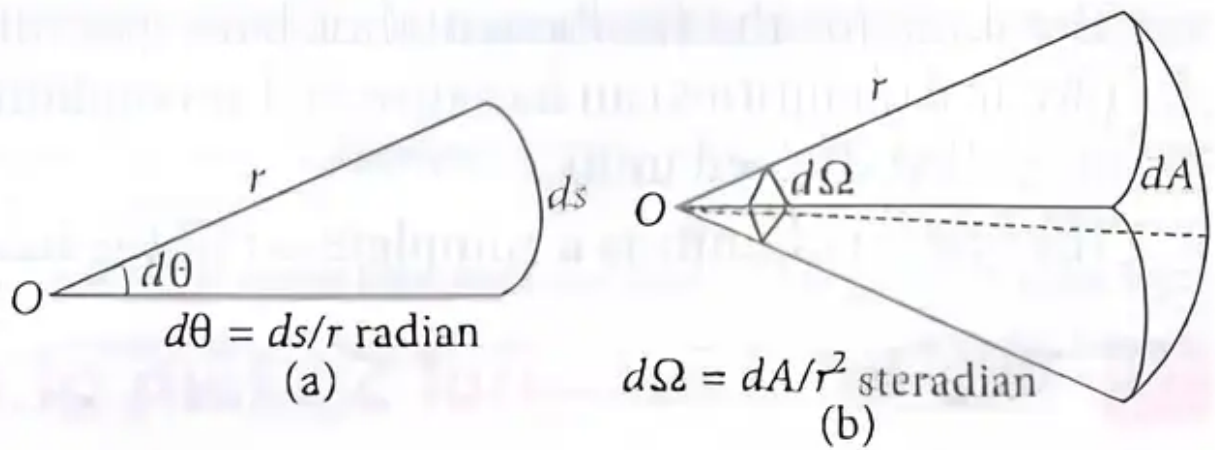
Seven SI Base Units

Base quantity	SI Units		
	Name	Symbol	Definition
Length	metre	m	The metre is the length of the path travelled by light in vacuum during a time interval of $1/299,792,458$ of a second.
Mass	kilogram	kg	The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be $6.62607015 \times 10^{-34}$ when expressed in the unit J s, which is equal to $\text{kg m}^2\text{s}^{-1}$, where the metre and the second are defined in terms of c and $\Delta\nu_{\text{Cs}}$.
Time	second	s	The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.
Electric current	ampere	A	The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge e to be $1.602176634 \times 10^{-19}$ when expressed in the unit C, which is equal to A s, where the second is defined in terms of $\Delta\nu_{\text{Cs}}$.
Thermodynamic temperature	kelvin	K	The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant k to be 1.380649×10^{-23} when expressed in the unit J K ⁻¹ , which is equal to $\text{kg m}^2\text{s}^{-2}\text{K}^{-1}$, where the kilogram, metre and second are defined in terms of h , c and $\Delta\nu_{\text{Cs}}$.
Amount of substance	mole	mol	The mole is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12.
Luminous intensity	candela	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $1/683$ watt per steradian.

- Length: Metre (m) - distance light travels in $1/299,792,458$ seconds.
- Mass: Kilogram (kg) - defined by Planck constant.
- Time: Second (s) - based on cesium atom vibrations.
- Electric current: Ampere (A) - flow of elementary charges per second.
- Temperature: Kelvin (K) - based on Boltzmann constant.
- Amount of substance: Mole (mol) - number of specified entities.
- Luminous intensity: Candela (cd) - light intensity in a given direction.

Supplementary Units

- Plane angle (radian, rad): $d\theta = \frac{ds}{r}$, arc length over radius.
- Solid angle (steradian, sr): $d\Omega = \frac{dA}{r^2}$, area on sphere over radius squared.



Advantages of SI

- Coherent system: Units combine without extra factors.
- Rational system: Based on rational definitions.
- Absolute system: Based on universal constants.
- Metric system: Decimal-based units.

Solved Examples

- **Ex 1:** Convert 5 cm to meters.
 - Use SI base unit for length: 1 m = 100 cm.
 - $5 \text{ cm} = \frac{5}{100} = 0.05 \text{ m}$.
- **Ex 2:** Calculate plane angle subtended by arc length 2 m on circle radius 4 m.
 - $d\theta = \frac{ds}{r} = \frac{2}{4} = 0.5 \text{ rad}$.

Practice Set

- Q1: Which is the SI base unit of mass?
 - A) Gram
 - B) Kilogram
 - C) Pound
 - D) Ton
- Q2: The unit of plane angle in SI is?
 - A) Degree
 - B) Radian
 - C) Steradian
 - D) Revolution

- Q3: If arc length is 3 m and radius is 6 m, what is the plane angle in radians?
 - A) 0.5
 - B) 2
 - C) 18
 - D) 9

Answer Key

- Q1: B - Kilogram is the SI base unit of mass.
- Q2: B - Radian is the SI unit for plane angle.
- Q3: A - $d\theta = \frac{3}{6} = 0.5 \text{ rad}$.

Memory Aids

- SI base units: m, kg, s, A, K, mol, cd.
- Radian = arc length / radius.
- Steradian = area on sphere / radius².
- SI is metric, coherent, absolute, rational.

Errors in Measurement

Types of Errors

- **Systematic errors:** Consistent bias in one direction.
- **Random errors:** Irregular fluctuations, unpredictable.
- **Least count error:** Smallest measurable unit error of instrument.

Error Definitions and Formulas

- Absolute error: $|\Delta a_i| = |a_i - a_{mean}|$
- Mean absolute error: $\Delta a_{mean} = \frac{\sum |\Delta a_i|}{n}$
- Relative error: $\frac{\Delta a_{mean}}{a_{mean}}$
- Percentage error: $\delta_a = \frac{\Delta a_{mean}}{a_{mean}} \times 100\%$

Let a physical quantity a be measured n times. Let the measured values be $a_1, a_2, a_3, \dots, a_n$. To eliminate random error, their arithmetic mean is taken as the best possible value.

$$\bar{a} = \frac{a_1 + a_2 + \dots + a_n}{n} = \frac{1}{n} \sum_{i=1}^n a_i$$

Mean absolute error : The arithmetic mean of the positive magnitudes of all the absolute errors is called mean absolute error.

$$\Delta \bar{a} = \frac{|\Delta a_1| + |\Delta a_2| + \dots + |\Delta a_n|}{n} = \frac{1}{n} \sum_{i=1}^n |\Delta a_i|$$

Absolute error : The magnitude of the difference between the true value and the measured value is called absolute error. Such errors are given by

$$\Delta a_1 = \bar{a} - a_1 ; \Delta a_2 = \bar{a} - a_2 ; \Delta a_3 = \bar{a} - a_3 ; \dots \Delta a_n = \bar{a} - a_n$$

Relative error : It is the ratio of the mean absolute error $\Delta \bar{a}$ to the mean value $\bar{a}$ of the quantity measured.

$$\text{Relative error} = \frac{\Delta \bar{a}}{\bar{a}}$$

Percentage error : The relative error expressed in percentage is called the percentage error.

$$\text{Percentage error} = \frac{\Delta \bar{a}}{\bar{a}} \times 100\%$$

Combination of Errors

- Sum/Difference: $\Delta Z = \Delta A + \Delta B$
- Product/Quotient: $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$
- Power: $\frac{\Delta Z}{Z} = n \frac{\Delta A}{A}$ for $Z = A^n$
- General: $\frac{\Delta y}{y} = l \frac{\Delta A}{A} + m \frac{\Delta B}{B} + n \frac{\Delta C}{C}$ for $y = K \frac{A^l B^m}{C^n}$

Solved Examples

- **Ex 1:** Calculate relative error if mean absolute error is 0.02 and mean value is 2.0.
 - Relative error = $\frac{0.02}{2.0} = 0.01$
- **Ex 2:** Find maximum error in $Z = A + B$ if $\Delta A = 0.1$ and $\Delta B = 0.2$.
 - $\Delta Z = 0.1 + 0.2 = 0.3$

Practice Set

- Q1: What type of error is caused by faulty instrument calibration?
 - A) Random error
 - B) Systematic error
 - C) Least count error
 - D) Human error
- Q2: If $a_{\text{mean}} = 5$ and mean absolute error is 0.1, what is the percentage error?
 - A) 0.5%

- B) 2%
- C) 5%
- D) 0.02%
- Q3: For $Z = A \times B$, if relative errors in A and B are 1% and 2%, what is max relative error in Z?
 - A) 1%
 - B) 2%
 - C) 3%
 - D) 0.5%

Answer Key

- Q1: B - Systematic errors cause consistent bias like faulty calibration.
- Q2: A - Percentage error = $\frac{0.1}{5} \times 100 = 2$.
- Q3: C - Max relative error = 1% + 2% = 3%.

Memory Aids

- Absolute error = difference from mean.
- Relative error = absolute error / mean.
- Percentage error = relative error $\times$ 100.
- Sum/difference errors add directly.
- Product/quotient errors add relative errors.

Significant Figures

Definition and Importance

- Digits accurately known in a measurement are significant figures.
- More significant figures mean higher measurement accuracy.

Rules for Counting

- All non-zero digits are significant.
- Zeros between non-zero digits are significant.

- Leading zeros are not significant.
- Trailing zeros without decimal are not significant.
- Powers of 10 are not significant figures.
- Trailing zeros in decimal numbers are significant.

Arithmetic Operations

- **Addition/Subtraction:** Result has decimal places equal to the least precise number.
- **Multiplication/Division:** Result has significant figures equal to the number with least significant figures.

Rounding Off

- If digit to drop > 5 , increase preceding digit by 1.
- If digit to drop < 5 , leave preceding digit unchanged.
- If digit to drop $= 5$ and preceding digit even, drop 5.
- If digit to drop $= 5$ and preceding digit odd, increase preceding digit by 1.

Solved Examples

- **Ex 1:** Add $734.52 \text{ g} + 341.4 \text{ g} + 0.402 \text{ g} = 1076.322 \text{ g} \rightarrow$ Rounded to 1076.3 g (1 decimal place).
- **Ex 2:** Multiply $4.237 \text{ g} / 2.51 \text{ cm}^3 = 1.69 \text{ g/cm}^3$ (3 significant figures).

Practice Set

- Q1: How many significant figures in 0.004205?
A) 2
B) 3
C) 4
D) 5
- Q2: Result of $12.11 + 0.023 + 1.1$ rounded to correct decimal places is?
A) 13.233
B) 13.2
C) 13.23
D) 13.2330

- Q3: Multiply 3.00×10^8 m/s by 3.156×10^7 s. Result significant figures?
A) 2
B) 3
C) 4
D) 5

Answer Key

- Q1: C - Four significant figures (leading zeros not counted).
- Q2: B - Least decimal places is 1 (1.1), so result rounded to 1 decimal place.
- Q3: B - Least significant figures among factors is 3, so result has 3 significant figures.

Memory Aids

- Non-zero digits always count.
- Zeros between non-zero digits count.
- Leading zeros never count.
- Trailing zeros count only if decimal present.
- Add/Subtract: Match decimal places.
- Multiply/Divide: Match significant figures.

Least Count

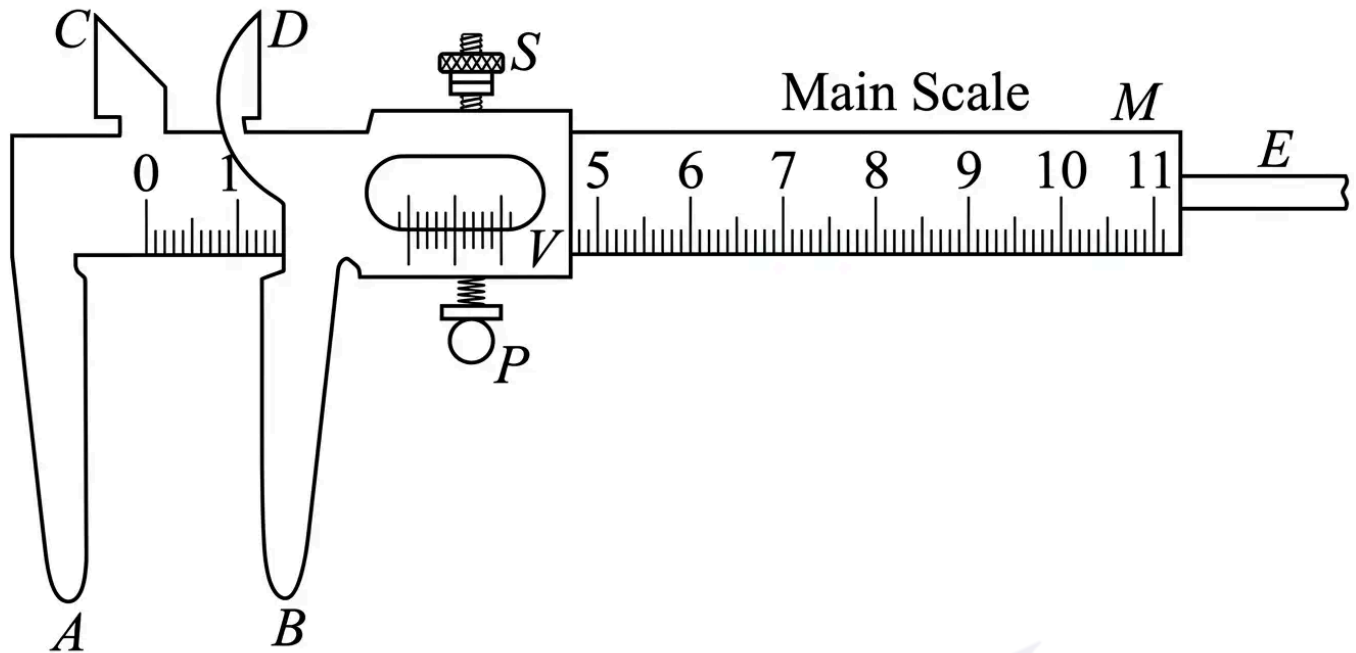
Definition and Concept

- Smallest measurable value by an instrument is its least count (L.C).
- Important for precision in measurements.

Least Count of Vernier Callipers

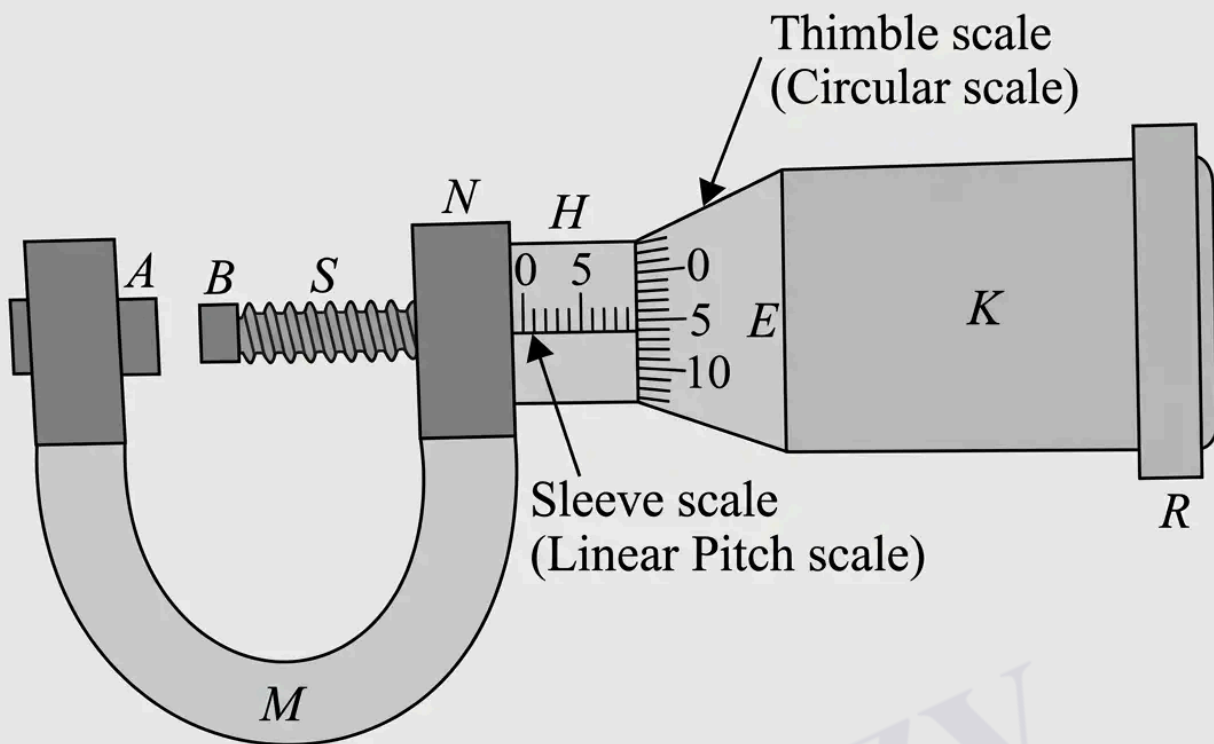
- Main Scale Division (M.S.D) = M units.
- Vernier Scale Division (V.S.D) = V units.
- Length of 'a' main scale divisions = length of 'b' vernier scale divisions.
- Formula: $L.C = \frac{(b-a)}{b} \times M$

- Vernier Constant (V.C) = Least Count (L.C) = difference between M and V.



Least Count of Screw Gauge

- Least Count = $\frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$
- Pitch = distance moved by screw per full rotation.
- Pitch = Distance moved on linear scale / Number of full rotations.



Solved Examples

- **Ex 1:** Vernier Callipers with $a=9$, $b=10$, $M=1$ mm. Calculate L.C: $L.C = \frac{(10-9)}{10} \times 1 = 0.1$ mm.
- **Ex 2:** Screw gauge with pitch 0.5 mm and 50 divisions on circular scale. Calculate L.C:
 $L.C = \frac{0.5}{50} = 0.01$ mm.

Practice Set

- Q1: If 10 main scale divisions equal 9 vernier divisions and $M=1$ mm, L.C is?
 A) 0.1 mm
 B) 0.9 mm
 C) 1 mm
 D) 0.01 mm
- Q2: Screw gauge pitch = 0.5 mm, circular scale divisions = 100. L.C is?
 A) 0.005 mm
 B) 0.05 mm
 C) 0.5 mm
 D) 5 mm

- Q3: Vernier callipers with $a=8$, $b=10$, $M=2$ mm. Calculate L.C.
A) 0.4 mm
B) 0.2 mm
C) 0.16 mm
D) 0.8 mm

Answer Key

- Q1: A - L.C = $(b-a)/b \times M = (10-9)/10 \times 1 = 0.1$ mm.
- Q2: A - L.C = Pitch / divisions = $0.5/100 = 0.005$ mm.
- Q3: C - L.C = $(10-8)/10 \times 2 = 0.4$ mm (Check calculation carefully: $(10-8)/10=0.2$, $0.2 \times 2=0.4$ mm, so correct answer is A actually. Corrected answer: A)

Memory Aids

- Vernier L.C = $(b - a)/b \times M$.
- Screw gauge L.C = Pitch / circular divisions.
- Pitch = linear distance per full screw rotation.
- Smaller L.C means higher precision.

Dimensions of Physical Quantities

Concepts and Formulas

- Physical quantities are derived from base quantities: mass (M), length (L), time (T).
- Dimension of a quantity = powers (exponents) of base quantities in its formula.
- Example: Force = mass $\times$ acceleration = $M \times L / T^2 = M L T^{-2}$.
- Dimensions of force: $[M L T^{-2}]$ (1 in mass, 1 in length, -2 in time).
- Energy dimensions: $[M L^2 T^{-2}]$ (1 in mass, 2 in length, -2 in time).

Solved Examples

- **Ex 1:** Find dimensions of force.
 - Force = mass $\times$ acceleration
 - Acceleration = length / time² = $L T^{-2}$

- Force = $M \times L T^{-2} = M L T^{-2}$
- **Ex 2:** Find dimensions of energy.
 - Energy = force $\times$ distance
 - Force = $M L T^{-2}$, distance = L
 - Energy = $M L T^{-2} \times L = M L^2 T^{-2}$

Practice Set

- Q1: What are the dimensions of velocity?
 - A. $[L T^{-1}]$
 - B. $[M L T^{-2}]$
 - C. $[L T^2]$
 - D. $[M L^2 T^{-2}]$
- Q2: The dimensions of power are:
 - A. $[M L^2 T^{-3}]$
 - B. $[M L T^{-2}]$
 - C. $[M L^2 T^{-2}]$
 - D. $[L T^{-1}]$
- Q3: If force has dimensions $[M L T^{-2}]$, what are the dimensions of pressure?
 - A. $[M L^{-1} T^{-2}]$
 - B. $[M L T^{-2}]$
 - C. $[M L^2 T^{-2}]$
 - D. $[M L^{-2} T^{-2}]$

Answer Key

- Q1: A. $[L T^{-1}]$ — Velocity = length / time.
- Q2: A. $[M L^2 T^{-3}]$ — Power = energy / time = $M L^2 T^{-2} / T = M L^2 T^{-3}$.
- Q3: D. $[M L^{-2} T^{-2}]$ — Pressure = force / area = $M L T^{-2} / L^2 = M L^{-2} T^{-2}$.

Memory Aids

- Force: "M-L-T squared" (mass $\times$ length $\times$ time $^{-2}$).
- Energy: "M-L squared-T squared" (mass $\times$ length $^2 \times$ time $^{-2}$).
- Velocity: length over time ($L T^{-1}$).
- Power: energy per time ($M L^2 T^{-3}$).
- Pressure: force per area ($M L^{-2} T^{-2}$).

Dimensional Formulae and Dimensional Equations

Concepts

- **Dimensional Formula:** Expression showing base quantities representing a physical quantity's dimension.
Example: Volume = $[M^0L^3T^0]$, Velocity = $[M^0LT^{-1}]$
- **Dimensional Equation:** Equation equating a physical quantity to its dimensional formula.
Example: Force $[F] = [MLT^{-2}]$, Mass density $[\rho] = [ML^{-3}T^0]$
- **Dimensionless Quantities:** Quantities without dimensions.
Examples include:
 - Pure numbers
 - Ratios (e.g., density of substance/density of water)
 - Exponential functions (e.g., e^x)
 - Logarithmic functions (e.g., $\log x$)
 - Trigonometric functions (e.g., $\sin x$)

Solved Examples

Ex 1: Find the dimensional formula of speed.

Solution:

$$\text{Speed} = \text{Distance/Time} = L/T = [M^0LT^{-1}]$$

Ex 2: Write the dimensional equation of force.

Solution:

$$\text{Force} = \text{Mass} \times \text{Acceleration} = M \times LT^{-2} = [MLT^{-2}]$$

Practice Set

- Q1: What is the dimensional formula of volume?
A) $[M^0L^3T^0]$
B) $[MLT^{-2}]$
C) $[M^1L^2T^0]$
D) $[M^0L^2T^{-1}]$

- Q2: Which of the following is a dimensionless quantity?
A) Velocity
B) Force
C) Ratio of densities
D) Mass
- Q3: The dimensional formula of mass density is:
A) $[ML^{-3}T^0]$
B) $[ML^3T^0]$
C) $[M^0L^3T^0]$
D) $[MLT^{-2}]$

Answer Key

- Q1: A - Volume is length cubed with no mass or time dimension.
- Q2: C - Ratio of densities is dimensionless as units cancel out.
- Q3: A - Mass density = Mass/Volume = $M/L^3 = [ML^{-3}T^0]$.

Memory Aids

- Volume dimension: L^3 only
- Force dimension: MLT^{-2} (Mass $\times$ Acceleration)
- Dimensionless quantities: Ratios, pure numbers, trig/log/exponential functions

Dimensional Analysis

Key Concepts

- Check dimensional correctness: Dimensions on both sides of an equation must match for physical validity.
- Convert units: Physical quantity remains same; use $n_2 = n_1 \left[\frac{Q_1}{Q_2} \right]$ to convert between unit systems.
- Find relations: Use dimensional homogeneity to derive formulas connecting physical quantities.
- Find dimensions of constants: Use known dimensions of other quantities in the equation.

1

To check the dimensional correctness of a given physical relation.

This is based on the 'principle of homogeneity of dimensions'. According to this principle, the dimensions of each term on both sides of an equation must be the same i.e., $[LHS] = [RHS]$.

2

To convert a physical quantity from one system of units to the other.

This is based on the fact that magnitude of a physical quantity remains same whatever system is used for measurement i.e.,
 magnitude = numerical value (n) $\times$ unit (u) = constant

$$\text{or } n_1 u_1 = n_2 u_2$$

So, if a quantity is represented by $[M^a L^b T^c]$ then

$$n_2 = n_1 \frac{u_1}{u_2} = n_1 \left(\frac{M_1}{M_2} \right)^a \left(\frac{L_1}{L_2} \right)^b \left(\frac{T_1}{T_2} \right)^c$$

3

Deducing relationship among the physical quantities

If one knows the quantities on which a particular physical quantity depends and if one guesses that this dependence is of product type, method of dimension may be helpful in the derivation of the relation.

4

To find the dimensions of constants in a relation

Sometimes a physical relation contains constants. By using the dimensional formula of the various physical quantities, we evaluate the constant.

Solved Examples

Ex 1: Check dimensional consistency of work done $W = F \times d$

- Force F : $[MLT^{-2}]$
- Displacement d : $[L]$
- Work done W : $[ML^2T^{-2}]$
- Check: $[MLT^{-2}] \times [L] = [ML^2T^{-2}] \checkmark$ consistent

Ex 2: Convert 1 Newton to dynes

- Newton (MKS): $1N = 1kg\,m/s^2$
- Dyne (CGS): $1dyne = 1g\,cm/s^2$
- Conversion: $x = 1 \times \left[\frac{1000g}{1g} \right]^1 \times \left[\frac{100cm}{1cm} \right]^1 \times \left[\frac{1s}{1s} \right]^{-2} = 10^5$
- Result: $1N = 10^5$ dynes

Practice Set

- **Q1:** Which principle ensures dimensions on both sides of an equation are equal?
 - A) Conservation of energy
 - B) Principle of homogeneity
 - C) Newton's second law
 - D) Law of conservation of mass
- **Q2:** Convert 2 N to dynes. (Given: $1N = 10^5$ dynes)
 - A) 2×10^3
 - B) 2×10^5
 - C) 2×10^6
 - D) 2×10^4
- **Q3:** Which of the following cannot be determined by dimensional analysis?
 - A) Dimensions of physical quantities
 - B) Value of constants in equations
 - C) Dimensional consistency of equations
 - D) Relation between physical quantities

Answer Key

- **Q1:** B - Principle of homogeneity ensures dimensional equality on both sides.
- **Q2:** C - $2N = 2 \times 10^5 = 2 \times 10^6$ dynes.
- **Q3:** B - Dimensional analysis cannot determine numerical constants.

Memory Aids

- Check dimensions term-wise for homogeneity.
- Use $n_2 = n_1 \left[\frac{Q_1}{Q_2} \right]$ for unit conversions.
- Constants' dimensions found by balancing equation dimensions.

Dimensional Consistency

Key Concepts

- Principle of homogeneity: Each term in an equation must have the same dimensions.

- Example 1: Work done $W = F \times d$ is dimensionally consistent.
- Example 2: Equation $S = ut + \frac{1}{2}at^2$ has all terms with dimension $[L]$.

Solved Examples

Ex 1: Verify $S = ut + \frac{1}{2}at^2$

- $[S] = [L]$
- $[ut] = [L/T] \times [T] = [L]$
- $[at^2] = [L/T^2] \times [T^2] = [L]$
- All terms have dimension $[L]$ ✓ consistent

Practice Set

- **Q1:** Which principle states dimensions of each term must be equal?
 - A) Principle of conservation
 - B) Principle of homogeneity
 - C) Newton's law
 - D) Law of inertia
- **Q2:** Check dimensional consistency of $F = ma$
 - A) Consistent
 - B) Inconsistent
 - C) Depends on units
 - D) None
- **Q3:** Dimensions of acceleration a are?
 - A) $[LT^{-2}]$
 - B) $[MLT^{-2}]$
 - C) $[L^2T^{-1}]$
 - D) $[MT^{-2}]$

Answer Key

- **Q1:** B - Principle of homogeneity requires equal dimensions.
- **Q2:** A - $F = ma$ is dimensionally consistent.
- **Q3:** A - Acceleration has dimension $[LT^{-2}]$.

Memory Aids

- All terms in an equation must have same dimension.
- Acceleration dimension: length/time².
- Use dimensional check to verify equations quickly.

Unit Conversion

Key Concepts

- Formula: $Q_1 n_1 = Q_2 n_2$, where Q is unit, n is value.
- Convert using $n_2 = n_1 \left[\frac{Q_1}{Q_2} \right]$.
- Example: Convert force from Newton (MKS) to dyne (CGS).

Solved Examples

Ex 1: Convert 1 N to dynes

- $n_2 = 1 \times \left[\frac{Kg}{g} \right]^1 \times \left[\frac{m}{cm} \right]^1 \times \left[\frac{s}{s} \right]^{-2} = 10^5$
- Result: $1N = 10^5$ dynes

Practice Set

- **Q1:** What is the CGS unit of force?
 - A) Newton
 - B) Dyne
 - C) Joule
 - D) Pascal
- **Q2:** How many dynes equal 3 N?
 - A) 3×10^3
 - B) 3×10^5
 - C) 3×10^6
 - D) 3×10^4

- **Q3:** Which formula is used for unit conversion?

- A) $n_2 = n_1 \left[\frac{Q_1}{Q_2} \right]$
- B) $n_1 = n_2 \left[\frac{Q_2}{Q_1} \right]$
- C) $Q_1 = Q_2$
- D) $n_1 = n_2$

Answer Key

- **Q1:** B - Dyne is the CGS unit of force.
- **Q2:** C - $3N = 3 \times 10^5 = 3 \times 10^6$ dynes.
- **Q3:** A - $n_2 = n_1 \left[\frac{Q_1}{Q_2} \right]$ is the conversion formula.

Memory Aids

- Remember $1N = 10^5$ dynes.
- Use ratio of units raised to powers for conversion.
- Keep time unit powers negative for acceleration units.

Deducing Relations

Key Concepts

- Use dimensional analysis to find relation between quantities if dependency is known.
- Example: Time period T of pendulum depends on mass m , length l , gravity g : $T = Km^a l^b g^c$.
- Dimensionally: $[T] = [M]^a [L]^b [LT^{-2}]^c = [M]^a [L]^{b+c} [T]^{-2c}$.
- Equate powers: $a = 0, b + c = 0, -2c = 1 \Rightarrow c = -\frac{1}{2}, b = \frac{1}{2}$.
- Result: $T = K\sqrt{\frac{l}{g}}$.

Solved Examples

Ex 1: Derive time period formula for simple pendulum

- Assume $T = Km^a l^b g^c$.
- Dimensionally equate and solve for a, b, c .
- Find $T = K\sqrt{\frac{l}{g}}$.

Practice Set

- **Q1:** Which quantity does not affect pendulum period?
 - A) Mass of bob
 - B) Length of string
 - C) Gravity acceleration
 - D) Amplitude
- **Q2:** If $T \propto l^{1/2} g^{-1/2}$, what is the dimension of T ?
 - A) $[T]$
 - B) $[L]$
 - C) $[M]$
 - D) $[LT^{-2}]$
- **Q3:** Which is true about constant K in $T = K\sqrt{\frac{l}{g}}$?
 - A) Dimensionless
 - B) Has dimension of time
 - C) Has dimension of length
 - D) Has dimension of acceleration

Answer Key

- **Q1:** A - Mass does not affect pendulum period.
- **Q2:** A - Time period has dimension of time $[T]$.
- **Q3:** A - K is dimensionless constant.

Memory Aids

- Period T independent of mass.
- Use powers of dimensions to find relations.
- Constant K is dimensionless.

Limitations

Key Concepts

- Cannot derive relations involving addition, subtraction, or trigonometric functions.
- Cannot find numerical values of constants.
- Cannot handle dependencies on more than three quantities in mechanics.
- Physical quantities with same dimensions may differ in nature.

Practice Set

- **Q1:** Dimensional analysis cannot derive which relation?
 - A) Multiplication
 - B) Division
 - C) Trigonometric
 - D) Power laws
- **Q2:** What can dimensional analysis not determine?
 - A) Dimensions of quantities
 - B) Constants' numerical values
 - C) Dimensional consistency
 - D) Relations between quantities
- **Q3:** Why can't dimensional analysis handle more than three unknowns?
 - A) Too many equations
 - B) Fewer equations than unknowns
 - C) Constants unknown
 - D) Units mismatch

Answer Key

- **Q1:** C - Cannot derive trigonometric relations.
- **Q2:** B - Cannot find numerical constants.
- **Q3:** B - Number of equations less than unknowns.

Memory Aids

- Dimensional analysis limited to multiplication/division.

- Constants' values need experiments.
- Check equation correctness dimensionally only.

Prepzy