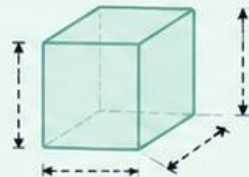


Chapter 1

Units and Measurement

SI Units • Measurement • Dimensions



m

kg

s

A

+



MEASUREMENT, QUANTITIES & UNITS

Physics becomes quantitative when a physical quantity is compared with an agreed reference standard.

PHYSICAL QUANTITY

a measurable property
such as length, mass
or time.

UNIT

a defined, reproducible
reference standard of
the same kind.

MEASUREMENT

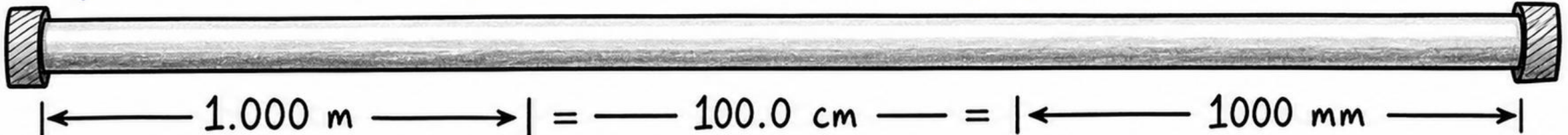
$$\text{physical quantity} = \text{numerical value} \times \text{unit}$$

$$\text{length} = 2.30 \text{ m}$$

2.30 = numerical value

m = unit

- a number alone is incomplete for a dimensional quantity
- changing the unit changes the numerical value, not the physical quantity
- a good standard is stable, accessible and internationally agreed



same length, different numerical measures

SYSTEMS OF UNITS & THE SI

EARLIER SYSTEMS

CGS:	centimetre, gram, second
FPS:	foot, pound, second
MKS:	metre, kilogram, second

INTERNATIONAL SYSTEM (SI)

- internationally agreed system for science, technology and trade
- seven base quantities and coherent derived units
- decimal multiples and submultiples make conversion convenient

BASE QUANTITY —
independently chosen



DERIVED QUANTITY —
expressed through base quantities

speed: m s^{-1} | force: $1 \text{ N} = 1 \text{ kg m s}^{-2}$ | energy: $1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2}$

Units multiply, divide and cancel algebraically, but only after every value is written in compatible units.

THE SEVEN SI BASE UNITS

BASE QUANTITY	SI UNIT	SYMBOL
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

→ unit symbols are upright and do not take a plural s

→ leave a space between number and unit: 25 m, 300 K

→ quantity names are lowercase; symbols named after people are uppercase, such as A and K

seven base units → every coherent SI derived unit

MODERN SI — EXACT CONSTANTS

Since 20 May 2019, SI base units are realised by fixing exact values of fundamental constants.

second: $\Delta\nu_{\text{Cs}} = 9\,192\,631\,770\text{ Hz}$

metre: $c = 299\,792\,458\text{ m s}^{-1}$

kilogram: $h = 6.62607015 \times 10^{-34}\text{ J s}$

ampere: $e = 1.602176634 \times 10^{-19}\text{ C}$

kelvin: $k_{\text{B}} = 1.380649 \times 10^{-23}\text{ J K}^{-1}$

mole: $N_{\text{A}} = 6.02214076 \times 10^{23}\text{ mol}^{-1}$

candela: $K_{\text{cd}} = 683\text{ lm W}^{-1}\text{ at }540 \times 10^{12}\text{ Hz}$

- $\Delta\nu_{\text{Cs}}$: caesium-133 hyperfine frequency
- fixed means exact; practical measurements still have uncertainty

EXACT CONSTANTS → REPRODUCIBLE REALISATIONS → UNIVERSAL UNITS

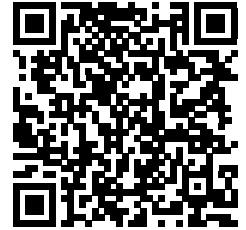


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