▶ Video explanation (YouTube Short)

Units and Measurement: Chapter Introduction

1. Why units matter: the Mars Climate Orbiter

In 1999 NASA's **Mars Climate Orbiter** (about 125 million dollars) reached Mars and was lost. The ground software of one team gave thruster data in **pound-force seconds**; the navigation team expected **newton-seconds**. The numbers were the same, the units were different, and the orbiter came far too close to Mars.

Key fact: 1 pound-force = 4.45 N. A number read in the wrong unit is wrong by that factor.

2. A measurement = number + unit

Physical quantity: anything that can be measured (length, mass, time …).
Unit: a fixed, agreed reference used to measure a quantity.
Measurement: comparing a quantity with its unit: **quantity = numerical value × unit**.

5 m, 5 s and 5 kg have the same number but describe three completely different things. A number alone is meaningless.

3. The SI system: 7 base units

The **Système International (SI)** is the system used worldwide. It has 7 **base units**; every other unit is a **derived unit** built from them.

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

Derived unit example: force = mass × acceleration, so **1 N = 1 kg m s^{-2}**.

4. Significant figures

No measurement is perfect. **Significant figures** are the reliably known digits plus the first uncertain digit. More significant figures = a more precise reading.

Reading	Significant figures	Meaning

2.5 cm	2	read to the nearest 0.1 cm
2.54 cm	3	read to the nearest 0.01 cm: more precise

Quick rules: all non-zero digits count; zeros between non-zero digits count; leading zeros (0.0025) do not count; trailing zeros after a decimal point (2.50) count.

5. Dimensions: check a formula without an experiment

The **dimensions** of a quantity show how it depends on the base quantities, written with [M], [L], [T]. Velocity = $[LT^{-1}]$, acceleration = $[LT^{-2}]$, force = $[MLT^{-2}]$.

Principle of homogeneity: every term added or equated in a correct physical equation must have the same dimensions.

Solved example 1. Is $v = u + at$ correct?
$[v] = [LT^{-1}]$; $[u] = [LT^{-1}]$; $[at] = [LT^{-2}][T] = [LT^{-1}]$. All terms match → dimensionally correct ✓.

Solved example 2. Is $v = u + at^2$ correct?
$[at^2] = [LT^{-2}][T^2] = [L]$, but $[v] = [LT^{-1}]$. The terms do not match → wrong ✗.

Limit: dimensions cannot check pure numbers (½, 2π), so a dimensionally correct formula may still be wrong by a constant.

6. The chapter map

SI units (base and derived) → significant figures and rounding → dimensions and dimensional formulae → dimensional analysis (checking equations, converting units, deducing relations).

Key takeaways

- Every measurement = number + unit.
- SI has exactly 7 base units; all others are derived.
- Significant figures show how precise a reading is.
- Dimensional analysis checks formulas without an experiment, but not numerical constants.

Practice questions (CBSE style)

1. (MCQ) Which is NOT an SI base unit? (a) metre (b) newton (c) kelvin (d) candela
2. (MCQ) The dimensions of acceleration are: (a) $[LT^{-1}]$ (b) $[LT^{-2}]$ (c) $[MLT^{-2}]$ (d) $[L^2T^{-1}]$
3. (Very short) How many significant figures are in 0.0250?
4. (Very short) Write the SI unit of force in base units.
5. (Short) Why is a number without a unit not a measurement? Give an example.
6. (Numerical) Check dimensionally: $s = ut + \frac{1}{2}at^2$.
7. (Numerical) 1 pound-force = 4.45 N. Convert 10 pound-force to newton.
8. (Application) A student writes $v^2 = u^2 + 2as^2$. Use dimensions to show it is wrong.

Answer key

1. (b) newton: it is derived, 1 N = 1 kg m s^{-2}.

2. (b) $[LT^{-2}]$: acceleration = velocity ÷ time.
3. 3 (2, 5 and the final 0); leading zeros do not count.
4. kg m s^{-2}.
5. The unit says what is measured: 5 m, 5 s and 5 kg are different quantities; the Mars Climate Orbiter was lost when a number was read in the wrong unit.
6. [s] = [L]; [ut] = $[LT^{-1}][T]$ = [L]; $[½at^2] = [LT^{-2}][T^2]$ = [L]. All terms are [L], so it is dimensionally correct.
7. 10 × 4.45 = 44.5 N.
8. $[v^2] = [L^2T^{-2}]$, $[u^2] = [L^2T^{-2}]$, but $[2as^2] = [LT^{-2}][L^2] = [L^3T^{-2}]$. The last term does not match, so the equation is wrong (the correct form is $v^2 = u^2 + 2as$).

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