UNITS AND MEASUREMENTS

– PART 1 –

CLASS 11 PHYSICS – NCERT CHAPTER 1

1 WHAT IS MEASUREMENT?

Measurement is the process of comparing an unknown quantity with a standard quantity.

Physical Quantity = Numerical Magnitude × Unit

Example: Length = 12 m

12 × m (metre)

12 → Numerical Magnitude

m → Unit

"12 long" is meaningless without a unit.

2 PHYSICAL QUANTITIES

Physical quantities are measurable quantities that can be expressed in terms of a number (multiplier) and a unit.

Length · Mass · Time · Temperature · Electric Current

3 THE INTERNATIONAL SYSTEM OF UNITS (SI)

The SI (Système International d'Unités) is the modern form of the metric system and is the most widely used system of units in the world. It provides a common standard for scientific measurements for easy communication and consistency.

4 SEVEN SI BASE QUANTITIES

Physical 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

5 BASE vs DERIVED QUANTITIES

BASE QUANTITIES

Cannot be expressed in terms of other physical quantities.

Examples:

- Length
- Mass
- Time
- Electric Current
- Temperature
- Amount of Substance
- Luminous Intensity

DERIVED QUANTITIES

Obtained by combining base quantities through mathematical relations.

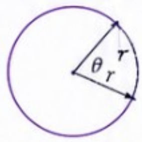
Examples:

- Speed $= \frac{\text{Distance}}{\text{Time}}$
- Force = Mass × Acceleration
- Pressure $= \frac{\text{Force}}{\text{Area}}$
- Energy = Force × Distance

6 PLANE AND SOLID ANGLES

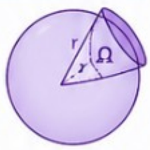
Radian (rad)

→ Plane angle



Steradian (sr)

→ Solid angle



Both are Dimensionless Derived Units

7 2019 SI REDEFINITION – A NEW ERA OF MEASUREMENT

Second (s)

Redefined using the Caesium-133 atomic transition frequency.

Metre (m)

Redefined using the speed of light in vacuum (c).

h

6.626×10^{-34}

Kilogram (kg)

Redefined using the Planck constant (h).

EXAM TIP: Learn all 7 SI base units and symbols perfectly!

DIMENSIONS & DIMENSIONAL ANALYSIS

– PART 2 –

CLASS 11 PHYSICS – NCERT CHAPTER 1

1 WHAT ARE DIMENSIONS?

The dimensions of a physical quantity show how it depends on fundamental quantities.

- M → Mass
- L → Length
- T → Time
- I → Electric Current
- Θ → Temperature
- N → Amount of Substance
- J → Luminous Intensity

☆ These are called **Fundamental Quantities.**

2 DIMENSIONAL FORMULA

Force = Mass × Acceleration

$$\text{Acceleration} = \frac{\text{Length}}{\text{Time}^2}$$

Therefore,

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

Dimensions describe the **nature** of a quantity, not the particular unit.

3 IMPORTANT DIMENSIONAL FORMULA TABLE

Quantity	Formula	Dimensions	Quantity	Formula	Dimensions
Velocity (v)	$\frac{\text{Distance}}{\text{Time}}$	$[LT^{-1}]$	Work / Energy (W)	Force × Distance	$[ML^2T^{-2}]$
Acceleration (a)	$\frac{\text{Velocity}}{\text{Time}}$	$[LT^{-2}]$	Power (P)	$\frac{\text{Work}}{\text{Time}}$	$[ML^2T^{-3}]$
Momentum (p)	Mass × Velocity	$[MLT^{-1}]$	Pressure (P)	$\frac{\text{Force}}{\text{Area}}$	$[ML^{-1}T^{-2}]$
Force (F)	Mass × Acceleration	$[MLT^{-2}]$	Density (ρ)	$\frac{\text{Mass}}{\text{Volume}}$	$[ML^{-3}]$

4 USES OF DIMENSIONAL ANALYSIS

1 Check an equation

Both sides must have the same dimensions.

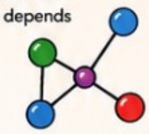
2 Convert units

Helps in converting a quantity from one system to another.

Example:
CGS system ⟺ SI system

3 Derive relationships

Helps in finding how one physical quantity depends on others.



5 EXAMPLE OF DIMENSIONAL CHECKING

$$s = ut + \frac{1}{2}at^2$$

Check dimensions:

$[s] = L$

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

$[at^2] = [LT^{-2}][T^2] = L$

Conclusion:
L = L + L ✓
Dimensionally Correct

6 LIMITATIONS

- ✖ Cannot distinguish quantities with identical dimensions.
  Example: Work and Torque → $[ML^2T^{-2}]$
- ✖ Cannot find dimensionless constants.
  Examples: $\frac{1}{2}$, 2, π
- ✖ A dimensionally correct equation may still be physically incorrect.

7 COMMON MISTAKES

- **Confusing units with dimensions**
  m → kg → s
  (Units) ≠ (Dimensions)
- **Forgetting powers of time** (t^n)
  Time has powers (+ve / −ve)
- **Ignoring dimensionless constants**
  Constants like $\frac{1}{2}$, 2, 2, π are dimensionless.
- **Assuming dimensional correctness proves an equation**
  Always check the physical meaning too!

PRACTICE TIP:
Write dimensional formulas of **15–20** quantities.

SIGNIFICANT FIGURES & ERRORS IN MEASUREMENT

★ PART 3 ★

CLASS 11 PHYSICS – NCERT CHAPTER 1

1 SIGNIFICANT FIGURES

Significant figures indicate the precision of a measured value.

1. All non-zero digits are significant. → 247 → 3 significant figures
2. Zeros between non-zero digits are significant. → 1007 → 4 significant figures
3. Leading zeros are not significant. → 0.0056 → 2 significant figures
4. Trailing zeros after a decimal point are significant. → 12.30 → 4 significant figures
5. Trailing zeros in whole numbers without a decimal point can be ambiguous. 1200 Ambiguous

   Scientific notation:
   1.200×10^3 → 4 significant figures

2 ROUNDING RULES

For ADDITION / SUBTRACTION:
Round according to the least number of decimal places.

Example:
12.11 + 18.0 + 1.013 = 31.123
↓
Final answer: 31.1

Avoid rounding repeatedly during intermediate calculations.

3 ERRORS IN MEASUREMENT — NO MEASUREMENT IS PERFECT

4 SYSTEMATIC ERRORS

Follow a consistent pattern.

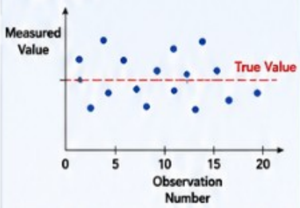
Types:

- Instrumental errors
- Imperfect calibration
- Zero error
- Error in measuring technique
- Personal errors

Example: A wrongly calibrated instrument gives readings consistently higher or lower than the true value.

5 RANDOM ERRORS

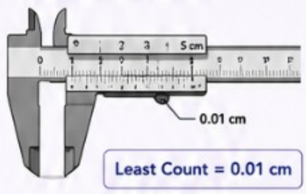
Unpredictable variations in size and direction caused by uncontrollable changes in conditions.



Random errors may be reduced by taking many observations and using the mean value.

6 LEAST COUNT ERROR

The smallest measurement an instrument can detect.



Least Count = 0.01 cm

Example: Vernier caliper least count = 0.01 cm

A more precise instrument generally has a smaller least count.

7 ERROR CALCULATIONS

Absolute Error
= |Measured Value − True Value|

Relative Error
$$= \frac{\text{Absolute Error}}{\text{True Value}}$$

Percentage Error
= Relative Error × 100 %

8 COMMON EXAM MISTAKES

- ✗ Confusing systematic and random errors
- ✗ Counting leading zeros as significant — 0.0025
- ✗ Incorrect final rounding — 12.345 ≠ 12.35 (correct: 12.3)
- ✗ Rounding every intermediate answer
- ✗ Forgetting units in the final answer — 9.81 ✗ Correct: 9.81 m/s^2

FINAL SUMMARY

UNITS + DIMENSIONS + SIGNIFICANT FIGURES + ERRORS = FOUNDATION OF PHYSICS

MASTER THIS CHAPTER, AND EVERY PHYSICS NUMERICAL BECOMES EASIER!