

Introduction to Measurement

Introduction to Measurement

Fundamentals, Units, Tools, and Best Practices

1. What Is Measurement?

Aspect	Description
Definition	The process of assigning a numerical value to a physical quantity by comparing it with a standard.
Purpose	Quantify observations, enable communication, support calculations, and facilitate scientific/engineering decisions.
Key Elements	• Quantity (what is being measured) • Unit (reference standard) • Instrument (tool used) • Result (numerical value + unit).

2. Types of Physical Quantities

Category	Examples
Fundamental	Length, Mass, Time, Electric current, Thermodynamic temperature, Amount of substance, Luminous intensity.
Derived	Speed ($m \cdot s^{-1}$), Force (N), Pressure (Pa), Energy (J), Power (W), Voltage (V).
Auxiliary	Angle, Plane angle (rad), Solid angle (sr).

Derived quantities are expressed as algebraic combinations of fundamental units.

3. Systems of Units

System	Characteristics	Common Use
International System of Units (SI)	7 base units, coherent derived units, universal acceptance.	Science, industry, education worldwide.

Introduction to Measurement

System	Characteristics	Common Use
CGS (centimeter-gram-second)	Based on cm, g, s; older system.	Some fields of physics, astrophysics.
Imperial / US Customary	Inches, feet, pounds, seconds, etc.	United States (construction, everyday life).
Specialized	e.g., atomic units, natural units (Planck).	High-energy physics, quantum chemistry.

When working internationally, always state the system and, if needed, provide conversion factors.

4. Standard Units (SI)

Quantity	Symbol	Unit	Symbol	Definition (2024)
Length	L	meter	m	Distance light travels in vacuum in $1/299\,792\,458$ s.
Mass	M	kilogram	kg	Defined by the Planck constant ($h = 6.626\,070\,15 \times 10^{-34}$) J·s.
Time	T	second	s	Duration of $9\,192\,631\,770$ periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of cesium-133.
Electric current	I	ampere	A	Flow of 1 C/s ¹ (based on elementary charge (e)).
Thermodynamic temperature	?	kelvin	K	$1/273.16$ of the thermodynamic temperature of the triple point of water.
Amount of substance	N	mole	mol	Amount containing exactly $(6.022\,140\,76 \times 10^{23})$ elementary entities.
Luminous intensity	J	candela	cd	Luminous power per steradian of a source emitting monochromatic radiation of frequency 540×10^{12} Hz with radiant intensity $1/683\text{ W}\cdot\text{sr}^{-1}$.

Derived units (e.g., newton, joule) are built from these base units.

Introduction to Measurement

5. Measurement Process

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