Physical Quantities and Measurement — SLO-Based Exam Notes

(Comprehensive 10 page exam-oriented notes)

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1. Introduction to Physics

Definition of Physics

Physics is the most fundamental branch of science that deals with **matter, energy, and their interactions**. The laws and principles of physics help us understand natural phenomena and the physical world.

Physics in Science

Physics forms the foundation of other sciences:

- **Biology:** Blood flow, nerve signals, biomechanics
- **Chemistry:** Atomic structure, chemical bonding
- **Earth & Space Sciences:** Climate, motion of planets

Physics and Technology

Modern technologies such as:

- Computers and smartphones
- Medical imaging (X-rays, PET scans)
- Rockets, satellites, and space shuttles

are all based on principles of physics.

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2. Branches of Physics

Major branches include:

- Mechanics
- Optics
- Oscillations and Waves
- Thermodynamics
- Electromagnetism
- Atomic Physics
- Nuclear Physics

- Quantum Physics
- Astrophysics

Key Point: Physics is closely related to mathematics; mathematical tools are essential to understand physical laws.

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3. Physical and Non-Physical Quantities

Physical Quantities

Quantities that can be **measured** and expressed with a **number and a unit**.

Examples:

- Length
- Mass
- Time
- Temperature
- Density

Non-Physical Quantities

Quantities that **cannot be measured**.

Examples:

- Taste
- Feelings
- Color

Measurement

Measurement consists of:

- **Numerical magnitude**
- **Unit**

Example: 1.65 m → 1.65 (magnitude), metre (unit)

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4. Base and Derived Physical Quantities

Base (Fundamental) Quantities

These are independent quantities.

Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Derived Quantities

Obtained by combining base quantities.

Examples:

- Area = m^2
- Velocity = m/s
- Acceleration = m/s^2
- Force = kg m s^{-2} (newton)

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5. International System of Units (SI)

A **system of units** is a complete set of standard units.

The **SI system** is internationally accepted and based on seven base units.

Advantages:

- Uniformity
- Accuracy
- Reproducibility

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6. Scientific Notation (Standard Form)

Used to express **very large or very small numbers**.

Format

Number = Mantissa × 10^n

Where:

- Mantissa: $1 \leq M < 10$
- Exponent: power of 10

Examples

- 880000000000000000000000000 m = 8.8×10^{26} m
- 0.0000000000000017 m = 1.7×10^{-15} m

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7. Prefixes to Powers of Ten

Prefixes simplify large and small numbers.

Prefix	Symbol	Power
kilo	k	10^3
mega	M	10^6
giga	G	10^9
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Example:

- 1000 m = 1 km
- 0.001 m = 1 mm

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8. Scalars and Vectors

Scalar Quantities

Quantities described by **magnitude only**.

Examples:

- Distance
- Speed
- Mass
- Time
- Energy

Vector Quantities

Quantities described by **magnitude and direction**.

Examples:

- Displacement
- Velocity
- Acceleration
- Force
- Momentum

Vector Representation

- Represented by arrows
- Length → magnitude
- Arrowhead → direction

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9. Addition of Vectors

Vectors cannot be added by simple algebra.

Graphical Method (Head-to-Tail)

Steps:

1. Draw vectors to scale
2. Place head of one vector to tail of the other
3. Resultant is drawn from tail of first to head of last

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10. Measuring Instruments

Least Count

The **smallest value** that can be measured by an instrument.

10.1 Metre Rule & Measuring Tape

- Least count: 1 mm
- Used for length measurement

10.2 Vernier Caliper

Used for measurements smaller than 1 mm.

Least Count:

Least Count = (Smallest main scale division) / (Total vernier divisions)

Typical LC = 0.1 mm

Zero Error:

- Positive
- Negative
- No zero error

10.3 Screw Gauge (Micrometer)

Used for very small measurements.

- Pitch: distance moved in one rotation
- Least Count = Pitch / No. of circular divisions

Typical LC = 0.01 mm

More precise than vernier caliper.

10.4 Physical Balance

Used to measure **mass**.

- Uses standard weights

- Highly sensitive

10.5 Measuring Cylinder

Used to measure **volume of liquids** and irregular solids.

- Least count: 1 mL (or cm^3)

10.6 Stopwatch

Used to measure time intervals.

Type	Least Count
Mechanical	1 s
Digital	0.1 s

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11. Errors in Measurement

Error

Uncertainty in measurement.

Types of Errors

Systematic Errors

- Instrumental errors
- Zero error
- Personal errors

Can be reduced by calibration.

Random Errors

- Occur unpredictably
- Reduced by taking repeated readings and calculating mean

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12. Precision and Accuracy

Precision

- Reproducibility
- Consistency of results

Accuracy

- Closeness to true value

Possible cases:

- Accurate & precise
- Accurate but not precise
- Precise but not accurate

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13. Significant Figures

Definition

All certain digits plus the first uncertain digit.

Rules

1. All non-zero digits are significant
2. Zeros between non-zero digits are significant
3. Leading zeros are not significant
4. Trailing zeros after decimal are significant

Examples

- 0.0029 → 2 significant figures
- 2.900×10^3 → 4 significant figures

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14. Rounding Off

Rules

- Digit < 5 → drop
- Digit ≥ 5 → increase previous digit by 1

Example:

- 3.876 → 3.88 (two decimal places)

✓ Exam Tips

- Memorize SI un
- its and prefixes
- Practice numerical problems on LC, errors, scientific notation
- Learn definitions word-to-word
- Draw neat diagrams for instruments
- Always mention unit and direction where required

End of SLO-Based Notes