PHYSICS

Main Concepts: Physical and Non-Physical Quantities

1. Physical Quantities

- **Definition:** Quantities that can be **measured** directly or indirectly using tools or instruments.
- **Examples:** Length, volume, density, time, temperature.
- **Importance:** These are the foundation of **physics**; laws and principles are based on them.

2. Non-Physical Quantities

- **Definition:** Quantities that **cannot be measured** with instruments; based on human **perception or emotions**.
- **Examples:** Love, fear, wisdom, beauty.
- **Use:** Help understand **human behavior** and **social interactions**; studied through **qualitative methods** or surveys.

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3. Need for Standard Units

- In the past, people used body parts (hand, foot) for measurement — caused **confusion**.
- A **standard unit** ensures measurements are **consistent and reliable**.

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4. What is Measurement?

- **Definition:** A measurement includes **two parts**:
  - A **number** (value)
  - A **unit** (standard quantity)
- **Note:** A number alone is meaningless without a unit.

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5. International System of Units (SI Units)

- **Why needed?** Different countries used different units → caused problems in **trade** and **scientific communication**.
- **Established in 1961** by the international committee.
- SI system includes **7 base units** used **worldwide**.

- SI units allow **easy comparison and sharing** of scientific data.

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6. Derived Units

- **Derived units** are units that are **formed using base units**.
- They are used to measure physical quantities like **area, volume, speed, force, pressure**, and **electric charge**.
- These units are **not basic** themselves but are made by **combining base units**.

Examples:

- **Area** = Length × Width = metre × metre = **metre² (m²)**
- **Speed** = Distance / Time = metre / second = **m/s**
- **Volume** = metre × metre × metre = **m³**

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7. SI Prefixes

- The **SI system** is a **decimal system**.
- **Prefixes** are used to write very large or very small values **using powers of 10**.
- This makes numbers **easier to read and write**.

Examples:

- **50,000,000 m = 5 × 10^{7} m**
- **0.00004 m = 4 × 10^{-5} m**

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8. Scientific Notation

□ What is Scientific Notation?

- A **short way to write very large or very small numbers**.
- It helps in **saving space**, **easy reading**, and **quick calculations**.
- Numbers are written as:
  a × **10^{n}**, where:
    - **a** is a number between **1 and 9**
    - **n** is the **power of 10**

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9. How to Write in Scientific Notation?

1. **Move the decimal point** until there's only **one non-zero digit** on the left.
2. **Count the number of places** you moved the decimal:
    - Move **left** → exponent is **positive**

- Move **right** → exponent is **negative**

✓***Examples:***

- 138,000,000 km
  → **1.38×10^8 km** (Decimal moved 8 places to the left)
- 0.000000000052 m (Diameter of hydrogen atom)
  → **5.2×10^{-11} m** (Decimal moved 11 places to the right)

Important Notes:

- **Addition/Subtraction Rule:** Exponents **must be same**.
- **Prefix Care:** Always use proper **symbols** (e.g., *s*, *m*, *kg*) not abbreviations.
- **No Plurals in Symbols:**
  ✓10 mN
  ✗10 mNs
- **Capitalization Rule:**
  - Unit names = lowercase (metre, second)
  - Unit symbols = lowercase (m, s), **except L for litre**
  - Only **Celsius** uses capital (°C)

Vernier Callipers – Simple Explanation

10. What is a Vernier Callipers?

Vernier Callipers is a tool used to **measure small lengths** very accurately — up to **0.1 mm** (1/10th of a millimeter).
It is used to measure:

- **Thickness** of an object
- **Inner and outer diameter**
- **Depth** of a hollow object

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11. Parts of Vernier Callipers

1. **Main Scale**
   - Fixed scale
   - Each division = **1 mm**
2. **Vernier Scale**
   - Sliding scale
   - 9 mm long, divided into 10 parts
   - Each part = **0.9 mm**
3. **Least Count**

  - Smallest value the instrument can measure
  - **Least Count = 1 mm - 0.9 mm = 0.1 mm**
4. **Jaws A & B**
  - Measure **external** size (like the thickness of a rod)
5. **Jaws C & D**
  - Measure **internal** size (like the diameter of a hole)
6. **Depth Rod**
  - Measures **depth** of a hollow object (like a tube)

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12. How to Measure with Vernier Callipers

1. **Place** the object between the jaws.
2. **Note the main scale reading** just before the "0" of Vernier scale.
3. **Find the matching line** on the Vernier scale that lines up exactly with a line on the main scale.
4. Use the formula:

□ **Length = Main Scale Reading + (Vernier Scale Reading × Least Count)**
Example:
Main scale = 4.3 cm
Vernier scale = 4th line matches
Least Count = 0.01 cm
Length = 4.3 + (4 × 0.01) = 4.34 cm

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13. Zero Error

Sometimes the instrument shows an error even when it should show zero.

- If Vernier 0 is **right of main 0** → **Positive Error** (Subtract from result)
- If Vernier 0 is **left of main 0** → **Negative Error** (Add to result)

How to Find Zero Error:

1. Check which Vernier division lines up with the main scale.
2. Multiply that number by the least count.
3. Apply correction (+ or -) based on error type.

Fun Fact

□ **Inventor**: Pierre Vernier (France), in **1631**
□ **Parallax Error**: Happens when eye is not straight with the scale. Always view from straight above.

Measuring Tape: It can measure 1 mm to several metres. Its least count is 1 mm. It is used to measure longer distances.

□ Activity to Try

Find thickness of one coin:

1. Stack 10 coins → Measure total height with a meter rule
2. Divide by 10 → Average thickness
3. Measure one coin with Vernier Callipers
4. Compare both results in class!

Micrometer Screw Gauge - Easy Notes

What is it used for?

- To measure very **small things**, like the **diameter of a wire** or **thickness of a metal sheet**.

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14. Important Parts:

1. **Main Scale**
    - Found on the **sleeve**.
    - Each marking = **0.5 mm** (sometimes **1 mm**).
2. **Circular Scale**
    - Found on the **thimble**.
    - Has **50 divisions** (sometimes **100 divisions**).

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15. Pitch of Screw Gauge:
Distance moved by spindle in one full turn of thimble.
Example: **0.5 mm** per full turn.

16. Least Count (L.C.):
The smallest measurement that can be read.
Formula:

Least count = Pitch of the screw gauge / No. of divisions on the circular scale

0.5 mm/ 50 = 0.01 mm

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17. Zero Error:

- **No Zero Error:**
  - Zero of circular scale is exactly at horizontal line.
- **Positive Zero Error:**
  - Zero of circular scale is **above** the horizontal line.
  - **Add** the error to the reading.
- **Negative Zero Error:**
  - Zero of circular scale is **below** the horizontal line.
  - **Subtract** the error from the reading.

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18. How to Measure with Screw Gauge:

1. Read the **main scale** (sleeve) marking just before thimble.
2. Read the **circular scale** marking which lines up with the main scale.
3. Formula:

Thickness = Main scale reading + (Circular scale reading × Least Count)

Example:

- Main Scale: 6.5 mm
- Circular Scale: 25 divisions
- L.C.: 0.01 mm

Calculation:

$6.5+(25\times0.01)=6.5+0.25=6.75$ mm

Extra Tip:

- The most accurate balance for measuring mass is the **digital electronic balance**.
  - It can measure mass as small as **0.1 mg**.
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Mass Measuring Instruments - Easy Notes

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19. Important Points:

- **Mass** and **Weight** are **different** in Physics.
  - **Mass:** Amount of matter in an object.
  - **Weight:** Force with which Earth pulls an object (can be measured with a **spring balance**).

- **Mass is measured** by **comparing** it with known masses.
  - This process is called **weighing**.

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20. Physical Balance:

- Used in **laboratories** to measure mass **accurately**.
- Works on the **principle of levers**.

Steps to Use a Physical Balance:

1. **Level the balance** using the **levelling screws** until the **plumb line** is exactly above the mark.
2. **Raise the pans** by turning the knob.
3. Check if the **beam is horizontal** and the **pointer** is at the **center**.
   - If not, adjust using **balancing screws**.
4. **Place the object** to be measured on the **left pan**.
5. **Place known standard weights** on the **right pan** using **forceps** (special tool for holding weights).
6. Adjust until the **pointer is at zero** or swings equally on both sides.
7. The **total weight** placed on the right pan = **mass of the object**.

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21. Key Definitions:

- **Mass:**
  - The amount of matter in an object.
- **Weight:**
  - The gravitational force acting on an object.
- **Weighing:**
  - Finding the mass by comparing it with standard known masses.

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22. Time Measuring Instruments - Easy Notes

Important Points:

- **Stopwatch** is used to measure the **duration** of an event.
- It has **two needles**:
  - One for **seconds**
  - One for **minutes**
- The **dial** is divided into **30 big divisions**.
  - Each big division has **10 small divisions**.

- **Each small division = 1/10 second**.
- **Least Count:**
    - The smallest time that can be measured is **one-tenth (1/10) of a second**.

23. How to use a Mechanical Stopwatch:

2. Press the top knob to **start** the watch.
3. Press the knob again to **stop** the watch.
4. Press again to **reset** the needles to zero.

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24. Digital Stopwatch:

- Modern **digital stopwatches** are also available.
- They can measure even smaller time intervals:
    - **One-hundredth (1/100) of a second**.

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25. Volume Measuring Instruments

Measuring Cylinder

A **measuring cylinder** is a transparent tube (glass or plastic) marked with a scale in **millilitres (mL)** or **cubic centimetres (cm^3)**. It is commonly used to measure the **volume of liquids** and **irregular solids** (via water displacement).

26. How to Use It Correctly:

- Place the cylinder on a **flat surface**.
- Keep your eye **level with the liquid surface**.
- **Liquids form a curved surface** called a **meniscus**.
    - **Water (concave meniscus):** Read from the **bottom** of the curve.
    - **Mercury (convex meniscus):** Read from the **top** of the curve.

Note:

To measure the volume of a **non-dissolving solid**, note the **rise in water level** after submerging the solid. The difference gives the solid's volume.

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27. Displacement Can Method

When a solid is too large to fit into a measuring cylinder, a **displacement (or overflow) can** is used to measure its volume.

Procedure:

1. **Place** the can on a **level surface**.
2. **Fill** it with water until it begins to overflow from the side spout.
3. **Wait** until overflow stops, ensuring the water level is exactly at the spout.
4. **Tie** a thread to the solid and **lower it gently** into the can.
5. **Collect** the displaced water in a beaker.
6. **Measure** the collected water using a **measuring cylinder**.

✅The volume of displaced water equals the **volume of the solid**.

Concept:

This method is based on **Archimedes' principle**—a solid submerged in a liquid displaces a volume of liquid equal to its own volume.

Errors in Measurement

Do You Know?

Even with the widespread use of SI units, some old units are still in use—e.g., font size is measured in **points**, where **1 point = 1/72 inch = 0.35 mm**.

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28. Why Do Errors Occur?

No measurement is perfectly accurate. All instruments have limitations, and human involvement introduces errors. We aim to **minimize** these errors and always mention the **estimated uncertainty** in any scientific measurement.

Types of Experimental Errors

29. Human Errors

- Caused by carelessness, poor technique, or misreading instruments (e.g., wrong eye position, reaction time).
- **Minimized by** training, focusing, and using **digital tools**.

30. Systematic Errors

- Affect all measurements consistently due to a fixed cause (e.g., zero error, poor calibration).
- **Minimized by** comparing with standard instruments and applying correction.

31.Random Errors

- Unpredictable changes due to environmental factors (e.g., temperature, voltage).
- **Minimized by** taking **multiple readings** and using **average values**.

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32. Uncertainty in Measurement

Every measuring instrument has a **least count**—the smallest division it can measure.
Uncertainty is often ± **half of the least count**.

For example:

- If a ruler is marked in mm, and a length lies between 10.3 cm and 10.4 cm, the uncertainty is **±0.05 cm**.

Use **averages** in repeated measurements (e.g., timing 30 oscillations instead of one) to reduce uncertainty.

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33. Significant Figures

Significant figures show how reliable a measurement is.
They include:

- All **certain digits**, and
- **The first uncertain digit**.

34. Rules:

- Digits 1–9 are significant.
- Zeros **between** digits are significant: 5.06 → 3 s.f.
- Zeros **before** digits are not: 0.0034 → 2 s.f.
- Zeros **after** decimal are significant: 2.40 → 3 s.f.
- In scientific notation, all digits before ×10 are significant.

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35. Precision vs Accuracy

- **Precision** = Repeated values are close to each other.
- **Accuracy** = Values are close to the **true value**.

Example:
Arrows on a target:

- Grouped together = Precise
- Hitting bulls eye = Accurate
- Both = Precise and Accurate

Smaller least count → Higher **precision**
More significant figures → Better **accuracy**

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36. Rounding Off Rules

- If the digit after rounding place is **>5**, increase the last kept digit.
- If **<5**, keep the last digit as it is.
- If **exactly 5**:
    - If previous digit is **odd**, round up.
    - If **even**, leave unchanged.

Examples:

- 2.512 → 2.5 (to 2 s.f.)
- 3.4567 → 3.46 (to 3 s.f.)
- 4.45 → 4.4, but 4.55 → 4.6 (to 2 s.f.)

Key Takeaway

Every measurement involves uncertainty.
Always aim for **precision**, **accuracy**, and **clarity** using appropriate instruments, significant figures, and rounding rules.