

Chapter 1

Physical Quantities and Measurement

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Short Questions

1. How does physics play an important role in our life?

Physics helps us understand the natural laws of the universe. It plays a role in almost everything we use daily, like electricity, transportation, and communication. For example, principles of physics allow us to use cars, mobile phones, and even cook food efficiently. It also helps in technological advancements like space exploration and medical equipment.

2. Estimate your age in minutes and seconds.

To estimate:

- Multiply your age in years by the number of days in a year (365).
- Multiply this by 24 (hours in a day), then by 60 (minutes in an hour).
For seconds, multiply the result further by 60.

Example:

If your age is 15 years:

- Minutes: $15 \times 365 \times 24 \times 60 = 7,884,000$
 $15 \times 365 \times 24 \times 60 = 7,884,000$ minutes
- Seconds: $7,884,000 \times 60 = 473,040,000$
 $7,884,000 \times 60 = 473,040,000$ seconds

This calculation gives a detailed estimate of your age in smaller units.

3. What base quantities are involved in these derived physical quantities?

- **Force:** Base quantities are mass (kg), length (m), and time (s).
Formula: $F = m \times a$ (Force = Mass $\times$ Acceleration)
- **Pressure:** Base quantities are mass (kg), length (m), and time (s).
Formula: $P = \frac{F}{A}$ (Pressure = Force $\div$ Area)

- **Power:** Base quantities are mass (kg), length (m), and time (s).
Formula: $P = \frac{W}{t}$ or $P = tW$ (Power = Work ÷ Time)
- **Charge:** Base quantities are electric current (A) and time (s).
Formula: $Q = I \times t$ or $Q = I \times t$ (Charge = Current × Time)

4. Show that prefix micro is thousand times smaller than prefix milli.

- **Micro (μ):** Represents 10^{-6} (one-millionth).
- **Milli (m):** Represents 10^{-3} (one-thousandth).
- To compare: $\frac{10^{-6}}{10^{-3}} = 10^{-3}$
This proves that a micro-unit is 1000 times smaller than a milli-unit.

5. Justify that displacement is a vector quantity while energy is a scalar quantity.

- **Displacement:** It has both magnitude (size) and direction, e.g., 5 meters north. This makes it a vector quantity.
- **Energy:** Energy only has a value (e.g., 20 Joules) and no direction. This makes it a scalar quantity.
In simple terms, displacement tells "how far and in which direction," while energy just tells "how much."

6. Screw gauge can give more precise length than vernier calipers. Why?

A screw gauge has a smaller least count (0.01 mm), which means it can measure even very tiny differences in length. In contrast, a vernier caliper's least count is larger (0.1 mm), so it is less precise. This is why screw gauges are used for highly accurate measurements, like measuring thin wires.

7. Differentiate between mechanical stopwatch and digital stopwatch.

- **Mechanical Stopwatch:** Uses gears and springs, readings are shown on dials, and it is operated manually.
- **Digital Stopwatch:** Displays time readings electronically and is more accurate and easier to read.
Digital stopwatches are preferred for precise measurements, such as in sports.

8. How is a measuring cylinder used to measure the volume of an irregular-shaped stone?

- Fill the cylinder with water and note the initial water level.
- Submerge the stone fully into the water.
- Note the new water level.
- Subtract the initial water level from the final level to find the volume of the stone.

This method works because the stone displaces a volume of water equal to its own volume (Archimedes' principle).

9. What precaution should be kept in mind while taking measurements using a measuring cylinder?

- Always place the cylinder on a flat and stable surface.
 - Read the water level at eye level to avoid parallax error.
 - Ensure the object being measured is fully submerged but does not splash water out of the cylinder.
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10. Why do we need to consider significant digits in measurements?

Significant digits show how precise and reliable a measurement is. Ignoring them can lead to inaccurate results. For example, if a measurement is given as 3.25, all three digits are significant and must be considered in calculations.

11. How can random error be reduced?

Random errors are reduced by:

- Taking multiple measurements and averaging them.
 - Using precise instruments.
 - Conducting the experiment in controlled conditions to avoid environmental factors like wind or vibrations.
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12. Differentiate between precision and accuracy.

- **Precision:** Refers to how close repeated measurements are to each other. For example, measuring an object three times and getting 4.2 cm, 4.3 cm, and 4.2 cm indicates high precision.
- **Accuracy:** Refers to how close a measurement is to the true value. For example, if the actual value is 4.0 cm and your measurement is 4.1 cm, it is accurate.

Example: A dartboard: Precision means hitting the same spot repeatedly, while accuracy means hitting the bullseye.

Long Questions

1. Define Physics. Describe its revolutionary role in technology.

Physics is the branch of science that deals with the study of matter, energy, and the interactions between them. It explains natural phenomena, the laws governing the universe, and the behavior of physical entities under different conditions.

Revolutionary Role in Technology:

Physics has been a driving force behind technological advancements. Some examples include:

- **Electricity and Electronics:** The understanding of electromagnetism led to the invention of devices like generators, transformers, and computers.
- **Transportation:** Newton's laws of motion and mechanics paved the way for the development of vehicles, airplanes, and rockets.
- **Medical Technology:** X-rays, MRIs, and laser surgeries are applications of physics in healthcare.
- **Communication:** Principles of wave propagation enable technologies like mobile phones, satellites, and the internet.

Physics transforms theoretical knowledge into practical applications, revolutionizing industries and daily life.

2. List with brief description of different branches of physics.

Physics is divided into several branches, each focusing on a specific aspect of the physical world:

1. Mechanics:

- Deals with the motion of objects and the forces acting upon them.
- Applications: Vehicle dynamics, construction, and space exploration.

2. Thermodynamics:

- Studies heat, temperature, and energy transfer.
- Applications: Refrigerators, engines, and power plants.

3. Electromagnetism:

- Focuses on electric and magnetic fields and their interactions.
- Applications: Electric motors, transformers, and wireless communication.

4. Optics:

- Studies the behavior and properties of light.
- Applications: Lenses, microscopes, and fiber optics.

5. Nuclear Physics:

- Explores the behavior of atomic nuclei and nuclear reactions.

- Applications: Nuclear energy and medical imaging.
 - 6. **Quantum Mechanics:**
 - Deals with the behavior of particles at atomic and subatomic levels.
 - Applications: Semiconductor devices and quantum computers.
 - 7. **Astrophysics:**
 - Studies celestial bodies and the universe.
 - Applications: Space research and satellite technology.
-

3. What are physical quantities? Distinguish between base physical quantities and derived physical quantities. Give at least three examples to show that derived physical quantities are obtained from base physical quantities.

Physical Quantities:

A physical quantity is a property of a phenomenon or object that can be measured and expressed with a value and a unit (e.g., length, mass, time).

Base Physical Quantities:

These are fundamental quantities that are independent and cannot be derived from other quantities. Examples: Length (meter), Mass (kilogram), Time (second), Electric Current (ampere).

Derived Physical Quantities:

These are quantities derived from one or more base quantities through mathematical relationships. Examples:

1. Speed = Distance $\div$ Time (Derived from Length and Time).
2. Force = Mass $\times$ Acceleration (Derived from Mass, Length, and Time).
3. Pressure = Force $\div$ Area (Derived from Mass, Length, and Time).

Difference:

- **Base Quantities:** Fundamental and do not depend on others.
 - **Derived Quantities:** Depend on base quantities for their definition.
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4. What do you mean by unit of a physical quantity? Define base units and derived units.

Unit of a Physical Quantity:

A unit is a standard measurement used to express the magnitude of a physical quantity. For example, meters for length, kilograms for mass, and seconds for time.

Base Units:

These are the units of base physical quantities defined by the International System of Units (SI).

Examples:

- Meter (m) for Length
- Kilogram (kg) for Mass

- Second (s) for Time

Derived Units:

These are the units of derived physical quantities obtained from the base units.

Examples:

- Newton (N) for Force = $\text{kg} \cdot \text{m/s}^2$
- Pascal (Pa) for Pressure = N/m^2
- Joule (J) for Energy = $\text{N} \cdot \text{m}$

5. What are prefixes? What is their use in measurements?

Prefixes:

Prefixes are symbols or words added before a unit to indicate multiples or submultiples of that unit. They help in expressing very large or very small quantities in a compact form.

Examples of Prefixes:

1. Kilo (k): 10^3 or 1000 times the unit.
2. Milli (m): 10^{-3} or 1/1000th of the unit.
3. Micro (μ): 10^{-6} or 1/1,000,000th of the unit.
4. Mega (M): 10^6 or 1,000,000 times the unit.

Use in Measurements:

- They simplify calculations by reducing the number of zeros.
For example, 1000 meters can be written as 1 kilometer (1 km).
- They make scientific communication more standardized and universal.

6. What is scientific notation or standard form of noting down a measurement? Give at least five examples.

Scientific Notation:

It is a way of expressing very large or very small numbers in the form:

$$N \times 10^n$$

Where N is a number between 1 and 10, and n is an integer.

Examples:

1. Speed of light: $3 \times 10^8 \text{ m/s}$
2. Mass of an electron: $9.11 \times 10^{-31} \text{ kg}$
3. Diameter of Earth: $1.27 \times 10^7 \text{ m}$
4. Size of a virus: $5 \times 10^{-7} \text{ m}$
5. Charge of an electron: $1.6 \times 10^{-19} \text{ C}$

Scientific notation makes it easier to work with extreme values in physics and other sciences.

7. Describe construction and working of vernier calipers in detail.

Construction:

Vernier calipers consist of:

1. **Main Scale:** A fixed scale marked in millimeters or centimeters.
2. **Vernier Scale:** A sliding scale that moves along the main scale, divided into smaller divisions for precision.
3. **Jaws:**
 - **Upper Jaws:** Used for measuring internal diameters (e.g., the inner diameter of a cylinder).
 - **Lower Jaws:** Used for measuring external dimensions (e.g., the diameter of a sphere).
4. **Depth Rod:** A thin rod at the bottom for measuring the depth of objects.
5. **Lock Screw:** Locks the vernier scale in position during measurement.

Working:

- Place the object between the jaws.
- Adjust the vernier scale so that the jaws fit tightly around the object.
- Read the measurement on the main scale (before the vernier zero mark).
- Find the vernier scale reading that aligns exactly with a main scale division.
- Add the main scale reading to the vernier scale reading to get the final measurement.

Formula:

$$\text{Measurement} = \text{Main Scale Reading} + (\text{Vernier Reading} \times \text{Least Count})$$
$$\text{Measurement} = \text{Main Scale Reading} + (\text{Vernier Reading} \times \text{Least Count})$$

Applications:

- Measuring diameters of objects, depths of containers, and lengths of rods.

8. What is screw gauge? What is its pitch and least count? How is it used to measure thickness of thin copper wire?

Screw Gauge:

A screw gauge is an instrument used for measuring very small lengths or thicknesses with high precision, such as the diameter of a thin wire or the thickness of a sheet.

Pitch:

The pitch of a screw gauge is the distance moved by the spindle in one complete rotation. It is measured by dividing the distance moved by the spindle by the number of rotations.

Least Count:

The least count is the smallest measurement the screw gauge can read. It is calculated as:

Least Count = $\frac{\text{Pitch}}{\text{Number of Divisions on Circular Scale}}$
Least Count = $\frac{\text{Pitch}}{\text{Number of Divisions on Circular Scale}}$

Measuring Thin Copper Wire:

1. Place the wire between the screw and the stud.
2. Rotate the screw to gently hold the wire without deforming it.
3. Note the main scale reading and circular scale reading.
4. Use the formula:
$$\text{Final Reading} = \text{Main Scale Reading} + (\text{Circular Scale Reading} \times \text{Least Count})$$
$$= \text{Main Scale Reading} + (\text{Circular Scale Reading} \times \text{Least Count})$$
5. The result gives the thickness of the wire.

9. Define error. Differentiate between random and systematic error. How can these errors be reduced?

Error:

Error refers to the difference between the measured value and the true value of a physical quantity.

Random Error:

- Occurs due to unpredictable fluctuations in measurement conditions.
- Example: Errors caused by environmental factors like temperature or pressure changes.
- **Reduction:** Take multiple readings and calculate the average.

Systematic Error:

- Occurs due to flaws in the measurement device or experimental setup.
- Example: Incorrect calibration of an instrument.
- **Reduction:** Use properly calibrated instruments and follow proper measurement techniques.

10. Differentiate between scalars and vectors. Justify that distance, speed, mass, and energy are scalars, while displacement, velocity, acceleration, and force are vectors.

Scalars:

- Quantities that have only magnitude (size) and no direction.
- Examples: Distance (5 m), Speed (10 m/s), Mass (50 kg), Energy (100 J).

Vectors:

- Quantities that have both magnitude and direction.
- Examples: Displacement (5 m North), Velocity (10 m/s East), Acceleration (2 m/s² Downward), Force (20 N Rightward).

Justification:

- **Distance:** Total path covered, no direction involved, hence scalar.
 - **Speed:** Rate of motion without specifying direction, scalar.
 - **Mass and Energy:** Have magnitude only, hence scalars.
 - **Displacement:** Involves magnitude and direction, vector.
 - **Velocity:** Speed with direction, vector.
 - **Acceleration and Force:** Both involve direction along with magnitude, making them vectors.
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11. Justify and illustrate the use of a measuring cylinder to measure the volume of a liquid.

Justification:

A measuring cylinder is a transparent container with graduations (markings) that allow precise measurement of liquid volume. It is used because of its accuracy and ease of handling.

Illustration:

1. **For Liquids:** Pour the liquid into the cylinder and note the volume at the bottom of the meniscus (the curved surface of the liquid).
2. **For Irregular Objects (Archimedes' Principle):**
 - Fill the cylinder with water and note the initial level.
 - Submerge the object completely and note the new water level.
 - The volume of the object is equal to the difference in water levels.

Precautions:

- Place the cylinder on a flat surface.
 - Read the scale at eye level to avoid parallax error.
-

12. Differentiate between precision and accuracy.

Precision:

- Refers to how close repeated measurements are to each other.
- Example: Measuring an object three times and getting results of 4.2 cm, 4.3 cm, and 4.2 cm shows high precision.

Accuracy:

- Refers to how close a measurement is to the actual or true value.
- Example: If the actual length of an object is 4.0 cm and the measurement is 4.1 cm, it is accurate.

Difference:

- Precision focuses on consistency, while accuracy focuses on correctness.
- A result can be precise without being accurate (e.g., all measurements close to each other but far from the true value).

Example (Dartboard):

- High precision: All darts hit the same spot.
- High accuracy: All darts hit the bullseye.

Numerical Problems

1. Write the following numbers in scientific notation:

a) 1234 m

$$1234 = 1.234 \times 10^3$$

b) 0.000023 s

$$0.000023 = 2.3 \times 10^{-5}$$

c) 469.3 × 10⁵

$$469.3 \times 10^5 = 4.693 \times 10^7$$

d) 0.00985 × 10⁷

$$0.00985 \times 10^7 = 9.85 \times 10^4$$

2. Express the following measurements using prefixes:

a) 27.5 × 10⁻¹⁰ m

Convert 10⁻¹⁰ to nm (10⁻⁹):

$$27.5 \times 10^{-10} = 2.75 \text{ nm}$$

b) 0.00023 × 10² s

Convert 0.00023 s into microseconds (μs = 10⁻⁶):

$$0.00023 = 230 \text{ μs}$$

3. If a boy has an age of 15 years, 2 months, and 10 days, convert his age into:

- a. Seconds:**

Convert the time:

$$15 \text{ years} = 15 \times 365 \times 24 \times 60 \times 60 = 473,040,000 \text{ s}$$

$$2 \text{ months} = 2 \times 30 \times 24 \times 60 \times 60 = 5,184,000 \text{ s}$$

$$10 \text{ days} = 10 \times 24 \times 60 \times 60 = 864,000 \text{ s}$$

$$\text{Total} = 473,040,000 + 5,184,000 + 864,000 = 479,088,000 \text{ s}$$

- b. Milliseconds:**

Multiply total seconds by 1000:

$$479,088,000 \times 1000 = 4.79088 \times 10^{11} \text{ ms}$$

- c. Megaseconds:**

Divide total seconds by 10⁶:

$$479,088,000 \div 10^6 = 479.088 \text{ Ms}$$

4. How many kilometers are there in 25 micrometers?

Convert micrometers to kilometers:

$$1 \mu\text{m} = 10^{-6} \text{ m} \quad \mu\text{m} = 10^{-6} \text{ m}$$

$$1 \text{ km} = 10^3 \text{ m} \quad \text{km} = 10^3 \text{ m}$$

$$25 \mu\text{m} = 25 \times 10^{-6} \text{ m} = 2.5 \times 10^{-8} \text{ km} \quad 25 \mu\text{m} = 25 \times 10^{-6} \text{ m} = 2.5 \times 10^{-8} \text{ km}$$

5. What is the pitch and least count of:

a) **Vernier calipers if the smallest division on the main scale is 1 mm, and total divisions on the vernier scale are 10?**

$$\text{Pitch} = 1 \text{ mm}$$

Least count =

$$\text{Least count} = \frac{\text{Smallest main scale division}}{\text{Number of vernier scale divisions}}$$

$$\text{Least count} = \frac{1 \text{ mm}}{10} = 0.1 \text{ mm}$$

$$\text{Least count} = 1 \text{ mm} / 10 = 0.1 \text{ mm}$$

b) **Screw gauge if the smallest division on the main scale is 0.5 mm, and its movable scale has 50 divisions?**

$$\text{Pitch} = 0.5 \text{ mm}$$

Least count =

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of circular scale divisions}}$$

$$\text{Least count} = \frac{0.5 \text{ mm}}{50} = 0.01 \text{ mm}$$

$$\text{Least count} = 0.5 \text{ mm} / 50 = 0.01 \text{ mm}$$

6. Look at the measurement of vernier calipers:

a) **What is its main scale reading?**

The main scale reading before the 0 mark of the vernier is 3 cm.

b) **What is its coinciding division on the vernier scale?**

The 4th division of the vernier scale coincides with the main scale.

c) **Calculate the total reading on the vernier calipers:**

$$\text{Total reading} = \text{Main scale reading} + (\text{Vernier scale division} \times \text{Least count})$$

$$\text{Least count} = 0.01 \text{ cm} \quad \text{Least count} = 0.01 \text{ cm}$$

$$\text{Total reading} = 3.0 + (4 \times 0.01) = 3.04 \text{ cm} \quad \text{Total reading} = 3.0 + (4 \times 0.01) = 3.04 \text{ cm}$$

7. Look at the figure of screw gauge:

a) **What is its main scale reading?**

The main scale reading is 0.5 mm.

b) **What is the coinciding division of the circular scale?**

The coinciding division on the circular scale is 45.

c) **Calculate the total diameter of the ball:**

$$\text{Total reading} = \text{Main scale reading} + (\text{Circular scale division} \times \text{Least count})$$

$$\text{Least count} = 0.01 \text{ mm} \quad \text{Least count} = 0.01 \text{ mm}$$

$$\text{Total diameter} = 0.5 + (45 \times 0.01) = 0.5 + 0.45 = 0.95 \text{ mm}$$

Let me know if further explanation is needed!

Extera Short Topic Wise

1.1 Introduction to Physics

Q1: What is physics?

A: Physics is the study of matter, energy, and the fundamental laws of nature. It explains phenomena like motion, forces, light, sound, and the structure of the universe.

Q2: Why is physics called the fundamental science?

A: Physics is considered fundamental because it provides basic principles that underlie other sciences like chemistry, biology, and geology.

Q3: How does physics contribute to technology?

A: Physics drives technological advancements such as electric motors, medical imaging devices, and communication systems like smartphones.

Q4: Name and explain two branches of physics.

A:

1. **Mechanics:** Studies motion and forces; applications include vehicle dynamics.
 2. **Electromagnetism:** Explores electric and magnetic fields; used in electric generators and motors.
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1.2 Physical and Non-physical Quantities

Q1: Define physical quantities with examples.

A: Physical quantities are measurable properties of matter, like mass (kg), time (s), and temperature (K).

Q2: What are non-physical quantities?

A: Non-physical quantities are abstract concepts like emotions, thoughts, and ideas, which cannot be measured.

Q3: What are the two types of physical quantities?

A:

1. **Base Quantities:** Fundamental quantities, such as mass and time.
2. **Derived Quantities:** Quantities derived from base quantities, like velocity and acceleration.

Q4: How are physical quantities used in experiments?

A: Physical quantities ensure precise measurement and analysis, enabling reproducibility and accuracy in scientific studies.

1.3 International Systems of Units (SI Units)

Q1: What is the International System of Units (SI)?

A: The SI system is a globally accepted system of measurement based on seven base units like meter (length) and kilogram (mass).

Q2: Why is the SI system important?

A: It standardizes measurements worldwide, ensuring consistency and accuracy in scientific and engineering fields.

Q3: Name the seven base quantities and their SI units.

A:

1. Length: Meter (m)
2. Mass: Kilogram (kg)
3. Time: Second (s)
4. Electric Current: Ampere (A)
5. Temperature: Kelvin (K)
6. Amount of Substance: Mole (mol)
7. Luminous Intensity: Candela (cd)

Q4: What are derived units in the SI system?

A: Derived units are combinations of base units, like Newton (N) for force and Pascal (Pa) for pressure.

1.4 Standard Form/Scientific Notation

Q1: What is scientific notation?

A: Scientific notation expresses large or small numbers in the form $N \times 10^n$, where N is a number between 1 and 10, and n is an integer.

Q2: Why is scientific notation used?

A: It simplifies calculations involving extremely large or small values, like the speed of light (3×10^8) or the mass of an electron (9.11×10^{-31}).

Q3: Convert 0.00045 into scientific notation.

A: $0.00045 = 4.5 \times 10^{-4}$

Q4: Convert 7.2×10^3 to its standard form.

A: $7.2 \times 10^3 = 7200$

Q5: How does scientific notation aid in physics?

A: It makes handling extremely large or small measurements manageable, reducing errors in calculations.

1.5 Prefixes to Power of 10

Q1: What are prefixes in the SI system?

A: Prefixes represent powers of ten to scale units up or down, such as kilo (10^3) or milli (10^{-3}).

Q2: What is the prefix for 10^6 ?

A: Mega (M).

Q3: Convert 0.001 kg to grams using prefixes.

A: $0.001 \text{ kg} = 1 \text{ g}$

Q4: List three commonly used SI prefixes with their powers of 10.

A:

1. Kilo (10^3)
2. Milli (10^{-3})
3. Micro (10^{-6})

Q5: Why are prefixes important in scientific measurements?

A: They allow compact representation of very large or small quantities, simplifying calculations and communication.

1.6 Scalars and Vectors

Q1: What is a scalar quantity?

A: A scalar quantity has only magnitude, such as mass (50 kg) or speed (20 m/s).

Q2: What is a vector quantity?

A: A vector quantity has both magnitude and direction, such as force (10 N east) or velocity (30 m/s north).

Q3: Differentiate between scalars and vectors with examples.

A: Scalars: Speed, Energy. Vectors: Velocity, Force.

Q4: Why is it important to differentiate between scalars and vectors?

A: Scalars simplify calculations, while vectors provide complete information about direction and magnitude.

1.7 Measuring Instruments

Q1: What is a vernier caliper used for?

A: Measuring the length, diameter, or depth of objects with high precision.

Q2: What is the least count of a screw gauge?

A: The least count is typically 0.01 mm.

Q3: How is a measuring cylinder used to find the volume of an irregular object?

A: By submerging the object in water and calculating the volume of displaced water.

Q4: Why is calibration important for measuring instruments?

A: It ensures accuracy and reliability in measurements.

1.8 Errors

Q1: What are random errors?

A: Errors caused by unpredictable factors like environmental conditions.

Q2: What are systematic errors?

A: Errors caused by flawed instruments or experimental setup.

Q3: How can random errors be minimized?

A: By taking multiple readings and averaging them.

Q4: How can systematic errors be reduced?

A: By using well-calibrated instruments and correcting procedural flaws.

1.9 Precision and Accuracy

Q1: What is precision?

A: Precision refers to the consistency of repeated measurements.

Q2: What is accuracy?

A: Accuracy refers to how close a measurement is to the true value.

Q3: Can a measurement be precise but not accurate? Explain with an example.

A: Yes, for example, repeatedly measuring 4.1 cm for an object that is actually 5.0 cm .

Q4: Why are precision and accuracy both important in experiments?

A: Precision ensures reproducibility, while accuracy ensures correctness.

1.10 Significant Figures

Q1: What are significant figures?

A: Significant figures are digits in a measurement that convey meaningful precision.

Q2: How do significant figures prevent rounding errors?

A: By maintaining consistent precision in calculations.

Q3: Identify the number of significant figures in 0.004500 .

A: Three significant figures.

Q4: Why are significant figures important in physics?

A: They ensure precision and clarity in reporting measurements and results.

Extera Long (Topic Wise)

Physics: Important Long Questions

1. Discuss the role of physics in everyday life and technological advancements.

Physics is the study of matter, energy, and the fundamental laws governing nature. Its significance in everyday life and technological advancements cannot be overstated. In daily life, physics explains simple phenomena such as the motion of a car, the flow of electricity in circuits, and even the way sound travels to our ears. For example, Newton's laws of motion help us understand how objects move, while the principles of thermodynamics allow us to design efficient home heating systems.

Physics is the foundation of numerous technological advancements. It has enabled the invention of electric motors, airplanes, and medical imaging devices like X-rays and MRIs. The principles of electromagnetism have revolutionized communication technologies, including mobile phones and the internet. Moreover, advancements in quantum physics have paved the way for modern computing and semiconductors.

In addition, physics contributes significantly to environmental sustainability. For instance, the study of renewable energy sources such as solar panels and wind turbines relies on physical principles. Understanding energy efficiency and heat transfer is crucial for developing eco-friendly technologies. Overall, physics not only enriches our understanding of the universe but also drives progress in various fields, making it indispensable in both science and society.

2. Explain the International System of Units (SI) and its importance in scientific measurements.

The International System of Units (SI) is a standardized system of measurement adopted globally to ensure uniformity and accuracy in scientific, engineering, and everyday measurements. It is based on seven fundamental quantities: length (meter), mass (kilogram), time (second), electric current (ampere), temperature (kelvin), amount of substance (mole), and luminous intensity (candela).

The SI system simplifies communication and collaboration in science and technology. For example, when scientists from different countries share research data, using SI units eliminates confusion caused by regional measurement systems. It also ensures precision in calculations, as the SI system is based on universally accepted constants.

Derived units, such as newton (N) for force and joule (J) for energy, are combinations of base units, making the SI system versatile. Prefixes like "kilo" ($\times 10^3$) and "milli" ($\times 10^{-3}$) allow representation of large or small quantities efficiently. For instance, the mass of a small particle can be expressed in micrograms (μg), while the distance to a star is measured in light-years.

The SI system's importance lies in its consistency and universality. It forms the backbone of scientific research, engineering designs, and global trade. Without it, accurate communication of measurements and standardization in industries would be impossible, leading to inefficiencies and errors.

3. Differentiate between scalars and vectors with examples and their significance in physics. Scalars and vectors are two fundamental types of physical quantities in physics. Scalars are quantities that have only magnitude, while vectors have both magnitude and direction. This distinction is essential in understanding and analyzing physical phenomena.

Scalars: Examples of scalar quantities include mass, temperature, time, speed, and energy. For instance, a car's speed of 60 km/h is a scalar because it does not specify direction. Scalars are simpler to work with mathematically, as they involve basic addition, subtraction, and multiplication.

Vectors: Examples of vector quantities include velocity, displacement, force, and acceleration. For instance, if a car is moving at 60 km/h north, the velocity specifies both magnitude and direction, making it a vector. Vectors are represented graphically using arrows, where the arrow's length indicates magnitude, and its orientation shows direction.

In physics, vectors are crucial for analyzing forces, motion, and fields. For example, in projectile motion, the vector components of velocity (horizontal and vertical) determine the path of the object. Similarly, understanding forces acting in different directions requires vector addition.

The significance of scalars and vectors lies in their application to real-world problems. Scalars provide a basic understanding of quantities, while vectors allow detailed analysis of physical systems, making them indispensable in physics.

4. Describe errors in measurements, their types, and methods to minimize them.

Errors in measurements refer to the deviations of measured values from the true value. These errors arise due to limitations in measuring instruments, environmental conditions, or human factors. Understanding errors is essential for improving accuracy and reliability in experiments.

Types of Errors:

1. **Random Errors:** These occur unpredictably due to environmental fluctuations or observer errors. For example, changes in temperature or slight variations in reading an instrument can cause random errors. They can be minimized by taking multiple measurements and averaging the results.
2. **Systematic Errors:** These are consistent and arise due to faulty instruments, improper calibration, or procedural flaws. For instance, a weighing scale that is improperly zeroed will consistently give incorrect readings. Systematic errors can be reduced by regularly calibrating instruments and following standardized procedures.
3. **Gross Errors:** These are human errors caused by mistakes in observation or recording data. For example, misreading a scale or writing down incorrect values.

Minimizing Errors:

- Use precise and calibrated instruments.
- Take repeated measurements to identify outliers.
- Ensure environmental conditions are stable during experiments.
- Follow standard operating procedures to reduce human errors.

By understanding and addressing errors, scientists and engineers can ensure the validity of their results, leading to accurate and reliable conclusions.

5. Discuss precision, accuracy, and significant figures in measurements.

Precision and Accuracy: Precision refers to the consistency of repeated measurements, while accuracy measures how close a measurement is to the true value. For example, if a ruler repeatedly measures an object's length as 4.0 cm, the measurements are precise. If the true length is also 4.0 cm, the measurement is both precise and accurate. However, if the true length is 5.0 cm, the result is precise but not accurate.

Significant Figures: Significant figures represent the meaningful digits in a measurement, indicating its precision. For instance, in 4.0 cm, all four digits are significant, showing a high level of precision. Significant figures prevent overestimation of accuracy in calculations.

Importance in Physics: Precision and accuracy ensure reliable measurements in experiments, while significant figures maintain consistency in reporting results. For example, when calculating the speed of light, reporting it as with three significant figures reflects the precision of the measurement.

To improve precision, scientists use high-quality instruments and stable environments. To enhance accuracy, they calibrate tools and follow standardized methods. Together, precision, accuracy, and significant figures form the backbone of scientific measurements, ensuring reliability and reproducibility in experiments.

Physics MCQs with Highlighted Answers

1. What is the study of matter, energy, and their interactions called?

- Chemistry
- Biology
- Physics
- Geology

2. What is the SI unit of force?

- Joule
- Pascal
- Newton
- Watt

3. What is the standard prefix for 10^3 ?

- Milli
- Micro
- Kilo
- Mega

4. How many base quantities are in the SI system?

- 5
- 6
- 7
- 8

5. What is the value of acceleration due to gravity?

- 8.9 m/s^2
- 9.8 m/s^2
- 10.2 m/s^2
- 9.2 m/s^2

6. Which of the following is a vector quantity?

- Speed
- Energy
- Velocity
- Time

7. What is the scientific notation for 0.00034?

- 3.4×10^{-5}
- 3.4×10^{-3}
- 3.4×10^{-4}
- 3.4×10^{-6}

8. What instrument is used to measure the diameter of a sphere?

- Screw gauge
- Vernier caliper
- Measuring tape
- Ruler

9. What is the least count of a vernier caliper?

- 0.1 mm
- 0.01 mm
- 1 mm
- 0.001 mm

10. What does precision in measurement mean?

- Closeness to true value
- Closeness of repeated values
- Closeness to expected value
- None of these

11. What are significant figures?

- A random value
- Meaningless digits
- Meaningful digits in a measurement
- Approximate numbers

12. What is a scalar quantity?

- A quantity with magnitude and direction
- A quantity with only magnitude
- A unitless value
- None of these

13. What is a vector quantity?

- A quantity with only magnitude
- A quantity with magnitude and direction
- A constant value
- None of these

14. What is the SI unit of temperature?

- Celsius
- Fahrenheit
- Kelvin
- Rankine

15. Which branch of physics deals with light?

- Mechanics
- Thermodynamics
- Optics
- Electromagnetism

16. What is the SI unit of pressure?

- Newton
- Joule
- Pascal
- Watt

17. What is the formula for speed?

- Time / Distance
- Distance $\times$ Time
- Distance / Time
- None

18. What is the least count of a screw gauge?

- 0.1 mm
- 0.01 mm
- 1 mm
- 0.001 mm

19. What is the unit of energy in the SI system?

- Newton
- Watt
- Joule
- Pascal

20. What is the prefix for 10^{-3} ?

- Micro
- Milli
- Nano
- Centi

21. What is the formula for force?

- Mass $\times$ Velocity
- Mass $\times$ Acceleration
- Velocity $\times$ Time
- None

22. What is the value of 1 m/s in km/h?

- 1 km/h

- 3.6 km/h
- 6.3 km/h
- 0.36 km/h

23. What is the speed of light in a vacuum?

- 3×10^6 m/s
- 3×10^8 m/s
- 3×10^{10} m/s
- None

24. What is the relationship between force, mass, and acceleration?

- Force = Mass / Acceleration
- Force = Mass $\times$ Acceleration
- Force = Acceleration / Mass
- None

25. What is the formula for work?

- Force $\times$ Distance
- Force / Distance
- Energy $\times$ Time
- None

26. What is the SI unit of electric current?

- Watt
- Newton
- Ampere
- Joule

27. What is the formula for acceleration?

- (Final velocity - Initial velocity) / Time
- (Final velocity $\times$ Initial velocity) / Time
- Velocity / Time
- None

28. What does a flat line on a speed-time graph indicate?

- Accelerating motion
- Decelerating motion
- Constant speed
- Stationary object

29. What is the prefix for 10^6 ?

- Giga
- Mega

- Kilo
- None

31. What is the branch of physics that deals with heat and temperature?

- Mechanics
- Optics
- Thermodynamics
- Electromagnetism

32. What is the unit of power in the SI system?

- Joule
- Newton
- Watt
- Pascal

33. What is the prefix for 10^{-6} ?

- Milli
- Micro
- Nano
- Pico

34. What does the slope of a speed-time graph represent?

- Speed
- Distance
- Acceleration
- Time

35. What is the formula for density?

- Mass / Volume
- Mass $\times$ Volume
- Volume / Mass
- None

36. What is the SI unit of luminous intensity?

- Lumen
- Candela
- Lux
- Watt

37. What does the area under a speed-time graph represent?

- Acceleration
- Distance traveled

- Speed
- Time

38. What is the acceleration of an object in free fall?

- 10 m/s^2
- 9.8 m/s^2
- 9.2 m/s^2
- 8.9 m/s^2

39. What is the unit of frequency?

- Hertz
- Watt
- Newton
- Pascal

40. What is the formula for momentum?

- Mass $\times$ Acceleration
- Mass $\times$ Velocity
- Force $\times$ Distance
- None

41. What is the SI unit of electric charge?

- Coulomb
- Ampere
- Volt
- Ohm

42. What is the unit of potential difference?

- Watt
- Ampere
- Volt
- Coulomb

43. What does the term 'inertia' refer to?

- Resistance to change in motion
- Acceleration
- Momentum
- Force

44. What is the SI unit of magnetic flux?

- Tesla
- Weber
- Ampere

- Ohm

45. What is the formula for kinetic energy?

- mgh
- $\frac{1}{2}mv^2$
- mv
- None

46. What is the formula for pressure?

- Force $\times$ Area
- Force / Area
- Area / Force
- None

47. What is the SI unit of work?

- Newton
- Joule
- Watt
- Pascal

48. What is the term for materials that do not allow current to pass through?

- Conductors
- Insulators
- Resistors
- Capacitors

49. What is the SI unit of capacitance?

- Ohm
- Farad
- Volt
- Coulomb

50. What is Newton's first law of motion also known as?

- Law of Acceleration
- Law of Inertia
- Law of Action-Reaction
- None

51. What is the speed of sound in air at room temperature?

- 300 m/s
- 343 m/s
- 330 m/s
- 360 m/s

52. What does the term 'wavelength' refer to?

- Speed of a wave
- Height of a wave
- Distance between two consecutive peaks
- Amplitude

53. What is the formula for gravitational potential energy?

- $\frac{1}{2} mv^2$
- mgh
- mv
- None

54. What is the primary cause of tides on Earth?

- Gravitational pull of the Sun
- Gravitational pull of the Moon
- Wind
- Ocean currents

55. What is the SI unit of resistance?

- Volt
- Ampere
- Ohm
- Coulomb

56. What does Hooke's Law state?

- Force is inversely proportional to extension
- Force is proportional to extension
- Force is constant
- None

57. What is the formula for power?

- $\text{Work} \times \text{Time}$
- $\text{Work} / \text{Time}$
- $\text{Time} \times \text{Force}$
- None

58. What is the term for the bending of light as it passes through a medium?

- Reflection
- Refraction
- Diffraction
- Dispersion

59. What is the unit of angular velocity?

- Degree per second
- Radian per second
- Meter per second
- None

60. What is the formula for angular momentum?

- Force $\times$ Distance
- Mass $\times$ Velocity
- Moment of Inertia $\times$ Angular Velocity
- None