1 CHAPTER

PHYSICAL QUANTITIES AND MEASUREMENTS

INTRODUCTION TO PHYSICS

We are living in a physical world where we observe many natural phenomena and objects around us such as Sun, stars, moon, oceans, plants, winds, rains, etc. People have always been curious to know the reality of such happenings. This has led certain people to investigate the facts and laws working in this world. This field of observation and experimentation to understand about the world around us is known as science. Everything in our lives is closely linked to science and the discoveries made by the scientists. In order to obtain reliable results from experiments, the primary thing is to make accurate measurements.

Physical quantities and their measurements have always been the matter of interest for the scientists. They have been investigating to improve the methods and instruments for accurate measurements of the physical quantities. In this chapter, we will discuss physical quantities, their measurements and related contents.

1.1PHYSICAL AND NON-PHYSICAL QUANTITIES

LONG QUESTIONS

Q.1 What are physical quantities? Write a note on their types.

Ans:

PHYSICAL QUANTITIES

Definition:

"Physical quantities are those quantities which can be measured using tools and instruments whereas non-physical quantities are those quantities which cannot be measured using tools and instruments".

Examples of Physical Quantities:

Length, mass, time, density, temperature, etc.

Examples of non-Physical Quantities:

Characteristics of Physical Quantities:

A physical quantity possesses at least two characteristics in common.

- Physical quantity consists of numerical magnitude (number representing the size of the quantity).
- Unit in which it is measured.

Example:

If the length of the person is 1.65 meters (5 foot and 5 inches), 1.65 is the numerical magnitude and meter is the unit of measurement.

TYPES OF PHYSICAL QUANTITIES

There are two types of physical quantities.

(i) Base Quantities (ii) Derived Quantities

BASE QUANTITIES

Definition:

Base (or fundamental) physical quantities (like mass, length and time) are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them.

OR

The scientists have selected arbitrarily some quantities to play a key role. They are called base quantities.

Base quantities, Their SI Units with Symbols.

TABLE 1.1 BASE UNITS FOR INTERNATIONAL SYSTEM OF UNITS	
SI Base Quantity	**SI Derived Unit**
NAME	**SYMBOL**
Length	ℓ
Mass	m
Time	t
Electric current	I
Temperature	T
Amount of substance	n
Intensity of light	I

DERIVED QUANTITIES

Definition:

The physical quantity obtained by multiplying or dividing base physical quantities are termed as the derived physical quantities.

OR

All the quantities which can be described in terms of one or more base quantities are called derived physical quantities.

Table 1.2 Derived units for international system of units	
Derived Quantity	**SI Derived Unit**
Name	**Symbol**
Area	A
Volume	V
Speed, velocity	v
Acceleration	a
Density	ρ
Force	F
Pressure	P
Energy	E

Q.2 How can a Physical Quantity be measured?

Ans:

Measurement:

A measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity.

Component of measurement:

A measurement consists of two parts,

- a number
- a unit.

A measurement without unit is meaningless.

Unit:

To avoid any confusion, there is a need of a standard so that measurement by any person may result the same. This standard of measurement is known as a unit.

Explanation:

In the early day's people used to measure length using hand or arm, foot or steps. This measurement may result in confusion as the measurement of different people may differ from each other because of different sizes of their hands, arms or steps.

Need of common system:

Not very far in the past, every country in the world had its own units of measurements. However, problems were faced when people of different countries exchanged scientific information or traded with other countries using different units. Eventually, people got the idea of standardizing the units of measurements which could be used by all countries for efficient working and growth of mutual trade, business and share scientific information.

INTERNATIONAL SYSTEM OF UNITS

Q.1 What is international system of units? Write a role development in of science.

Ans: INTERNATIONAL SYSTEM OF UNITS

Introduction:

A complete set of units for all physical quantities is called system of units.

The international system of units is termed as System International (abbreviated as SI), a short form of the French name 'System international d' Units' which means 'International system of Units'.

Use of SI measurements helps all scientists to share and compare their observations and results easily. The seven base units and their values are fixed with reference to international standards.

Definition:

The international committee on weights and measures in 1961 recommended the use of a system consisted of seven base units known as international system of units, abbreviated as SI. This system is in use all over the world.

Types:

- Base units
- Derived units

BASE UNITS

Definition:

"Base (or fundamental) physical quantities (like mass, length and time are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them."

Formation:

Each base quantity has its SI unit, as defined by International System of units. Base units are seven in numbers.

Base Quantities, Their SI Units with Symbols:

Base quantities with their S.I units are as follows:

QUANTITIES		UNITS	
Name	**Symbol**	**Name**	**Symbol**
Length	ℓ	Meter	m
Mass	m	Kilogram	Kg
Time	t	Second	s
Electric current	I	Ampere	A
Intensity of light	L	Candela	Cd
Temperature	T	Kelvin	K
Amount of a substance	n	Mole	mol

DERIVED UNITS

Definition:

Units of derived quantities are obtained by multiplying and or dividing base quantities. In SI units all other physical quantities can derived from the seven base units.

Formation:

Derived units are defined in terms of base units and are obtained by multiplying or dividing one or more base units with each other. They are multiples in number.

Derived Quantities, Their SI Units with Symbols:

Derived quantities with their S.I units are as follows:

DERIVED UNITS FOR INTERNATINAL SYSTEM OF UNITS		
Derived Quantity	**SI Derived Unit**	
Name	**Name**	**Symbol**
Area	Square meter	m^2
Volume	Cubic meter	m^3
Speed, velocity	Meter per second	ms^{-1}
Acceleration	Meter per second squared	ms^{-2}
Density	Kilogram per cubic meter	kgm^{-3}
Force	newton (N)	$kgms^{-2}$
Pressure	Pascal (Pa)	$kgm^{-1}s^{-2}$
Energy	joule (J)	kgm^2s^{-2}

SHORT QUESTIONS

Q.1 Define Science.

Ans:

SCIENCE

Definition:

"This field of observation and experimentation to understand about the world around us is known as science."

Importance:

Everything in our lives is closely linked to science and the discoveries made by the scientists. In order to obtain reliable results from experiments, the primary thing is to make accurate measurements".

Q.2 Define Physics?

Ans:

PHYSICS

Definition:

"Physics is a science of physical world where we interact with many different types of material objects".

Q.3 What are Physical quantities?

Ans:

PHYSICAL QUANTITIES

Definition:

"Physical quantities are those quantities which can be measured whereas no physical quantities are those quantities which cannot be measured".

Examples:

length, mass, time, density, temperature, etc.

Q.4 What are the basic characteristics of physical quantities?

Ans:

CHARACTERISTICS

A physical quantity possesses at least two characteristics in common.

- Physical quantity consists of numerical magnitude (number representing the size of the quantity).
- Unit in which it is measured

Q.5 Define Unit.

Ans:

Definition:

"To avoid such confusion, there is a need of a standard so that measurement by any person may result the same. This standard of measurement is known as a unit."

Examples:

The unit of length is meter.
The unit of mass is kilogram.

Q.6 What are Base quantities? Enlist them.

Ans:

BASE QUANTITIES

Definition:

"Base (or fundamental) physical quantities (like mass, length and time are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them."

Base Quantities, Their SI Units with Symbols:

Base quantities with their S.I units are as follows:

QUANTITIES		UNITS	
Name	**Symbol**	**Name**	**Symbol**
Length	L	Meter	m
Mass	m	Kilogram	Kg
Time	T	Second	s
Electric current	I	Ampere	A
Intensity of light	L	Candela	Cd
Temperature	T	Kelvin	K
Amount of a substance	n	Mole	mol

Q.7 What are Derived quantities?

Ans:

DERIVED QUANTITIES

Definition:

The physical quantity obtained by multiplying or dividing base physical quantities are termed as the derived physical quantities.

Derived Quantities, Their SI Units with Symbols:

DERIVED UNITS FOR INTERNATINAL SYSTEM OF UNITS			
Derived Quantity		**SI Derived Unit**	
Name	**Symbol**	**Name**	**Symbol**
Area	A	Square meter	m^2
Volume	V	Cubic meter	m^3
Speed, velocity	v	Meter per second	ms^{-1}
Acceleration	A	Meter per second squared	ms^{-2}
Density	ρ	Kilogram per cubic meter	kgm^{-3}
Force	F	newton (N)	$kgms^{-2}$

Q.8 What are Base units? Write their names and symbols.

Ans:

BASE UNITS

Definition:

"Base (or fundamental) physical quantities (like mass, length and time are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them."

Formation:

Each base quantity has its SI unit, as defined by International System of units. Base units are seven in numbers.

Base Quantities, Their SI Units with Symbols:

Base quantities with their S.I units are as follows:

QUANTITIES	
Name	**Symbol**
Length	ℓ
Mass	m
Time	T
Electric current	I
Intensity of light	L
Temperature	T
Amount of a substance	n

Q.9 What are derived units?

Ans:

DERIVED UNITS

Definition:

Units of derived quantities are obtained by multiplying and or dividing base quantities. In SI units all other physical quantities can derived from the seven base units.

Formation:

Derived units are defined in terms of base units and are obtained by multiplying or dividing one or more base units with each other. They are multiples in number.

Derived Quantities, Their SI Units with Symbols:

Derived quantities with their S.I units are as follows:

DERIVED UNITS FOR INTERNATINAL SYSTEM OF UNITS	
SI Derived Unit	
Name	**Symbol**
Square meter	m^2
Cubic meter	m^3
Meter per second	ms^{-1}
Meter per second squared	ms^{-2}
Kilogram per cubic meter	kgm^{-3}
newton (N)	$kgms^{-2}$
Pascal (Pa)	$kgm^{-1}s^{-2}$
joule (J)	kgm^2s^{-2}

Q.10 How can you differentiate between base and derived quantities?

Ans: **DIFFERENTIATION**

Definition:

Differences between Base and Derived quantities are as follows:

BASE QUANTITIES	DERIVED QUANTITIES
Definition	
• Base (or fundamental) physical quantities (like mass, length and time are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them.	• The physical quantity obtained by multiplying or dividing base physical quantities are termed as the derived physical quantities.
Unit	
• The units used to describe base quantities are called base units.	• The units to describe derived quantities are called derived units.

MULTIPLE CHOICE QUESTIONS

The branch of science which deals with the study of properties of matter, energy and their mutual relationship is called:
(A) Astronomy **(B) Physics**
(C) Geology (D) Chemistry

1 **The international system of units is abbreviated as:**
(A) IS **(B) SI**
(C) Both a & b (D) none

2. **Which one of the following is a derived unit?**
(A) kg **(B) m^3**
(C) kelvin (D) mole

3. **The SI unit of luminous intensity is:**
(A) Newton (B) Kelvin
(C) Kilogram **(D) Candela**

4. **Amount of a substance in terms of numbers is measured in:**
(A) Gram (B) kilogram
(C) Newton **(D) mole**

5. **Identify the base quantity in the following:**
(A) Speed (B) Area
(C) Force **(D) Distance**

6. **S.I unit of pressure is:**
(A) Pa (B) Nm^2
(C) Nm^{-2} **(D) Both (A) and (C)**

QUICK QUIZ

TABLE 1.1:

Feature	Physical Quantity	Non-Physical Quantity
1.Measurement	YES	NO
2.Instrument used	YES	NO
3.Numericalvalueand unit	YES	NO
4.Examples	1. length 2. time	1. love 2. fear

SHORT QUESTIONS FROM QUICK QUIZ

Q.1 Is a non-physical quantity has dimensions?

Ans: **No,** a non-physical quantity do not have dimensions.

Reason: These quantities are unit less or scalar number that do not have dimensions.

Q.2 Write the unit of charge in terms of base unit ampere and second.

Ans: the unit of charge in terms of base unit is

1 Coulomb=1 As (Ampere second)

Q. 3 Express the unit of pressure "Pascal" in some other units.

Ans: Unit of pressure in some other units is

1 Pascal= 1 Nm^{-2} (newton per meter square)

1.4 STANDARD FORM / SCIENTIFIC NOTATION
1.3PREFIXES TO POWER OF TEN

LONG QUESTIONS

Q.1 Define and Explain Scientific Notation.

Ans: **SCIENTIFIC NOTATION**

Introduction:

It is short way of representing very large or very small numbers. Writing otherwise, the values of these quantities, take up much space. They are difficult to read, their relative sizes are difficult to visualize and they are awkward to use in calculations. Their decimal places are more conveniently expressed as powers of 10.

Definition:

The numerical part of the quantity is written as a number from 1 to 9 multiplied by whole number power of 10.

Rule:

"To write numbers using scientific notation, move the decimal point until only one non-zero digit remains on the left. Then count the number of places through which the decimal point is moved and use this number as the power or exponents of 10**"**.

number = mantissa × $10^{exponent}$

Examples:

The average distance from the Sun to the Earth is 138,000,000 km. In scientific notation, this distance would be written as 1.38 10^8 km. The number of places, decimal moved to the left is expressed as a positive exponent of 10. Diameter of hydrogen atom is about 0.000,000,000,052m. To write this number in scientific notation, the decimal point is moved 11 places to the right. A sa result, the diameter is written as 5.2 10^{-11}m.The number of places moved by the decimal to the right is expressed as a negative exponent of 10.

Q.2 Define Prefixes with examples and write their advantages.

Ans: **PREFIXES**

Definition:

"Prefixes are the words or symbols added before SI unit such as milli centi, kilo, mega, giga.**"**.

The SI is a decimal system Prefixes are used to write units by powers of 10. The big quantities like 50000000 m and small quantities like 0.00004 m are not convenient to write down. The use of prefixes makes them simple. The quantity 50000000m can be written as $_{5}10^{7}$m. Similarly, the quantity 0.00004 m can be written as $_{4}10^{5}$m.

i.e. kilometer some prefixes in SI to replace powers of 10 are given in table 1.4.

Table 1.4: Prefixes used with SI units

Prefix	Symbol	Powers of Ten	Prefix	Symbol	Powers of Ten	Prefix	Symbol	Powers of Ten
Atto	a	10^{-18}	centi	c	10^{-2}	peta	P	10^{15}
femto	f	10^{-15}	deci	d	10^{-1}	exa	E	10^{18}
Pico	p	10^{-12}	kilo	K	10^{3}			
Nano	n	10^{-9}	mega	M	10^{6}			
micro	μ	10^{-6}	giga	G	10^{9}			
Milli	m	10^{-3}	tera	T	10^{12}			

For Example:

a. The number of seconds in a day are:
$86400s = 8.64 \times 10^4 s = 86.4 \times 10^3 s = 86.4ks$.

b. The distance to the nearest start alpha centauri is:
$4.132 \times 10^{16} m = 41.32 \times 10^{15} m = 41.23Pm$

c. The thickness of the pages of the page of this book is about:
4.0×10^{-5} m = 40×10^{-3}m = 40mm

d. 1.0×10^{-4} g = 100×10^{-2} g = 100mg

Q.3 What are the rules of writing Prefixes?

Ans:

RULES

Use of SI units require special care, particularly in writing prefixes.

- Use of SI units require special care, particularly in writing prefixes.
- Symbols do not take plural form. Forexample,10mN,100N,5kg,60s.
- Full name of unit does not begin with capital letter. For example, metre, second, newton except Celsius.
- Symbols appear in lower case, m for metre, s for second, exception is only L for litre.
- Symbols named after scientist's name have initial letters capital. For example, N for newton, K for kelvin and Pa for pascal.
- Units are written one space apart. For example, N m, N s.
- Compound prefixes are not allowed. For example,

i. 7 μ us should be written as 7 ps.

ii. $_5 10^4$cm should be written as 5×10^2 m.

SHORT QUESTIONS

Q.1 Define Scientific Notation.

Ans: **SCIENTIFIC NOTATION**

Definition:

The numerical part of the quantity is written as a number from 1 to 9 multiplied by whole number power of 10.

Examples:

- The mass of earth is 5,980, 000, 000, 000, 000, 000, 000, 000 kg which is written as 5.98×10^{24} kg
- The diameter of hydrogen nucleus is about 0.0000000000000017 meters, which is 1.7×10^{-15}m.
- 0.0045 is written in scientific notation as 4.5×10^{-3}

Q.2 The speed of light is 299,792,458 m/s

(a) Express the number of standard form.

(b) Express speed of light up to three significant figure

Ans: **(a)** A number 299,792458 can be expressed a 2.99792458×10^8 m/s

(b) The above number can be expressed in standard form upto three significant figure is 2.99×10^8 m/s.

Q.3 What do you know about prefixes? OR Define Prefixes also give examples.

Ans: **PREFIXES**

Definition:

"Prefixes are the words or symbols added before SI unit.
centi, kilo, mega, giga**"**.

Examples:

- Kilo (k) = 10^3
- Mega (M) = 10^6
- Giga (G) = 10^9
- Milli (m) = 10^{-3}

Q.4 Why no prefix is used with kilogram?

Ans: **NO PREFIX WITH KILOGRAM**

No prefix is used with kilogram since it already contains the prefix kilo. We cannot use two prefixes together.

Example:

The width of a wire cannot be written as $3\text{m}\mu\text{m}\left(3\times10^{-3}\times10^{-6}\text{m}\right)$ instead it should be written as $3\text{nm}\left(3\times10^{-9}\text{m}\right)$.

Q.5 Write Multiples and Submultiples of Length.

Ans: **MULTIPLES AND SUBMULTIPLES**

Some multiples and submultiples of length are as follows:

Multiples	Submultiples
1km	10^3 m
1cm	10^{-2} m
1mm	10^{-3} m
1µm	10^{-6} m
1nm	10^{-9} m

Q.6 Name five prefixes most commonly used.

Ans: **PREFIXES**

Following are the prefixes most commonly used:

(i) kilo (k) = 10^3
(ii) mega (M) = 10^6
(iii) micro (µ) = 10^{-6}
(iv) milli (m) = 10^{-3}
(v) nano (n) = 10^{-9}

Table 1.5	
100kg 10quintalor 1000kg	1quintal 1tonne

Q.7 Express 1mL = 1 cm³

Ans: **Solution:**

1L = 1000 mL

1L = 1dm^3
= $(10\text{ cm})^3$
= 1000 cm^3
1000 mL = 1000 cm^3 (1dm = 10cm)
1mL = 1 cm_3

Q.8 Express $1m^3 = L$

Ans: Solution:

1 m = 10 dm

Taking cube on both sides

$$\left(1m^3\right) = \left(10dm\right)^3$$

$$1m^3 = 1000dm^3$$

As,

$$1L = 1dm^3$$

Hence,

$$1m^3 = \underline{1000}L$$

EXAMPLE 1.1: SCIENTIFIC NOTATION

Solve the following:

1. $5.123\times10^4m+3.28\times10^5m$

2. $2.57\times10^{-2}mm-3.43\times10^{-3}mm$

SOLUTION

(a) $5.123\times10^4m+3.28\times10^5m$

$=5.123\times10^4m+32.8\times10^4m$

$=(5.123+32.8)10^4m$

$=37.923\times10^4m$

$=3.7923\times10^5m$

(b) $2.57\times10^{-2}mm-3.43\times10^{-3}mm$

$=2.57\times10^{-2}mm-0.343\times10^{-2}mm$

$=(2.57-0.343)10^{-2}mm$

$=2.227\times10^{-2}mm$

$=2.227\times10^{-2}\times10^{-3}m$

$=2.227\times10^{-5}m$

EXAMPLE 1.2: PREFIXES

Find the value of each of the following quantities:

(a) $(4\times10^3kg)(6\times10^6m)$

(b) $\underline{6\times10^6m^3}\ 2\times10^{-2}m^2$

SOLUTION

(a) $(4\times10^3kg)(6\times10^6m) = (4\times6)\times10^{3+6}\ kgm$

$=24\times10^9kgm$

$=2.4\times10^{10}kgm$

(b) $$\frac{6\times10^6\,m^3}{2\times10^{-2}\,m^2} = \frac{6}{2}\times10^{6-(-2)}\,m^{3-2}$$

$$=3\times10^8\,m$$

SHORT QUESTIONS (DO YOU KNOW)

Q.1 Which base unit has prefixes in it?

Ans: The kilogram is the only base unit that has a prefix **(kg)**

Q.2 How addition and subtraction of number is possible?

Ans: Addition and subtraction of numbers is only possible if they have the same exponents. If they do not have the same exponents, make them equal by the displacement of the position of the decimal point

Q.3

Express the following into scientific notation:

a) 0.00534m b) 2574.32kg
c) 0.45m d) 0.004kg
e) 186000s

Solution:

a) $0.00534m = 5.34\times10^{-3} m$

b) $2574.32kg = 2.574\times10^{6} g$

c) $0.45m = 4.5\times10^{-1} m$

d) $0.004kg = 4g$

e) $186000s = 18.6\times10^{4} s$

MULTIPLE CHOICE QUESTIONS

1. **The terms used internationally for multiples and submultiples of various units are known as:**
(A) Standard (B) Scientific notation
(C) Prefixes (D) All of above

2. **One meter is equal to:**
(A) 10^3 mm (B) 10^{-3} km
(C) 10^2 cm **(D) All**

3. **One Femto is equal to:**
(A) 10^{15} **(B) 10^{-15}**
(C) 10^{-9} (D) 10^{-12}

4. **10^6 Stands for:**
(A) micro (B) pico
(C) nano **(D) mega**

5. **1µs is equal to:**
(A) 10^{-9} s (B) 10^{-3} s
(C) 10^{-6} s (D) 10^{-12} s

6. **For scientific notation internationally, accepted practice is that there should be how many digit(s) before the decimal point.**
(A) One (B) Two
(C) Three (D) No

7. **The number of second in a day are**
(A) 85.4 ks (B) 86.4 Ms
(C) 86.4 ks (D) 86.4 s

8. **What is the name and value of the unit of power written as MW?**
(A) megawatt (10^{-3} W) **(B) megawatt (10^6 W)**
(C) milliwatt (10^{-3} W) (D) milliwatt (10^6 W)

9. **100m is equal to:**
a) $1000 \mu m$ b) 1000cm
c)100,000mm d) 1km

1.5 LENGTHMEASURING INSTRUMENTS METRE RULE, MEASURING TYPE, VERNIER CALLIPERS, SCREW GUAGE

SHORT QUESTIONS

Q.1 What is measuring instrument?

Ans:

MEASURING INSTRUMENTS

Physics is built on definitions that are expressed in terms of measurements. For measurements of physical quantities, we need devices termed as measuring instruments. These range from simple objects such as rulers and stopwatches to Atomic Force Microscope (AFM) and Scanning Tunneling Electron Microscope (STEM).

All measuring instruments have some measuring limitations.

Least count is the minimum value that can be measured on the scale of measuring instruments. The measurement of every instrument is therefore limited to its least count.

Q.2 What do you know about Metre Rule?

Ans:

METRE RULE

Introduction:

"A meter rule is a physics laboratory tool, used to measure the length of objects."

Figure: A Metre Rule

Scale:

Meter rules are one meter long (as compared to the standard meter). Meter Rulers usually have 1000 small divisions on them called millimeters.

Least Count:

"The minimum measurement that can be taken by an instrument accurately is called its least count**"**.

The least count of meter rule is 1mm. This is the minimum length that can be accurately measured by the meter rule.

Method to use Meter Rule:

To measure the length of an object, the meter ruler is placed in such a way that its zero coincides one edge of the object and then the reading in front of the other edge is the length of the object.

Precautions:

One common source of error comes from the angle at which an instrument is read. Metre ruler should either be tipped on its edge or read when the person's eye is directly above the ruler.

Parallax Error:

If the meter ruler is read from an angle, such as from point A or C, the object will appear to be of different length. This is known as parallax error.

VERNIER CALLIPERS

Q.3 Write a detail note on Vernier Calipers?

Ans:

VERNIER CALLIPERS

Introduction:

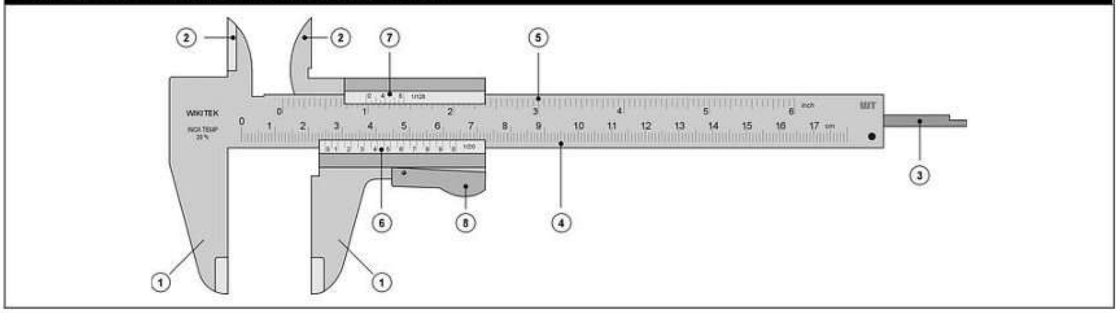
In Physics, sometimes we need to measure a length smaller than 1 mm. A Vernier caliper can help take smaller than a millimeter reading.

Definition:

'It is an instrument used to measure small lengths down to 1/10th of a millimeter. It can be used to measure the thickness, diameter, width or depth of an object.

Construction:

FIGURE: VERNIER CALLIPERS



There are two scales on Vernier caliper.

- As main scale which has markings of usually of 1 mm each and it contains jaw on its left end.

A Vernier (sliding) scale of length 9mm and it is divided into 10 equal parts.

Minimum length which can be measured accurately with the help of a Vernier caliper is called least count (Vernier constant) of Vernier caliper.

There are two Jaws A and B to measure external dimension of an object whereas jaws C and D are used to measure internal dimension of an object. A narrow strip that projects from behind the main scale known as tail or depth gauge is used to measure the depths of a hollow object.

Vernier Constant:

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Hence, Least count = 1M.Sd iv–1V.Sdiv

Usually, the least count is found by dividing the length of one small division on main scale by the total number of divisions on the Vernier scale which is again 1mm/10 = 0.1mm. The parts of the Vernier Calipers

VERNIER CALLIPER DIAGRAM

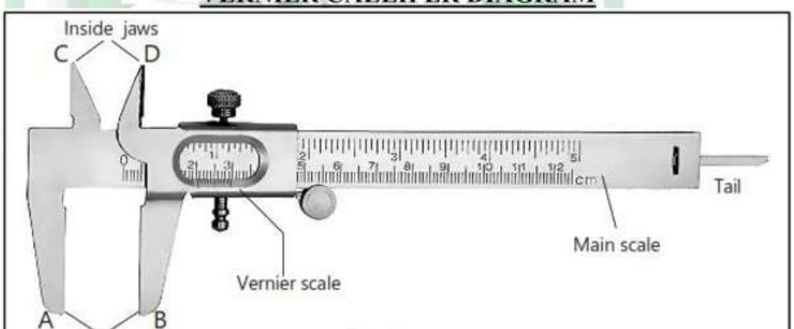


Fig. 1.2

Zero error will exist if zero line of the Vernier scale is not coinciding with the zero of the mains scales.

Measurement using Vernier Calipers

Suppose, an object is placed between the two jaws, the position of the Vernier scale on the main scale is shown in Fig. 1.3.

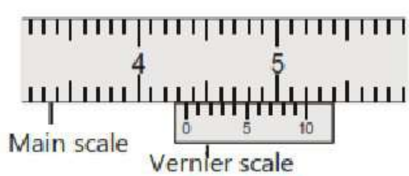


Fig. 1.3

1. Read the main scale marking just in front of zero of the Vernier scale. It shows 4.3 cm.
2. Find the Vernier scale marking or division which is in line with any of the main scale marking. This shows:

Length of object = Main scale reading + (Least count × Vernier scale reading).

$= 4.3 + 0.01 \times 4 = 4.34\text{cm}$

3. Checking for zero error. Following are some important points to keep in mind before checking zero error:

(a) If on joining the jaws A and B, the zeros of the main scale and Vernier scale do not exactly coincide with each other then there is an error in the instrument called zero error.

(b) If the zero of the Vernier scale is on the right side of the zero of the main scale (Fig. 1.4-a) then this instrument will show slightly more than the actual length. Hence, these zero errors are subtracted from the observed measurement.

Zero Error:

To find the zero error, note the number of the division of the Vernier scale which is exactly in front of any division of the main scale. Multiply this number with the least count. The resultant number is the zero error of this instrument. The observed reading is corrected by subtracting the zero error from it.

Types of Zero Errors:

There are two types of zero errors.

- **Positive Zero Error:**

Zero error will be positive if zero line of Vernier scale is on the right side of the zero of the main scale as shown in the figure below:

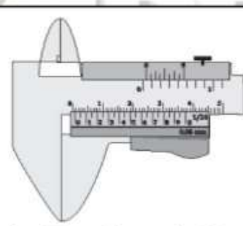


Figure: Positive Zero Error in Vernier Calipers

- **Negative Zero Error:**

Zero error will be negative if zero line of Vernier scale is on the left side of the zero of the main scale.

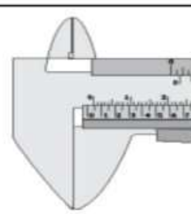


Figure: Negative Zero Error in Vernier Calipers

Zero Correction:

Knowing the zero error, necessary correction can be made to find the correct measurement. Such a correction is called zero correction of the instrument. Zero correction is the negative of zero error.

LABORATORY SAFETY RULES

Q.4 Write down laboratory safety rules?

Ans: **LABORATORY SAFETY RULES**

Laboratory safety rules are as follows:

- Handle all apparatus and chemicals carefully and correctly. Always check the label on the container before using the substance it contains.
- Do not taste any chemical unless otherwise instructed by the teacher.
- Do not eat, drink or play in the laboratory.
- Do not tamper with the electrical mains and other fittings in the laboratory. Never work with electricity near water.
- Don't place flammable substance near naked flames.
- Wash your hands after all laboratory work.

SHORT QUESTIONS

Q.1 Define Vernier Constant or Define Least Count of Vernier Calipers.

Ans: **VERNIER CONSTANT**

Definition:

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Q.2 What is digital Vernier Calipers?

Ans: **DIGITAL VERNIER CALLIPERS**

Digital Vernier Calipers have greater precision than mechanical Vernier Calipers. Least count of Digital Vernier Calipers is 0.01 mm.

Q.3 How many divisions are there on Vernier scale of Vernier Callipers?

Ans: **VERNIER SCALE DIVISIONS**

There are 10 divisions on Vernier scale of the Vernier Callipers. The length of each division is 0.9mm.

Q.4 Write three laboratory safety rules.

Ans: Two laboratory safety rules are as follows

- Do not taste any chemical unless otherwise instructed by the teacher.
- Do not eat, drink or play in the laboratory

Q.5 What is parallax error?

Ans: If the meter ruler is read from an angle, such as from point A or C, the object will appear to be of different length. This is known as parallax error.

Q.6 What is the cause of parallax error?

Ans: Parallax error is due to incorrect position of eye when taking measurements. It can be avoided by keeping eye perpendicular to the scale reading.

Q.7 What is a measuring tape?

Ans: A measuring tape can measure 1 mm to several meters. It's least count is1mm. It is used to measure longer distances.

Q.8 By whom and when vernier was invented?

Ans: Vernier calipers was invented by a French Scientist Pierre Vernier in 1631.

Q.9 Write any two laboratory safety rules.

Ans: Laboratory safety rules are as follows:

- Do not taste any chemical unless otherwise instructed by the teacher.
- Do not eat, drink or play in the laboratory.

MULTIPLE CHOICE QUESTIONS

1. **The least count of Vernier Callipers is:**
   (A) 0.1cm | **(B) 0.1mm**
   (C) 0.05mm | (D) Both b & c
2. **Total length of the Vernier Scale is:**
   (A) 1mm | **(B) 19 mm**
   (C) 10 mm | (D) 1 cm
3. **Number of divisions on the Vernier Scale are:**
   (A) 1 | (B) 9
   (C) 10 | (D) 20
4. **Length of the smallest division on main scale of the Vernier Callipers is:**
   (A) 1 cm | **(B) 1 mm**
   (C) 0.95 mm | (D) All
5. **Separation between division on the Vernier Scale of the Vernier Callipers is:**
   (A) 1 cm | (B) 1 mm
   (C) 0.9 mm | (D) All
6. **If zero of the Vernier scale is on the right side of the zero of the main scale then it is known as:**
   (A) Positive | (B) Negative
   (C) No error | (D) none of these
7. **If zero of the Vernier scale is on the left side of the zero of the main scale then it is known as zero error:**
   (A) Positive | **(B) Negative**
   (C) None of these | (D) No error
8. **If zero of the Vernier scale is on the right side of the zero of the main scale then zero error is to be:**
   (A) Added | **(B) Subtracted**
   (C) Multiplied | (D) Divided
9. **If zero of the Vernier scale is on the left side of the zero of the main scale then zero error is to be:**
   (A) Added | (B) Subtracted
   (C) Multiplied | (D) Divided
10. **The least count of digital Vernier Callipers is:**
    (A) 0.1cm | (B) 0.01mm
    (C) 0.001cm | **(D) Both (B) and (C)**
11. **Vernier Constant is also known as:**
    (A) Pitch | (B) Proportionality constant
    (C) Vernier value | **(D) Least count**
12. **Which one is more precise?**
    (A) Metre rule | (B) Measuring tape
    (C) Vernier Callipers | **(D) Digital Vernier Callipers**
13. **Least count of measuring tape is?**
    A) 1mm | B) 0.1 mm
    C) 0.1 cm | **D) Both a & c**

1.7.3 SCREW GAUGE

LONG QUESTIONS

Q.1 Write a note on the Screw Gauge.

Ans: **SCREW GAUGE**

Definition:

"Screw gauge is a length measuring device and is used for measurements even smaller than vernier caliper."

It is used to measure very small lengths such as diameter of a wire or thickness of a metal sheet. It has two scales:

Pitch of screw gauge:

The distance traveled by the circular scale on linear (or main) scale in one rotation is called the pitch of the screw gauge.

When the thimble makes one complete turn, the spindle moves 0.5 mm (1scaledivision) on the main scale which is called pitch of the screw gauge.

The minimum length which can be measured accurately by a screw gauge is called least count of the screw gauge.

Least count:

The least count of screw gauge is found by dividing its pitch by the number of circular scale divisions.

$$\text{Least Count} = \frac{\text{pitch of screw gauge}}{\text{no. of divisions on circular scale}}$$

$$= \frac{0.5 \text{ mm}}{50}$$

$$= 0.01 \text{ mm} = 0.001 \text{ cm}$$

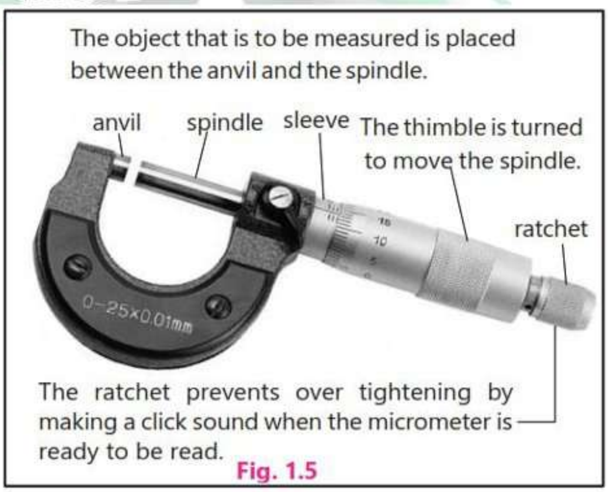


Fig. 1.5

Zero error and screw gauge:

Turn the thimble unit the anvil and spindle meet; datum line of the linear scale must meet with the zero on the thimble scale.

If the zero mark on the thimble scale (or circular scale) does not lie directly opposite the datum line of the main scale we say the there is zero error.

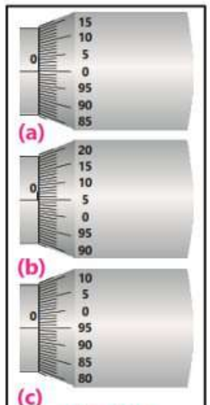


Fig. 1.6

Types of Zero Errors:

There are two types of zero errors:

i) Positive Zero Error

ii) Negative Zero Error

Positive Zero Error:

Zero error will be positive if the zero of circular scale is behind the index line. In this case multiply the number of divisions on the circular scale that has not crossed the index line with the least count of the screw gauge to find positive zero error.

Negative Zero Error:

Zero error will be negative if the zero of circular scale has crossed the index line. In this case multiply the number of divisions on the circular scale that has crossed the index line with the least.

TAKING MEASUREMENT WITH SCREW GAUGE

Suppose when a steel sheet is placed in between the anvil and spindle, then position of circular scale.

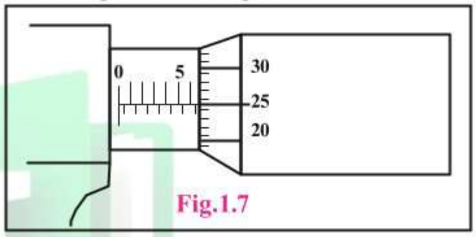


Fig.1.7

- Read the marking on the sleeve just before the thimble. It shows 6.5 mm.
- Read the circular scale which is in line with the main scale. This shows 25. Hence,
- Thickness= main scale reading + (circular scale reading × L.C.)

  $=6.5mm+25\times0.01mm$

  $=6.5mm+0.25mm=6.75mm$

SHORT QUESTIONS

Q.1 Define Pitch of Screw Gauge.

Ans: **PITCH OF SCREW GAUGE**

Definition:

"The distance covered by the spindle along the index line by one complete rotation of the thimble is called pitch of Screw Gauge".

Value:

Pitch of Screw Gauge is 1 mm. It is because the distance between consecutive threads on the spindle is 1 mm.

Q.2 What is the least count of a Screw Gauge?

Ans: **LEAST COUNT**

Definition:

"The minimum measurement which can be taken using a Screw Gauge is known as its Least Count".

Value:

The least count of screw gauge is 0.01 mm or 0.001 cm.

Q.3 Explain the statement, "A micrometer screw gauge measures more accurately than a vernier calipers".

Ans: **MORE ACCURATE**

We know,

Least count of Screw Gauge = L.C = 0.01mm

Least count of Vernier Callipers = L.C = 0.1mm

This shows that:

A micrometer Screw Gauge can measure more accurately than Vernier Calipers because a micrometer Screw Gauge can accurately measure up to one 100th part of a millimeter whereas Vernier Callipers can only measure accurately up to one 10th part of a millimeter.

MULTIPLE CHOICE QUESTIONS

1. **The least count of Screw Gauge is:**
   (A) 0.1 mm **(B) 0.01 mm**
   (C) 0.1 cm (D) 0.01 cm

2. **Total number of divisions on the circular scale of Screw Gauge are:**
   (A) 10 (B) 20
   (C) 100 (D) 200

3. **Pitch of the Screw Gauge is:**
   (A) 1m **(B) 1 mm**
   (C) 1 cm (D) 0.1 mm

4. **If the zero of the circular scale is above the horizontal line then the zero error will be:**
   (A) Positive **(B) Negative**
   (C) None of these (D) No error

5. **If the zero of the circular scale is below the horizontal line then the zero error will be:**
   (A) Positive (B) Negative
   (C) None of these (D) No error

6. **If the zero of the circular scale is above the horizontal line then the zero error is to be: (K.B)**
   (A) Added **(B) Subtracted**
   (C) Multiplied (D) Divided

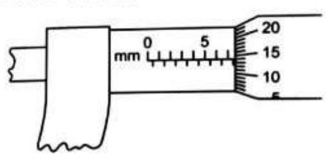
7. **If the zero of the circular scale is below the horizontal line then the zero error is to be:**
   (A) Added (B) Subtracted
   (C) Multiplied (D) Divided

8. **In Screw Gauge, the distance moved forward or backward in one complete rotation of the circular scale is known as:**
   (A) Least count **(B) Pitch**
   (C) Constant (D) None of above

9. **The least count of screw gauge having pitch 0.5mm and 50 divisions on its circular scale is:**
   (A) 0.001cm (B) 0.01cm
   (C) 0.1cm (D) 1.0cm

10. **What is measured using a micrometer?**
    (A) area (B) current
    (C) length (D) mass

11. **The diagram shows a micrometer scale.**



Which reading is shown?
(A) 5.64 mm (B) 7.14 mm
(C) 7.16 mm **(D) 7.64 mm**

1.7.4 MASS MEASURING INSTRUMENTS
PHYSICAL BALANCE

LONG QUESTIONS

Q.1 What is Physical Balance? Write its construction and working.

Ans:

PHYSICAL BALANCE

Introduction:

There are many kinds of balances used for measuring mass of an object. In our daily life, we use the term weight instead of mass.

In Physics, they have different meanings. Mass is the measure of quantity of matter in a body whereas the weight is the force by which the body is attracted towards the Earth. Weight can be measured using spring balance (Fig. 1.8). The mass of an object is found by comparing it with known standard masses. This process is called weighing. In

Fig. 1.8

laboratories, we use physical balance shown in Fig. 1.9 which is based on the principle of levers. The Fig. 1.8 process of measurement is given below:

Fig. 1.9

1. Level base of the balance using levelling screws until the plumb line is exactly above the pointed mark
2. Turn the knob so that the pans of the balance are raised up. Is the beam horizontal and pointer at the centre of the scale? If not, turn the balancing screws on the beam so that it becomes horizontal.
3. Place the object to be weighed on the left pan.
4. Place the known weight from the weight box in the right pan using forceps.
5. Adjust the weight so that pointer remains on zero or oscillates equally on both sides of the zero of the scale.
6. The total of standard masses (weights) is a measure of the mass of the object in the left pan.

MEASURING CYLINDER

LONG QUESTIONS

Q.1. What do you know about Measuring Cylinder? How volume of liquids is measured by using this cylinder?

Ans:

MEASURING CYLINDER

Introduction:

It is a cylinder made of glass or transparent plastic with a scale divided in cubic centimeters (cm^3 or cc) or millilitres (mL) marked on it.

It is used to find the volume of liquids and non-dissolvable solids. The level of liquids in the cylinder is marked to find the volume. In order to read the volume correctly, the cylinder must be placed on a horizontal surface and the eye shall be kept in level with meniscus of water surface as shown in Fig. 1.12. The meniscus is the top level of the liquid surface. Water in the cylinder curves downward and its surface is called concave surface. The reading is taken corresponding to the bottom edge of the surface. The mercury in the cylinder curves upward. Its surface is convex and the reading is taken corresponding to the top edge. The cylinder can be used to find the volume of solids.

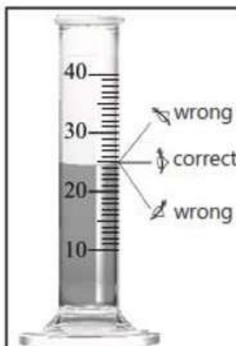


Fig. 1.12
Measuring cylinder

DISPLACEMENT CAN METHOD

If the body does not fit into the measuring cylinder, then an overflow can or displacement can of wide opening is used. Place the displacement can on the horizontal table. Pour water in it until it starts overflowing through its opening. Now tie a piece of thread to the solid body and lower it gently into the displacement can. The body displaces water which overflows through the side opening. The water or liquid is collected in a beaker and its volume is measured by the measuring cylinder. This is equal to the volume of solid body.

SHORT QUESTIONS

Q.1 What is the function of balancing screws in physical balance?

Ans: FUNCTION OF SCREWS

The function of balancing screws is to bring the pointer at zero position on raising the beam.

Q.2 Why do we use different balances for measuring mass?

Ans: USE OF DIFFERENT BALANCES

The precision of a balance in measuring mass of an object is different for different balances. A sensitive balance cannot measure large masses. Similarly, a balance that measures large masses cannot be sensitive.

Some digital balances even smaller difference of the order of 0.0001g or 0.1 mg. Such balances are considered the most precise balance.

Q.3 What is displacement can method?

Ans: DISPLACEMENT METHOD

If the body does not fit into the measuring cylinder, then an overflow can or displacement can of wide opening is used. Place the displacement can on the horizontal table. Pour water in it until it starts overflowing through its opening. Now tie a piece of thread to the solid body and lower it gently into the displacement can. The body displaces water which overflows through the side opening. The water or liquid is collected in a beaker and its volume is measured by the measuring cylinder. This is equal to the volume of solid body.

STOP WATCH

Q.1 Write a note on the Stop Watch.

Ans: STOP WATCH

Introduction:

"The duration of specific interval of time is measured by a stop watch."

Types of Stop Watch:

There are two types of stop watch.

- Mechanical stop watch (Analogue Stop Watch)
- Digital stop watch (Electronic stop watch)

Mechanical Stop Watch

It has two circular dials, a large circular dial in which a second hand of watch rotates and a small minute hand in which minute hand of watch rotates as shown in figure 1.14. The watch starts and stops by pressing the knob at top it, pressing it for some time will reset the watch back to zero.

FIGURE 1.14 MECHANICAL AND DIGITAL STOP WATCH

Generally the least count of analogue stop watch is 1 s and digital stop watch is 0.1 s

Use:

A mechanical stopwatch has a knob that is used to wind the spring that powers the watch. It can also be used as a start-stop and reset button. The watch starts when the knob is pressed once. When pressed second time, it stops the watch while the third press brings the needle back to zero position.

Electronic/Digital Stop Watch:

Digital stop watch are usually controlled by two buttons on the case as shown in the figure. Pressing the left button starts the timer and by pressing it again the time stops, thus the elapsed time it shown in the figure 1.14.

Pressing the right button resets the stopwatch to zero. The right button is also used to record split timer or lap times.

Digital stop watch commonly used in laboratories can measure a time interval accurately up to 1/100 second or 0.01 second.

Use:

The digital stop watch starts to indicate the time lapsed as start/stop button is pressed. As soon as start/stop button is pressed again, it stops and indicates the time interval recorded by it between start and stop of an event. A reset button restores its initial zero setting.

SHORT QUESTIONS

Q.1 What are the cautions of taking a reading in measuring cylinder?

Ans: While taking a reading, keep your eye in front and in line with the lower meniscus of the water.

Q.2 How ancient Chinese were measured the volume of grains?

Ans: Ancient Chinese used to estimate the volume of grains by sounding their containing vessels.

MULTIPLE CHOICE QUESTIONS

1. A physical balance is used to measure:

(A) Weight **(B) Volume**
(C) Length (D) mass

2. Least count of mechanical stop watch is:

(A) 1 second (B) 1 minute
(C) 0.1 second (D) 0.01 second

3. Stop-watches are used to time the runners in a race.
The top-watches show the times recorded for the winner and another runner.

4. What is the difference in time between the winner and the other runner?

(A) 0.4608 s **(B) 6.08 s**
(C) 46.08 s (D) 608 s

5. Least count of digital stop watch is:

(A) 1 second (B) 1 minute
(C) 0.1 second **(D) 0.01 second**

6. Digital stop watch can measure up to part of second:

(A) 1000th **(B) 100th**
(C) 50th (D) 10th

7. The level of water in a measuring cylinder is 75 cm^3. A stone of volume 20 cm^3 is lowered into the water. What is the new reading of the water level?

(A) 20 cm^3 (B) 55 cm^3
(C) 75 cm^3 **(D) 95 cm^3**

8. Despite the use of SI in most countries, the old measure is still in use, such as printers type is measured in point. One point is 1/72 of an inch equivalent to ____________ ?

A) 0.30 mm **B) 0.35 mm**
C) 0.50 mm D) 0.55 mm

9. The ________ of the base units are universal independent of the language used in the written text.

A) symbol B) magnitude
C) Both D) None

1.8 ERRORS

LONG QUESTIONS

Q.1 What do you know about errors in a measurement? Explain different types of errors.

Definition:

Every measurement, no matter how carefully taken, has a certain amount of doubt known as error. Error is simply the uncertainty that arises during measurement. This means that all measurements are only approximately

Explanation:

Measurements using tools and instruments are never perfect. They inherit some errors and differ from their true values. The best we shall do is to ensure that the errors are as small as reasonably possible. A scientific measurement should indicate the estimated error in the measured values.

Types of Errors:

Usually, there are three types of experimental errors affecting the measurements.

- **Human Errors**
- **Systematic Errors**
- **Random Errors**

HUMAN ERRORS

Reason:

They occur due to personal performance. The limitations of the human perception such as the inability to perfectly estimate the position of the pointer on a scale.

Explanation:

Personal errors can also arise due to faulty procedure to read the scale. The correct measurement needs to line up your eye right in front of the level. In timing experiments, the reaction time of an individual to start or stop clock also affects the measured value.

How to reduce Human Error:

Human error can be reduced by ensuring proper training, techniques and procedure to handle the instruments and avoiding environmental distraction or disturbance for proper focusing. The best way is to use automated or digital instruments to reduce the impact of human errors.

SYSTEMATIC ERRORS

Reason:

It occurs due to some definite rule. It may occur due to zero error of instrument, poor calibration of instrument or incorrect marking.

Explanation:

They refer to an effect that influences all measurements of particular measurements equally. It produces a consistence difference in reading.

How to reduce Systematic Error:

The effect of this kind of error can be reduced by comparing the instrument with another which is known to be more accurate. Thus, a correction factor can be applied.

RANDOM ERRORS

Reason:

It is due to some unknown causes which are unpredictable.

The experimenter have a little or no control over it. Random error arise due to sudden fluctuation or variation in the environmental conditions.

Explanation:

It is said to occur when repeated measurements of a quantity give different values under the same conditions.

Example:

For example, changes in temperature, pressure, humidity, voltage, etc.

How to reduce Random Error:

The effect of random errors can be reduced using several or multiple readings and then taking their average or mean value. Similarly, for the measuring time period of oscillating pendulum, the time of several oscillations, say 30 oscillations is noted and then mean or average value of one oscillation is determined.

SHORT QUESTION

Q.1 What is the main difference between systematic and random errors?

Ans: Systematic errors are consistent and predictable inaccuracies caused by flaws in the measurement system or method, leading to results that are consistently off in the same direction. Random errors, on the other hand, are unpredictable and vary in magnitude and direction, typically arising from unpredictable fluctuations in measurements.

Q.2 How can systematic errors be corrected in an experiment?

Ans: Systematic errors can be corrected by identifying and addressing the source of the error, such as recalibrating equipment, adjusting measurement techniques, or correcting procedural flaws. Regular calibration and maintenance of instruments can also help reduce systematic errors.

Q.3 What effect do random errors have on the precision of measurements?

Ans: Random errors affect the precision of measurements by introducing variability in the results. While they do not affect the accuracy of measurements (i.e., how close the measurements are to the true value), they can cause the measured values to scatter around the true value.

Q.4 Give an example of a situation that might lead to random errors in an experiment.

Ans: An example of a situation leading to random errors could be fluctuations in the room temperature affecting the performance of sensitive electronic measuring instruments, causing slight variations in measurements each time they are taken.

Q.5 Why is it important to take multiple measurements when dealing with random errors?

Ans: Taking multiple measurements helps to average out the effects of random errors, reducing their impact on the final result. By averaging multiple measurements, you can obtain a more reliable estimate that is less influenced by the variability and randomness inherent in individual measurements.

Q.6 Identify Personal, Systematic and Random Errors (Quick Quiz Page no. 19)

Ans:

- Your eye level may move a bit while reading the meniscus.**(Human Error)**
- Air current may cause the balance to fluctuate.**(Random Error)**
- The balance may not be properly calibrated.**(Systematic Error)**
- Some of the liquid may have evaporated while it is being measured.**(Random Error)**

MULTIPLE CHOICE QUESTIONS

1. **Which of the following could contribute to random errors in an experiment?**
   A) Instrument calibration issues B) Variability in experimental conditions
   C) Consistent measurement technique D) Use of standard procedures
2. **What is a common strategy to identify systematic errors?**
   A) Comparing measurements from different instruments
   B) Increasing the number of trials
   C) Performing measurements under different conditions
   D) Checking for consistency in results from the same instrument

3. **Random errors can be minimized by:**
A) Using more precise equipment
B) Reducing human intervention
C) Repeating measurements and averaging results
D) Calibrating instruments

4. **Which type of error is often described as 'bias'?**
A) Random Error **B) Systematic Error**
C) Measurement Error D) Human Error

5. **If an experiment consistently yields results that are all slightly higher than the true value, what type of error is likely present?**
A) Random Error **B) Systematic Error**
C) Human Error D) Calculation Error

6. **Random errors can be minimized by:**
A) Using more precise equipment
B) Reducing human intervention
C) Repeating measurements and averaging results
D) Calibrating instruments

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C) Measurement Error D) Human Error

8. **If an experiment consistently yields results that are all slightly higher than the true value, what type of error is likely present?**
A) Random Error B) Systematic Error
C) Human Error D) Calculation Error

UNCERTAINTY IN A MEASUREMENT

LONG QUESTIONS

Q.1 What is meant by uncertainty? Explain why uncertainty occurs in a measurement?

Ans: **Explanation:**

There is no such thing as a perfect measurement. Whenever a physical quantity is measured except counting, there is inevitably some uncertainty about its determined value due to some instrument. This uncertainty may be due to use of a number of reasons. One reason is the type of instrument being used. We know that every measuring instrument is calibrated to a certain smallest division and this fact puts a limit to the degree of accuracy which can be achieved while measuring with it. Suppose that we want to measure the length of a straight line with the help of a metre rule calibrated in milli metres. Let the end point of the line lies between 10.3cm and 10.4cm marks. By convention, if the end of the line does not touch or cross the midpoint of the smallest division, the reading is confined to the previous division. In case the end of the line seems to be touching or have crossed the midpoint, the reading is extended to the next division. Thus, in this example, the maximum uncertainty is$\pm$ 0.05 cm. It is, in fact, equivalent to an uncertainty of 0.1cm equal to the least count of the instrument divided into two parts, half above and half below the recorded reading.

The uncertainty in small length such as diameter of a wire and short interval of time can be reduced further by taking multiple readings and then finding average value. For example, the average time of one oscillation of a simple pendulum is usually found by measuring the time for thirty oscillations.

The uncertainty or accuracy in the value of a measured quantity can be indicated conveniently by using significant figures.

1.7 SIGNIFICANT FIGURES

LONG QUESTIONS

Q.1 Define Significant figures? Write Rules for finding significant figures in a measurement.

Ans:

SIGNIFICANT FIGURES

Definition:

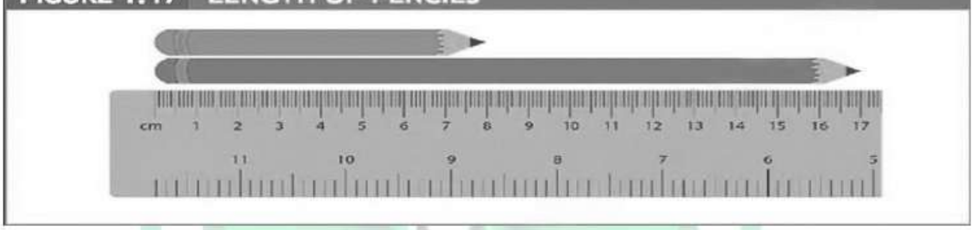
"The significant figures or digits are the digits of a measurement which are reliably known".

Example:

There are two types of values exact and measured. Exact values are those that are counted clearly. For example, while reporting 3 pencils or 2 books, we can indicate the exact number of these items.

The numerical value of any measurement will always contain some uncertainty. Suppose for example, that you are measuring the length of two pencils as shown in figure 1.17.

FIGURE 1.17 LENGTH OF PENCILS



Explanation:

We can count the number of candies in a jar and know it exactly by counting but we cannot measure the height of the jar exactly. All measurements include uncertainties depending upon the refinement of the instrument which is used for measurement.

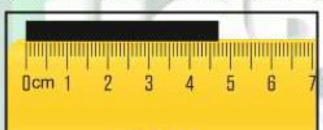


Fig.1.14

Figure 1.14 shows a rod whose length is measured with a ruler. The measurement shows the length in between 4.6cm and 4.7cm. Since the length of the rod is slightly more than 4.6cm but less than 4.7cm, so the first student estimates it to be 4.6cm whereas the second student takes it as 4.7cm. The first student thinks that the edge is nearer to 6mm mark whereas the second student considers the edge of the rod nearer to 7mm mark. It is difficult to decide what is the true length.

RULES:

The following points are to be kept in mind while determining the number of significant figures in any data. All digits from 1 to 9 are significant. However, zeros may or may not be significant. In case of zeros, the following rules apply:

(a) A zero between two digits is considered significant. For example in 5.06m, the number of significant figures is 3.

(b) Zeros on the left side of the measured value are not significant. For example, in 0.0034 m, the number of significant figures is 2.

(c) Zeros on the right side of a decimal are considered significant. For example, in 2.40mm the significant digits are 3.

(d) If numbers are recorded in scientific notation, the nall the digits before the exponent are significant. For example, in3.50×10^4 m, the significant figures are 3.

Precision and Significant Figures:

Significant figures reflect the precision in a measured quantity. Greater the number of significant figures greater will be the precision in the measurement.

QUICK QUIZ:

How many significant figures are there in each of the following?

(a)1.25×10^2m (b)12.5cm (c)0.125m (d)0.000125km

SOLUTION

a) All the three digits are significant.

b) All digits are significant because non zero digits are always significant.

c) There are three significant figures because zeros using for spacing purpose are not significant.

d) There are three significant figures because zeros using for spacing purpose are not significant.

1.9 PRECISION AND ACCURACY

LONG QUESTIONS

Q.1 What do you know about precision and accuracy Explain?

Ans: Introduction:

Precision and accuracy are both important factors in determining the reliability and validity of measurements and experimental results. While precision focuses on the consistency and repeatability of result.

Accuracy is concerned with how close the measured values are to the true or accepted values.

Precision can be thought of as the degree of agreement between repeated measurements of the same quantity. If a set of measurements consistently yields similar result, with little variation her same quantity.

A physical measurement should be precise as well as accurate. These are two separate concepts and need clear distinction.

PRECISION:

Precision of a measurement refers to how close together a group of measurements actually are to each other.

Dependence:

The smaller the least count, the more precise is the measurement.

Instrument used:

The smaller the size of physical quantity, the more precise instrument is needed to be used.

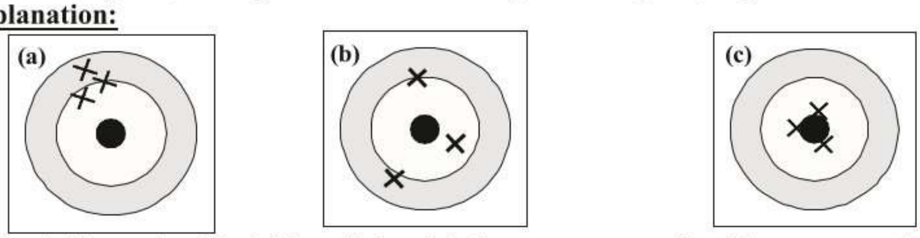
ACCURACY:

Accuracy of a measurement refers how close the measured value is to some accepted or true value.

Dependence:

Accuracy depends on fractional uncertainty in the measurement. In fact, it is relative measurement which is important. The smaller the size of physical quantity, the more precise instrument is needed to be used. The accuracy of measurement is reflected by the number of significant figures, the larger is the number of significant figures, higher is the accuracy.

Explanation:



A classic illustration is helpful to distinguish the two concepts. Consider a target or bulls eye hit by arrows in Fig.1.15. To be precise, arrows must hit near each other (Fig.1.15-a) and to be accurate, arrows must hit near the bulls eye (Fig. 1.15-b). Consistently hitting near the centre of bulls eye indicates both precision and accuracy (Fig. 1.15-c). When these concepts are applied to measurements, the precision is determined by the instrument being used for measurement.

Accurate and precise: Your darts hit the bulls eye and are tightly grouped.

Accurate but not precise: Your darts land near the center, but they're scattered all over the place

Precise but not accurate: your darts are tightly grouped but they're all off center in the same direction.

In practice, both precision and accuracy are desirable qualities in measurements. A measurement can be precise but not accurate, or accurate but not precise. Ideally measurements should be both precise and accurate meaning that they are both consistent and close to the true value. Achieving both precision and accuracy often requires careful calibration of instruments, control of experimental conditions and consideration of sources of error.

Q.2 What are some timing devices used for accuracy?

Ans: <u>TIMING DEVICES</u>

Some Timing Devices	
Type of clock/watch	**Use and accuracy**
Atomic clock	Measures very short time intervals of about 10^{-10} seconds.
Digital stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to±0.01s.
Analogue stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to±0.1s.
Ticker-tape timer	Measures short time intervals of 0.02s.
Watch/Clock	Measures longer time intervals in hours, minutes and seconds.
Pendulum clock	Measures longer time intervals in hours, minutes and seconds.
Radioactive decay clock	Measures (in years) the age of remains from thousands of years ago.

SHORT QUESTION

Q.1 What is the primary difference between precision and accuracy?

Ans: Precision refers to the consistency and repeatability of measurements, meaning how closely repeated measurements of the same quantity agree with each other. Accuracy refers to how close a measurement is to the true or accepted value of the quantity being measured.

Q.2 Can a set of measurements be precise but not accurate? Provide an example.

Ans: Yes, a set of measurements can be precise but not accurate. For example, if a scale consistently reads 2 grams more than the actual weight every time it measures, the measurements are precise (consistent) but not accurate (not close to the true value).

Q.3 Why is precision important in scientific experiments?

Ans: Precision is important because it indicates the reliability and reproducibility of the experimental results. High precision ensures that repeated measurements yield similar results, which is essential for identifying true trends and patterns in data.

Q.4 How can accuracy be improved in measurements?

Ans: Accuracy can be improved by calibrating measurement instruments correctly, using standardized procedures, and reducing systematic errors through careful technique and proper equipment maintenance.

Q.5 What is an example of a measurement system that is accurate but not precise?

Ans: An example would be a thermometer that provides an accurate reading of the temperature but has a high degree of variability in repeated measurements due to poor construction or sensitivity issues.

MULTIPLE CHOICE QUESTIONS

1. What does precision refer to in measurements?

A) Closeness to the true value B) Consistency of repeated measurements

C) Measurement range D) Measurement average

2. Accuracy in measurements is defined as:

A) Consistency in repeated measurements B) Closeness to the true or accepted value

C) Variability of measurements D) Precision of measurements

3. What characterizes high precision but low accuracy?
A) Measurements close to the true value
B) Measurements scattered around the true value
C) Measurements consistently close together but away from the true value
D) Measurements varying widely

4. What indicates accurate but not precise measurements?
A) Measurements close to each other
B) Measurements clustered around the true value
C) Measurements close to the true value but scattered
D) Measurements far from the true value

5. Which type of error primarily affects precision?
A) Systematic error B) Random error
C) Gross error D) Calibration error

6. What is the primary factor for determining accuracy?
A) Closeness to the true value B) Consistency of measurements
C) Measurement range D) Measurement repeatability

7. What scenario illustrates both high accuracy and high precision?
A) Measurements clustered around the true value
B) Measurements spread out but averaging to the true value
C) Measurements far from the true value but consistent
D) Measurements varying randomly

8. Which error is most likely to impact accuracy?
A) Random error B) Systematic error
C) Human error D) Instrument error

9. How does systematic error affect precision?
A) It improves precision B) It has no effect
C) It can distort precision D) It makes precision unreliable

ROUNDING OFF THE DIGIT

LONG QUESTION

Q.1 Write down the rules to round off the numbers?

Ans: **ROUNDING OFF NUMBERS AND SIGNIFICANT FIGURES**

When rounding off numbers to a certain number of significant figures, do so to the nearest value. If the last digit is more than 5, the retained digit is increased by one and if it is less than 5, it is retained as such.

For Example:

- Round to 2 significant figures: 2.512×10^3m.

Answer: 2.5×10^3m

- Round to 3 significant figures: 3.4567×10^4kg.

Answer: 3.46×10^4kg

For the integer 5, there is an arbitrary rule:

If the number before the 5 is odd, one is added to the last digit retained.
If the number before the 5 is even, it remains the same:

For Example:

(i) Round to 2 significant figures: 4.45×10^2m.
(ii) Round to 2 significant figures: 4.55×10^2m.

Answer: 4.4×10^2m
Answer: 4.6×10^2 m

Sometimes, logic is applied to decide the fact of a digit. If we round to 2 significant figures 4.452×10^2m, the answer should be 4.5×10^2m since 4.452×10^2m is more closer to 4.5×10^2m than 4.4×10^2m.

SHORT QUESTIONS

Q.1 Write factors effecting accuracy in a measurement.

Ans: <u>ACCURACY IN A MEASUREMENT</u>

The accuracy in measuring a physical quantity depends upon various factors.

- The quality of the measuring instrument
- The skill of the observer
- The number of observations made

Q.2 What is meant by uncertainty or error in measurement?

Ans: <u>UNCERTAINITY</u>

<u>Definition</u>:

"Deviation of the measured value from the true value is called uncertainty in the measurement.**"**

<u>Causes of Uncertainty</u>:

- Instrument error (zero error)
- Inexpertness of observer
- Unpredictable environment changes.

MULTIPLE CHOICE QUESTIONS

1. In any measurement, the accurately known digits and first doubtful digit are known as

(A) Prefixes **(B) Significant figures**
(C) Real numbers (D) All

2. The radius of wire is 0.022 cm. The number of significant figures in the measurements are:

(A) 1 **(B) 2**
(C) 3 (D) 4

3. The number of significant figures in 1.406 are:

(A) 4 (B) 3
(C) 2 (D) 1

4. The number of significant figures in 1.40 x 10^5 are:

(A) 1 (B) 2
(C) 3 (D) 4

5. The zeroes in between the digits are considered:

(A) Significant (B) Insignificant
(C) Constant (D) None of above

6. 1.35 is rounded off as:

(A) 1.36 **(B) 1.4**
(C) 1.45 (D) 1.3

7. The number of significant figures in 0.036 are:

(A) 1 **(B) 2**
(C) 3 (D) 4

8. 2.1203 cm is the length measured by meter rule, the number of significant figures in measurement are:

(A) 1 **(B) 2**
(C) 3 (D) 4

9. An electronic timer can measure time intervals as short as_________ of a second?

A) 1/100 B) 1/1000
B) 1/10,000 D) 1/10

STUDENTS LEARNING OBJECTIVES

MULTIPLE CHOICE QUESTIONS

1. The branch of physics that deals with the study of properties and behavior of positrons:
(A) Atomic Physics (B) Plasma Physics
(C) Nuclear physics (D) Mechanics

2. Pick the list of represented values in ascending order from left to right
(A) 6.02×10^{-3}cm, 8.0×10^{-3} cm, 7.05×10^{-2} cm (B) 6.02×10^{-2}cm, 8.0×10^{-3} cm, 7.05×10^{-1} cm
(C) 6.02×10^{-2}cm, 8.0×10^{-1} cm, 7.05×10^{-3} cm (D) 6.02×10^{3}cm, 8.0×10^{-3} cm, 7.05×10^{-2} cm

3. One of the following is not a unit of work:
(A) J **(B) Ws**
(C) Nm (D) Kgm^{-1}

4. $kgms^{-2}$ is equal to:
(A) Joule **(B) Newton**
(C) Pascal (D) Coulomb

5. 1C = ____
(A) As^{-1} **(B) As**
(C) $kgms^{-1}$ (D) $kgms^{-2}$

6. Pair of physical quantities having same SI units:
(A) Work and momentum (B) Power and work
(C) Energy and power **(D) Energy and work**

7. 8 kmh^{-1} = ms^{-1}
(A) 2.22 (B) 2
(C) 3.22 (D) 4.2

8. 10^{-6} second =
(A)Deci second (B) Milli second
(C) Micro second (D) Nano second

9. 32×10^{5} in standard form is equal to
(A) 3.2×10^{4} (B) 3.2×10^{6}
(C) 3.2×10^{7} (D) 3.2×10^{5s}

10. 1000 picometer= ?
(A) 10^{-9} m (B) 47.5 cm^2
(C) 47.57 cm^2 (D) 47.570 cm^2

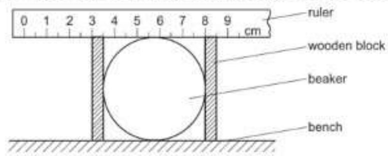
11. Following Number is in standard form:
(A) 0.07843×10^{5} (B) 3.0079×10^{-6}
(C) 47679.0 (D) None

12. The standard scientific notation of 0.6743 is:
(A) 6.743×10^{-1} (B) 6.743×10^{-4}
(C) 6743 (D) 6743×10^{1}

13. A student determines the circumference of a golf ball.
Which instrument gives a reading that is the circumference of the golf ball?
(A) vernier (B) screw gauge
(C) metre rule (D) measuring tape

14. A student determines the circumference of a football.
Which instrument gives a reading that is the circumference of the football?
(A) calipers (B) micrometer
(C) rule **(D) tape**

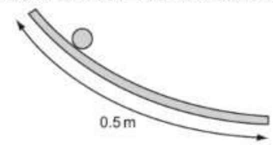
15. The diagram shows one method of measuring diameter of a beaker



The diameter of the beaker is:

(A) 4.5 cm (B) 5.0 cm
(C) 5.5 cm (D) 8.0 cm

16. In an experiment, a ball is rolled down a curved track that is about half a metre long.



In this case the measuring device used to measure length accurately is:

(A) Metre rule (B) micrometer
(C) Measuring Tape (D) Vernier callipers

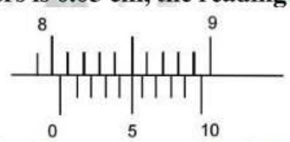
17. The length of a path between two index lines of screw gauge is called:

(A) Displacement (B) Distance
(C) Speed **(D) Pitch**

18. What is the least count of digital Vernier calipers is the smallest division on main scale is 1 mm and total divisions on Vernier scale are 20?

(A) 0.01 mm (B) 0.001 cm
(C) 0.05 mm (D) 0.05 cm

19. The least count of Vernier calipers is 0.05 cm, the reading of Vernier calipers will be:

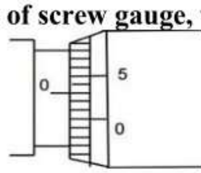


(A) 7.95cm **(B) 8.0 cm**
(C) 7.25 cm (D) 8.25cm

20. The quantity related to the extent to which an instrument can measure a minimum length is called:

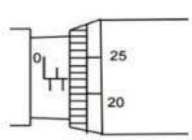
(A) Limitation (B) Evaluation
(C) Precision **(D) Precision and accuracy**

21. The zero error in the given image of screw gauge, when its least count is 0.01mm will be:



(A) +0.03 mm (B) – 0.03 mm
(C) +0.02 mm (D) -0.02 mm

22. The zero error of screw gauge, shown in image, is -0.02 mm. The final reading of the screw gauge will be:



(A) 1.74mm (B) 47.5 cm^2
(C) 47.57 cm^2 (D) 47.570 cm^2

23. A physical balance is enclosed in a glass case:
(A)To protect it from miss handling while balancing
(B) The glass casing is not necessary
(C) To protect it from the disturbance of air currents during balancing
(D) to protect it from dust

24. The position of the pointer at which the lever balance balances and we get the value of mass of the substance is:
(A) Mid Position **(B) Zero Position**
(C) Extreme Position (D) At 100 Mark

25. Least count of measuring cylinder is:
(A) 1mL (B) 10 Ml
(C) 0mL (D) 0.1mL

26. A measuring cylinder contains 50 cm^3 of water. A stone of irregular shape is immersed in the cylinder and its volume increases to 66 cm^3. Then the volume of the stone is:
(A) 116 cm^3 **(B) 16 cm^3**
(C) 50 cm^3 (D) 66 cm^3

27. A lump of metal has mass of 210g. It is lowered into a measuring cylinder containing water. The level of the water rises from 35 cm^3 to 140 cm^3.
The density of the metal is
(A) 0.67 g / cm^3 (B) 1.5 g / cm^3
(C) 2.0 g / cm^3 (D) 6.0 g / cm^3

28. A measuring cylinder contains 118 cm^3 of water. When a small object is fully immersed in the water, the reading goes up to 132 cm^3. The object has mass 42g.
The density of the object is:
(A) $\frac{14}{42}$ g / cm^3 **(B) $\frac{42}{14}$ g / cm^3**
(C) $\frac{42}{148}$ g / cm^3 (D) $\frac{132}{42}$ g / cm^3

29. The measured value of the temperature of a room is 0.056°C. The significant figures in this value are:
(A) 2 (B) 4
(C) 3 (D) 0

30. Add 0.69 g and 0.0003 g, to the correct value of significant figures.
(A) 0.6903 g (B) 0.693 g
(C) 0.6930 g (D) 0.7 g

31. The dimensions of a cube are 9 cm, 6.1 cm and 8.2 cm. The volume of the cube after rounding it to 4 significant figures is:
(A) 450.2 cm^3 (B) 450.25 cm^3
(C) 450 cm^3 (D) 450.9 cm^3

32. The value having all the zeros as significant:
(A) 0.27500 (B) 0.003
(C) 3.009 (D) 0.30090

33. If you are not able to understand or do a part of experiment, you should:
(A) Ask the teacher about it (B) Figure it out by trial and error method
(C) Leave it and turn to next page (D) Try try again

34. A small piece of paper is 7.1 cm long and 6.7 cm wide. Its area with the correct significant figures is:
(A) 48 cm^2 (B) 47.5 cm^2
(C) 47.57 cm^2 (D) 47.570 cm^2

35. The number of significant figures in 0.00360 is:
(A) 6 (B) 5
(C) 4 **(D) 3**

36. The final result of rounding 8360095 upto 3 significant figures is:
(A) 836 **(B) 86300**
(C) 30095 (D) 863

STUDENTS LEARNING OBJECTIVES

SHORT QUESTIONS

Q.1 Why area is called a derived quantity?

Ans: **AREA IS DERIVED QUANTITY**

Area is the multiplication of two base physical quantities length and width. Therefore, it is known as derived physical quantity.

Mathematically,

Area = length x width

$A = l \times w$

Unit:

The SI unit of area is m^2.

Q.2 Calculate the number of seconds in "one week". Express the number in standard form.

Ans: We know that there are seven days in a week, So,

1 day = 86400 s

7 days = 7 × 86400 s

= 604800 s

For standard form, we can write the term as

$= 6.04 \times 10^5$ s

Q.3 Can you measure distance smaller than 1 mm on meter rule why?

Ans: No, an measure instrument can measure a quantity upto its least count it can not measure a quantity less than its least count. As least count of meter rule is 1 mm or 0.1 cm so it can not measure length less than 1 mm or 0.1 cm.

Q.4 What its formula for measuring volume of a cylinder?

Ans: **FORMULA FOR VOLUME**

Formula for volume of the cylinder is given below

Volume of cylinder = $\pi r^2 l$

or

Volume of cylinder = $\pi r^2 h$

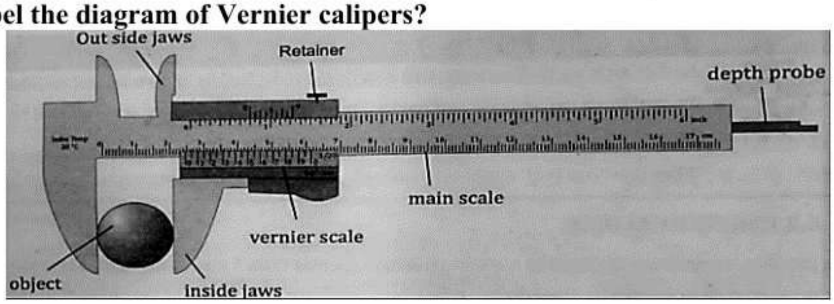
Q.5 Why do we use upper jaws of Vernier calipers?

Ans: **USE OF UPPER JAWS**

We use upper jaws of Vernier calipers for finding internal diameter of an object like test tube and pipe etc. As shown in the figure

Q.6 Draw & label the diagram of Vernier calipers?

Ans:



Q.7 Draw & label the diagram of Screw gauge?

Ans:

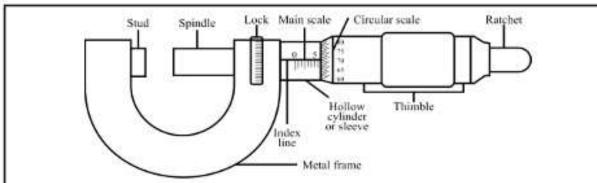


Figure: **A Screw Gauge**

Q.8 You have to measure the thickness of page and internal diameter of a breaker which instruments would you use vernier caliper or screw gauge why?

Ans: Vernier caliper:

Reason: As screw gauge cannot be used to measure internal diameter of a beaker. So it is more appropriate to use vernier caliper instead of screw gauge.

Q.9 On what factor does the accuracy in measuring a physical quantity depend?

Ans: Accuracy of measurement of physical quantity depends on difference of measured value and true value.

Q.10 What are the significant figures in the following measurements?

(a) 1.009 m (b) 0.00450 kg (c) 1.66 x 10^{-27} kg (d) 2001 s

Solution:

(a) 1.009 m has 4 significant figures.

(b) 0.00450 kg has 3 significant figures.

(c) 1.66 x 10^{-27} kg has 3 significant figures.

(d) 2001 s has 4 significant figures.

SUMMARY

Physics	Physics is the branch of science which deals with the study of matter and energy.
Physical Quantities	Physical quantities are measurable quantities
System International (SI)	System International (SI) is the system of units which consists of seven base units and a number of derived units.
Seven Base SI Units	second (time), ampere (current), candela (luminous intensity), Kelvin (temperature) and mole (amount of substance)
Scientific Notation	Scientific Notation is an internationally accepted way of writing numbers in which numbers are recorded using the power of ten and there is only one non-zero digit before the decimal.
Vernier caliper	Vernier caliper is a device used to measure a fraction of smallest scale division by sliding another scale over it
Screw Gauge	Screw Gauge is a device used to measure a fraction of smallest scale division by rotatory motion of circular scale over it.
Stop Watch	Stop Watch is an instrument used for measurement of time interval.
Significant Figures	Significant Figures are the accurately known digits and first doubt full digit in any measurement

TEXT BOOK EXERCISE MULTIPLE CHOICE QUESTIONS

A. Encircle the correct answer from the given choices.

1. The instrument that is most suitable for measuring the thickness of a few sheets of cardboard is a:

(a) meter rule
(b) measuring tape
(c) Vernier Callipers
(d) micrometer screw gauge

2. One femto meter is equal to:

(a) 10^{-9}m
(b) 10^{-15}m
(c) 10^{9}m
(d) 10^{15}m

3. A light year is a unit of:

(a) light
(b) time
(c) distance
(d) speed

4. Which one is a non-physical quantity?

(a) distance
(b) density
(c) colour
(d) temperature

5. When using a measuring cylinder, one precaution to take is to:

(a) Check for the zero error
(b) Look at the meniscus from below the level of the water surface
(c) Take several readings by looking from more than one direction
(d) Position the eye in line with the bottom of the meniscus

6. Volume of water consumed by you per day is estimated in:

(a) Milli litre
(b) litre
(b) kilogram
(d) cubic meter

7. A displacement can is used to measure:

(a) mass of a liquid
(b) mass of a solid
(c) volume of a liquid
(d) volume of a solid

8. Two rods with lengths 12.321cm and 10.3cm are placed side by side, the difference in their lengths is:

(a) 2.02cm (b) 2.0cm (c) 2 cm (d) 2.021cm

9. Four students measure the diameter of a cylinder with Vernier Callipers. Which of the following readings is correct?

(a) 3.4cm (b) 3.475cm **(c) 3.47cm** (d) 3.5cm

10. Which of the following measures are likely to represent the thickness of a sheet of this book?

(a) 6×10^{-25}m
(b) 1×10^{-4}m
(b) 1.2×10^{-15}m
(d) 4×10^{-2} m

11. In a Vernier Callipers ten smallest divisions of the Vernier scale are equal to nine smallest divisions of the main scale. If the smallest division of the main scale is half milli metre, the Vernier constant is equal to:

(a) 0.5mm
(b) 0.1mm
C) 0.05mm
(d) 0.001mm

EXERCISE SHORT QUESTIONS

B. Short Answer Questions:

1.1 Can a non-physical quantity be measured? If yes, then how?

Ans:

REASON

No, a physical quantity cannot be measured because if it can be measured then it will be a physical quantity as all measureable quantities are physical quantities.

1.2 What is a measurement? Name its two parts?

Ans:

Measurement:

A measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity.

Component of measurement:

A measurement consists of two parts,

- a number
- a unit.

A measurement without unit is meaningless.

1.3 Why do we need a standard unit for measurements?

Ans:

Not very far in the past, every country in the world had its own units of measurements. However, problems were faced when people of different countries exchanged scientific information or traded with other countries using different units. Eventually, people got the idea of standardizing the units of measurements which could be used by all countries for efficient working and growth of mutual trade, business and share scientific information.

1.3 Write the name of 3 base quantities and 3 derived quantities.

Ans:

BASE QUANTITES

Sr. No.	Physical quantity	Unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s

DERIVED QUANTITIES

Sr. No.	Physical quantity	Unit	Symbol
1.	Area	Square metre	m^2
2.	Volume	Cubic metre	m^3
3.	Speed	Metre per second	Ms^{-1}

1.4 Which SI unit will you use to express the height of your desk?

Ans: We will use the unit meter to express the length of a desk.

1.6 Write the name and symbols of all SI base units.

Ans:

BASE UNITS

Table1.2			
Sr. No.	**Physical quantity**	**Unit**	**Symbol**
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Temperature	kelvin	K
5.	Electric current	ampere	A
6.	Intensity of light	Candela	cd
7.	Amount of substance	mole	mol

1.7 Why prefix is used? Name three sub-multiples and three multiple prefixes with their symbols.

Ans: The SI is a decimal system. Prefixes are used to write units by powers of 10. The big quantities like 50000000 m and small quantities like 0.00004 m are not convenient to write down. The use of prefixes makes them simple. The quantity 50000000 m can be written as 5×10^{7}m. Similarly, the quantity 0.00004 m can be written as 4×10^{5}m.

Prefix	Symbol	Powers of Ten
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}

1.8 What is meant by:

(a) 5pm
(b) 15ns
(c) 6μm
(d) 5fs

Ans:

a) 5 pm = 5 pico meter = $5\times10^{-12}\,m$ =0.000000000005m

b) 15ns = 15 nano second = 15×10^{-9} sec = 0.000000015 sec

c) $6\,\mu m = 6 micrometer = 6\times10^{-6}\,m$ = 0.000006m

d) 5fs = 5 femto second = 5×10^{-15} sec = 0.000000000000005sec

1.9 a) For what purpose, a Vernier Callipers *is* used?
b) Name its two main parts.
c) How is least count found?
d) What is meant by zero error?

Ans:

a) Purpose:

It is an instrument used to measure small lengths down to 1/10th of a milli metre. It can be used to measure the thickness, diameter, width or depth of an object.

b) Parts:

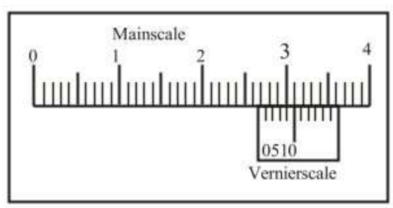
It has two parts:

a) A main scale which has marking of 1mm each.

b) A Vernier (sliding) scale of length 9mm and it is divided into 10 equal parts.

c) Least Count:

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.



Hence,

Least count = 1 M.S div – 1 V.S div

= 1mm – 0.9mm = 0.1mm

d) Zero Error:

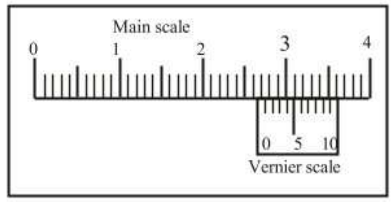
To find the zero error, note the number of the division of the Vernier scale which is exactly in front of any division of the main scale. Multiply this number with the least count. The resultant number is the zero error of this instrument. The observed reading is corrected by subtracting the zero error from it.

1.10 State least count and Vernier scale reading as shown in the figure and hence, find the length.

Ans: **Least count:**

According to the diagram

$$\text{Least Count} = \frac{smallestreadingonmainscale}{No.ofdivisiononvernierscale} = \frac{1mm}{10} = 0.01mm = 0.001\text{cm}$$



Vernier scale reading:

Vernier scale reading = $4 \times 0.1mm = 0.4\text{mm}$

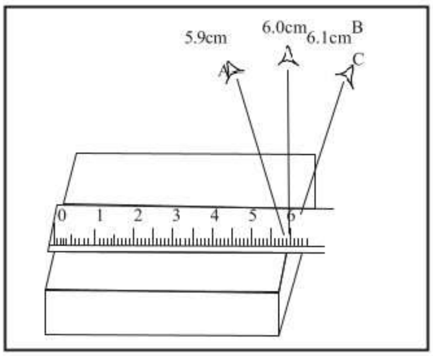
Length:

Length = main scale reading + vernier scale reading

= 26 + 0.4 mm = 26.4 mm

1.11 Which reading out of A, B and C shows the correct length and why?

Ans: **B** is the correct reading because in this, eye level is exact vertically upward the meter rule.



CONSTRUCTED RESPONSE QUESTIONS PROBLEMS

1.1 In what unit will you express each of the following?

(a) Thickness of a five-rupee coin: mm

(b) Length of a book: inch/cm

(c) Length of football field: m^2

(d) The distance between two cities: km

(e) Mass of five-rupee coin: g

(f) Mass of your school bag: kg

(g) Duration of your class period: minute

(h) Volume of petrol filled in the tank of a car: liters

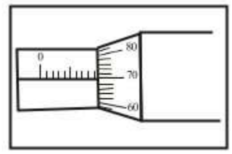
(i) Time to boil one liter milk: minute

1.2 Why might a standard system of measurement be helpful to a tailor?

Ans: A standard system of measurement is crucial to a tailor for several reasons:

1. **Consistency**: It ensures that measurements are uniform, reducing the possibility of errors and miscommunication. A standard system provides a common language for tailors, customers, and manufacturers to discuss garment sizes.
2. **Accuracy**: Tailors rely on precise measurements to create garments that fit properly. A standard system provides clear guidelines for how measurements should be taken, allowing for better-fitting clothing.
3. **Efficiency**: With a standardized system, a tailor can work more quickly by following a set pattern of measurements, which speeds up both the fitting process and garment construction.

1.3 The minimum main scale reading of a micrometer screw gauge is 1mm and there are 100 divisions on the circular scale. When thimble is rotated once, 1mm is its measurement on the main scale. What is the least Count of the instrument? The reading for thickness of a steel rod is as shown in the figure. What is the thickness of the rod?



Ans: **Least Count:**

Least Count = $\frac{pitch of screw gauge}{No. of division on circular scale} = \frac{1mm}{100}$ =0.01mm/0.001cm

Thickness of the rod = main scale reading + circular scale reading

= $9 + 70 \times 0.01mm$ = 9+0.07mm=9.07mm

1.4 State the similarities and differences between Vernier calipers and micrometer screw gauge?

Ans: **SIMILARITIES**

- Both use to measure extremely small things less than 0.1mm.
- Both instruments are used for precise measurement of small objects, typically in engineering and mechanical fields.
- Both are hand-operated instruments that require human intervention to measure objects.

DIFFERENCES

Measurement Range:

- **Vernier Calipers:** Can measure both external and internal dimensions (such as length, width, height, and internal diameters). They can measure a wider range of dimensions, typically from 0 to 150 mm or even 0 to 300 mm.
- **Micrometer Screw Gauge:** Primarily measures the external dimensions of small objects, especially their diameter or thickness, with a more limited range, typically from 25 mm to 50 mm.

Precision:

- **Vernier Calipers:** Generally provide measurements to the nearest 0.02 mm or 0.01 mm, depending on the model.
- **Micrometer Screw Gauge:** Provides higher precision, typically measuring to the nearest 0.001 mm.

1.5 You are provided a metre scale and a bundle of pencils; how can the diameter of a pencil be measured using the metre scale with the same precision as that of Vernier Callipers? Describe briefly.

Ans: To measure the diameter of a pencil using a meter scale with the same precision as a Vernier caliper, we can use the **"method of measuring the circumference"** and then calculate the diameter.

1. Take a thin, flexible string or thread and wrap it around the pencil once, making sure it is tightly fitted and does not overlap. Mark the point where the string ends.
2. Using the meter scale, measure the length of the string around the pencil, which will give you the **circumference** of the pencil. You can do this by laying the string along the scale and reading the value.
3. Use the formula for the circumference of a circle.

1.6 The end of a metre scale is worn out. Where will you place a pencil to find the length?

Ans: Place one end of the pencil at the **starting point** (0 cm) on the meter scale, where the markings are still visible and accurate. Ensure the pencil is straight and aligned along the scale, with the other end extending past the worn-out part of the scale. Use the part of the meter scale that is still readable (the end that isn't worn out) to find the position of the pencil's other end. If the worn-out portion of the scale affects ability to measure accurately, place another object of known length (like another pencil or ruler) at the worn-out end and use it to help align the pencil with the remaining readable part of the scale.

1.7 Why is it better to place the object close to the metre scale?

Ans: It is better to place the object close to the meter scale for several reasons:

1. Minimizes Parallax Error:
2. Reduces the Effect of Worn-Out Ends:
3. Improves Accuracy and Precision:
4. Easier Reading:

1.8 Why a standard unit is needed to measure a quantity correctly?

Ans: A standard unit is needed to measure a quantity correctly for several important reasons:

1. Consistency and Universality
2. Accuracy in Communication
3. Reproducibility
4. Eliminates Ambiguity
5. Facilitates Comparisons
6. International Trade and Cooperation

1.9 Suggest some natural phenomena that could serve as a reasonably accurate time standard.

Ans:

COMPREHENSIVE QUESTIONS

1.1 What is meant by base and derived quantities? Give the names and symbols of SI base units.

Ans:

BASE QUANTITIES

Definition:

"Base (or fundamental) physical quantities (like mass, length and time are selected as the simplest form of physical quantities, such that all other physical quantities can be derived from them."

Name	Symbol	Name	Symbol
Length	L	Meter	M
Mass	M	Kilogram	Kg
Time	T	Second	S
Electric current	I	Ampere	A
Luminous Intensity	L	Candela	Cd
Temperature	T	Kelvin	K
Amount of a substance	N	Mole	Mol

DERIVED QUANTITIES

Definition:

The physical quantity obtained by multiplying or dividing base physical quantities are termed as the derived physical quantities.

1.2 Give three examples of derived unit in SI. How are they derived from base units? Describe briefly.

Ans:

DERIVED UNITS

Definition:

Units of derived quantities are obtained by multiplying and or dividing base quantities. In SI units all other physical quantities can derived from the seven base units.

Formation:

Derived units are defined in terms of base units and are obtained by multiplying or dividing one or more base units with each other. They are multiples in number.

Derived Quantities, Their SI Units with Symbols:

Derived quantities with their S.I units are as follows:

DERIVED UNITS FOR INTERNATINAL SYSTEM OF UNITS			
Derived Quantity		**SI Derived Unit**	
Name	**Symbol**	**Name**	**Symbol**
Area	A	Square meter	m^2
Volume	V	Cubic meter	m^3
Speed, velocity	V	Meter per second	ms^{-1}
Acceleration	A	Meter per second squared	ms^{-2}

1.3 Identify and explain the reasons for human errors, random errors and systematic errors in experiments.

Ans:

Definition:

Every measurement, no matter how carefully taken, has a certain amount of doubt known as error. Error is simply the uncertainty that arises during measurement. This means that all measurements are only approximately

Explanation:

Measurements using tools and instruments are never perfect. They inherit some errors and differ from their true values. The best we shall do is to ensure that the errors are as small as reasonably possible. A scientific measurement should indicate the estimated error in the measured values.

Types of Errors:

Usually, there are three types of experimental errors affecting the measurements.

- **Human Errors**
- **Systematic Errors**
- **Random Errors**

HUMAN ERRORS

Reason:

They occur due to personal performance. The limitations of the human perception such as the inability to perfectly estimate the position of the pointer on a scale.

Explanation:

Personal errors can also arise due to faulty procedure to read the scale. The correct measurement needs to line up your eye right in front of the level. In timing experiments, the reaction time of an individual to start or stop clock also affects the measured value.

How to reduce Human Error:

Human error can be reduced by ensuring proper training, techniques and procedure to handle the instruments and avoiding environmental distraction or disturbance for proper focusing. The best way is to use automated or digital instruments to reduce the impact of human errors.

SYSTEMATIC ERRORS

Reason:

It occurs due to some definite rule. It may occur due to zero error of instrument, poor calibration of instrument or incorrect marking.

Explanation:

They refer to an effect that influences all measurements of particular measurements equally. It produces a consistence difference in reading.

How to reduce Systematic Error:

The effect of this kind of error can be reduced by comparing the instrument with another which is known to be more accurate. Thus, a correction factor can be applied.

RANDOM ERRORS

Reason:

It is due to some unknown causes which are unpredictable.

The experimenter has a little or no control over it. Random error arise due to sudden fluctuation or variation in the environmental conditions.

Explanation:

It is said to occur when repeated measurements of a quantity give different values under the same conditions.

Example:

For example, changes in temperature, pressure, humidity, voltage, etc.

How to reduce Random Error:

The effect of random errors can be reduced using several or multiple readings and then taking their average or mean value. Similarly, for the measuring time period of oscillating pendulum, the time of several oscillations, say 30 oscillations is noted and then mean or average value of one oscillation is determined.

1.4 Differentiate between precision and accuracy of a measurement with examples.

Ans:

Introduction:

Precision and accuracy are both important factors in determining the reliability and validity of measurements and experimental results. While precision focuses on the consistency and repeatability of result.

Accuracy is concerned with how close the measured values are to the true or accepted values.

Precision can be thought of as the degree of agreement between repeated measurements of the same quantity. If a set of measurements consistently yields similar result, with little variation her same quantity.

A physical measurement should be precise as well as accurate. These are two separate concepts and need clear distinction.

PRECISION:

Precision of a measurement refers to how close together a group of measurements actually are to each other.

Dependence:

The smaller the least count, the more precise is the measurement.

Instrument used:

The smaller the size of physical quantity, the more precise instrument is needed to be used.

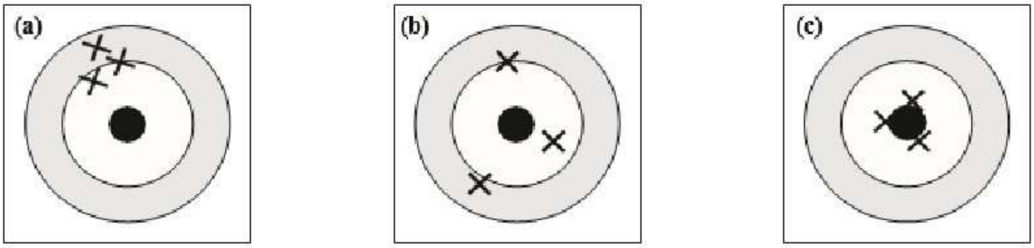
ACCURACY:

Accuracy of a measurement refers how close the measured value is to some accepted or true value.

Dependence:

Accuracy depends on fractional uncertainty in the measurement. In fact, it is relative measurement which is important. The smaller the size of physical quantity, the more precise instrument is needed to be used. The accuracy of measurement is reflected by the number of significant figures, the larger is the number of significant figures, higher is the accuracy.

Explanation:



A classic illustration is helpful to distinguish the two concepts. Consider a target or bulls eye hit by arrows in Fig.1.15. To be precise, arrows must hit near each other (Fig.1.15-a) and to be accurate, arrows must hit near the bulls eye (Fig. 1.15-b). Consistently hitting near the centre of bulls eye indicates both precision and accuracy (Fig. 1.15-c). When these concepts are applied to measurements, the precision is determined by the instrument being used for measurement.

Accurate and precise: Your darts hit the bulls eye and are tightly grouped.

Accurate but not precise: Your darts land near the center, but they're scattered all over the place

Precise but not accurate: your darts are tightly grouped but they're all off center in the same direction.

In practice, both precision and accuracy are desirable qualities in measurements. A measurement can be precise but not accurate, or accurate but not precise. Ideally measurements should be both precise and accurate meaning that they are both consistent and close to the true value. Achieving both precision and accuracy often requires careful calibration of instruments, control of experimental conditions and consideration of sources of error.

NUMERICAL PROBLEMS

1.1 Calculate the number of second in a
(a) day
(b) week
(c) month
and state your answers using SI prefixes.

(a)

Seconds in a day = ?
1 day = 24 hours
1 hour = 60 minutes
1 minute = 60 seconds

Seconds in a day = $1 \times 24 \times 60 \times 60$ sec
= 86400 sec
= 86.400×10^3 sec

As $1k = 10^3$ So,
= 86.4k sec

(b)

Seconds in a week = ?
1 week = 7 days
1 day = 24 hours
1 hour = 60 minutes
1 minute = 60 seconds

Seconds in a week = $7\times 24 \times 60 \times 60$ sec
= 604,800 sec
= $604,8\times 10^3$ sec
= 604.8k sec

As $1k = 10^3$ So,
= 86.4k sec

(c)

Seconds in a month= ?

1 month = 30 days
1 day = 24 hours
1 hour = 60 minutes
1 minute = 60 seconds

Seconds in a month = $30\times 24 \times 60 \times 60$ sec
= 2,592,000 sec
= 2.592×10^6 sec

As 10^6 = 1M So,
= 2.592 M sec

1.2 State the answer of problem 1.1 in scientific notion.

(a) Seconds in a day = 8.64×10^4sec
(b) seconds in a week = 6.048×10^5sec
(c) seconds in a month = 2.592×10^6 sec

1.3 Solve the following addition or subtraction. State your answers in scientific notation.

(a) 4×10^{-4} kg + 3×10^{-5} kg (b) 5.4×10^{-6} m – 3.2×10^{-5} m

(i) 4×10^{-4}kg = 0.0004 kg
(ii) 3×10^{-5}kg = 0.00003 kg
By adding both equations

$$\begin{array}{r} 0.0004\,\text{kg} \\ +\ 0.00003\,\text{kg} \\ \hline 0.00043\,\text{kg} \end{array}$$

Converting in scientific notations **= 4.3×10^{-4}kg**

(b)

5.4 × 10-6 m = 0.0000054 kg
3.2×10^{-5} m = 0.000032 kg

By subtracting both equations:

$$\begin{array}{r} 0.0000054\,\text{kg} \\ -\ 0.000032\,\text{kg} \\ \hline -\ 0.0000266\,\text{kg} \end{array}$$

Converting in scientific
= -2.66×10^{-5} kg

1.4 Solve the following multiplication or division. State your answers in scientific notation.

(a) $(5 \times 10^4\text{m}) \times (3 \times 10^{-2}\text{m})$ (b) $\dfrac{6\times10^8 kg}{3\times10^4 m^3}$

(a)

$$=\left(5\times10^4 m\right)\times\left(3\times10^{-2} m\right)$$
$$=\left(5\times3\right)\left(10^4\times10^{-2}\right)\left(m\times m\right)$$
$$=\left(15\right)\left(10^{4-2}\right)\left(m^2\right)$$
$$=\left(1.5\times10^1\right)\left(10^2\right)\left(m^2\right)$$
$$=1.5\times10^{1+2} m^2$$
$$=\boxed{1.5\times10^3 m^2}$$

(b)

$$\frac{6\times10^8\text{kg}}{3\times10^4\text{m}^3}$$

$$=\frac{\not{6}^2}{\not{3}_1}\times\left(10^8\times10^{-4}\right)\left(kgm^{-3}\right)$$

$$=2\left(10^{8-4}\right)\left(kgm^{-3}\right)$$

$$=\boxed{2.0\times10^4\,kgm^{-3}}$$

1.5 Calculate the following and state your answer in scientific notation. $\frac{\left(3\times10^2\text{kg}\right)\times\left(4.0\text{km}\right)}{5\times10^2\text{s}^2}$

1.6 State the number of significant digits in each measurement.
(a) 0.0045 (b) 2.047 m (c) 3.40m (d) 3.420 × 10^4m

(a) 0.0045m
It has two significant digits because zeros for spacing purposes are not significant.
(b) 2.047 m
It has four significant figures because zeros between significant are also significant
(c) 3.40 m
It has three significant because zero at right side of decimal value is also significant
(d) 3.420 × 10^4 m
It has four significant figures

1.7 Write in scientific notation:
(a) 0.0035m (b) 206.4 × 10^2m

(a) $0.0035m=\boxed{3.5\times10^{-3}\,m}$

(b) $206.4\times10^2\,m=\boxed{2.064\times10^4\,m}$

1.8 Write using correct prefixes:
(a) 5.0 × 10^4cm (b) 580 × 10^2g (c) 45 × 10^{-4}s

(a)

$5.0\times10^4\,\text{cm} \qquad \therefore 1\text{cm}=10^{-2}\,m$

$=5\times10^4\times10^{-2}\,m$

$=5\times10^{4-2}\,m$

$=5\times10^2\,m$

$=0.5\times10^1\times10^2\,m$

$=0.5\times10^{1+2}\,m$

$=0.5\times10^3\,m \qquad \therefore 10^3\,m=1km$

$=\boxed{0.5km}$

(b)

$580\times10^{2}g$

$=58\times10^{1}\times10^{2}g$

$=58\times10^{1+2}g$

$=58\times10^{3}g \quad \therefore 10^{3}g=1\text{kg}$

$=\boxed{58kg}$

(c)

$45\times10^{-4}\sec$

$=4.5\times10^{1}\times10^{-4}\sec$

$=4.5\times10^{1-4}\sec$

$=4.5\times10^{-3}\sec \quad \therefore 10^{-3}=1m$

$=\boxed{4.5ms}$

1.9 Light year is a unit of distance used in astronomy. It is the distance covered by light in one year. Taking the speed of light as $3.0\times10^{8}ms^{-1}$, calculate the distance.

Given Data:

Speed of light $=v=3\times10^{8}ms^{-1}$

$Time=t=1year=365\times24\times60\times60\sec$

$=31,536,000\sec$

To Find:

Distance = S = ?

S = V × t

Calculation:

$S=v\times t$

$S=(3\times10^{8})(31,536,000)$

$=\boxed{9.46\times10^{15}m}$

Result:

Distance with be 9.46×10^{15}m

1.10 Express the density of mercury given as 13.6 g cm^{-3} in kg m^{-3}.

Given Data:

Density of mercury = D = 13.6gcm^{-3}

To Find:

Density in kg m^{-3}= ?

Calculation:

As, 1 gcm^{-3} = 1000 kgm^{-3}

So,

13.6 gcm^{-3} = 1000 × 13.6

= 13600 kg m^{-3}

$=\boxed{1.36\times10^{4}kg\,m^{-3}}$

Result:

Density of mercury in kg m^{-3} is $\boxed{1.36\times10^{4}\,kg\,m^{-3}}$

MCQ'S ANSWER KEY (TOPIC WISE)

PHYSICAL AND NON-PHYSICAL QUANTITIES

1	2	3	4	5	6	7
B	B	B	D	D	D	D

SCIENTIFIC NOTATION AND PREFIXES

1	2	3	4	5	6	7	8
C	D	B	D	C	A	C	B

VERNIER CALIPER

1	2	3	4	5	6	7	8	9	10	11	12	13
B	B	C	B	C	A	B	B	A	D	D	D	D

SCREW GUAGE

1	2	3	4	5	6	7	8	9	10	11
B	C	B	B	A	A	B	B	A	C	D

PHYSICAL BALANCE, STOP WATCH, MEASURING CYLINDER

1	2	3	4	5	6	7	8	9
B	C		B	D	B	D	B	A

ERRORS

1	2	3	4	5	6	7	8
C	B	C	B	B	C	B	B

PRECISION AND ACCURACY

1	2	3	4	5	6	7	8	9
A								

STUDENTS LEARNING OBJECTIVES

ANSWER KEY

1	2	3	4	5	6	7	8	9
A	A	B	B	B	D	A	C	B

10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
A	B	A	A	D	A	C	D	C
19	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
B	D	A		C	B	A	B	C
28	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
B	A	A	A	C	A	C	D	B

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

ANSWER KEY

1	2	3	4	5	6	7	8	9	10	11
D	B	C	C	D	B	D	A	C	B	C