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UNIT 1 Physical Quantities And Measurement

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Students' Learning Outcomes

After completing this chapter, students will be able to:

[SLO: P-09-A-01] Differentiate between physical and non-physical quantities

[SLO: P-09-A-02] Explain with examples that physics is based on physical quantities [Including that these consist of a magnitude and a unit]

[SLO: P-09-A-03] Differentiate between base and derived physical quantities and units.

[SLO: P-09-A-04] Use the seven units of System International (SI) along with their symbols and physical quantities (standard definitions of SI units are not required)

[SLO: P-09-A-05] Analyse and express numerical data using scientific notation [in measurements and calculations.]

[SLO: P-09-A-06] Analyse and express numerical data using prefixes [interconverting the prefixes and their symbols to indicate multiple and submultiple for both base and derived units.]

[SLO: P-09-A-07] Justify and illustrate the use of common lab instruments to measure length [Including least count of instruments and how to measure a variety of lengths with appropriate precision using Tapes, Rulers and Vernier Callipers and Micrometres (including reading the scale on analogue and digital callipers and micrometres)]

[SLO: P-09-A-08] Justify and illustrate the use of measuring cylinders to measure volume [Including both measurement of volumes of liquids and determining the volume of a solid by displacement]

[SLO: P-09-A-09] Justify and illustrate how to measure time intervals using lab instruments [Including clocks and digital timers.

[SLO: P-09-A-10] Identify and explain the reason for common sources of human and systematic errors in experiments.

[SLO: P-09-A-11] Determine an average value for an empirical reading [Including small distance and for a short interval of time by measuring multiples (including the period of oscillation of a pendulum)] The uncertainty in measurements and describe the need using significant figures for recording and stating results of various measurements.

[SLO: P-09-A-12] Differentiate between precision and accuracy.

[SLO: P-09-A-13] Round off and justify measured estimates to make them reasonable. [Based on empirical data to an appropriate number of significant figures]

[SLO: P-09-A-14] Determine the least count of a data collection instrument (analogue) from its scale.

1.1 PHYSICAL AND NON-PHYSICAL QUANTITIES

Q-1. What are physical and non-physical quantities? Describe their characteristics.

Ans.

Physical Quantities:

All measurable quantities are called physical quantities such as length, speed, mass, time and temperature.

The foundation of physics rests upon physical quantities through which the laws and principles of physics are expressed.

Characteristics of Physical Quantities:

A physical quantity possesses at least two characteristics in common.

(i) Numerical magnitude

(ii) Unit to measure physical quantity

For Example: If height of a student is 104 cm then 104 is its numerical magnitude and centimetre is the unit of measurement.

Non-Physical Quantities:

Those quantities which cannot be measured are called non-physical quantities such as love, affection, fear, wisdom, and beauty cannot be measured so they are non-physical quantities.

These quantities can be described qualitatively or compared using some pre-determined criteria, indices or through survey techniques. Non-physical quantities mostly help to understand and to analyse human behaviour, emotions and social interactions.

1.2 BASE AND DERIVED PHYSICAL QUANTITIES

Q.2 What is the difference between base quantities and derived quantities?

Ans.

Base Quantities:

Base quantities are the quantities on the basis of which other quantities are expressed.

OR

Such quantities which can be expressed independently without the reference of any other quantity are called base quantities.

There are seven base quantities. These are length, mass, time, electric current, temperature, intensity of light and amount of substance.

Derived Quantities:

All the quantities which can be described in terms of one or more base quantities are called derived physical quantities. For example, speed is a derived quantity which depends on distance and time which are base quantities whereas density of a material is described in terms of mass and volume.

Q.3 What is meant by measurement and unit? Why do we need a standard unit for measurements?

Ans.

Measurement of a Physical Quantity

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

A measurement consists of two parts, a number and a unit. A measurement without unit is meaningless.

Unit:

To measure a physical quantity, we need to compare it with some standard quantity. This standard quantity is called unit.

Why do we need a standard unit for measurements?

In the early days 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. 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.

Q.4 With the help of an activity prove that for proper measurements a standard unit is required.

Ans. Activity:

One student should measure the length of a writing board with his hand. The same should be repeated by four or five students. Are all the measurements same? If they differ, then why? What is the solution to avoid confusion?

Solution:

The measurement of different students may differ from each other because of different sizes of their hands. 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.

1.3 INTERNATIONAL SYSTEM OF UNITS

Q.5 What do you know about International System of Units? Why was it developed?

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.

International System of Units:

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.

Q.6 What is the difference between base units and derived units? How derived units are derived from base units? Explain with the help of examples.

Ans. Base Units:

The units of base quantities are called base units.

Seven base quantities with their units are given in the table.

Quantity		Unit	
Name	*Symbol*	*Name*	*Symbol*
Length	l	metre	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 Substance	n	mole	mol

Derived Units:

Units of derived quantities are called derived units. The units which can be expressed in terms of base units are called derived units. Derived units are obtained by multiplying or dividing one or more base units with each other.

For Example:

(a) Speed $= \dfrac{\text{distance}}{\text{time}} = \dfrac{\text{meter}}{\text{second}} = \dfrac{\text{m}}{\text{s}} = \text{ms}^{-1}$

(b) Volume = length × breadth × height

$= \text{meter} \times \text{meter} \times \text{meter} = \text{cubic meter} = \text{m}^3$

(c) Force = mass × acceleration

$= \text{mass} \times \dfrac{\text{velocity}}{\text{time}} = \text{mass} \times \dfrac{\text{displacement}/\text{time}}{\text{time}}$

$= \text{mass} \times \dfrac{\text{displacement}}{(\text{time})^2} = \text{kilogram} \times \dfrac{\text{meter}}{(\text{second})^2}$

$= \text{kg} \times \dfrac{\text{m}}{\text{s}^2} = \text{kgms}^{-2} = \text{N}$

Some derived units and their symbols are given in the following table.

Quantity		Unit	
Name	*Symbol*	*Name*	*Symbol*
Speed	v	metre per second	ms^{-1}
Acceleration	a	metre per second per second	ms^{-2}
Volume	V	cubic metre	m^3
Force	F	newton	N or (kg ms^{-2})
Pressure	P	pascal	Pa or (Nm^{-2})
Density	ρ	kilogram per cubic metre	kgm^{-3}
Charge	Q	coulomb	C or (As)
Area	A	square metre	m^2
Plane angle	θ	radian	rad

Q.7 What are prefixes? Give examples.

Ans.

Prefixes:

The terms used internationally for the multiples and sub-multiples of various units are called prefixes. Prefixes are the words or symbols added before SI unit such as milli, centi, kilo, mega, giga,etc.

Importance of prefixes:

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^{-8} m.

Examples:

The following examples will explain the meaning of prefixes.

(i) $5000\,mm = \frac{5000}{1000}\,m = 5\,m$

(ii) $50000\,cm = \frac{50000}{100}\,m = 500\,m$

(iii) $3000\,g = \frac{3000}{1000}\,kg = 3\,kg$

(iv) $2000\,\mu s = 2000 \times 10^{-6} s = 2 \times 10^{-3} s = 2ms$

Some Prefixes for SI Units:

Factor	Prefix	Symbol
10^{18}	Exa	E
10^{15}	Peta	P
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k
10^{2}	Hecto	h
10^{1}	Deca	da

Factor	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d

Note:

Double prefixes are not used. For example no prefix can be used with kilogram because it already contains a prefix kilo.

Q.8 What are multiples and sub multiples? Describe some multiples and sub multiples of mass and length.

Ans.

Multiples:

A unit can be increased or decreased by multiplying or dividing by positive powers of ten. Positive powers of ten are called multiples.

Sub-Multiples:

A unit can be increased or decreased by multiplying or dividing by negative powers of ten. Negative powers of ten are called sub-multiples.

Some multiples and sub-multiples of mass measurement are given in the followingTable:

Table	
100 kg 10 quintal or 1000 kg	1 quintal 1 tonne

Some multiples and sub-multiples of length measurement are given in the following Table:

Table

1m 1cm 1km	100 cm 10 mm 1000 m
1 mm 1 cm 1 km	10^{-3} m 10^{-2} m 10^{3} m

1.4 SCIENTIFIC NOTATION

Q.9 What is scientific notation (Standard Form)? describe its importance and explain th method to write numbers in scientific notation.

Ans.

Scientific Notation:

An internationally accepted way of writing numbers in which numbers are recorded using th power of ten or prefixes and there is only one non zero digit before the decimal.

For Example:

384000000 m $=3.84 \times 10^8$ m
62750 km $=6.275 \times 10^4$ km
0.00045 s $=4.5 \times 10^{-4}$ s

Importance of scientific notation:

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

Method of writing a number in scientific notation:

To write numbers using scientific notation, move the decimal point until only one non-zero digi remains on the left. Then count the number of places through which the decimal point is moved and us this number as the power or exponents of 10. The average distance from the Sun to the Earth i 138,000,000 km. In scientific notation, this distance would be written as 1.38×10^8 km. The number o places, decimal moved to the left is expressed as a positive exponent of 10.

Diameter of hydrogen atom is about 0.000,000,000,052 m. To write this number in scientifi notation, the decimal point is moved 11 places to the right. As a 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.10 Describe important rules required when using SI units and prefixes.

Ans.

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

- Each unit is represented by a symbol not by an abbreviation. For example, for SI not S.I., for second not sec, for ampere A not amp, for gram g not gm.
- Symbols do not take plural form. For example, 10 mN, 100 N, 5 kg, 60 s.
- Full name of unit does not begin with capital letter. For example, metre, second, newton excep Celsius.
- Symbois 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 fo kelvin and Pa for pascal.
- Prefix is written before and close to SI unit. Examples: ms, mm, mN, not m s, m m, m N.
- Units are written one space apart. For example, N m, N s.

- Compound prefixes are not allowed. For example.
    - (i) 7μμs should be written as 7 ps.
    - (ii) 5×10^4 cm should be written as 5×10^2 m

1.5 LENGTH MEASURING INSTRUMENTS

Q.11 Define measuring instruments and least count. Also write a note on meter rule and measuring tape.

Ans.

Measuring Instruments:

Measuring instruments are used to measure various physical quantities such as length, mass, time, volume, etc.

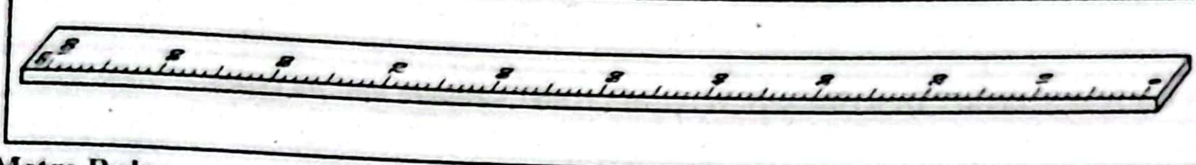
Least Count:

Minimum measurement that can be made by a measuring device is known as least count.

For Example: Least count of meter rod is 1mm.Least count of vernier calipers is 0.1mm. Least count of screw gauge is 0.01mm.

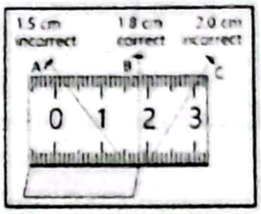
Metre Rule:

A metre rule is a length measuring instrument. It is one metre long which is equal to 100 centimetres. Each centimetre is divided into 10 small divisions called millimeter. One millimeter is the smallest reading that can be taken using a metre rule and it is called its least count.



Using Metre Rule:

To measure the length of an object, the metre 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.



One common source of error comes from the angle at which an instrument is read. While measuring length or distance, eye must be kept vertically above the reading point. The reading becomes doubtful if the eye is positioned either left or right to the reading point. In this case the object will appear to be of different length. This is known as parallax error.

The Measuring Tape:

Measuring tape is used to measure length in metres or centimeters. Its least count is 1 mm. It consists of a thin and long strip of cotton, metal or plastic. Measuring tapes are marked in centimeters as well as in inches.

Q.12 Write a note on vernier calipers. Also calculate its least count.

Ans.

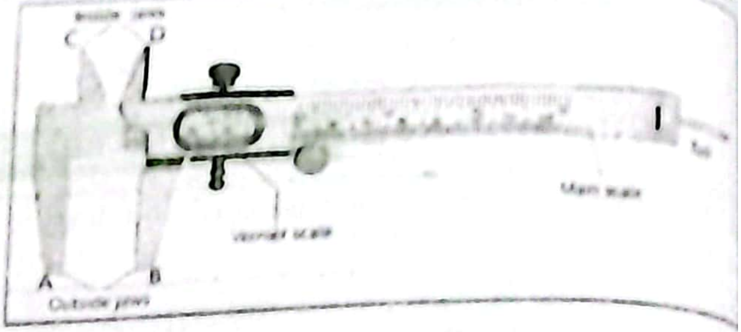
Usually a meter rod is used to measure the length of a body. Metre rod can measure the length of a body correct upto a millimeter. The length less than 1 millimetre cannot be measured accurately using metre rod. For measuring very small lengths we use Vernier calipers which can take smaller than a millimetre reading.

Parts of vernier Callipers:

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.

Scales of vernier callipers:

Vernier Callipers has two scales. Main scale and Vernier scale.



Main scale:

Main scale is on fixed jaw. It has centimeter and millimeter marks on it.

Vernier scale:

The second part of a vernier calipers is a vernier scale which is on a moveable jaw.

Vernier scale can be moved forward or backward on the main scale. The length of vernier scale is of 9 mm and it is divided into ten equal parts. Each part is called a vernier division. The separation between two vernier lines in 0.9 mm.

Least Count of Vernier Callipers:

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 - 1V.S div

= 1mm - 0.9 mm = 0.1 mm

Least count of vernier calipers can also be found as given below:

$$\text{Least count of vernier calipers} = \frac{\text{Smallest division on main scale}}{\text{Total number of divisions on vernier scale}}$$

$$= \frac{1\text{ mm}}{10} = 0.1\text{ mm} = 0.01\text{ cm}$$

Q.13 What is zero error? Describe zero error of vernier calipers and its types.

Ans.

Zero Error:

No Zero Error:

If on joining the jaws of vernier callipers, the zero of the main and vernier scales are exactly in front of each other, then there is no zero error in the instrument.

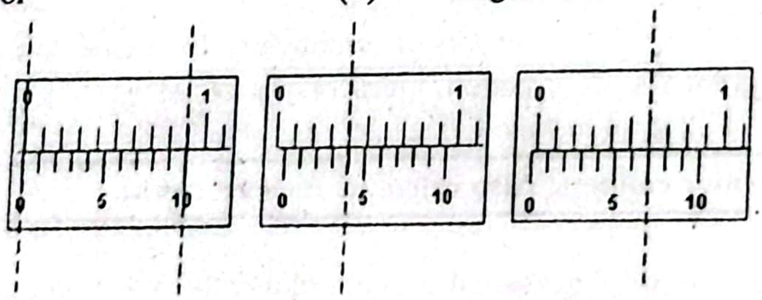
Zero Error of vernier callipers:

If on joining the jaws of vernier callipers, the zero of the main and vernier scales are not exactly in front of each other, then there is an error in the instrument called zero error.

Types of zero error:

There are two types of zero error

(i) Positive zero error **(ii)** Negative zero error



No Zero Error Positive Zero Error Negative Zero Error

Positive zero error:

If the zero of the vernier scale is on right side of the zero of the main scale, then this instrument will show slightly more than the actual length. This is called positive zero error.

How to find positive 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 the instrument.

Correction of positive zero error:

In case of positive zero error the observed reading is corrected by subtracting the zero error from it.

Negative zero error:

If the zero of the vernier scale is on left side of the zero of the main scale, then this instrument will show slightly less than the actual length. This is called negative zero error.

How to find negative zero error:

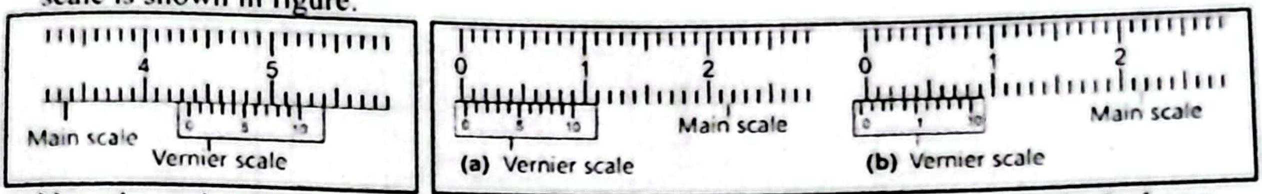
To find the zero error, note the number of the division of the Vernier scale which is exactly in front of any division of the main scale.For example, if 3 is the number of divisions coinciding with any main scale division then 3 is subtracted from 10 and the result is then multiplied with the least count. Therefore, the zero error in this case will be 0.7 mm.

Correction of negative zero error:

In case of negative zero error the observed reading is corrected by adding the zero error in it.

Q.14 Describe the method for taking reading with vernier calipers.

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



(i) Note the main scale reading just infront of Main scale zero of the Vernier scale. It shows 4.3 cm.

(ii) Find the vernier scale division that is coinciding with any main scale division. It is 4^{th} division.

(iii) Multiply it with least count and add it in the main scale reading. It is the required length.

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

$= 4.3 + 0.01 \times 4 = 4.34$ cm

Q.15 Write a note on screw gauge

Ans.

Screw Gauge:

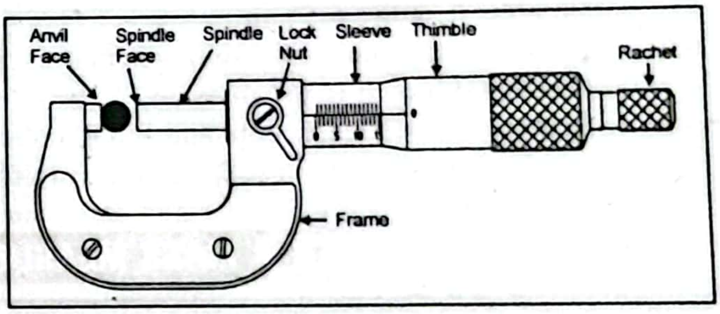
This is an instrument use to measure the thickness of very small objects such as a card board, a strip of metal or a wire accurately upto 100^{th} part of a millimeter. It is also called micrometer screw gauge.

Scales of Screw Gauge:

It has two scales:

(a) The main scale on the sleeve which has markings of 0.5 mm each.

(b) The circular scale on the thimble which has 50 divisions. Some instruments may have main scale marking of 1 mm and 100 divisions on the thimble.



Pitch of Screw Gauge:

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

This is the minimum length which can be measured accurately by using screw gauge. This is known as least count of screw gauge.

Least Count of screw gauge:

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

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

$$\text{Least count of screw gauge} = \frac{\text{Pitch of screw gauge}}{\text{number of circular scale divisions}} = \frac{0.5\text{mm}}{50} = 0.01 \text{ mm}$$

Q.16 Describe zero error of screw gauge and its types.

Ans.

No Zero Error:

If on joining the spindle with the stud of the screw gauge the zero of the circular scale coincides with horizontal line then there is no zero error in the instrument.

Zero Error:

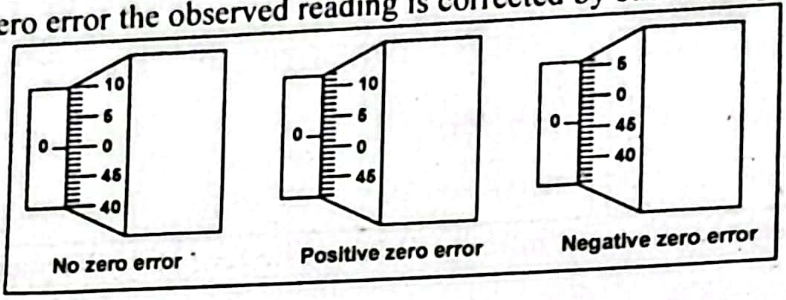
If the zero of the circular scale is not exactly in front of the horizontal line of the main scale on joining the spindle with the stud of the screw gauge, then there is an error in the instrument called zero error.

Positive Zero Error:

If zero of the circular scale is below the horizontal line then it will measure slightly more than the actual thickness. This is called positive zero error.

Correction:

In case of positive zero error the observed reading is corrected by subtracting the zero error from it.



Negative Zero Error:

If zero of the circular scale is above the horizontal line then it will measure slightly less than the actual thickness. This is called negative zero error.

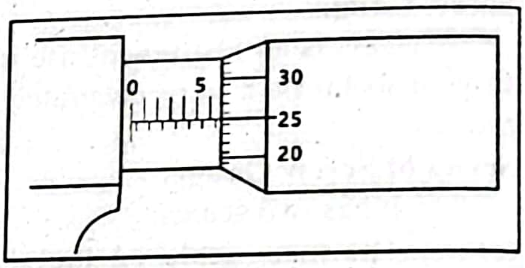
Correction:

In case of negative zero error the observed reading is corrected by adding the zero error in it.

Q.17 Describe the method for taking reading with vernier calipers.

Ans.

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



(i) Note the main scale reading on the sleeve just before the thimble. It shows 6.5 mm.

(ii) Find the circular scale division that is coinciding with horizontal line. It is 25th division.

(iii) Multiply it with least count and add it in the main scale reading. It is the required thickness.

Thickness = main scale reading + (circular scale reading × L.C.)

= 6.5 mm + 25 × 0.01 mm = 6.5 mm + 0.25 mm = 6.75 mm

1.6 MASS MEASURING INSTRUMENTS

Q.18 Define mass measuring instruments, mass and weight

Ans.

Mass Measuring Instruments:

In order to measure mass different types of balances are used throughout the world. Some important balances include beam balance, physical balance, lever balance and electronic balance.

Mass:

Mass is the measure of quantity of matter in a body. Its unit is kilogram (kg). The mass of an object is found by comparing it with known standard masses. This process is called weighing.

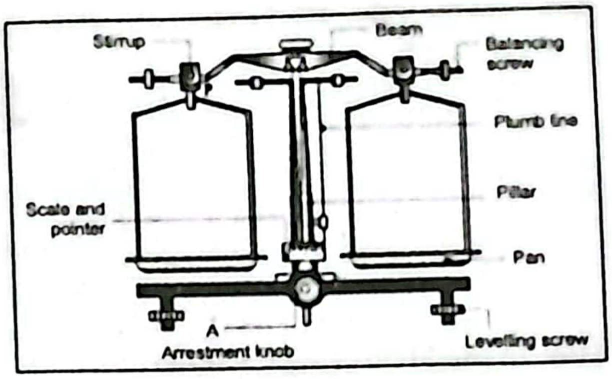
Weight:

Weight is the force by which a body is attracted towards the Earth. Its unit is newton (N). Weight can be measured using spring balance

Q.19 Describe the method for measuring mass with the help of physical balance.

Ans.

Follow the steps to measure the mass of a given object.



i. Adjusting the leveling screws with the help of plumb line to level the base of physical balance.

ii. Raise the beam gently by turning the arresting knob clockwise. Using balancing screws at the ends of its beam to bring the pointer at zero position and beam in horizontal position.

iii. Place the object to be weighed on its left pan.

iv. Place suitable standard masses (known weights) from the weight box on the right pan using forceps. Raise the beam and check the position of pointer.

v. If pointer is not at zero then adjust the weights so that pointer remains on zero or oscillates equally on both sides of the zero of the scale.

vi. Note the standard masses (weights) on the right pan. Their sum is the mass of the object on the left pan.

1.7 TIME MEASURING INSTRUMENTS

Q.20 What is stop watch? Explain its types and working.

Ans.

Stopwatch:

A stopwatch is used to measure the time interval of an event.

There are two types of stopwatches:

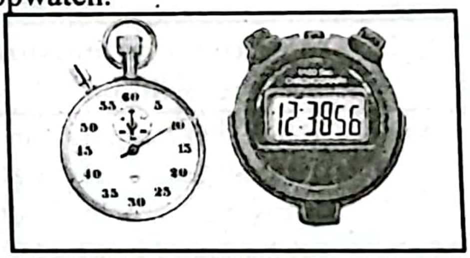
(i) Mechanical stopwatch **(ii)** Digital stopwatch

Least count of mechanical stopwatch is 0.1 second while least count of digital stopwatch is 1/100 second or 0.01 second.

Mechanical stopwatch:

It contains two needles, one for seconds and other for minutes. The dial is divided usually into 30 big divisions each being further divided into 10 small divisions. Each small division represents one tenth (1/10) of a second. Thus, one tenth of a second is the least count of this stopwatch.

How to use mechanical stop watch:



Mechanical stopwatch has a button on its top. To start the watch this button is pressed. In order to stop the watch this button is again pressed. The new position of needles gives the time interval for which the watch was in operation. After noting the time interval, the button B is again pushed to bring back the needles on zero position.

Digital stop watch:

Now-a-days, electronic/digital watches are also available which can measure one hundredth part of a second.

How to use digital stop watch:

Digital stop watch has a start/stop button. This button is pressed to start or stop the stop watch. After recording the time reset button is pressed to restore the watch to its initial zero setting.

1.8 VOLUME MEASURING INSTRUMENTS

Q.21 Write a note on measuring cylinder. Also explain displacement can method.

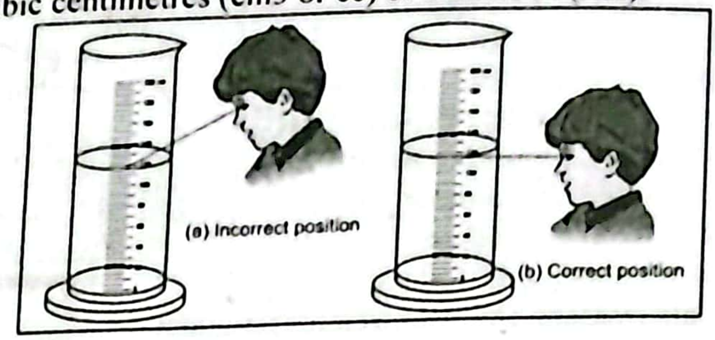
Ans.

Measuring Cylinder:

A measuring cylinder It is used to find the volume of liquids and non-dissolvable solids.

Construction of measuring cylinder:

A measuring cylinder is made of glass or transparent plastic. It has a scale along its length that indicates the volume in cubic centimetres (cm3 or cc) or millilitres (mL).



How to use Measuring Cylinder:

While using a measuring cylinder, it must be kept vertical on a plane surface. **The surface of liquids in the cylinder is curved. This curved surface of liquid is called meniscus.** Meniscus of the most liquids curve downwards while the meniscus of mercury curves upwards.

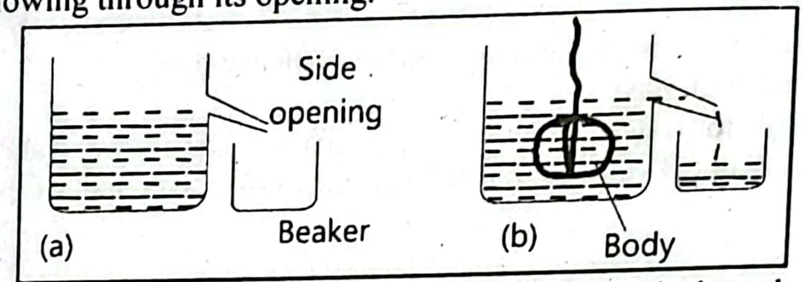
The correct method to note the reading is to keep the eye at the same level as the meniscus of the liquid.

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.

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 as shown in Figure. 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.

Q.22 How can you measure volume of an irregular shaped object that can sink and does not dissolve in liquid?

Ans. Measuring cylinder can be used to find the volume of an irregular shaped object that can sink and does not dissolve in a given liquid.
following the given instructions.

1. Take a liquid in which the given solid does not dissolve.
2. Note the initial position of liquid surface.
3. Put the solid in the cylinder containing liquid.
4. Note again the position of liquid surface in the cylinder which rises due to solid.
5. The difference of the two readings is the volume of the solid.

1.9 ERRORS IN MEASUREMENTS

Q.23 Write a note on errors in measurement and its types.

Ans. **Error:**

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.

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.

(i) **Human Errors**
(ii) **Systematic Errors**
(iii) **Random Errors**

(i) **Human Errors**

They occur due to personal performance.

Causes:

(a) The limitation of the human perception such as the inability to perfectly estimate the position of the pointer on a scale.

(b) 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.

(c) In timing experiments, the reaction time of an individual to start or stop clock also affects the measured value.

Methods to minimize personal errors:

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.

(ii) **Systematic Errors**

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

Causes:

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

Methods to minimize Systematic errors:

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.

(iii) **Random Errors**

It is said to occur when repeated measurements of a quantity give different values under the same conditions. It is due to some unknown causes which are unpredictable. The experimenter have a little or no control over it.

Causes:

Random error arise due to sudden fluctuation or variation in the environmental conditions. For example, changes in temperature, pressure, humidity, voltage, etc.

Methods to minimize random errors:

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.

1.10 UNCERTAINITY IN A MEASUREMENT

Q.24 What is meant by uncertainity in measurement? Explain

Ans.

Uncertainity in measurement:

Whenever a physical quantity is measured (except for counting), some level of uncertainty is present due to the limitations of the measuring instruments and the measurement process. It is to be noted that there is no such thing as a perfect measurement.

Causes of Uncertainty in Measurement:

One reason of uncertainty 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 millimetres. Let the end point of the line lies between 10.3 cm and 10.4 cm 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 ± 0.05 cm. It is, infact, equivalent to an uncertainty of 0.1 cm equal to the least count of the instrument divided into two parts, half above and half below the recorded reading.

Reducing Uncertainty:

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.

Indication of uncertainity:

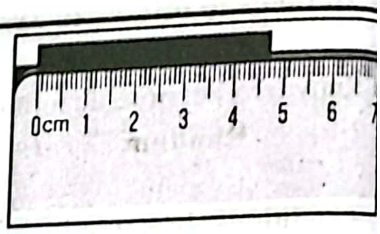
The uncertainty or accuracy in the value of a measured quantity can be indicated conveniently by using significant figures.

Uncertainty in Digital Instruments:

Some modern measuring instruments have a digital scale. We usually estimate one digit beyond what is certain. With digital scale, this is reflected in fluctuation of the last digit.

1.11 SIGNIFCANT FIGURES

Q.25 What do you mean by significant figures of measurement. Write down rules for determining the number of significant figures.



Ans.

Significant Figures:

In any measurement, the accurately known digits and the first doubtful digit are called significant figures.

Explanation:

Suppose two students measure the length of a rod with a ruler.

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

Both students agree on digit 4 but the next digit is doubtful which has been determined by estimation only and has a probability of error. Therefore, it is known as a doubtful digit. In any measurement, the accurately known digits and the first doubtful digit are known-as significant figures.

Rules for determining the number of significant figures in the data:

The following points should be kept in mind while determining the number of significant figures in numerical problems or data.

(i) All non zero digits 1, 2, 3, 4, 5, 6, 7, 8 and 9 are significant. Zero (0) may or may not be significant.

(ii) The zeros in between the digits are considered significant.
For example in 1.406, there are four significant figures.

(iii) In any observation the zeros on the left side of the measured value are not significant. For example in 0.0056, there are two significant figures.

(iv) The zeros on the right side of a decimal are considered significant.
For example in 2.450, there are four significant figures.

(v) In whole numbers that end in one or more zeros without a decimal point. These zeros may or may not be significant. In such a case, express the quantity in scientific notation to find the significant figures. For example, in a report that 29,000 spectators watched a cricket match. The digits 2 and 9 are significant but the zeros are not significant. When it is written in scientific notation with exact number of significant figures as in measurement e.g 2.90×10^2 showing three significant figures or 2.900×10^3 showing four significant figures or even 2.9000×10^5 showing 5 significant figures.

(vi) If numbers are recorded in scientific notation then all the digits before the power of ten are significant. For example in 1.40×10^4, the number of significant figures is three.

1.12 PRECISION AND ACCURACY

Q.26 What is meant by precision and accuracy? Explain. How can we achieve precision and accuracy in measurement?

Ans.

Precision:

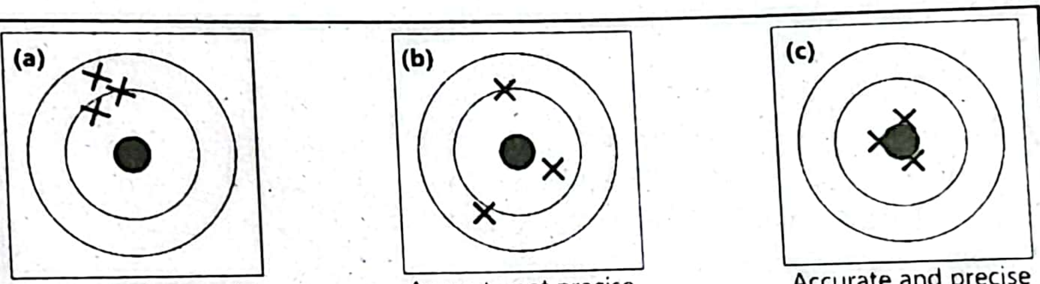
Precision refers to the consistency and repeatability of measurements. It describes how closely repeated measurements of the same quantity are to each other, regardless of whether they are correct or not. If you measure something multiple times and get nearly the same result every time, your measurements are precise. For example, a scale that always gives the same weight within a margin of 0.1 kg is precise, even if it consistently overestimates the true weight by 0.5 kg (not accurate).

Accuracy:

Accuracy on the other hand, refers to how close a measured value is to the true or accepted value. A measurement is accurate if it correctly reflects the actual quantity being measured. For instance, if a thermometer shows a temperature of 25°C when the actual temperature is 25°C, the thermometer is accurate. On the other hand if it reads 2 degrees Celsius higher than the actual temperature then it is not accurate, even if its readings are very precise.

Explanation:

A classic illustration is helpful to distinguish the two concepts. Consider a target or bullseye hit by arrows or darts. To be precise, arrows must hit near each other and to be accurate, arrows must hit near the bullseye.



Precise not accurate | Accurate not precise | Accurate and precise

There may be following different cases of the result of this experiment.

Accurate:

If your darts land close to the center of the target your aim will be referred as accurate.

Precise:

If your darts are grouped tightly together, even if they're not in the center your aim will be termed as precise.

Accurate and precise:

If your darts hit the bullseye and are tightly grouped.

Accurate but not precise:

If your darts land near the center, but they're scattered all over the place.

Precise but not accurate:

If your darts are tightly grouped, but they're all off-center in the same direction.

Both precision and accuracy are desirable qualities:

In practice, both precision and accuracy are desirable qualities in measurements. A measureme can be precise but not accurate, or accurate but not precise. Ideally, measurements should be both preci and accurate, meaning that they are both consistent and close to the true value.

Achievement of precision and accuracy:

When these concepts are applied to measurements, the precision is determined by the instrume being used for measurement. The smaller the least count, the more precise is the measurement. Th smaller the size of physical quantity, the more precise instrument is needed to be used.

A measurement is accurate if it correctly reflects the size of the object being measured. Accura depends on fractional uncertainty in the measurement. Infact, it is relative measurement which important. The accuracy of measurement is reflected by the number of significant figures, the. larger the number of significant figures, the higher is the accuracy.

Table 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 ±0.01 s.
Analogue stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to ±0.1 s.
Ticker-tape timer	Measures short time intervals of 0.02 s.
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.

1.13 ROUNDING OF THE DIGITS

Q.27 Describe important rules for rounding the numbers.

Ans. Numbers are rounded off according to following rules:

(i) If the last digit is less than 5 then it is simply dropped. This decreases the number of significant digits in the figures.

For Example: 1.943 is rounded to 1.94 (3significant figures)

(ii) If the last digit is greater than 5, then the digit on its left is increased by one. This also decreases the number of significant digits in the figure.

For Example: 1.47 is rounded to two significant digits 1.5.

(iii) If the last digit is 5, then it is dropped and the last retained digit is increased by one if it is odd.

For Example: 1.35 is rounded to 1.4

(iv) If the last digit is 5, then it is dropped and the last retained digit does not change if it is even.

For Example: 1.45 is rounded to 1.4

(v) If the digit to be dropped is 5 and there is another non zero digit on its right side then this 5 is dropped and the last retained digit is increased by one.

For Example: 1.352 is rounded to 1.4.

(vi) Sometimes, logic is applied to decide the fate of a digit.

For Example: If we round to 2 significant figures 4.452×10^2 m, the answer should be 4.5×10^2 m since 4.452×10^2 m is more closer to 4.5×10^2 m than 4.4×10^2 m.

EXERCISE

A Multiple Choice Questions

Tick (✓) the correct answer.

1.1. **The instrument that is most suitable for measuring the thickness of a few sheets of cardboard is a:**
(a) metre rule
(b) measuring tape
(c) Vernier Callipers
(d) micrometer screw gauge

1.2. **One femtometre is equal to:**
(a) 10^{-9} m
(b) 10^{-15} m
(c) 10^{9} m
(d) 10_{15} m

1.3. **A light year is a unit of:**
(a) light
(b) time
(c) distance
(d) speed

1.4. **Which one is a non-physical quantity?**
(a) distance
(b) density
(c) colour
(d) temperature

1.5. **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,

1.6. **Volume of water consumed by you per day is estimated in:**
(a) millilitre
(b) litre
(c) kilogram
(d) cubic metre

1.7. **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

1.8. **Two rods with lengths 12.321 cm and 10.3 cm are placed side by side, the difference in their lengths is:**
(a) 2.02 cm
(b) 2.0 cm
(c) 2 cm
(d) 2.021 cm

1.9. **Four students measure the diameter of a cylinder with Vernier Callipers. Which of the following readings is correct?**
(a) 3.4 cm
(b) 3.475 cm
(c) 3.47 cm
(d) 3.5 cm

1.10. **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
(c) 1.2×10^{-15} m
(d) 4×10^{-2} m

1.11. **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 millimetre, the Vernier constant is equal to:**
(a) 0.5 mm
(c) 0.05 mm
(b) 0.1 mm
(d) 0.001 mm

ANSWERS

1	micrometer screw gauge	2	10^{-15} m	3	distance	4	colour	5	position the eye in line with the bottom of the meniscus,
6	litre	7	volume of a solid	8	2.0 cm	9	3.47 cm	10	1×10^{-4} m
11	0.05 mm								

B Short Answer Question

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

Ans. Non-physical quantities are those quantities that cannot be measured using any tool or instrument. These quantities can be described qualitatively or compared using some pre-determined criteria, indices or through survey techniques.

1.2. What is measurement? Name its two parts.

Ans. A measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity. A measurement consists of two parts, a number and a unit. A measurement without unit is meaningless.

1.3. Why do we need a standard unit for measurements?

Ans. In the early days 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. 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.

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

Ans. Three base quantities are Length, Mass, Time.
Three derived quantities are Speed, Force, Area.

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

Ans. The height of desk can be expressed in meters (m) or centimeters (cm).

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

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. Prefixes are used to express very large or very small values conveniently.
Sub-multiples: milli (m), micro (μ), nano (n)
Multiples: kilo (k), mega (M), giga (G)

1.8. What is meant by:

(a) 5pm (b) 15 ns (c) 6 um (d) 5 fs

Ans. (a) 5 pm = 5 picometers = 5×10^{-12} meters
(b) 15 ns = 15 nanoseconds = 15×10^{-9} seconds
(c) 6 μm = 6 micrometers = 6×10^{-6} meters
(d) 5 fs = 5 femtoseconds = 5×10^{-15} seconds

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

(b) Name its two main parts: Main scale and Vernier scale.

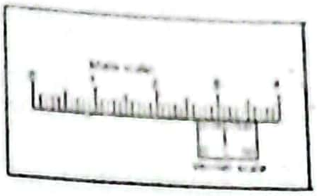
(c) Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Hence, Least count = 1 M.S div - 1V.S div
= 1mm - 0.9 mm = 0.1 mm

Usually, the least count is found by dividing the length of one small division on main scale by the total number of divisions on vernier scale.

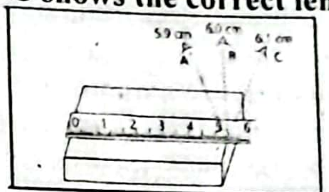
(d) If on joining the jaws of vernier calliper, the zeros of the main scale and Vernier scale do not exactly coincide with each other then there is an error in the instrument called zero error.

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



Ans. Least count = 0.1 mm (or 0.01 cm)
Zero Error = ± 0.0cm
Main scale reading = 2.6 cm
Vernier div. coinciding with main scale div. = 5 div
Vernier scale reading = 5×0.01 cm= 0.05 cm
Observed diameter of the cylinder = 2.6 cm + 0.05 cm = 2.65 cm
Correct diameter of the cylinder = 2.65 cm $\pm$ 0.0 cm = 2.65 cm

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



Ans. The correct reading is 6.0 cm at position B because at this point the eye is vertically above the reading point.

C Constructed Response Questions

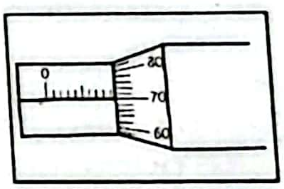
1.1 **In what unit will you express each of the following?**
(a) Thickness of a five-rupee coin
(b) Length of a book:
(c) Length of a football field
(d) Distance between two cities
(e) Mass of a five-rupee coin
(f) Mass of your school bag
(g) Duration of your class period
(h) Volume of petrol filled in the tank of a car
(i) Time to boil one liter of milk

Ans.
(a) Millimeter (mm) (b) Centimeter (cm) (c) Meter (m)
(d) Kilometer (km) (e) Gram (g) (f) Kilogram (kg)
(g) Minutes (min) (h) Liter (L) (i) Minutes (min)

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

Ans. A standard system ensures that the tailor's measurements are consistent and accurate, enabling proper fitting for garments.

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



Ans.
Number of divisions on circular scale = 100
Smallest main scale reading = Pitch of screw gauge = 1 mm

$$\text{Least count of screw gauge} = \frac{\text{Pitch of screw gauge}}{\text{number of circular scale divisions}}$$

$$= \frac{1\text{mm}}{100} = 0.01 \text{ mm}$$

Thickness of the rod:
Zero Error = ± 0.0 mm
Main scale reading = 9 mm
Circular scale div. in front of index line = 70 div.
Circular scale reading = 70×0.01 mm = 0.70 mm

Observed diameter of the given wire = 9 mm + 0.70 mm
= 9.70 mm

Correct diameter of the given wire = 9.70 mm ±0.0 mm = 1.61 mm

1.4 You are provided a meter scale and a bundle of pencils; how can the diameter of a pencil measured using the meter scale with the same precision as that of Vernier Calipers? Describe briefly.

Ans. Arrange pencils tightly in a straight line. Measure the total length of the row using the meter scale, then divide by the number of pencils to get an approximate diameter.

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

Ans. If the end of a meter scale is worn out, you can place the pencil on any other fully visible mark the scale and note the readings at both ends of the pencil on the meter scale. Subtract the two readings to get the length of the pencil.

1.6 Why is it better to place the object close to the meter scale?

Ans. When measuring an object with a meter scale, it is better to place the object close to the scale reduces chances of parallax error and ensures an accurate reading. Parallax error occurs when eye is not directly in line with the markings on the scale.

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

Ans. Standard units are needed to measure quantities correctly because they ensure that measurements are consistent and accurate, and can be understood by others. It ensures uniformity and allo measurements to be universally understood and compared.

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

Ans. Some natural phenomena that could serve as a reasonably accurate time standard are as under. Rotation of the Earth , vibration of a cesium atom (used in atomic clocks) and radioactive deca etc.

1.9 It is difficult to locate the meniscus in a wider vessel. Why?

Ans. In a wider vessel, the meniscus is harder to locate because its curvature is less pronounced, making it flatter and less visible. Additionally, reflections and parallax errors make it difficult to locate the meniscus further.

1.10 Which instrument can be used to measure:

(i) Internal diameter of a test tube,

(ii) Depth of a beaker

Ans. In both cases vernier calipers can be used.

D Comprehensive Questions

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

Ans. For answer See Q.No.2 and Q.No.6

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

Ans. **(a)** $\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{\text{meter}}{\text{second}} = \frac{\text{m}}{\text{s}} = \text{ms}^{-1}$

(b) $\text{Volume} = \text{length} \times \text{breadth} \times \text{height}$

$= \text{meter} \times \text{meter} \times \text{meter} = \text{cubic meter} = \text{m}^3$

(c) $\text{Force} = \text{mass} \times \text{acceleration}$

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}} = \text{mass} \times \frac{\text{displacement}/\text{time}}{\text{time}}$$

$$= \text{mass} \times \frac{\text{displacement}}{(\text{time})^2} = \text{kilogram} \times \frac{\text{meter}}{(\text{second})^2}$$

$$= \text{kg} \times \frac{\text{m}}{\text{s}^2} = \text{kgms}^{-2} = \text{N}$$

1.3. State the similarities and differences between Vernier Calipers and Micrometer Screw Gauge.

Ans. Similarities:

1. Both instruments are used to measure small lengths with high precision.
2. Both instruments consist of two scales, one main scale and other a secondary (Vernier or circular) scale to improve accuracy.

Differences:

Feature	Vernier Calipers	Micrometer Screw Gauge
Function	Measures internal and external dimensions and depth.	Measures external dimensions only.
Precision	Least count = 0.1 mm	Least count = 0.01 mm
Scale type	It has sliding vernier scale.	It has rotating circular scale
Usage	Suitable for larger objects (e.g., small rods, metallic bob etc).	Suitable for smaller objects (e.g., wires, card board etc.).
Construction	Has jaws for holding objects.	Has an anvil and spindle with a screw.

1.4 Identity and explain the reasons for human errors, random errors and systematic errors in experiments.

Ans. For answer See Q.No.23

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

Ans. For answer See Q.No.26

ADDITIONAL SLO BASED SHORT QUESTION

Quick Quiz

Quick Quiz Page No. 6

Is a non-physical quantity has dimensions?

Ans. No, a non-physical quantity does not have dimensions. These quantities do not have any fundamental quantities involved, and therefore do not have any dimensions or units.

Quick Quiz Page No. 9

(a) Write the unit of charge in terms of base unit ampere and second.

Ans. The unit of charge is coulomb which is equal to ampere second.

$$1\ C = 1\ As$$

(b) Express the unit of pressure "pascal" in some other units.

Ans. $1\ Pa = 1\ Nm^{-2} = kgm^{-1}s^{-2}$

Quick Quiz Page No. 10

100 m is equal to:

(a) $1000\mu m$ (b) 1000cm (c) 100,000mm (d) 1km

Ans. (c) 100,000mm

Quick Quiz Page No. 11

Express the following into scientific notation.

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

Ans.

a) $0.00534\ m = 5.34 \times 10^{-3}\ m$

b) $2574.32\ kg = 2.57432 \times 10^{3}\ kg$

c) $0.45\ m = 4.5 \times 10^{-1}\ m$

d) $0.004\ kg = 4 \times 10^{-3}\ kg$

e) $186000\ s = 1.86 \times 10^{5}\ s$

Quick Quiz **Page No. 19**

Identify Personal, Systematic and Random errors:

1. **Your eye level may move a bit while reading the meniscus.**
2. **Air current may cause the balance to fluctuate.**
3. **The balance may not be properly calibrated.**
4. **Some of the liquid may have evaporated while it is being measured.**

Ans.

1. Personal error.
2. Random error.
3. Systematic error.
4. Random error.

Quick Quiz **Page No. 21**

Name some repetitive processes occuring in nature which could serve as reasonable time standard

Ans. Repetitive natural phenomena like the rotation of Earth or orbit of Moon and radioactive decay of an elements could serve as time standards.

Quick Quiz **Page No. 21**

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

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

Ans. There are 3 significant figures in each of these numbers.

Brain Teaser! | Do You Know? | For Your Information!

Q.1 Which base unit prefix attached with it?

Ans. The kilogram is the only base unit that has a prefix.

Q.2 Write average lengths of a football ground, man, thickness of a book page and diameter of a pencil.

Ans.

Some specific lengths in (m)	
Football ground	9.1×10^1
Man	1.8×10^0
Thickness of book page	1.0×10^{-4}
Diameter of pencil	7.0×10^{-3}

Q.3 When and who invented vernier callipers?

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

Q.4 Write some laboratory safety rules.

Ans. Laboratory Safety Rules

- 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 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.

Q.5 How did ancient Chinese estimate the volume of grains?

Ans. Ancient Chinese used to estimate the volume of grains by sounding their containing vessels. 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 0.35 mm.

Q.6 What is least count of an electronic timer?

Ans. An electronic timer can measure time intervals as short as one-ten thousands (1/10,000) of a second.

Q.7 Do numbers smaller than one represent negative or positive exponents?

Ans. The negative exponents have values less than one. For example, $1 \times 10^{-2} = 0.01$

Q.8 Can we add or subtract numbers if they have different exponents? If not, then haw can they be added?

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.9 What is meant by parallex 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.10 Which is most precise balance?

Ans. The most precise balance is the digital electronic balance. It can measure mass of the order of 0.1mg

Q.11 Do symbols of base units depend on the language used in the text?

Ans. No, the symbol of the base units are universal independent of the language used in the written text.

Caution:

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

Q.12 Describe range and least count of different length measuring instruments.

Ans.

Limitations of measuring Instruments		
Instrument	**Range**	**Least Count**
Measuring Tape	1 cm to several metres	1 mm
Metre rule	1 mm to 1 m	1 mm
Vernier Callipers	0.1 mm to 15 cm	0.1 mm
Micrometer Screw gauge	0.01 mm to 2.5 cm	0.01 mms

Q.14 Can a sensitive (precise) balance measure large masses?

Ans. A sensitive balance cannot measure large masses. Similarly a balance that measures large masses cannot be sensitive.

Q.15 Which balance is considered more precise?

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

Q.16 Write a note on laboratory safety equipments.

Ans. A school laboratory must have safety equipments such as:

* Waste-disposal basket
* Fire extinguisher.
* Fire alarm.
* First Aid Box.
* Sand and water buckets.
* Fire blanket to put off fire.
* Substances and equipments that need extra care must bear proper warming signs.

Q.17 What is meant by the pitch of the screw gauge?

Ans. The distance covered by the circular scale in its one complete rotation is called pitch. The pitch of a screw gauge is usually 1mm.

Q.18 What is meant by the pitch of the vernier calipers?

Ans. The distance between two small lines on main scale is called pitch of vernier calipers. Its value is usually 1mm.

Q.19 Why a screw gauge measures more accurately than a vernier calipers?

Ans. Least count of screw gauge is 0.01 mm while least count of vernier calipers is 0.1 mm.Since screw gauge is more precise instrument than vernier calipers so it measures more accurately than a vernier calipers.

Q.20 What is the least count of the vernier calipers?

Ans. Least count of vernier calipers is 0.1 mm or 0.01 cm.

Q.21 What is the range of the vernier calipers used in your physics laboratory?

Ans. It can measure from 0.1 mm to 150 mm.

Q.22 How many divisions are there on its vernier scale?

Ans. There are ten divisions on its vernier scale.

Q.23 Why do we use zero correction?

Ans. In order to correct zero error zero correction is added or subtracted from the observ measurement.

Q.24 What is least count of digital vernier calipers?

Ans. Digital vernier callipers has greater precision than mechanical vernier callipers. Least count Digital Vernier Callipers is 0.01mm.

Q.25 What is the least count of a screw gauge?

Ans. Least count of screw gauge is 0.01 mm or 0.001 cm.

Q.26 What is the pitch of your laboratory screw gauge?

Ans. The pitch of laboratory screw gauge is 1 mm.

Q.27 What is the range of your laboratory screw gauge?

Ans. It can measure from 0.01 mm to 25 mm.

Q.28 Which one of the two instruments is more precise and why?

a. Vernier Callipers. b. Screw Gauge

Ans. Least count of vernier callipers is 0.1 mm and least count of micrometer screwgauge is 0.01 mm Thus micrometer screw gauge is more precise than the vernier callipers.

Q.29 What is meant by precise instrument?

Ans. An instrument with small least count or absolute uncertainty is called more precise.

Q.30 Measurement taken by which instrument is more precise? Ruler, vernier callipers an screw gauge.

Ans. Least count of ruler is 1mm. It is 0.1mm for Vernier Callipers and 0.01 mm for micrometer scre gauge. Thus measurements taken by micrometer screw gauge are the most precise than the othe two.

Q.31 What is the function of balancing screws in a physical balance?

Ans. In physical balance balancing screws are used to bring the pointer at zeroPosition.

Q.32 On what pan we place the object and why?

Ans. It is a convention to place the object to be measured on left pan.

Examples

[C.A , A.B]

Example 1.1

Solve the following:

(a) $5.123 \times 10^4 m + 3.28 \times 10^5 m$

(b) $2.57 \times 10^2 mm - 3.43 \times 10^3 mm$

Ans.

(a)

$$5.123 \times 10^4 m + 3.28 \times 10^5 m$$
$$= 5.123 \times 10^4 m + 32.8 \times 10^4 m$$
$$= (5.123 + 32.8)\, 10^4 m$$
$$= 37.923 \times 10^4 m$$
$$= 3.7923 \times 10^5 m$$

(b)

$$2.57 \times 10^{-2} mm - 3.43 \times 10^{-3} mm$$
$$= 2.57 \times 10^{-2} mm - 0.343 \times 10^{-2} mm$$
$$= (2.57 - 0.343)\, 10^{-2} mm$$
$$= 2.227 \times 10^{-2} mm$$
$$= 2.227 \times 10^{-2} \times 10^{-3} m$$
$$= 2.227 \times 10^{-5} m$$

Example 1.2

Find the value of each of the following quantities:

(a) $(4 \times 10^3 \text{ kg})(6 \times 10^6 \text{ m})$

(b) $\frac{6 \times 10^6 \text{m}^3}{2 \times 10^{-2} \text{m}^2}$

Ans.

(a) $(4\times10^3 \text{ kg})(6\times10^6 \text{ m}) = (4 \times 6) \times 10^{3+6} \text{ kg m} = 24 \times 10^9 \text{ kg m} = 2.4 \times 10^{10} \text{ kg m}$

(b) $\frac{6\times10^6 \text{m}^3}{2\times10^{-2} \text{m}^2} = \frac{6}{2}\times10^{6+2} \text{m}^{3-2} = 3\times10^8 \text{m}$

Solved Numericals

[C.A , A.B]

Numerical 1.1

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

Ans. **(a)** Seconds in a day = 24 hours X 60 minutes X 60 seconds = 86400 s

$= 86.4\times10^3 \text{s} = 86.4 \text{ks}$

(b) Seconds in a week = 7 days X 24 hours X 60 minutes X 60 seconds

$= 604800 \text{s} = 604.8\times10^3 \text{s} = 604.8 \text{ks}$

(c) Seconds in a month = 30 days X 24 hours X 60 minutes X 60 seconds

$= 2592000 \text{s} = 2.592\times10^6 \text{s} = 2.592 \text{Ms}$

Numerical 1.2

State the answers of problem 1.1 in scientific notation.

Ans. (a) $86400 \text{s} = 8.64\times10^4 \text{s}$

(b) $604800 \text{s} = 6.048\times10^5 \text{s}$

(c) $2592000 \text{s} = 2.592\times10^6 \text{s}$

Numerical 1.3

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

(a) $4\times 10^{-4} \text{ kg} + 3\times 10^{-5} \text{ kg}$

(b) $5.4 \times 10^{-6} \text{ m} - 3.2 \times 10^{-5} \text{ m}$

Ans. (a) $4\times 10^{-4} \text{ kg} + 3\times 10^{-5} \text{ kg}$

$=(4+3\times10^{-1})\times10^{-4} \text{kg}$

$= (4+0.3)\times10^{-4} \text{kg} = 4.3\times10^{-4} \text{kg}$

(b)

$5.4 \times 10^{-6} \text{ m} - 3.2 \times 10^{-5} \text{ m}$

$=(5.4\times10^{-1} - 3.2)\times 10^{-5} \text{ m}$

$= (0.54-3.2)\times 10^{-5} \text{ m} = -2.66\times 10^{-5} \text{ m}$

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

Ans. (a) $(5\times10^4 m)\times(3\times10^{-2} m)$

$=(5\times3)\times(10^4\times10^{-2})m^2$

$=15\times10^{4-2}m^2$

$=15\times10^2 m^2$

$=1.5\times10^3 m^2$

(b) $\frac{6\times10^8 kg}{3\times10^4 m^3}$

$=\frac{6}{3}\times\frac{10^8}{10^4}kgm^{-3}$

$=2\times10^{8-4}kgm^{-3}$

$=2\times10^4 kgm^{-3}$

Numerical 1.5

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

Ans. $\frac{(3\times10^2 kg)\times(4.0 km)}{5\times10^2 s^2}$

$=\frac{(3\times10^2 kg)\times(4\times10^3 m)}{5\times10^2 s^2}$

$=\frac{3\times4}{5}\times\frac{10^2\times10^3}{10^2}kgms^{-2}$

$=\frac{12}{5}\times10^{2+3-2}kgms^{-2}$

$=2.4\times10^3 kgms^{-2}$

Numerical 1.6

State the number of significant digits in each measurement.

(a) 0.0045 m, (b) 2.047 m, (c) 3.40 m, (d) 3.420 x 10' m

Ans. **(a) 0.0045 m**

There are 2 significent digits.

(b) 2.047 m

There are 4 significant digits.

(c) 3.40 m

There are 3 significant digits.

(d) 3.420 x 10' m

There are 4 significant digits.

Numerical 1.7

(a) 0.0035 m **(b) 206.4 x 10^2 m**

Ans. (a) $0.0035m=3.5\times10^{-3}m$

(b) $206.4\times10^2 m$

$=2.064\times10^2\times10^2 m$

$=2.064\times10^{2+2}m$

$=2.064\times10^4 m$

Numerical 1.8

Write using correct prefixes:

(a) 5.0×10^4 cm **(b) 580×10^2 g** **(c) 45×10^4s**

Ans. (a) 5.0×10^4cm

$=5.0\times10^4\times10^{-2}$m $=5.0\times10^{4-2}$m $=5.0\times10^2$m $=0.5\times10^{-3}$m $=0.5$km

(b) 580×10^2g $=58\times10^1\times10^2$g $=58\times10^{1+2}$g $=58\times10^3$g $=58$kg

(c) 45×10^{-4}s $=4.5\times10^1\times10^{-4}$s $=4.5\times10^{1-4}$s $=4.5\times10^{-3}$s $=4.5$ms

Numerical 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 x 108 ms^{-1}, calculate the distance.

Ans. Speed of light $=3.0\times10^8$ ms^{-1}

Time $=1$ year

$=1\times365\times24\times60\times60$s

$=31,536,000$s

$=3.1536\times10^7$s

To Find distance = ?

Solution

We know that

Distance = Speed $\times$ time

$=3.0\times10^8$ms$^{-1}\times3.1536\times10^7$s

$=9.4608\times10^{8+7}$ms^{-1+1}

$=9.46\times10^{15}$m

Numerical 1.10

Express the density of mercury given as 13.6 g cm3 in kg m^{-3}.

Ans.

Data

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

To Find

Density of mercury in kgm^{-3} = ?

Solution

We know that

1gcm^{-3} $=1000$kgm^{-3}

So density of mercury $=13.6\times1000$kgm^{-3}

$=1.36\times10^1\times10^3$ kgm^{-3} $=1.36\times10^{1+3}$ kgm^{-3} $=1.36\times10^4$ kgm^{-3}

ADDITIONAL SLO BASED MCQs

1.1 PHYSICAL AND NON-PHYSICAL QUANTITIES

1 **What are physical quantities?**
(A) Non-measurable quantities (B) Measurable quantities
(C) Abstract ideas (D) Emotions and feelings

2 **Which is a characteristic of physical quantities?**
(A) Emotional value (B) Numerical magnitude
(C) Human behavior (D) Social interactions

3 **What is an example of a non-physical quantity?**
(A) Mass (B) Love (C) Speed (D) Temperature

4 **How are non-physical quantities described?**
(A) Using units (B) Using qualitative methods
(C) With numerical magnitudes (D) By direct measurement

5 **What forms the foundation of physics?**
(A) Non-physical quantities (B) Abstract concepts
(C) Physical quantities (D) Social behaviors

ANSWERS

1	Measurable quantities	2	Numerical magnitude	3	Love
4	Using qualitative methods	5	Physical quantities		

1.1 PHYSICAL AND NON-PHYSICAL QUANTITIES
1.2 BASE AND DERIVED PHYSICAL QUANTITIES
1.3 INTERNATIONAL SYSTEM OF UNITS

1. **The number of base units in SI are:**
(A) 7 (B) 3 (C) 6 (D) 9

2. **Amount of a substance in terms of numbers:**
(A) gram (B) newton (C) mole (D) kilogram

3. **Identify the base quantity:**
(A) speed (B) area (C) force (D) distance

4. **Kilogram is:**
(A) base unit (B) base quantity (C) derived unit (D) derived quantity

5. **The number of base quantities in SI system is:**
(A) 3 (B) 4 (C) 5 (D) 7

6. **Base unit is:**
(A) Pascal (B) kilogram (C) Newton (D) watt

7 **In S.I system, the unit of mass is:**
(A) Second (B) Meter (C) Kilogram (D) Newton

8. **Which of the following unit is not a derived unit?**
(A) Pascal (B) Kilogramme (C) Newton (D) watt

9. **Which of the following is a derived unit?**
(A) newton (B) mole (C) meter (D) second

10. **The unit of volume is:**
(A) Meter (B) Force (C) Cubic meter (D) Second

11. **SI unit of electric current is:**
(A) second (B) ampere (C) mole (D) meter

ANSWERS

1	7	2	Mole	3	Distance	4	Base unit
5	7	6	Kilogram	7	kilogram	8	kilogram
9	newton	10	Cubic meter	11	ampere		

1.4 SCIENTIFIC NOTATION

1. **Which one of the following is the smallest quantity?**
(A) 0.01 g (B) 2 mg (C) 100μg (D) 5000 ng

2. **An interval of 200μs is equivalent to:**
(A) 0.2s (B) 0.02s (C) 2×10^{-4} s (D) 2×10^{-6}s

3. **One giga gram is equal to:**
(A) 10^9g (B) 10^6g (C) 10^3g (D) 10^{-6}g

4. **Volume of one litre is equal to:**
(A) $1cm^3$ (B) $10cm^3$ (C) $100cm^3$ (D) $1000cm^3$

5. **One litre is equal to ________ milli litre.**
(A) 10^2 (B) 10^3 (C) 10^4 (D) 10^5

6. **One tera is equal to:**
(A) 10^{-12} (B) 10^{-18} (C) 10^{12} (D) 10^{18}

7. **One mega is equal to:**
(A) 10^3 (B) 10^4 (C) 10^5 (D) 10^6

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

9. **Kilo = ?**
(A) 10 (B) 10^2 (C) 10^3 (D) 10^4

10. **One pico metre is equal to:**
(A) 10^{12} m (B) 10^{-12} m (C) 10^6 m (D) 10^{-6} m

11. **0.00002g is equal to how many micrograms?**
(A) 2.0 μg (B) 0.20 μg (C) 20 μg (D) 200 μg

12. **3.3 GHz is equal to:**
(A) 3300×10^6 Hz (B) 3.300×10^6 Hz (C) 3300×10^9 Hz (D) 3.300×10^{15} Hz

13. **$200000\,ms^{-1}$ is equal to :**
(A) $2\,kms^{-1}$ (B) $20\,kms^{-1}$ (C) $200\,kms^{-1}$ (D) $2000\,kms^{-1}$

14. **Mass of water molecule is:**
(A) 6×10^{27}g (B) 6×10^{-18}g (C) 2.9×10^{23}g (D) 3×10^{-4}g

15. **Standard form of 6400 km is ________.**
(A) 64×10^2 km (B) 6.4×10^3 km (C) 64×10^{-2} km (D) 64×10^{-3} km

ANSWERS

1	5000 ng	2	2×10^{-4} s	3	10^9g	4	1000 cm^3
5	10^3	6	10^{12}	7	10^6	8	10^{-15}
9	10^3	10	10^{-12}m	11	20 μg	12	3.300×10^6 Hz
13	$200\,kms^{-1}$	14	2.9×10^{23}g	15	6.4×10^3 km		

1.5 LENGTH MEASURING INSTRUMENTS
1.6 MASS MEASURING INSTRUMENTS
1.7 TIME MEASURING INSTRUMENTS
1.8 VOLUME MEASURING INSTRUMENTS

1. **The length of meter rule is:**
   (A) 1 meter (B) 0.5 meter (C) 2 meters (D) none of these
2. **One meter is equal to:**
   (A) 10cm (B) 100cm (C) 1000cm (D) 100mm
3. **The least count of metre rod is:**
   (A) 1mm (B) 0.01m (C) 0.01cm (D) 0.01mm
4. **The least count of vernier callipers is:**
   (A) 0.01 m (B) 0.01 mm (C) 0.001 cm (D) 0.01 cm
5. **The least count of digital vernier callipers is:**
   (A) 0.01mm (B) 0.001mm (C) 0.1mm (D) 1mm
6. **Instrument which is most suitable to measure the internal diameter of test tube is:**
   (A) meter rod (B) vernier callipers (C) screw gauge (D) measuring tape
7. **A student claimed the diameter of a wire as 1.032cm using vernier callipers. Upto what extent do you agree with?**
   (A) 1.03 cm (B) 1.0 cm (C) 1 cm (D) 1.032 cm
8. **Least count of the screw gauge is:**
   (A) 0.1 mm (B) 0.01 mm (C) 0.001 mm (D) 0.0001 mm
9. **The most sensitive balance for measuring mass of light object is:**
   (A) electronic balance (B) physical balance (C) beam balance (D) lever balance
10. **A measuring cylinder is used to measure:**
   (A) mass (B) area (C) volume (D) level of a liquid
11. **What is the least count of mechanical stop watch?**
   (A) 0.1s (B) 0.01s (C) 0.001s (D) 0.0001s

ANSWERS

1	1 meter	2	100 cm	3	1 mm	4	0.01 cm
5	0.001 mm	6	Vernier calipers	7	1.03 cm	8	0.01mm
9	electronic balance	10	Volume	11	0.1s		

1.9 ERRORS IN MEASUREMENTS

1 **What is an error in measurement?**
   (A) Perfect measurement (B) Measurement uncertainty
   (C) Accurate reading (D) Error elimination
2 **What causes human error?**
   (A) Environmental changes (B) Faulty calibration
   (C) Reaction delay (D) Consistent readings
3 **What defines systematic errors?**
   (A) Unpredictable (B) Affect all equally
   (C) Human perception (D) Always large
4 **How to minimize random errors?**
   (A) Compare instruments (B) Take averages
   (C) Align properly (D) Avoid distractions

5 **What causes systematic errors?**

(A) Fluctuations
(B) Zero error
(C) Reaction delay
(D) Environmental changes

ANSWERS					
1	Measurement uncertainty	2	Reaction delay	3	Affect all equally
4	Take averages	5	Zero error		

1.10 UNCERTAINITY IN A MEASUREMENT

1 **What causes measurement uncertainty?**

(A) Perfect instruments
(B) Instrument limits
(C) Calculation errors
(D) Reading mistakes

2 **What is the uncertainty using a meter rule?**

(A) ± 0.1 cm
(B) ± 0.05 cm
(C) ± 0.2 cm
(D) ± 0.5 cm

3 **How to reduce uncertainty?**

(A) Use larger instruments
(B) Take averages
(C) Rely on digital tools
(D) Estimate values

4 **What do significant figures show?**

(A) Least count
(B) Accuracy
(C) Repetition
(D) Scale size

5 **How do digital instruments show uncertainty?**

(A) Larger counts
(B) Last digit fluctuation
(C) No fluctuation
(D) No uncertainty

ANSWERS					
1	Instrument limits	2	± 0.05 cm	3	Take averages
4	Accuracy	5	Last digit fluctuation		

1.11 SIGNIFCANT FIGURES

1. **The number of significant figures in 100.8 s is:**

(A) 2 (B) 3 (C) 4 (D) 5

2. **The number of significant figures in 0.00580 is:**

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

3. **The number of significant figures in 210.0 g is:**

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

ANSWERS					
1	4	2	3	3	4

1.12 PRECISION AND ACCURACY

1 **What does precision refer to?**

(A) Closeness to true value
(B) Repeatability of measurements
(C) Correct measurement
(D) Number of significant figures

2 **What does accuracy indicate?**

(A) Consistency of measurements
(B) Closeness to the true value
(C) Measurement of small quantities
(D) Grouping of measurements

3 **How is precision achieved in measurements?**

(A) By increasing the least count (B) By using fewer readings
(C) By making accurate instruments (D) By reducing significant figures

4 **What does a larger number of significant figures indicate?**

(A) Lower accuracy (B) Higher precision
(C) Higher accuracy (D) Less repeatability

5 **What happens with precise but not accurate measurements?**

(A) Scattered (B) Grouped
(C) Correct (D) True value

ANSWERS					
1	Repeatability of measurements	2	Closeness to the true value	3	By increasing the least count
4	Higher accuracy	5	Scattered		

1.13 ROUNDING OF THE DIGITS

1 **What happens if the last digit is less than 5?**

(A) Dropped (B) Increased (C) Retained (D) Double

2 **What happens if the last digit is greater than 5?**

(A) Dropped (B) Decreased (C) Increased (D) Unchanged

3 **What happens if the last digit is 5 and the retained digit is odd?**

(A) Decreased (B) Increased (C) Dropped (D) Unchanged

4 **What happens if the last digit is 5 and the retained digit is even?**

(A) Increased (B) Dropped (C) Unchanged (D) Doubled

ANSWERS					
1	Dropped	2	Increased	3	Increased
4	Unchanged				

KEY POINTS

- A **physical quantity** can be measured directly or indirectly using some instruments.
- **Non-physical quantity** is not measurable using an instrument. It qualitatively depends on the perception of the observer and estimated only.
- **Base quantities** are length, mass, time, temperature, electric current, etc.
- **Derived quantities** are all those quantities which can be defined with reference to base quantities. For example, speed, area, volume, etc.
- **Standard unit** does not vary from person to person and understood by all the scientists.
- **Base units** of system international are: metre, kilogram, second, ampere, candela, kelvin and mole. The units which can be expressed in terms of base units are called **derived units.**
- **Scientific notation** is an internationally accepted way of writing numbers in which numbers are recorded using the powers of ten or prefixes and there is only one non-zero digit before the decimal.
- **Least count** is the least measurement recorded by an instrument.
- **Vernier Callipers** is an instrument which can measure length correct up to 0.1 mm.
- **Screw guage** is an instrument which can measure length correct up to 0.01 mm.
- Measurements using instruments are not perfect. There are inevitable **errors** in the measured values, may be due to human errors, systematic errors and random errors.
- Measurements using instruments errors are **uncertain** to some extent depending upon the limitations or refinement of the instrument.
- **Significant figures** are the accurately known digits and first doubtful digit in any measurement.
- The **precision** is detemined by the instrument being used for measurement whereas the **accuracy** depends on relative measurement reflected by the number of significant figures.