➢ **Science in modern context**

The word science originates from the verb '*scientia*' meaning 'to know'. There are two domain of interest of science: 1) macroscopic 2) microscopic

The macroscopic domain includes phenomena at the laboratory and astronomical scales.

The microscopic domain includes atomic, nuclear and molecular phenomena.

Classical physics deals mainly with macroscopic phenomena and includes subject like Mechanics, Electrodynamics, Optics and Thermodynamics.

The microscopic domain of physics deals with the constitution and structure of matter at the atomic scale.

➢ **Ancient scientific discoveries**

☞ The idea of zero: Mathematician Aryabhata was the first person to create a symbol for zero and it was through his efforts that mathematical operations like addition and subtraction started using the digit, zero.

☞ A Theory of Atom: One of the notable scientists of the ancient India was Kanad who is said to have devised the atomic theory centuries before John Dalton was born. He speculated the existence of anu or a small indestructible particles, much like an atom.

➢What is the scope of physics?

The scope of physics grew as the theory of relativity changed the way we used think about the world and atmosphere. It is most probably the most comprehensive theories which the whole world has acknowledged. The renowned physicist Richard Feynman introduced the world to Quantum Mechanics. It is the study of motion and interaction of subatomic particles, wave-particle duality with the help of suitable mathematical description.

➢What drived us to develop new technologies?

Did people living five hundred years ago know that there will exist a device that can tell us the position of any planet or constellation or such celestial bodies in seconds, should we wish to look for them? Context is about Sky Maps of course.

All this has been achieved only because of those people who were curious enough to know why everything exists like it does. The way to teleport is already out there, we just have to find that way how. Where there is a will there is a way, and the will is found through excitement!

➢ Interrelation between physics,technology and society.

Technology is the application of various laws of physics,doctrine of physics for practical applications.Practical applications of physics and other branches have played a wonderful role in improving the standards of life.

➢Understanding of elecromagnetic waves have paved the way for cell phones,with the help of which

we can talk to people who are far away in other countries.
Moreover we can take the example of satellite which help in weather forecasting.

➢ Gravity and electromagnetism are just two of the four fundamental forces of nature, specifically two that we can observe every day.

The remaining two forces work at the atomic level, which we never feel, despite being made of atoms. The strong force holds the nucleus together. Lastly, the weak force is responsible for radioactive decay, specifically, beta decay where a neutron within the nucleus changes into a proton and an electron, which is ejected from the nucleus.

➢ Physical laws are typically conclusions based on repeated scientific experiments and observations over many years and which have become accepted universally within the scientific community. The production of a summary description of our environment in the form of such laws is a fundamental aim of science. These terms are not used the same way by all authors.

➢ **Understanding conclusion and finding of an experiment**

Analyse the Data and Draw a Conclusion: As the experiment is conducted, it is important to note down the results. In an experiment, it is necessary to conduct several trials to ensure that the results are constant. The experimenter then analyses all the data and uses it to draw a conclusion regarding the strength of the hypothesis. If the data proves the hypothesis correct, the original question is answered. On the other hand, if the data disproves the hypothesis, the scientific inquiry continues by doing research to form a new hypothesis and then conducting an experiment to test it.

➢ Fastest speed that some animals can attain

Sr. No.	Name of Object	Speed in km/hr	Speed in m/s
1	Falcon	320	88.88
2	Cheetah	112	31.11
3	Blue fish	40 46	11.11-12.77
4	Rabbit	56	15.55
5	Squirrel	19	5.27
6	Domestic mouse	11	3.055
7	Human	40	11.11
8	Giant tortoise	0.27	0.075
9	Snail	0.05	0.013

➢ Common Measurement units used in daily life

Quantity	Units
Length	Metre
	1 Decimeter = 0.1m
	1 centimeter = 0.01m
	1 kilometer = 1000m
Volume	Cubic meter (m^3)
	1 Cubic centimeter = (cm^3) = 0.000001 m^3
Mass	1 Kilogram = 1000 gram
Time	1 minute = 60sec

➢ Common units for measurement in daily life

☞ 1 Feet =30.48 cm
☞ 1 Sq.feet =30.48 cm×30.48 cm=929.0304 sq.cm
☞ 1 Ground =2400 sq.feet
☞ 1 Kuzhi =145.2 sq.feet
☞ 1 Cent = 435.60 sq.feet
☞ 1 Acre =43560 sq. feet=300 Kuzhi=100 Cent

In practice, we use only rounded off values of the above measurements.

Measurement of Length

A meter scale is used for lengths from 1 mm to 100. A vernier caliper is used for lengths to an accuracy of 0.1 mm. A screw gauge and a spherometre can be used to measure lengths as small as to 0.01 mm. To measure lengths beyond these ranges, we make use of some special indirect methods. For e.g. large distances such as the distance of a planet or a star from the earth cannot be measured directly with a meter scale. Here, we use the parallax method.

Order of Magnitude and examples

An order of magnitude is an exponential change of plus-or-minus 1 in the value of a quantity or unit. The term is generally used in conjunction with power-of-10 scientific notation.
For example, the order of magnitude of 1500 is 3, hence 1500 may be written as 1.5×10^3

Measurement of Length

Generally a metre rule having its zero mark at one end and 100 cm mark at the other end is used to measure the length of an object. It has 10 subdivisions in each one centimetre length, so the value of its one small division is 1mm. Thus a metre rule can be used to measure length with still more accuracy i.e., up to second decimal place of centimetre. The reason is that if one end of object lies between two small divisions on metre rule, the mark nearer the end of the object is read and thus its length correct up to the second decimal point can not be measured. However, it becomes possible with the help of vernier callipers and screw gauge. They are more accurate since they have least count smaller than 0.1 cm.

Comparing Order of Magnitudes

An order-of-magnitude difference between two values is a factor of 10.
For example: The mass of the Sun is million times that of the Earth, so Saturn is 6 orders of magnitude more massive than Earth.

Methods of measurement of very small distances

A simple method for estimating the molecular size of oleic acid is as follows:
Oleic acid is a soapy liquid with large molecular size of the order of 10^{-9}m. A mono-molecular layer of oleic acid is first formed on water surface. 1 cm^3 of oleic acid is dissolved in alcohol to make a solution of $20cm^{-3}$. $1cm^3$ of this solution is then taken and diluted to 20 cm^3, using alcohol. So, the concentration of the solution is equal to $1/20\times20$ cc of oleic acid per cc of solution. Next, some lycopodium powder is lightly sprinkled on the surface of water in a large trough and one drop of this solution is put in the water. The oleic drop spreads into a thin large and roughly circular film of

molecular thickness on water surface. Then, the diameter of the thin film is quickly measured to get its area A. Suppose we have dropped n drops in the water. Initially, we determine the approximate volume of each drop (V cc).

Volume of n drops of solution = nV cc

Amount of Oleic acid in this solution = nV (1/20×20) cc

This solution of oleic acid spreads very fast on the surface of water and forms a very thin layer of thickness t. If this spreads to form a film of area A cm^2. Then the thickness of the film:

t=Volume of the film/Area of the film

or,

t=nV/20×20A cm

If we assume that the film has mono-molecular thickness, then this becomes the size or diameter of a molecule of oleic acid. The value of this thickness comes out to be of the order of 109 m.

- **Units for measurement of large distance**

Astronomical Unit

Astronomical unit is the mean distance of the center of the sun from the centre of the earth.

1 Astronomical Unit (AU) = 1.496×1011 m

Light year:

Light year is the distance traveled by light in one year in vacuum.

Distance travelled by light in one year in vacuum = Velocity of light ×× 1 year (in seconds) $=3\times10^{8}\times365.25\times24\times60\times60=9.467\times10^{15}$ m

Therefore , 1 light year $=9.467\times10^{15}$ m

One parsec =3.26 light-years.

- **Methods for measurement of very large distances**

For measuring long distances such as distance of the moon or a planet from the earth, special methods are adopted,which are as follows:

☞ Radio echo method.

☞ Laser pulse method

☞ Parallax method.

- **Simple problem to find distance in light year**

Example: Calculate the distance traveled by light in space in 5 light years?

Solution:

Distance traveled in 1 light year $=9.467\times10^{15}$ m

Distance traveled in 5 light year $=5\times9.467\times10^{15}$ m

$=47.34\times10^{15}$ m

➢ Measurement of volume of a regular shaped object

Measurement of volume of regular shaped object is done by two methods:
☞ Measuring the length of sides/radius using a screw gauge/vernier caliper, etc.
Example:
A regular cylinder has radius of r=1.225cm as measured by a screw gauge and length of l=2.15cm as measured by a vernier callipers. Then the volume of the cylinder is given by $V=\pi r^2 l=10.13cm^3$

☞ Measuring the rise of height in a liquid column in a cylindrical tube when an immiscible solid is immersed in it. This method is applicable also to the non-regular solids.
Example:
The rise in height of a liquid column when an object is immersed in it is observed to be 2.1 cm. It is given that the radius of the cylindrical vessel is 5 cm. Then volume of the immersed solid is given by, $V=\pi r^2 \Delta h=164.85\ cm^3$

➢ Method of measurement of Time

Time is measured using a mechanical, electric or atomic clock. The cesium atomic clocks are the most accurate. Atomic clocks use the frequency of electronic transitions in certain atoms to measure the second. The unit of time is second in SI units. It is defined as 9,192,631,770 cycles of the radiation that corresponds to the transition between two electron spin energy levels of the ground state of the $^{133}C_s$ atom.

➢ Measurement of Mass

Unified atomic mass unit (u), which has been established for expressing the mass of atoms as 1 unified atomic mass unit = 1u = (1/12) of the mass of an atom of carbon - 12 isotope including the mass of electrons = 1.66×10^{-27}

Mass of commonly available objects can be determined by common balance like the one used in grocery shop.

➢ Physical Quantity

Physical quantity: A physical quantity is a quantity in physics that can be measured, thus a physical property that can be quantified. Examples of physical quantities are mass, amount of substance, length, time, temperature, electric current, light intensity, force, velocity, density, and many others.

➢ Types of errors

☞ Instrumental (or constant) Error: These errors are caused due to fault construction of instruments. Such errors can be minimized by taking same measurement with different accurate instruments.
☞ Systematic (Persistent) Error: This is an error due to defective setting of an instrument. Such error can be minimised by detecting its causes.
☞ Personal Error: These errors introduced due to fault of an observer taking readings, referred to human error.
☞ Random (Accidental) Error: Even after minimising above types of errors, error may occur due to different factors like pressure, temperature fluctuation in voltage while the experiment is being performed. Such errors cannot be eliminated but can be minimised.

➢ Unit and its Need

Unit : Measurement means the comparison of an unknown quantity. This known fixed quantity is called a unit.
The result of a measurement is expressed in two parts. One part is a number. The other part is the unit of the measurement.
Need of Unit
Standard measurement unit is needed as the general method of measurement like measuring from hand, palm, foot varies from person to person and it always gives errors in measurement.

➢ Errors in measurement of Physical Quantities

Any measurement made with a measuring device is approximate. If you measure the same object two different times, the two measurements may not be exactly the same. The difference between two measurements is called an error. The error in measurement is a mathematical way to show the uncertainty in the measurement. It is the difference between the result of the measurement and the true value.

Types of errors:

☞ Systematic errors: The systematic errors are those errors that tend to be in one direction, either positive or negative.
☞ Instrumental errors
☞ Imperfection in experimental technique or procedure
☞ Personal Errors
☞ Random errors: These are the errors which occur irregularly and hence are random with respect to sign and size. These can arise due to random and unpredictable fluctuations in experimental conditions.
☞ Least count error: The least count error is the error associated with the resolution of the instrument.
Example: If the dimension of the diameter of a circular cross-sectional rod is 5cm. In the laboratory experiment, while measuring with vernier caliper it is found as 5.05 cm. So the error in measurement is 0.05 cm here.

➢ Least Count Error

The smallest value that can be measured by the measuring instrument is called its least count. Measured values are good only up to this value. The least count error is the error associated with the resolution of the instrument.

➢ Basics of standard unit of measurement

In ancient India length was measured using hand, muthi, fist etc, but measurement from it is not accurate, hence French created a standard unit of measurement called the metric system.
Metric System is further classified to SI system (Standard International System) and CGS (centimeter, gram and second system).
Foreg : In SI system,unit of length is metre denoted by "m" and 1 m has 100 division. 1division =1 cm (centimeter), which is the unit of length in CGS system.

➢ Unit and their types

Unit is the quantity of a constant magnitude which is used to measure the magnitudes of other quantities of the same order.
Kinds of unit:
☞ Fundamental Unit
☞ Derived Unit

➢ Backlash Error

Sometimes, due to wear and tear of threads of screw in instruments such as micrometer screw gauge, it is observed that on reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction at once due to slipping, but it remains stationary for a part of rotation. This causes error in observation which is called the backlash error. To avoid this, we should rotate the screw only in one direction.

➢ Random and Systematic Error

☞ Systematic errors: The systematic errors are those errors that tend to be in one direction, either positive or negative. Systematic errors can be minimized by improving experimental techniques, selecting better instruments and removing personal bias as far as possible. Types of systematic errors are as follows:

☞ Instrumental errors

☞ Imperfection in experimental technique or procedure

☞ Personal Errors

☞ Random errors: These are the errors which occur irregularly and hence are random with respect to sign and size. These can arise due to random and unpredictable fluctuations in experimental conditions (e.g. unpredictable fluctuations in temperature, voltage supply, mechanical vibrations of experimental set-ups, etc), personal (unbiased) errors by the observer taking readings, etc.

➢ Good unit

The product of magnitude of a quantity and numerical value of its corresponding unit. A good unit has the property that the magnitude in the corresponding unit system is neither too large nor too small and the values are easy to compare. For example, it is convenient to express the distance between two cities in km rather than in cm.

➢ CGS, MKS and FPS system of units

☞ The Centimetre Gram Second system of units (abbreviated CGS or cgs) is a variant of the metric system based on the centimetre as the unit of length, the gram as the unit of mass, and the second as the unit of time.

☞ MKS is the system of units based on measuring lengths in meters, mass in kilograms, and time in seconds. MKS is generally used in engineering and beginning physics, where the so-called cgs system (based on the centimeter, gram, and second) is commonly used in theoretic physics.

☞ The foot pound second system or FPS system is a system of units built on the three fundamental units foot for length, pound for either mass and second for time.

➢ Contributing Factors to Systematic Errors

Sources of systematic errors are as follows:
☞ Instrumental errors that arise from the errors due to imperfect design or calibration of the measuring instrument, zero error in the instrument, etc.
☞ Imperfection in experimental technique or procedure. For e.g. to determine the temperature of a human body, a thermometer placed under the armpit will always give a temperature lower than the actual value of the body temperature.
☞ Personal errors that arise due to an individual's bias, lack of proper setting of the apparatus or individual's carelessness in taking observations without observing proper precautions, etc.

➢ SI system of units

The International System of Units (SI) defines seven units of measure as a basic set from which all other SI units are derived. The SI base units and their physical quantities are:

☞ meter for length
☞ kilogram for mass
☞ second for time
☞ ampere for electric current
☞ kelvin for temperature
☞ candela for luminous intensity
☞ mole for the amount of substance

➢ Contributing Factors to Random Errors

Random errors can arise due to random and unpredictable fluctuations in experimental conditions (e.g. unpredictable fluctuations in temperature, voltage supply, mechanical vibrations of experimental set-ups, etc), personal (unbiased) errors by the observer taking readings, etc.

➢ SI unit of time

The S.I. unit of time is second (s).
A second is defined as 1/86400 th part of a mean solar day. i.e.,
1 s = 1/86400 X one mean solar day

➢ Accuracy of Measured Quantities

Accuracy: The accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity. The accuracy in measurement may depend on several factors, including the limit or the resolution of the measuring instrument.
For example, suppose the true value of a certain length is near 3.678cm. In one experiment, using a measuring instrument of resolution 0.1cm, the measured value is found to be 3.5 cm, while in another experiment using a measuring device of greater resolution , say 0.01 cm, the length is determined to be 3.38 cm. The first measurement has more accuracy because it is closer to the true value.

- **SI unit of length and identify its sub units**

The S.I. unit of length is meter (m).
The 17th General Conference on Weights and Measures (CGPM), 1983 has defined the meter as:
"The meter is the length of the path traveled by light in vacuum during a time interval of 1/299792458 of a second."
Sub units of meter: (1)
centimeter (cm), (2)
millimeter (mm), (3)
micrometer (µmµm) or micron, (4) nanometer (nm)

- **Precision**

Precision is a measurement of the repeatability, or consistency, of a measurement. It is possible to have a very precise measurement without scatter (or noise) that is repeatable and would be considered precise (repeatable), however, it can be inaccurate because of an instrument error.

Example: Let us consider a weight measuring instrument which measures the weight of steel cube.
Exact weight of the steel cube is 50 kg.
The instrument shows the weight of the cube as 47.819 kg, 47.823 kg, 47.835 kg and 47.847 kg.
From the above observations, we can conclude that the instrument has some precision since it almost reproduces same output value 47.8 kg. But the instrument does not have accuracy since the measured values are not close to the actual weight 50 kg.

- **SI unit of mass and its sub units**

The S.I. unit of mass is kilogram (kg).
The 3rd General Conference on Weights and Measures (CGPM), 1901 has defined the kilogram as:
"The kilogram is the unit of mass; it is equal to the mass of the international prototype of kilogram (which is an artifact made up of platinum-iridium kept at specific conditions)."
Sub units of kilogram:
☞ gram (g)
☞ milligram (mg)

- **difference between accuracy and precision**

☞ The level of agreement between the actual measurement and the absolute measurement is called accuracy. The level of variation that lies in the values of several measurements of the same factor is called as precision.
☞ Accuracy represents the nearness of the measurement with the actual measurement. On the other hand, precision shows the nearness of an individual measurement with those of the others.
☞ Accuracy is the degree of conformity, i.e. the extent to which measurement is correct when compared to the absolute value. On the other hand, precision is the degree of reproducibility, which explains the consistency of the measurements.
☞ Accuracy is based on a single factor, whereas precision is based on more than one factor.
☞ Accuracy is a measure of statistical bias while precision is the measure of statistical variability.
☞ Accuracy focuses on systematic errors, i.e. the errors caused by the problem in the instrument. As against this, precision is concerned with random error, which occurs periodically with no recognizable pattern.

- **Accuracy, precision and error**

Accuracy: Measure of closeness of the measured value to its actual value.
Precision: Measure of repeatability of a set of values of measurement.
Error: Difference between the true value and measured value.
To minimize error, instruments need to calibrated well, noise from the surroundings need to be reduced, multiple measurements must be recorded, etc.

- **Identification of fundamental quantities**

A fundamental unit is a unit adopted for measurement of a base quantity. A base quantity is one of a conventionally chosen subset of physical quantities, where no subset quantity can be expressed in terms of the others.
☞ Length (meter)
☞Mass (kilogram)
☞ Time (second)
☞ Electric current (ampere)
☞ Thermodynamic temperature (kelvin)
☞ Amount of substance (mole)
☞Luminous intensity (candela)

- **Definition of SI units**

☞ Unit of length: Metre
Definition: The metre is the length of the path travelled by light in vacuum during a time interval of 1 / 299792458 of a second.

☞ Unit of Mass: kg,
Definition: The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

☞ Unit of time: Second
Definition: The second is the duration of 9192631770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the ceasium 133 atom.

☞ Current: Ampere
Definition: The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 210^7 newton per metre of length.

☞ Unit of Temperature: Kelvin
Definition: The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

☞ Unit for amount of substance: mol
Definition: The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12, its symbol is 'mol'.

☞ Unit of luminous Intensity: Candela
The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 5401012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

➢ Identify and give examples of some derived units
The units of all quantities other than fundamental units is called derived unit. Derived units are obtained in terms of fundamental quantities.

Quantity	Definition	Derived Unit	Abbreviation/Symbol
1. Area	length X breadth	metre X metre	m^2
2. Volume	length X breadth X height	metre X metre X metre	m^3

➢ Volume

The amount of space that a substance or object occupies, or that is enclosed within a container. Volume has units m^3, litre and cc.

➢ Conventions for writing SI units

The conventions followed while writing SI units:

☞ Only units of the SI and those units recognised for use with the SI should be used to express the values of quantities.
☞ All unit names are written in small letters (newton or kilogram) except Celsius.
☞ The unit symbol is in lower case unless the name of the unit is derived from a proper name, in which case the first letter of the symbol is in upper case.
☞ Unit symbols are unaltered in the plural.
☞ Unit symbols and unit names should not be mixed.
☞ Abbreviations such as sec (for either s or second) or mps (for either m/s or meter per second are not allowed.
☞ For unit values more than 1 or less than -1 the plural of the unit is used and a singular unit is used for values between 1 and -1.
☞ A space is left between the numerical value and unit symbol (25 kg, but not 25-kg or 25kg). If the spelled-out name of a unit is used, the normal rules of English are applied.
☞ Unit symbols are in roman type, and quantity symbols are in italic type with superscripts and subscripts in roman or italic type as appropriate.

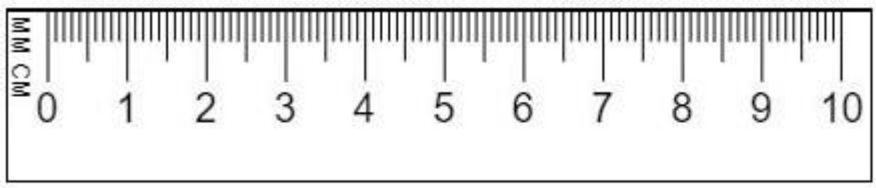
➢ Guidelines for writing the units

☞ The symbol for a unit, which is not named after a scientist, written in small letter. For example, symbol of metre is m, for second is s.
☞ The full name of the unit, irrespective of the fact whether it is named after a scientist or not, is always written with a lower initial letter. e.g., unit of mass is written as kilogram.
☞ A compound unit formed by multiplication of two or more units is written after putting a dot, cross or leaving a space between the two symbols. For example, the unit of torque is written as N.m.
☞ Negative power is used for compound units, which are formed by dividing one unit by the other.
☞ A unit in its short form is never written in plural. For example, 10 metres can not be written as 10 ms.
☞ To avoid powers of ten in the magnitude of a quantity, prefix can be used with its unit, But a unit must not written with more than one prefixes. For example, 1×10^9 W should be written as 1 GW and not 1 kMW.

➢ Units for Measurement of Time and Speed

Physical Quantity	Unit
Time	second (s), millisecond (ms) , minute (min) , hour (hr)
Speed	metre/second (m/s), kilimetre/hour (km/hr)

- **Calculate Range of Instrument**



Problem: Calculate the range of ruler as shown in the figure.
Explanation: A ruler can measure lengths between 0 and 10cm so it has a range of 10cm.

- **Define Range of Instrument**

Set of values of quantities of the same kind that can be measured by a given measuring instrument or measuring system with specified instrumental uncertainty, under defined conditions. Or simply we can say that range of measuring instrument is maximum or minimum value an instrument can measure.
Example:
The range of voltmeter is 250 volts. This means we can measure maximum 250 volts using that meter or we can apply just 250 volts across the probes of that meter.

- **Range of Instrument**

The values between the minimum measurable value and the maximum value that can be measured called the range of the instrument.
For example,the range of the scale is zero centimeter to thirty centimeters.Usually, we state the maximum value as the range since the minimum value is generally zero.When we say, the range of the metre scale is 100cm, we mean that the range is from zero to 100cm.

- **Least Count**

The least count of an instrument is the smallest measurement that can be taken accurately with it.

- **Symbol for Units of Time and Speed**

Unit of time is second denoted by s
Unit of speed is metre/second denoted by m/s, higher unit is denoted by km/hr

- **Basic Unit to Measure Time and Speed**

S.I unit of time is second denoted by s.
Speed is rate of change of distance hence its S.I unit is metre/second denoted by m/s.Higher unit to measure speed is km/hr or miles/hr

➢ Least Count

The smallest value up to which an instrument can measure is called least count of the instrument.
Example:
least count of meter rule is up to 1 mm.
least count of Vernier caliper is 0.01 cm.

➢ Other common units of time

Smaller units of time:
☞ Millisecond
☞ Microsecond
☞ Shake
☞ Nanosecond

Bigger Units of Time:
☞ Minute
☞ Hour
☞ Day
☞ Month
☞ Lunar Month
☞ Year
☞ Leap Year
☞ Decade
☞ Century
☞ Millenniums

➢ Instruments to measure time

Clock is basic time measuring device, it works on the principle of periodic motion.Clock are of different types table clock, digital clock, wall clock etc.
Simple Pendulum is the basic instrument to measure time period.

- **Metric and Non- metric unit for measurement of length**

Meter	Centimeter	Millimeter	Kilometer
1	100	1000	0.001
100	10,000	1,00,000	0.1

Inch	Foot	Yard	Chain
1	1/12	1/36	0.00126
2	0.166667	0.0555556	0.00252525

Smaller Units:
☞ Angstrom
☞ Fermi

- **Identify and understand the working of different types of clock**

☞ Sundial:
The sundial has a stick or object to cast a shadow on the horizontal surface. As the sun moves across the sky, the position of the shadow moves on the dial face to indicate time. The least count of such sundials again varied a great deal and improved from about one hour to about 15 minutes in the later years.

☞ Water Clock:
It was an evenly marked container with a float and pointer into which water dripped in at a fixed rate. As the water dripped into the container, the level of water increased.The time was read off on the level markings on the wall of the container. Since the rate of flow of water depended on the level of water in the upper container it was improved to provide a constant rate of flow.The least count of such instruments varied a great deal but people were happy to have a least count of about a quarter of an hour.

☞ Sand Clock:
It was made up of two rounded glass bulbs connected by a narrow neck of glass, between them. When the hourglass is turned upside down, a measured amount of sand particles stream through from the top bulb to the bottom bulb of the glass. These were more like timers which measured one hour typically and were therefore also called hourglass and had to be inverted every hour. They can also be built to measure smaller units of time for special purposes.

☞ Atomic clock:

Atomic clocks are the most accurate time keepers ever known. The best ones lose or gain 1 second in 109 days(approximately 2739726 years). This means that once synchronized, for generations your family members need not reset the clock. Therefore, these clocks are used as primary standards for international time. Atomic clocks can be made to look like any other clock with a least count of one second or with a least count of one millisecond for scientific purposes.

- **Odometer**

Odometer: Meter that measures the distance moved by the wheeled vehicle is known as an odometer.

- **Non metric units of mass**

The mass of atomic particles such as the proton, neutron, and electron expressed in a unit called the atomic mass unit (a.m..u.).

1 a.m.u. is 1/12th the mass of one carbon-12 atom.

1 a.m.u. = 1.66×10^{-27}

- **Units and symbols of some common fundamental quantities**

Quantity	Unit	Symbol
Length	metre	M
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Luminous Intensity	candela	cd
Electric current	ampere	A
Amount of substance	mole	mol*
Angle	radian	rd

- **Some commonly used derived units**

A derived unit is a SI unit of measurement comprised of a combination of the seven base units. Like SI unit of force is the derived unit, newton or N where $N=1\times m\times kg/s^2$

There are some commonly used derived units which includes:

☞ Pressure = Force/Area=N/m^2
☞ Mass density= kg/m^3
☞ Specific volume = m^3/kg
☞ Current density = Ampere/meter^2 =A/m^2
☞ Magnetic field strength = Ampere/Meter=A/m
☞ Capacitance =Farad=F=C/V=$m^{-2}kg^{-1}s^4A^2$

- **Identification of units and quantities from each other**

It is possible to define a unit for a given physical quantity. For example, length and distance can have the units of meter, inch, miles, light year, etc.

It is possible to estimate the physical quantity from its units. However, it should be noted that multiple quantities can have the same unit and hence this estimate is not accurate. So, if a quantity is given as 1J, then it can represent work or some form of energy.

- **Bob**

A simple pendulum consists of a small metallic ball or a piece of stone suspended from a rigid stand by a thread called the bob of the pendulum.

Time period of pendulum doesn't depend on the size or mass of the pendulum, it depends on the length of the pendulum and factor of earth's gravity.

- **Terms related to Simple Pendulum**

These are important terms pertaining to simple pendulum:

☞ Oscillation: One complete to and fro motion of the pendulum is called one oscillation
☞ Time period: This is the time taken to complete one oscillation.
☞ Frequency of oscillation: It is the number of oscillations made in one second.

- **Effective Length of Pendulum**

It is the distance of point of oscillation (i.e. the centre of gravity of the bob) from the point of suspension.

- **Interpret length vs time period graphs of a simple pendulum**

The following graph shows variation of time period with the length of pendulum.

- **Vernier Constant**

The Vernier Constant is equal to the difference between values of one main scale division and one vernier scale division.

Vernier Constant: Value of 1 main scale division - Value of 1 vernier scale division

- **Zero error and its types**

The zero error is equal to the length between the zero mark of the main scale and the zero mark of the vernier scale. (Here it's defined with respect to Vernier callipers)

Kinds of Zero Error:

☞Positive Zero Error

☞ Negative Zero Error

- **Calculating zero error in vernier caliper**

The attached diagram shows cases of zero error in a vernier caliper.

Case (a): No zero-error

Case (b): Positive zero-error of 3 vernier scale division (3rd line coinciding). Positive zero-error correction is done by subtracting the positive zero-error from the actual reading.

Case (c): Negative zero-error of 2 vernier scale division (8th line coinciding). Negative zero-error correction is done by adding the negative zero-error from the actual reading.

- **Principle of Screw gauge**

The screw gauge works under the principle of the screw. When a screw is rotated in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

➢ Construction of screw gauge

The Screw Gauge is an instrument to measure the dimensions of very small objects upto 0.01 mm.The Screw Gauge consists of aU shaped metal frame.A hollow cylinder is attached to one end of the frame. Grooves are cut on the inner surface of the cylinder through which a screw passes. On the cylinder parallel to the axis of the screw a scale is graduated in millimeter called Pitch Scale.

One end of the screw is attached to a sleeve. The head of the sleeve is divided into 100 divisions called the Head Scale. The other end of the screw has a plane surface (S1). A stud (S2) is attached to the other end of the frame, just opposite the tip of the screw. The screw head is provided with a Ratchat arrangement (safety device) to prevent the user from exerting undue pressure.

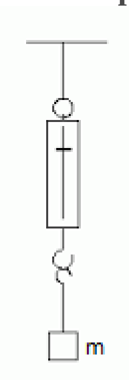
➢ Least count of a screw

The least count of a screw is the distance moved along the axis by it in rotating the circular scale by one division.
Least Count=Pitch/Number of circular scale divisions Least

➢ Principle and working of a stop watch

A stopwatch is a handheld timepiece used to measure the amount of time elapsed from a particular time when it is started, to the time when the piece is stopped. A stopwatch can be mechanical, resembling a pocket watch with an analog or digital face. Digital stopwatches are more accurate. Mechanical stopwatches are powered by a mainspring, which must be periodically wound up by turning the knurled knob at the top of the watch. It is designed to be manually started, for example at the beginning of an event, then stopped with the press of a button at the exact moment a runner crosses a finish line or a swimmer reaches the end lap, etc.

➢ Principle and working of a spring balance



A spring balance is a type of weighing scale which consists of spring fixed at one end with a hook to attach an object at the other end. A spring balance measures the weight of an object by opposing the force of gravity with the force of an extended spring.

Principle:

The principle of a spring balance is based upon the Hooke's law. Hooke's law states that "If the deformation is small, the stress in a body is proportional to the corresponding strain." The extension of the spring is the difference between its actual length and its natural length (i.e. no load condition).

Working:

A spring balance has a spring, one end of which is fixed. The other end of the spring is attached to a hook to hold an object. The steel spring is enclosed in a metallic case. There is a pointer, which is attached to the spring

The pointer moves over a scale marked on the metallic case. When a load is attached to the hook, the spring gets elongated because of the weight of the body. Along with the spring, the pointer also moves over the scale. The final position of the pointer gives the weight of the body.

➢Working of a beam balance

The working principle of beam balance depends on the balance of moments. The beam will be balanced only when the moments of force on the both sides of the balance are equal.

- **Precautions to be taken while using a beam balance**

☞ The stirrups and beam must be lifted off their pivot knife edges by the beam arrest. They must remain so at all times, except when a reading is being taken.
☞ The balance case should be kept closed. Even in weighing it should be opened only to place material or weights in the pans, and immediately closed.
☞ In adjusting the zero reading of a balance, complete arrestment should be made if the rider is moved on the beam.
☞ The stirrups and the balance must never be released with a quick jerking motion.
☞ In arresting a balance that is swinging free, always bring it to a stationary position by the pan arrests first.
☞ Any containers placed on the pans should be wiped clean of chemicals or other materials that might corrode the pans.

- **Instruments used to measure volume of objects**

Some common instruments used to measure the volume are measuring cup (immiscible and irregular solids), pippete tube (liquids), Eudiometer (gases), etc. Generally, the working principle of these instruments involve the measurement of rise of liquids in cylindrical column.

- **Different types of tabular forms**

A tabular form is a multi-record form that enables you to view multiple records from a table and edit them. Each record is displayed as a single row in the tabular form and each field is displayed as a column, creating a table within the form itself. Tabular forms are named after the table with which they are associated only in plural. For example, the tabular form associated with the country/region table is called Countries/Regions. In the case of associated tables that have multiple fields in the primary key, the name can be different. For example, the tabular form associated with the general posting setup table is called General Posting Setup.

- **Conversion of units between two systems of units**

Some conversion formulae between systems are listed below:

QuantityQuantity	SISI	CGSCGS	MKSMKS	FPSFPS
Length	1m	1 cm = 0.01 m	1m	1 foot = 0.3048 m
Mass	1 kg	1 g = 0.001 kg	1 kg	1 pound = 0.4536 kg
Time	1 s	1 s	1 s	1 s

Example:
If mass of a man is 200 pounds, its MKS weight can be found as follows:
1 pound=0.4536 kg
200 pound=0.4536×200=90.72 kg

- **Prefix for exponents**

If it is given that the mass of an object is 1000.2 kg, then it can also be written in mega-gram as follows.

$1kg=10^3g$

$1Mg=10^6g$

$\therefore 1kg=10^{-3}Mg$

1000.24kg=1000.24×10−3Mg=1.00024Mg

- **Advantages of presentation of data in a tabular form**

☞ Data can be presented in condensed and simple form.
☞ Different types of data can be compared easily.
☞ It provides information about the problem in a simple and clear manner.
☞ It saves time and space as the data is presented in condensed form.
☞ It makes checking of data easier.

- **Presentation of data in a graphical form**

The information can usually be presented in graphical form, which makes it easier to understand. Graphs tell a story with visuals rather than in words or numbers and can help readers understand the substance of the findings rather than the technical details behind the numbers.

- **Use of straight line graph in identifying proportional relationships**

If two physical quantities are varying linearly and one quantity is increasing with increment in other , then they are said to be in a proportional relationship.

For example according to Ohm's law V=IR

Here Voltage and Current has linear relationship and hence they have straight line graph.

- **Reporting Numbers**

In scientific notation all numbers are written in the form:

$m \times 10^n$

where, n is the power.

- **Dimension**

Dimension, an expression of the character of a derived quantity in relation to fundamental quantities, without regard for its numerical value. In any system of measurement, such as the metric system, certain quantities are considered fundamental, and all others are considered to be derived from them.

- **Dimensional Formula**

The dimensional formula is defined as the expression of the physical quantity in terms of its basic unit with proper dimensions. For example, dimensional force is $F=[MLT^{-2}]$ It's because the unit of Force is

N(newton) or kg×m/s^2.

➢ Significant Digits

Every measurement involves errors. Thus, the result of measurement should be reported in a way that indicates the precision of measurement. Normally, the reported result of measurement is a number that includes all digits in the number that are known reliably plus the first digit that is uncertain. The reliable digits plus the first digit are known as significant digits or significant figures.
Example: If we say that the period of oscillation of a simple pendulum is 1.62 s, the digits 1 and 6 are reliable and certain, while the digit 2 is uncertain. Thus, the measured value has three significant figures.

➢ Dimensional formula of function of quantities

Let dimensional formulas of two quantities be given by $[A] = [M^{am}L^{al}T^{at}]$ and $[B] = [M^{bm}L^{bl}T^{bt}]$
Then dimensional formula of A^xB^y is given by
$[A^xB^y] = [M^{xam+ybm}L^{xal+ybl}T^{xat=ybt}]$

➢ Rules for determining number of significant digits

Rules are as follows:
☞ All the non-zero digits are significant
☞ All the zeros between 2 non-zero digits are significant, no matter where the decimal point is.
☞ If the number is less than 1, the zeros on the right side of decimal point but to the left of the first non-zero digit are not significant (i.e leading zeros are never significant).
☞ In a number with a decimal point, trailing zeros, those to the right of the last non-zero digit, are significant.
☞ The trailing zeros in a number without a decimal point, are not significant.
☞ The trailing zeros in a number with a decimal point, are significant.
For example in 1.001 number of significant digits is 4.

➢ Rules for arithmetic operations with significant figures

As there are rules for determining the number of significant figures in directly measured quantities, there are rules for determining the number of significant figures in quantities calculated from these measured quantities.
Only measured quantities figure into the determination of the number of significant figures in calculated quantities. Exact mathematical quantities like in the formula for the area of a circle with radius r, r^2 has no effect on the number of significant figures in the final calculated area. Similarly the in the formula for the kinetic energy of a mass m with velocity v, mv^2, has no bearing on the number of significant figures in the final calculated kinetic energy. The constants and are considered to have an infinite number of significant figures.
For quantities created from measured quantities by multiplication and division, the calculated result should have as many significant figures as the measured number with the least number of significant figures.
For example,
1.001+2.03=3.031

Number of significant figures are 4 and 3 in the numbers added and after addition of numbers it's 4.

- **Rules of Rounding off**

The rule by convention is that the preceding digit is raised by 1 if the insignificant digit to be dropped is more than 5, and is left unchanged if the latter is less than 5. In the case where the insignificant digit is 5, the convention is that if the preceding digit is even, the insignificant digit is simply dropped and, if it is odd, the preceding digit is raised by 1.

- Absolute error

The magnitude of the difference between mean value and each individual value is called absolute error.absolute error.
For the measurement a_1 the absolute error is
$|\Delta a1|=|am-a1|$
Similarly in the measurment a_2 it is
$|\Delta a2|=|am-a2|$
Example:
The length of metal plate was measured using a vernier callipers of least count 0.01 cm. The measurements made were 3.11 cm, 3.13 cm, 3.14 cm and 3.10 cm. Find absolute error for measurements.
Solution:
Mean length amam = 3.11+3.13+3.14+3.104=3.12cm3.
Absolute error for measurements
$|\Delta a1|=|am-a1|=|3.12-3.11|=0.01cm$
$|\Delta a2|=|am-a2|=|3.12-3.13|=0.01cm$
$|\Delta a3|=|am-a3|=|3.12-3.14|=0.02cm$
$|\Delta a4|=|am-a4|=|3.12-3.10|=0.02cm$

- Uses of Dimensional Analysis

☞ To check the correctness of a physical equation.
☞ To derive the relation between different physical quantities involved in a physical phenomenon.
☞To change from one system of units to another.

- **Absolute error**

The magnitude of the difference between mean value and each individual value is called absolute error.
Example:
The diameter of a wire as measured by a screw gauge was found to be 1.002 cm, 1.004 cm and 1.006 cm. The absolute error in the readings will be:
Solution:
Mean=1.002+1.004+1.0063
=1.004cm
Hence, absolute errors
$\Delta a1=1.002-1.004 =0.002cm$
$\Delta a3=1.004-1.004 =0.000cm$

$\Delta a3=1.006-1.004=0.002cm$

- **Mean Absolute Error**

The arithmetic mean of all the absolute errors is called mean absolute absolute error in the measurement of the physical quantity.

Suppose that 'n' readings taken for the measurement of a physical quantity are a1,a2,......... an then the mean value is

amean=a1+a2+....... /n

Mean absolute error = |amean−a1|+|amean−a2|+ ...... |amean−an|/n

- **Correctness of Physical Equation Using Dimensional Analysis**

Checking the correctness of physical equation is based on the principle of homogeneity of dimensions. According to this principle, only physical quantities of the same nature having the same dimensions can be added, subtracted or can be equated. To check correctness of given physical equation, the physical quantities on two side of the equations are expressed in terms of fundamental units of mass, length and time. The powers of M,L & T are same on two sides of the equations, then the physical equation is correct otherwise not.

- **Establishment of relationship between physical quantities**

If all the factors affecting a derived quantity is known, then the function relating it from the quantities can be established using dimensional analysis.

Example: Finding time-period of a simple pendulum (T) given it depends on length of the pendulum (l) and acceleration due to gravity (g).

Dimensional formulae of the quantities are:

$[T]=[M^0L^0T^1]$

$[l]=[M^0L^1T^0]$

$[g]=[M^0L^1T^{-2}]$

Let $T=kl^A g^B$ where k,A,B are constants.

Then, $[T]=[k][l^A][g^B]$

$[M^0L^0T^1]=[M^0L^{A+B}T^{-2B}]$ Equating the powers on LHS and RHS,

$A+B=0$

$-2B=1$

Solving, $A=1/2, B=-1/2$

Hence, time-period is given by: $T=kl^{1/2}g^{-1/2}$

Note:

The established relation between the physical quantities is not unique and hence may or may not be absolutely correct.

- **Mean Absolute Error**

The magnitude of the difference between the individual measurement and the true value of the quantity is called the absolute error of the measurement. The arithmetic mean of all the absolute error is taken as the mean absolute error of the value of the physical quantity.

- **Example on Relative error**

Example:

John measures the size of the metal ball as 3.97 cm but the actual size of it is 4 cm. Calculate the relative error.

Solution:

The measured value of metal ball xo=3.97cm

The true value of ball x = 4 cm

Absolute error=Δx=True value−Measured value=x−xo=0.03

Relative error=Δx/x=0.03/4=0.0075

- **Difference between science and technology**

☞ Science: Science is all about acquiring knowledge of the natural phenomenon along with the reasons for such phenomenon.

eg: Why the sky is blue? Why are the leaves green?

☞ Technology: When the scientific knowledge is put to practice to solve human needs or problems, it is termed as technology.

- **Indian Scientists and their Achievements**

Indian scientists have made their contributions in many different fields. Below is the list of the scientists and their achievements.

☞ 1) C. V. Raman: C. V. Raman is one of the most famous Indian scientists of the world and his work on light scattering, which won him the noble prize, is still known as the most significant discovery of all time.

☞ 2) Homi Jehangir Bhabha: Dr. Bhabha has done a great deal of work and put an enormous amount of work to get the India feature in the list of the countries which hold the nuclear power of their own.

☞ 3) Dr. A.P.J. Abdul Kalam: Dr. Kalam is better known as the missile man of India. His work has made sure that India doesnt fall behind in the defense sector.

☞ 4) Jagadish Chandra Bose: He is the first in the world to claim and to prove that even the plants have feelings like humans. He was known for his work in plant science.

☞ 5) Srinivasa Ramanujan: He is known as one of the greatest mathematician ever produced in the history.He has many papers published on the various topics of mathematics like algebra, trigonometry, integer functions and others which lead other scientists to do calculate more results and simplify the complex mathematics problems.

☞ 6) Vikram Sarabhai: Dr. Sarabhai is known to us as the father of the Indian Space program. It was his efforts that India launched its first satellite.

➢ **Method for Measuring the Length of Curved Line**

We cannot measure the length of a curved line directly by using a metre scale. We can use a thread to measure the length of a curved line.

Method to measure length using string
Use a thread to measure the length of the curved line AB. Put a knot on the thread near one of its ends.Place this knot on the point A. Now, place a small portion of the thread along the line, keeping it taut using your fingers and thumb. Hold the thread at this end point with one hand. Using the other hand, stretch a little more portion of the thread along the curved line. Go on repeating this process till the other end B of the curved line is reached.Make a mark on the thread where it touches the end B. Now stretch the thread along a metre scale. Measure the length between the knot in the beginning and the final mark on the thread. This gives the length of the curved line AB.

➢ Scientific method steps

☞ Make an Observation: Scientists are naturally curious about the world. Many people may ignore a curious phenomenon. But scientists think over it.
☞ Form a Question: After making an interesting observation, a scientific mind wants to find out more about it. This is in fact a natural phenomenon. If you have ever wondered why or how something occurs, you have been listening to the scientist in you.
☞ Form a Hypothesis: A hypothesis is a guessed answer of the question. The hypothesis may be formed as soon as the question is posed, or it may require a great deal of background research and inquiry. The purpose of the hypothesis is not to arrive at the perfect answer to the question but to provide a direction to further scientific investigation.
☞ Conduct an Experiment: Once a hypothesis has been formed, it must be tested. This is done by conducting a carefully designed and controlled experiment.

➢ Methods for Measurement of Length

There are various methods to measure length or distances,out of which few are mentioned below:

☞ Small lengths can be measured using scales and tapes.
☞ Very small distance could be measured using vernier caliper and screw gauge.
☞ Very large distance could be measured by parallax method. Basically used to measure distance between earth and other heavenly bodies.

➢ Limitations of Dimensional Methods

☞ Dimensional analysis has no information on dimensionless constants.
☞ If a quantity is dependent on logarithmic, trigonometric or exponential functions, this method cannot be used. e.g. :
$y=a\cos(\omega t-kx)$ can not be derived using this method.
☞ In some cases, it is difficult to guess the factors while deriving the relation connecting two or more physical quantities.
☞This method cannot be used in an equation containing two or more variables with same dimensions. Therefore, a dimensionally correct relation may not always be the actual correct relation. e.g. : dimension of 1T and 2T are same.
☞ This method cannot be used if the physical quantity contains more than one term, say sum or difference of two terms i.e it does not always tell us the exact form of a relation. eg. $v=u+at$ cannot be derived using this relation.
☞ It does not tell whether a given physical quantity is a scalar or a vector.

➢ Relative error

The ratio of the mean absolute error in the measurement of a physical quantity to its most probable value is called relative error.
Relative error=$|\Delta am|/am$

➢ Calculate Relative error

The ratio of the mean absolute error in the measurement of a physical quantity to its most probable value is called relative error.
Relative error=$|\Delta am|/am$

➢ Relative Error

The relative error is the ratio of the mean absolute error (δamean) to the mean value (amean) of the quantity measured.
Relative error =δamean/amean

- **Percentage error**

The relative error expressed in percentage (i.e. multiplied by 100) is called percentage error.

∴Percentage error=$\Delta am/am \times 100\%$

- Absolute, Relative or Percentage Error for a quantity that is sum of measured quantities

If $y=y1+y2+y3..yn$

Then absolute error will be given by:

$\Delta y=\Delta y1+\Delta y2+\Delta y3+..\Delta y$

And its relative error will be given by $\Delta y/y$

Absolute, Relative or Percentage Error for a quantity that is product of measured quantities

If $y=y1\times y2$

Relative error is given by:

$\Delta y/y=\Delta y1/y1+\Delta y2/y2$

Absolute error will be given by measuring Δy value.