Measurement & Motion

Need for Measurement
1. <u>To measure distance</u> for travelling.
2. <u>To measure dimensions</u> of various objects. Eg. For making a house or for making furniture.
3. <u>To measure capacity.</u> E.g. filling up petrol in the car or buying milk from the shop.
4. <u>To measure quantity</u>. E.g. weight of mangoes.
5. Measurements of cloth by the tailor.

We can measure different physical quantities in different ways.
These physical quantities could be:
- Length
- Time
- Mass
- Temperature

Q. What are units?
Ans.
1. Measurement means the comparison of an unknown quantity with some known quantity. This known fixed quantity is called a unit.
2. The result of a measurement is expressed in two parts. One part is a number. The other part is the unit of the measurement.

Types of Units:

a) **Non-standard Unit -** these will vary from person to person-Hand span, foot, palm, cubit.
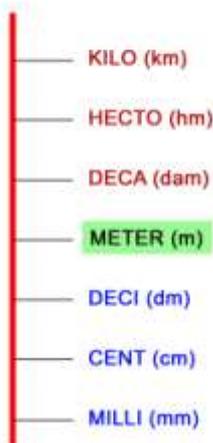b) **Standard Unit –** these are fixed and remain constant-Meter, kilogram, liter.

LENGTH
The distance between one end to another end is called Length.
Various devices can be used to measure length.
- Meter Scale
- Measuring Tape
- Meter Rod
- Rulers

Units of Measuring Length

KILO (km)

HECTO (hm)

DECA (dam)

METER (m)

DECI (dm)

CENT (cm)

MILLI (mm)

Note: certain special units are used to measure extremely small or extremely large units
e.g. …size of atoms/ size of nucleus-Fermi (10^{-10}m), Angstorm (1 Fermi=10^{-15}m
e.g. …distance between planets / dis between Sun & earth cannot use kilometers. Here Astronomical Units are used.

- 1 AU = distance between Sun & Earth = $1.496 * 10^{11}$ m
- 1 ly = distance light travels in 1 year = $9.46 * 10^{15}$ m

Correct Measurement of Length

In taking measurement of a length, we need to take care of the following:

1. Place the scale in contact with the object along its length. The scale should be always kept straight along the edge of the object to be measured
2. If a scale is broken then we should avoid taking measurements from the zero mark of the scale. We should take it from say 1 cm. Then we must subtract the reading at the other end. Say 14cm. So the length would actually be 14 -1 = 13cm.
3. Your eye must be exactly in front of the point where the measurement is to be taken.

CONVERSION OF UNITS
To Convert units, METRE is kept as the REFERENCE POINT

Steps:

1) Whenever you have to convert a big unit to a small unit, multiply the number with multiples of 10.
2) Whenever you have to convert a big unit to a small unit, divide the number with multiples of 10.

MASS
It is the quantity of matter contained in an object.
The SI unit of mass is kilogram(kg)
Beam balance or digital (electronic) balance are two commonly used balances.

TEMPERATURE
Use to measure the degree of hotness or coldness in a body.
The SI unit of temperature is Kelvin (K)

other units for measuring temperature are Fahrenheit (F) and Celsius (C)

Instrument used in calculating temperature is called a Thermometer.

TIME

It is the duration elapsed between the one event and the next event. i.e. measurement of the time between 2 events.

The SI unit of time is second.

60 seconds	1 minute
60 minutes	1 hour
24 hours	1 day
365 days	1 year
10 years	1 decade
10 decade	1 century
10 centuries	1 millenium

Different instruments have been used to measure time over the ages

Some instruments used in earlier times were:

1. **Sundial**
- It measured time by the position of the sun.
2. **Water Clock**
- In this clock water is allowed to flow from a hole made at the bottom of a bowl shaped container into another bowl kept in a upside down position.
- The emptying of the water filled bowl into different levels corresponds to specific time periods.

3. **Sand Clock / Hour Glass**
- This consists of two bulb shaped containers made of glass and connected through a narrow glass tube.
- Sand is filled in one of the containers and the clock is kept on a plane surface with the filled container on the top.
- When all the sand falls down into the lower container, a definite time period (usually an hour) is over.

4. **Candle Clock**
- This uses a candle with nails put into it at fixed intervals.
5. **Mechanical Clock**
- Mechanical clocks had a weight that would slowly lower down and move the gears.
- The gears then moved a hand which showed the hour.
- These clocks worked for a short period of time only (maximum two hours).

Some other clocks that are in use are:

1. **Mechanical Wrist Watch**: It has a balance wheel instead of pendulum.
2. **Electronic Wrist Watches**: These have crystals of a substance called quartz.
3. **Stopwatch**: This is use for measuring short intervals of time accurately.
4. **Digital Watch**: They display time in digits. Many digital watches can also be used as stopwatches.
5. **Atomic Clocks**: These are the most accurate which are based on the vibration of atoms. These vibration are very regular and hence atomic clocks are accurate to one second in 3000 years.

Motion

REST

When the position of a body does not change with the change of time and the surroundings remain the same, the body is said to be at rest. E.g. a book lying on a table is at rest.

MOTION –

When the position of a body changes with the change of time, it is said to be in motion
-Moving train
-Running water
-Blades of an electric fan.

MODES OF MOTION

Old means of transport for motion : Bullock cart, cycle, ship, rickshaw, boat.
New means of transport for motion : Car, train, trams, metro, aeroplane, helicopter, bus.

SPECIFIC MOTION Vs RANDOM MOTION

Types of motion

1. **Rectilinear Motion –Linear Motion-** Is the motion in which an object moves along a straight line. E.g. Jawans walking in an army parade, cars on the straight road, light from a torch, stone falling from height, sprinters running in 100m race.

2. **Circular Motion** – When an object moves around in a circular path and comes back to its original position, it is said to be in a circular motion.
   - Toy train moving in a circular path.
   - Car moving in a circular path (road).
   - Blades of a fan
   - Movement of hands of a clock

3. **Rotary Motion -** A motion in which a body moves about on a fixed axis in a circular fashion is called rotary motion. Here the object rotates but might move from one place to another.
   - giant wheel
   - earth's rotation.

Periodic Motion –Any motion that repeats itself at fixed interval of time is called periodic motion. The same pattern of motion repeats itself in the same time.
For e.g.
   - Rotation of the Earth about its axis.
   - Revolution of the Earth around on its orbit.
   - Bouncing of a ball
   - Movement of the pendulum of a clock

The scientist Galileo, was the 1st to experiment with pendulums and explaining the Periodic Motion.

SIMPLE PENDULUM

Structure:

- A simple pendulum consist of a metallic ball / rock which is tied to a rod or thread and suspended from a pivot point fixed to a rigid stand or support.
- The metallic ball / mass is called the bob of the pendulum.

Fig. 13.4 A simple pendulum

Fig. 13.4 Different positions of the bob of an oscillating simple pendulum
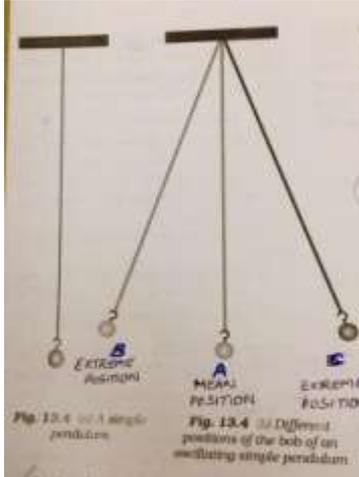
- When the pendulum is at rest at position 'A', it is said to be in its mean position.
- When the bob is pulled to one side and released it swing due to the effect of gravity.
- The 'to' and 'fro' motion or the back and forth motion of a simple pendulum is an example of periodic or oscillatory motion.

OSCILLATORY MOTION

Oscillation is a motion that repeats itself regularly

- The movement of the pendulum bob, starting from the mean position (A), to the extreme position (B), to the extreme position (C) and then back to its mean position (A), is said to complete 1 oscillation.
- So 1 Oscillation is A→B→A→C→A
- The pendulum also completes one oscillation when its bob moves from one extreme position (B or C) , to the other extreme position (C or B) and then back to the starting mean position (B or C)

TIME PERIOD

The time after which the motion repeats itself or the time taken by pendulum to complete one oscillation is called the Time Period.

- It is denoted by 'T'.
- It is expressed in seconds.

MEASUREMENT OF TIME USING PERIODIC MOTION

- The regular motion of the pendulum controls the motion of the hands of a clock.
- The length of the pendulum in a clock is defined so that every oscillation is completed in one second and the needle of the clock moves ahead by one second.

Objects showing two types of motion at the same time

1. **Sewing Machine -** Wheel is moving in rotary motion & Needle is moving in periodic motion.

2. **Car on straight road –** Wheel is moving in rotary motion & Car is moving in rectilinear motion.
3. **Hands of a clock -** Rotary motion & Periodic motion.
4. **Ball moving in straight path -** Rotary motion & Rectilinear motion.

Q. Write the similarities and differences between the motion of a bicycle and a ceiling fan that has been switched on.
Ans.
Similarity – Both are in motion, and both the wheel of a bicycle and a ceiling fan execute a motion on a fixed axis (rotary).
Differences - The bicycle executes rectilinear motion also, which the fan does not.

SLOW AND FAST MOTION

- **When the position of a body changes continuously with respect to its time and surroundings, the body is said to be in motion.**
- **Some objects have slow motion and some have fast motion.**
- **The distance covered by an object in at a given interval of time is called speed.**
- Therefore,
    Speed of an object, is a distance it covers in a unit time.

$$\text{Speed} = \frac{\text{Distance Covered}}{\text{Time taken}} \quad \left(S = \frac{D}{T} = \frac{m}{s} \right)$$

$$\text{So,} \quad S = m/s \quad \text{(meter/second)}$$

- **The speed of a moving vehicle is recorded with the help of a device called speedometer.** It indicates the instantaneous speed of the vehicle (i.e., the speed of a vehicle at an instant of time).
- Another instrument called an odometer is also used to measure the distance moved by the vehicle.

UNIFORM AND NON-UNIFORM MOTION

UNIFORM MOTION:
- A body is said to be in uniform motion when it covers equal distances in equal intervals of time.
- The body in a uniform motion moves in a straight line and the graph obtained for the same also is a straight line.

NON-UNIFORM MOTION:
- A body is said to be in non-uniform motion when it moves unequal distance in equal intervals of time or equal distances in unequal intervals of time. Hence, it is said to non-uniform motion if its speed or direction does not remain constant.
- The body does not move in a straight line and hence the graph does not show straight line.

DISTANCE - TIME GRAPH
- The motion of an object (uniform or non-uniform), can be represented by a distance – time graph.
- It also tells us the speed and distance covered by an object in given interval of time.
- The graphical representation makes the interpretation of the motion of objects easier.

- In a distance- time graph, distance is always taken along the y-axis while the time is taken along the x-axis.
- The distance – time graphs can also be made in the form of pie charts & bar graphs.
- If the distance – time graphs of two or more objects are plotted in the same graph, than we can compare their speeds.

INTERPRETATION OF GRAPHS

1. Interpreting of Uniform vs. Non-uniform motion:
(a) When the distance – time graph for an object is a straight line, the object is said to be in uniform motion & having constant speed.
(b) The graph for non-uniform motion, does not show a straight line. Hence, such objects do not have constant speed.

2. Slope of the line / Gradient:
(a) The inclination that the line of the graph makes with the horizontal or the X-axis, is called the slope of the line or the Gradient.
(b) The gradient indicates the speed of the object / vehicle.
(c) The more than inclination of the gradient more the speed of the vehicle.
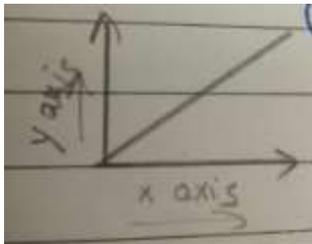
3   The distance – time graph for two or more objects can be plotted in the same graph to compare the speeds.
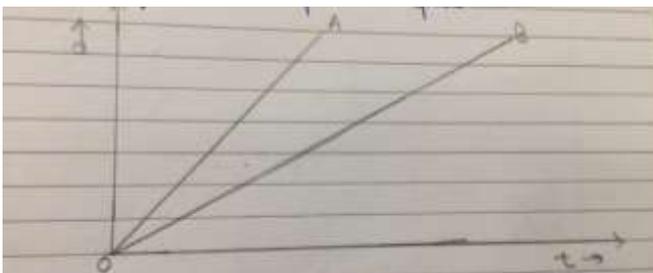
In the image above we see that:
- Object A is moving faster than object B.
- The inclination of the graph of object A is more than is that of object B, which means that object A is covering more distance in the same time than object B.