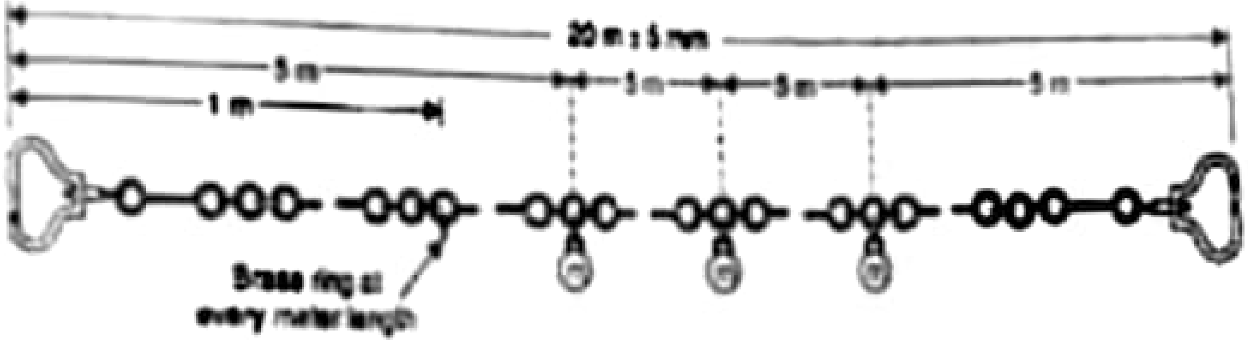
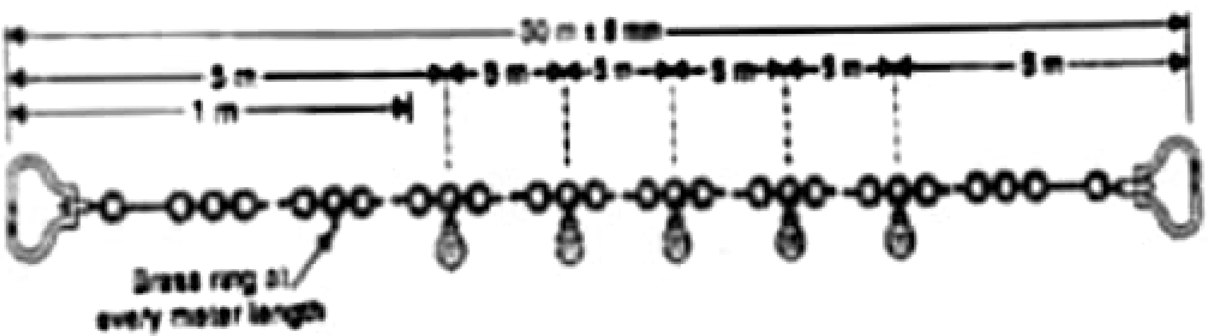
## ❑ WHAT IS CHAIN SURVEING ?

- Chain surveying is the type of surveying in which only linear measurements are taken in the field.
- This type of surveying is done for surveys of small extent to describe the boundaries of plot of land to locate the existing features on them.

- It is the method of surveying in which the area is divided into network of triangles and the sides of the various triangles are measured directly in the field with a chain or a tape and no angular measurements are taken.




20 METER CHAIN




20 METER CHAIN

## ❑PRINCIPAL OF CHAIN SURVEYING

- The principal of chain surveying is to divide the area into a number of triangles of suitable sides.

- As a triangles is the only simple plane of geometrical figure which can be plotted from the lengths of the three sides even if the angels are not known.

- A network of triangles (triangulation) is preferred to in chain surveying .

- If the area to be surveyed is triangular in shape and if the lengths and sequence of its three sides are recorded the plane of area can be easily drawn.

# Instruments Used in Chaining

- The following instruments are used while chaining.
- Chains
- Tapes
- Arrows
- Ranging rods and offset rods
- Laths & Whites
- Pegs
- Plumb bob
- Line Ranger

# Instruments Used in Chaining

**Chains**

- Various types of chains used in surveying are
- Metric Chain
- Gunter's Chain or Surveyor's Chain
- Engineer's Chain
- Revenue Chain
- Steel Band or band chain

# Instruments Used in Chaining

## Metric Chain

- Normally this chain consists of galvanized mild steel wire of 4 mm diameter known as link. The ends of the links are bent into loop and connected together by means of three oval rings which provide the flexibility to the chain and make it less liable to kinking. Both ends of the chain have brass handle with swivel joint so that the chain can be turned round without twisting

# Metric Chain

- In a metric chain at every one meter interval of chain, a small brass ring is provided. Brass tallies are also provided at every 5.0 m length of chain. Each tally has different shape which indicates 5 , 10, 15m from any one side of the chain, metric chains are available in 20 m and 30 m length.
- A 20 m chain has 100 links each of 20 cm and 30 m chain has 150 links. Length of chain is embossed on the brass handles of the chain.

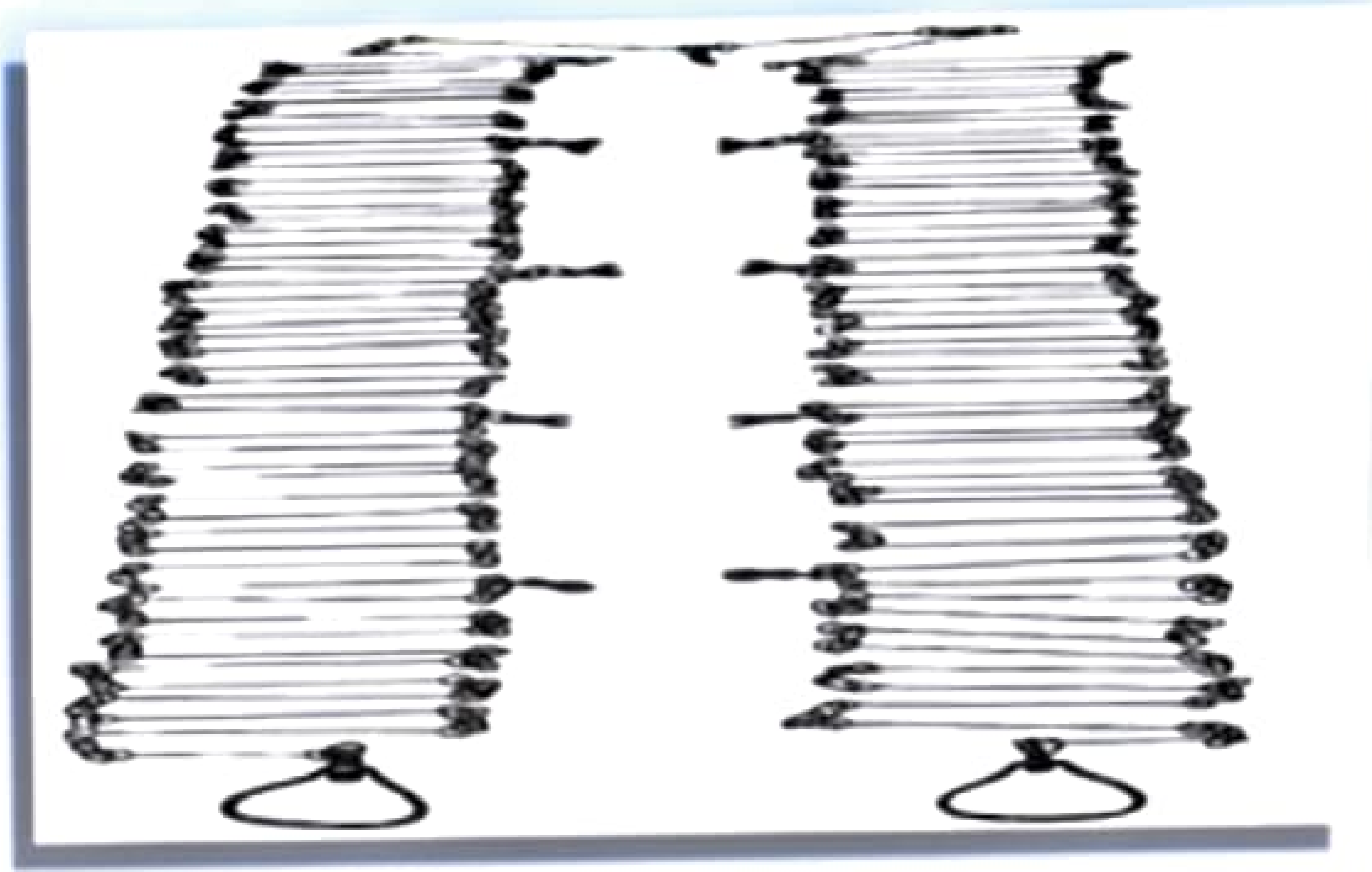
# Metric Chain

# Instruments Used in Chaining

**Günter's chain**

- A 66 feet long chain consists of 100 links each of 0.66 ft it is known as Gunter's Chain
- Here, 10 sq chain are equal to 1 acre.
- 10 chains= 1 furlong and 8 furlongs = 1 mile
- This chain is suitable for taking length in miles and areas in acres.

# Günter's Chain



# Instruments Used in Chaining

## Engineer's Chain

- A 100 ft chain of 100 links each of 1 foot is known as Engineer's chain. Brass tags are fastened at every 10 links. This chain is used to measure length in feet and area in square yards.

# Engineer's Chain

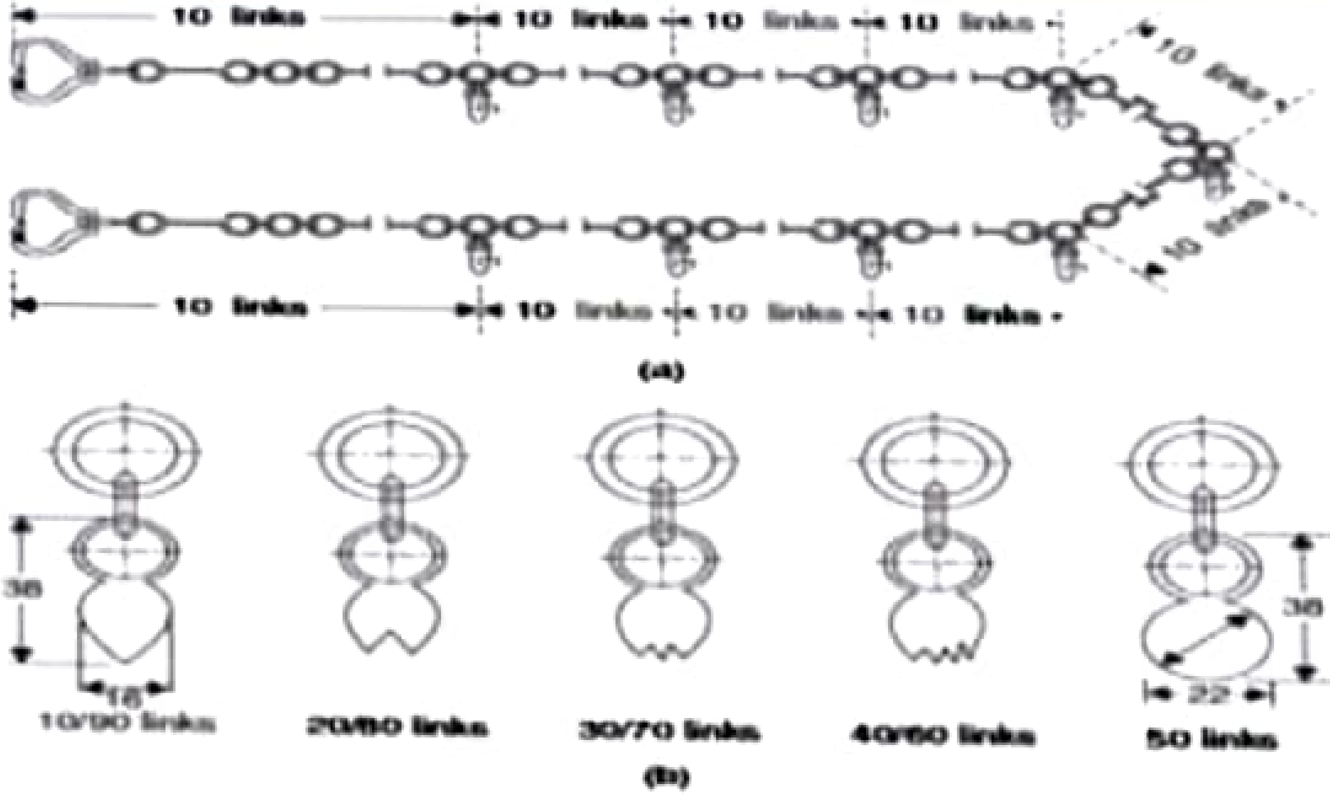


Fig. 12.1. Chain

# Instruments Used in Chaining

**Revenue Chain**

- Revenue chain is 33 ft long chain consisting of 16 links. This chain is used for distance measurements in feet & inches for small areas.

# Instruments Used in Chaining

**Steel Band or Band Chain**

- Steel bands are preferred than chains because they are more accurate, but the disadvantages is that they get broken easily and are difficult to repair in the field. They are 20 and 30 m long, 12 to 16 mm wide and 0.3 to 0.6 mm thick. They are numbered at every metre and divided by brass studs at every 20 cm

# Steel Band or Band Chain

# Testing and Adjustment of Chain

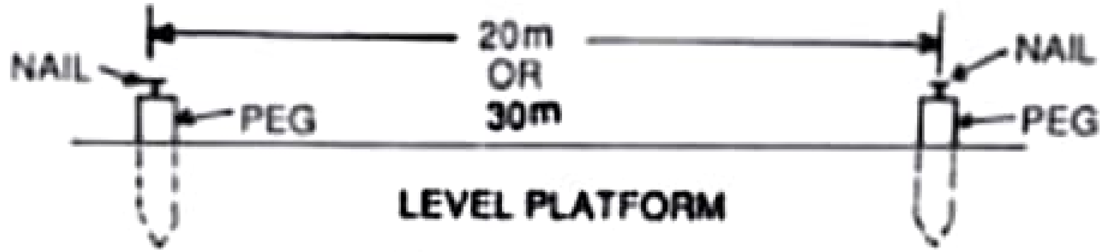



Fig. 1.8 Test Gauge

# Testing and Adjustment of Chain

**If chain is found to be too long**

- It can be adjusted by;
- Closing up the joints of the rings if found to be opened out
- Reshaping damaged rings
- Removing one or more small rings
- Adjusting the links at the end.

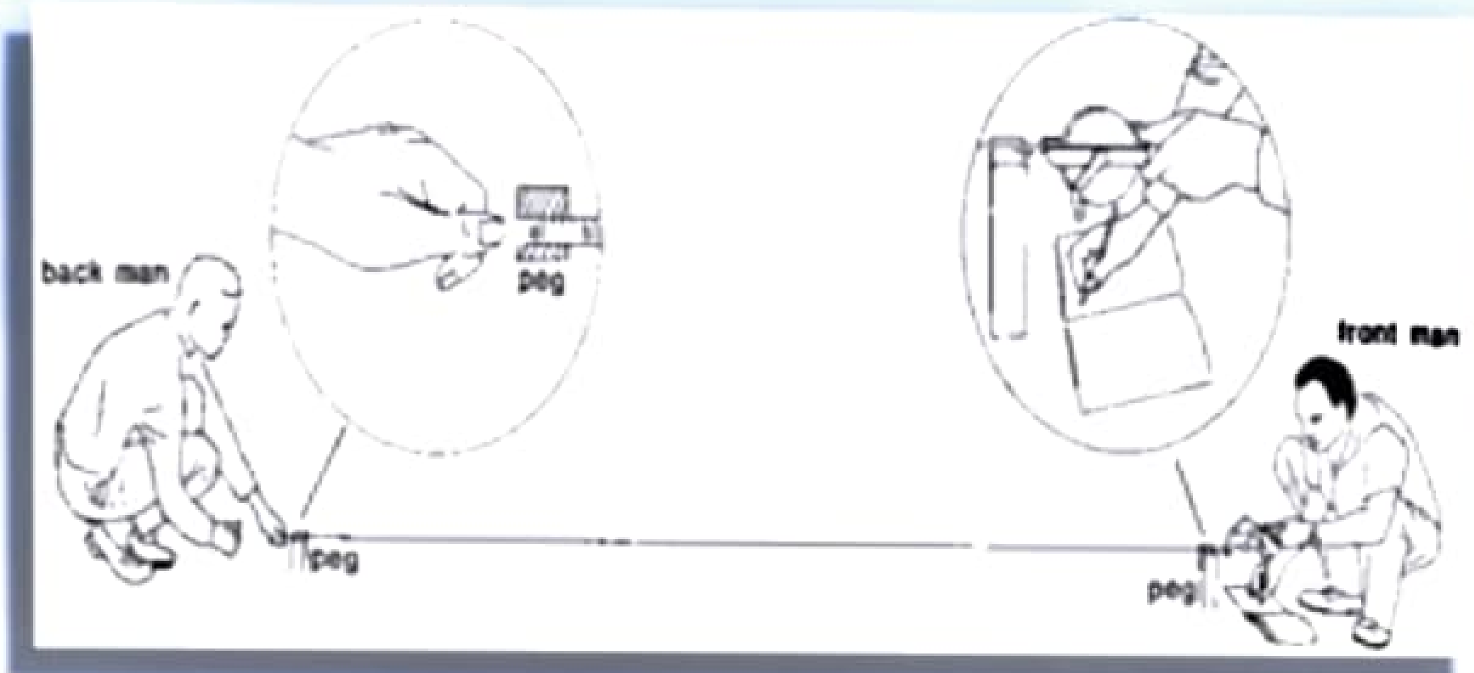
# Testing and Adjustment of Chain

- If the chain is found to be too short
- Straightening the bent links
- Opening the joints of the rings
- Replacing one or more small circular rings by bigger ones.
- Inserting new rings where necessary.
- Adjusting the links at the end.

# Measuring Tapes

- Tapes are used for more accurate measurement. The tapes are classified based on the materials of which they are made of such as:
- Cloth or linen tape
- Fibre Tape
- Metallic Tape
- Steel tape
- Invar Tape

# Measuring Tapes



# Arrows

- Arrows are made of tempered steel wire of diameter 4 mm. one end of the arrow is bent into ring of diameter 50 mm and the other end is pointed. Its overall length is 400 mm. Arrows are used for counting the number of chains while measuring a chain line. An arrow is inserted into the ground after every chain length measured on the ground.

# Arrows

# Ranging Rods and Offset Rods

- Ranging rods are used for ranging some intermediate points on the survey line. Ranging rods are generally 2 to 3 m in length and are painted with alternate bands of black or white or red and white colour with length of each equalizing 20 cm. The location of any survey station can be known from long distances only by means of ranging rods. If the distance is too long, a rod of length 4.0 to 6.0 m is used and is called ranging pole.
- The offset rod is similar to ranging rod with the exception that instead of the flag, a hook is provided at the top for pushing and pulling the chain or the tape. It is also used for measuring small offsets

# Ranging Rods and Offset Rods

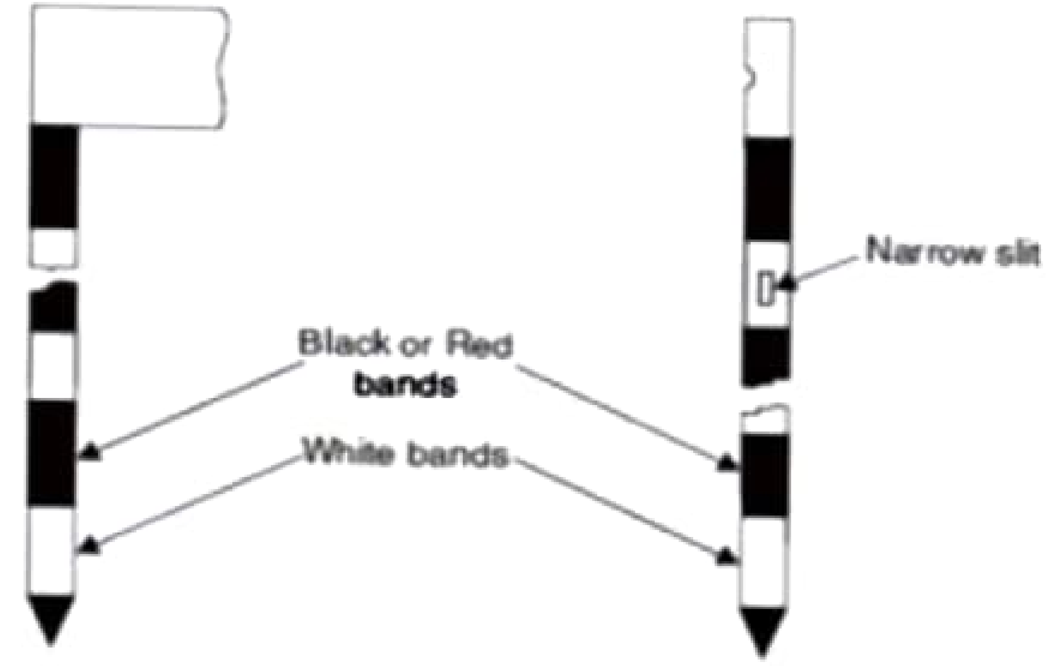


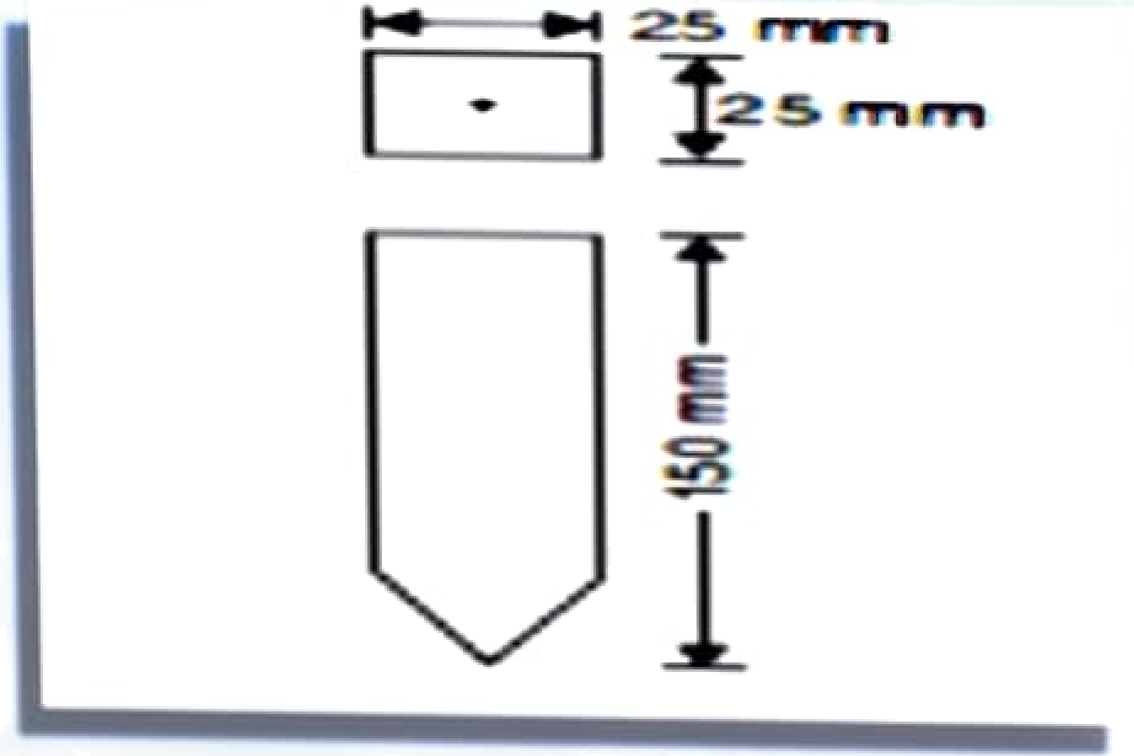

Fig. 12.7 Ranging rod

Fig. 12.8. Offset rod

# Pegs

- Pegs are made of timber or steel and they are used to mark the position of the station or terminal points of a survey line. Wooden pegs are 15 cm long and are driven into the ground with the help of a hammer.

# Pegs



# Plumb Bob

- Plumb-bob is used to transfer points on the ground. It is also used for fixing the instruments exactly over the station point marked on the ground by checking the centre of the instrument whether coincides with the centre of the peg or station not, by suspending the plumb-bob exactly at the centre of the instrument under it. Plumb bob is thus used as centring aid in theodolites and plane table.

# Plumb Bob

## (1) SURVEY STATIONS

Survey stations are the points at the beginning and at the end of the chain line. They may also occur at any convenient position on the chain line. Such stations may be :

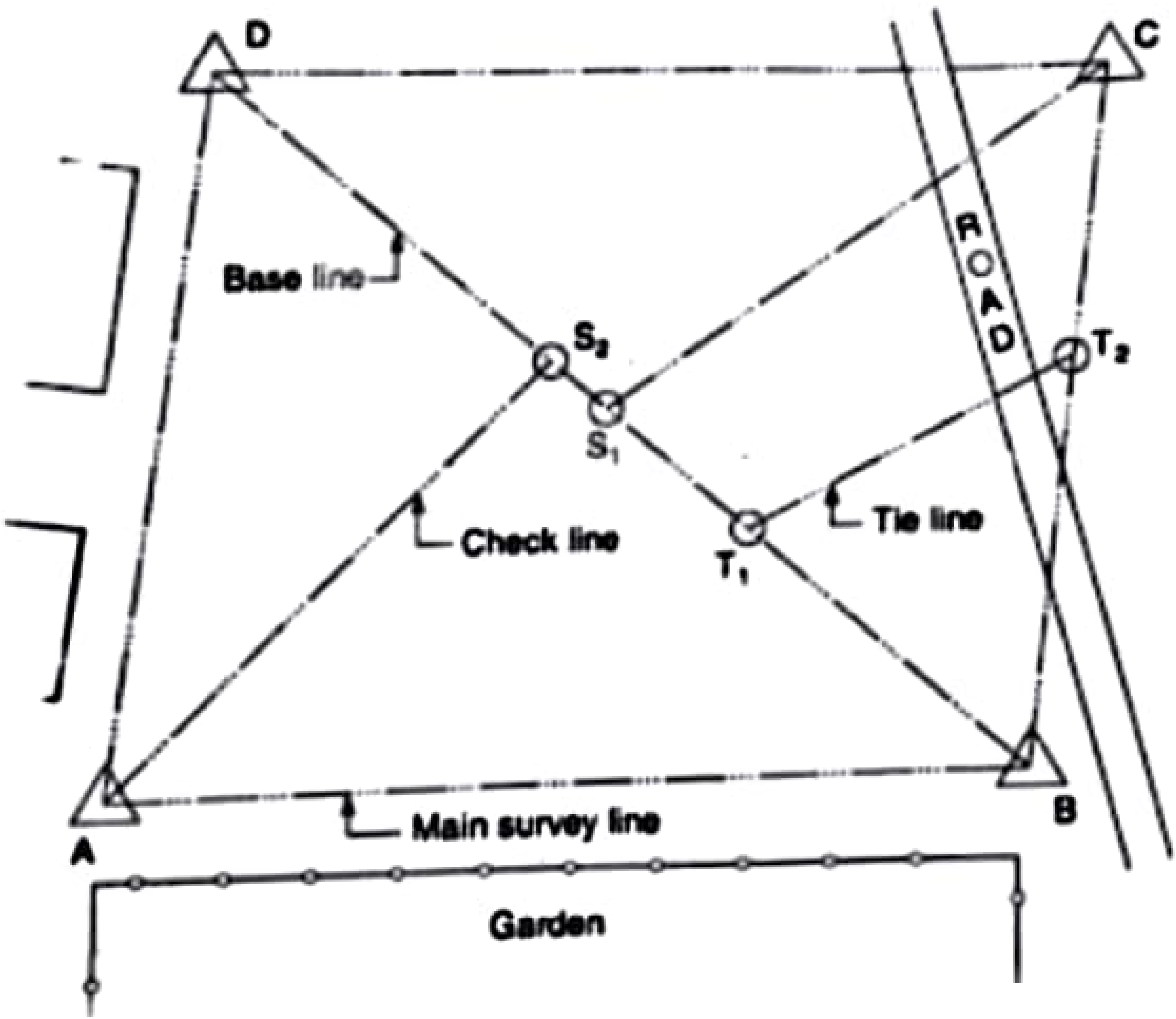
(a) Main stations

(b) Subsidiary stations

(c) Tie stations

## (a) Main stations :

Stations taken along the boundary of an area as controlling points known as 'main stations'. The lines joining the main stations are called 'main survey lines'. The main survey lines should be cover the whole area to be surveyed. The main stations are denoted by '▲' with letters A,B,C,D, etc.


D
C
Base line
ROAD
$S_2$
$T_2$
$S_1$
Tie line
Check line
$T_1$
Main survey line
A
B
Garden

### (B) Subsidiary stations :

Stations which are on the main survey lines or any other survey lines are known as 'Subsidiary stations'. These stations are taken to run subsidiary lines for dividing the area into triangles , for checking the accuracy of triangles and for locating interior details.

these stations are denoted by '○ ' with letters $S_1$, $S_2$, $S_3$, etc.

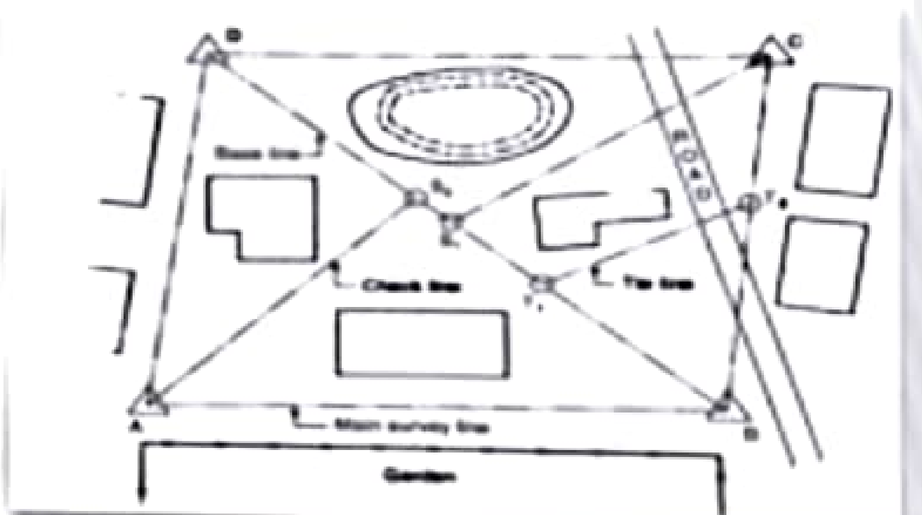
### (c) Tie stations :

These are also subsidiary stations taken on the main survey lines. Lines joining the tie stations are known as ‘tie lines’.

Tie lines are taken to locate interior details. The stations are denoted by ‘●’ with letters $T_1$ , $T_2$ , $T_3$ , etc.

## (2) MAIN SURVEY LINES :

The lines joining the main stations are called 'main survey lines' or chain lines in fig. AB,BC,CD and DA are the main survey lines.



## (3) BASE LINE :

The line on which the framework of the survey is built is known as the 'base line' . It is the most important line of the survey . Generally , the longest of the main survey line is considered as the base line. This line should be measured very carefully and accurately. In fig. BD is the base line.

## (4) CHECK LINE :

The line joining the apex point of a triangle to some fixed points on its base is known as the 'check line'. It is taken to check the accuracy of the triangle . Sometimes this line is helps to locate interior details . In fig. $CS_1$ , $AS_2$ are the check lines.

## (5) TIE – LINE :

A line joining tie stations is termed as a tie line. It is run to take the interior details which are far away from the main lines and also to avoid long offsets. It can also serve as check line. In Fig.

$T_1$ $T_2$ is the tie line.

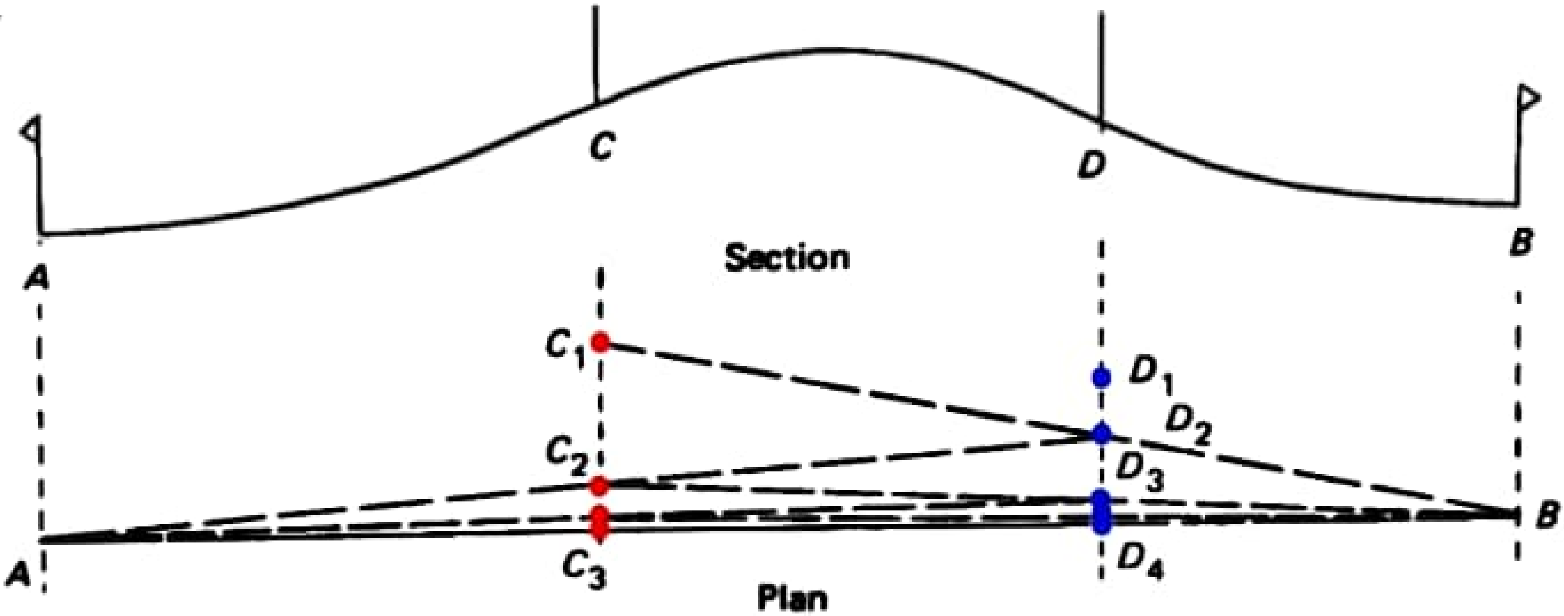
# Offsets

- Lateral measurements to chain line for locating ground features are known as Offsets.
- There are two types of offsets used in chain surveying viz. PERPENDICULAR OFFSET and OBLIQUE OFFSET.
- In case of perpendicular offset, foot of the perpendicular on chain line is found from the object and the surveyor notes down offset distance and the chainage of foot of the perpendicular.
- In case of oblique offset, the distance of the object from two convenient points on the chain lines are measured and noted down.

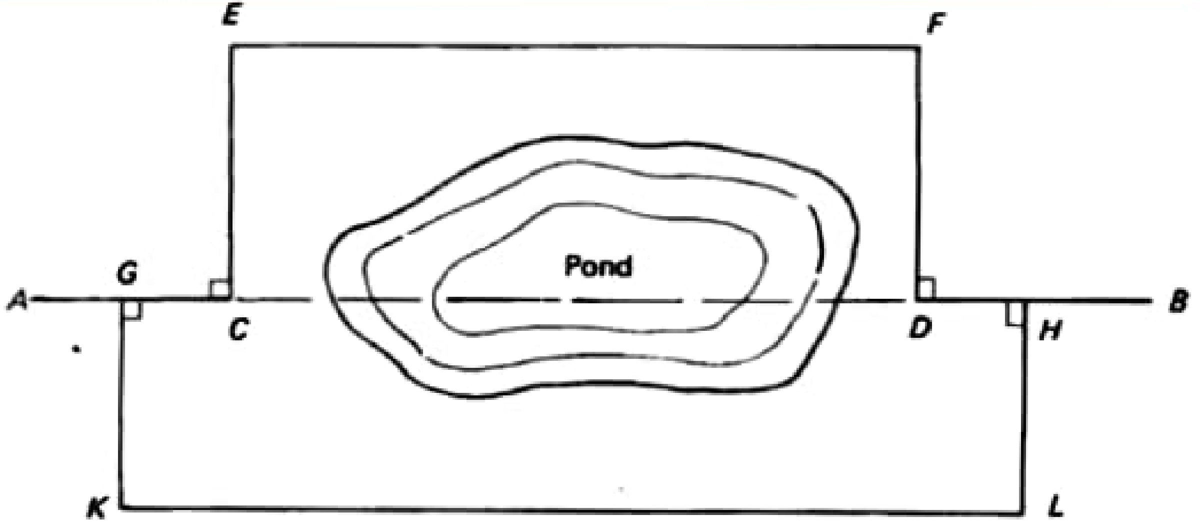
# Chaining Obstacles

- Vision is obscured, Chaining is Possible
- Vision Possible, Chaining is Obscured
- Both of Vision and Chaining are Obscured

# Vision is obscured, Chaining is Possible



# Vision is Possible, Chaining is Obscured

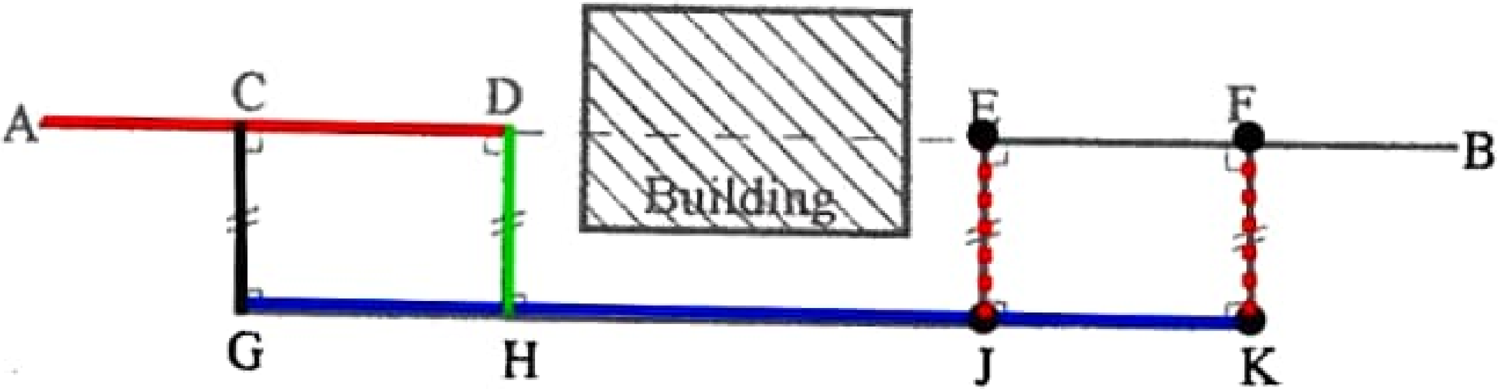



**AB=AC+EF+DB**

**=AG+KL+HB**

# Both of Vision and Chaining are Obscured

## Prolonged Line




DE = HJ

FOLDING:

- Bring the two handles together on the ground by pulling the chain at the center.
- Commencing from the center two pairs of links are taken at a time with the right hand and placed alternatively in both directions in the left hand.
- When the chain is completely folded the two brass handles will appear at the top.
- Now tie the chain with leather strap.

# Technique of unfolding and folding of a metric chain.

UNFOLDING:

- Remove the strap of the folded chain and take both the handles in the left hand and hold the remaining portion of the chain in the right hand.
- Holding both the handles in the left hand, throw the remaining portion o f the chain in the forward direction on the ground.
- Now the follower stands at the starting station by holding one handle and directs the leader to move forward by holding the other handle until the chain is fully stretched.

## 2.21 ERROR IS CHAINING

Error is the difference between measured quantity and true value of that measured. It can be – ve or + ve depending upon the magnitude of measured and true quantity. If the measured quantity is more than true there the error will be + ve and vice versa.

Error = Measured quantity – True quantity

The correction is opposite in nature than error but equal in magnitude.

### 2.21.1 Sources of Error

They may be three sources of errors :

(i) **Instrumental errors** : The errors caused by faulty adjustment of the instruments are called instrumental errors. For example tape too long or too short.

(ii) **Natural errors** : The errors caused by natural causes such as due to variation in temperature, heavy winds, refraction, magnetic declination, are called natural errors.

(iii) **Personal Errors** : The errors caused by person such as applying unequal tension in the chain, not removing parallax, not sighting the object correctly etc. are called personal errors.

### 2.21.2 Classification of Errors

In chaining, three classes of errors are met with :

(*a*) Cumulative errors

(*b*) Compensating errors

(*c*) Mistakes in chaining

(*a*) **Cumulative errors** : The cumulative errors are those which occur in one direction only and go on cumulating. These errors have got a serious effect on the accuracy of the survey work.

The errors in chaining are regarded as + ve or −ve according as they make the result too great or too small.

**Causes :**

(*i*) Incorrect length of chain (+ve or −ve).

(*ii*) Sag is chain in stepping method (+ve).

(*iii*) Measurement made along wrong ranging (+ve).

(*iv*) Chain not being straight (+ve).

(*v*) Variation in temperature (+ve or −ve).

**(*b*) Compensating errors :** Errors which may occur in both directions (*i.e.* both positive and negative) and which finally tend to compensate are known as compensating errors. These errors do not affect survey work seriously.

**Causes :**

(*i*) Incorrect holding of chain

(*ii*) Incorrect placing of arrow

(*iii*) Incorrect plumbing

(*iv*) Incorrect measurement of right angle

(*v*) Incorrect functional part of chain.

**(c) Mistakes :** These are errors occurring due to carelessness or inexperience of chainmen.

1. Mistake in counting the chain length.
2. Reading from wrong end of chain.
3. Displacement of arrows.
4. Reading number wrongly 6 for 9 for tape upside down.
5. Booking wrongly by interchanging the figure.
6. Called number wrongly such as 30.2 as thirty two.

## 2.24 ADVANTAGES OF CHAIN SURVEY

1. No angular instrument is required.
2. The length of lines are required only.
3. There is complete check on measurements due to check lines and tie lines in the frame work.
4. It is easy to performance and plotting as the number of the lines can be run between the frame work so as to reduce the length of off sets.
5. It requires less and easy calculation to obtain area.
6. It requires less time.
7. It a cheap.

## 2.25 DISADVANTAGES OF CHAIN SURVEY

1. This method cannot be adopted when the boundary is broken.
2. It is unsuitable for narrow strip or road as it is difficult to run triangles.

# COMPASS SURVEYING

# INTRODUCTION

- Chain surveying can be used when the area to be surveyed is comparatively is small and is fairly flat.
- But when the area is large , undulating and crowded with many details , triangulation(which is the principle of chain survey) is not possible.
- In such an area , the method of surveying is used.

# Principle of compass surveying

- The principle of compass surveying is traversing; which involves a series of connected lines.
- The magnetic bearing of the lines are measured by prismatic compass.
- Compass surveying is recommended when the area is large, undulating and crowded with many details.
- Compass surveying is not recommended for areas where local attraction is suspected due to the presence of magnetic substances like steel structures, iron ore deposits, electric cables , and so on.

# Traversing

- In traversing , the frame work consist of connected lines.
- The length are measured by a chain or a tape and the direction measured by angle measuring instruments.
- Hence in compass surveying direction of survey lines are determined with a compass and the length of the lines are measured with a tape or a chain. This process is known as compass traversing.

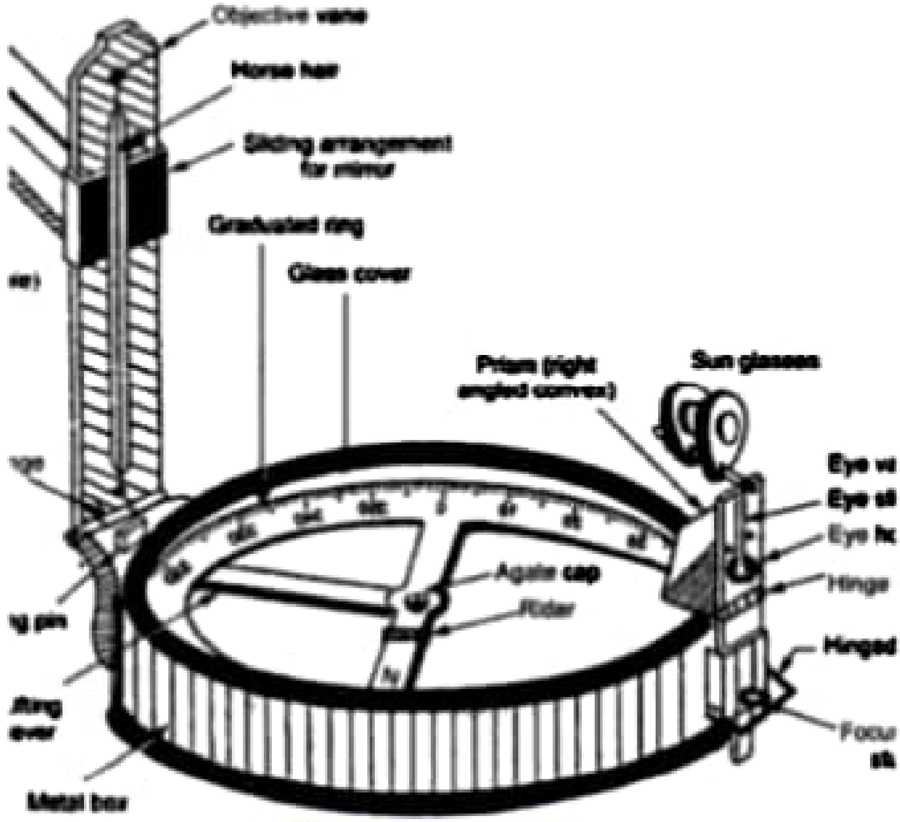
# Compass

- A compass is a small instrument essentially consisting of a graduated circle, and a line of sight.
- The compass can not measures angle between two lines directly but can measure angle of a line with reference to magnetic meridian at the instrument station point is called magnetic bearing of a line.

# Types of compass

- There are two types of compass they are as follows:-
- The prismatic compass

# PRISMATIC COMPASS




Prismatic compass parts

# Elements of prismatic compass

- **Cylindrical metal box**: Cylindrical metal box is having diameter of 8to 12 cm. It protects the compass and forms entire casing or body of the compass. It protect compass from dust, rain etc.
- **Pivot:** pivot is provided at the center of the compass and supports freely suspended magnetic needle over it.
- **lifting pin and lifting lever:** a lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin. The lifting pin with the help of lifting lever then lifts the magnetic needle out of pivot point to prevent damage to the pivot head.
- **Magnetic needle**: Magnetic needle is the heart of the instrument. This needle measures angle of a line from magnetic meridian as the needle always remains pointed towards north south pole at two ends of the needle when freely suspended on any support.
- **Graduated circle or ring:** This is an aluminum graduated ring marked with $0^{0}$ to $360^{0}$ to measures all possible bearings of lines, and attached with the magnetic needle. The ring is graduated to half a degree.
- **Prism :** prism is used to read graduations on ring and to take exact reading by compass. It is placed exactly opposite to object vane. The prism hole is protected by prism cap to protect it from dust and moisture.

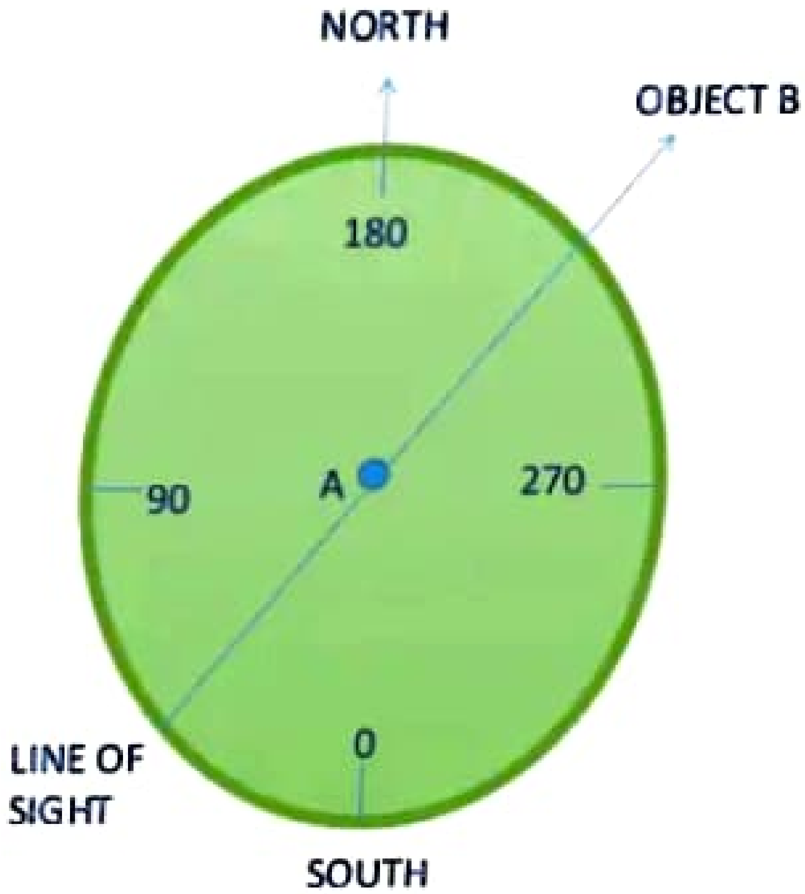
- **Object vane:** object vane is diametrically opposite to the prism and eye vane. The object vane is carrying a horse hair or black thin wire to sight object in line with eye sight.
- **Eye vane:** Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.
- **Glass cover:** its covers the instrument box from the top such that needle and graduated ring is seen from the top.
- **Sun glasses:** These are used when some luminous objects are to be bisected.
- **Reflecting mirror:** It is used to get image of an object located above or below the instrument level while bisection. It is placed on the object vane.
- **Spring brake or brake pin:** to damp the oscillation of the needle before taking a reading and to bring it to rest quickly, the light spring brake attached to the box is brought in contact with the edge of the ring by gently pressing inward the brake pin

# Temporary adjustment of prismatic compass

- The following procedure should be adopted after fixing the prismatic compass on the tripod for measuring the bearing of a line.
- **Centering** : Centering is the operation in which compass is kept exactly over the station from where the bearing is to be determined. The centering is checked by dropping a small pebble from the underside of the compass. If the pebble falls on the top of the peg then the centering is correct, if not then the centering is corrected by adjusting the legs of the tripod.
- **Leveling** : Leveling of the compass is done with the aim to freely swing the graduated circular ring of the prismatic compass. The ball and socket arrangement on the tripod will help to achieve a proper level of the compass. This can be checked by rolling round pencil on glass cover.
- **Focusing** : the prism is moved up or down in its slide till the graduations on the aluminum ring are seen clear, sharp and perfect focus. The position of the prism will depend upon the vision of the observer.

# Observing Bearing of Line

- Consider a line AB of which the magnetic bearing is to be taken.
- By fixing the ranging rod at station B we get the magnetic bearing of needle wrt north pole.
- The enlarged portion gives actual pattern of graduations marked on ring.



# The Surveyor`s Compass

- It is similar to a prismatic compass except that it has a only plain eye slit instead of eye slit with prism and eye hole.
- This compass is having pointed needle in place of broad form needle as in case of prismatic compass.

SURVEYOR'S
COMPASS

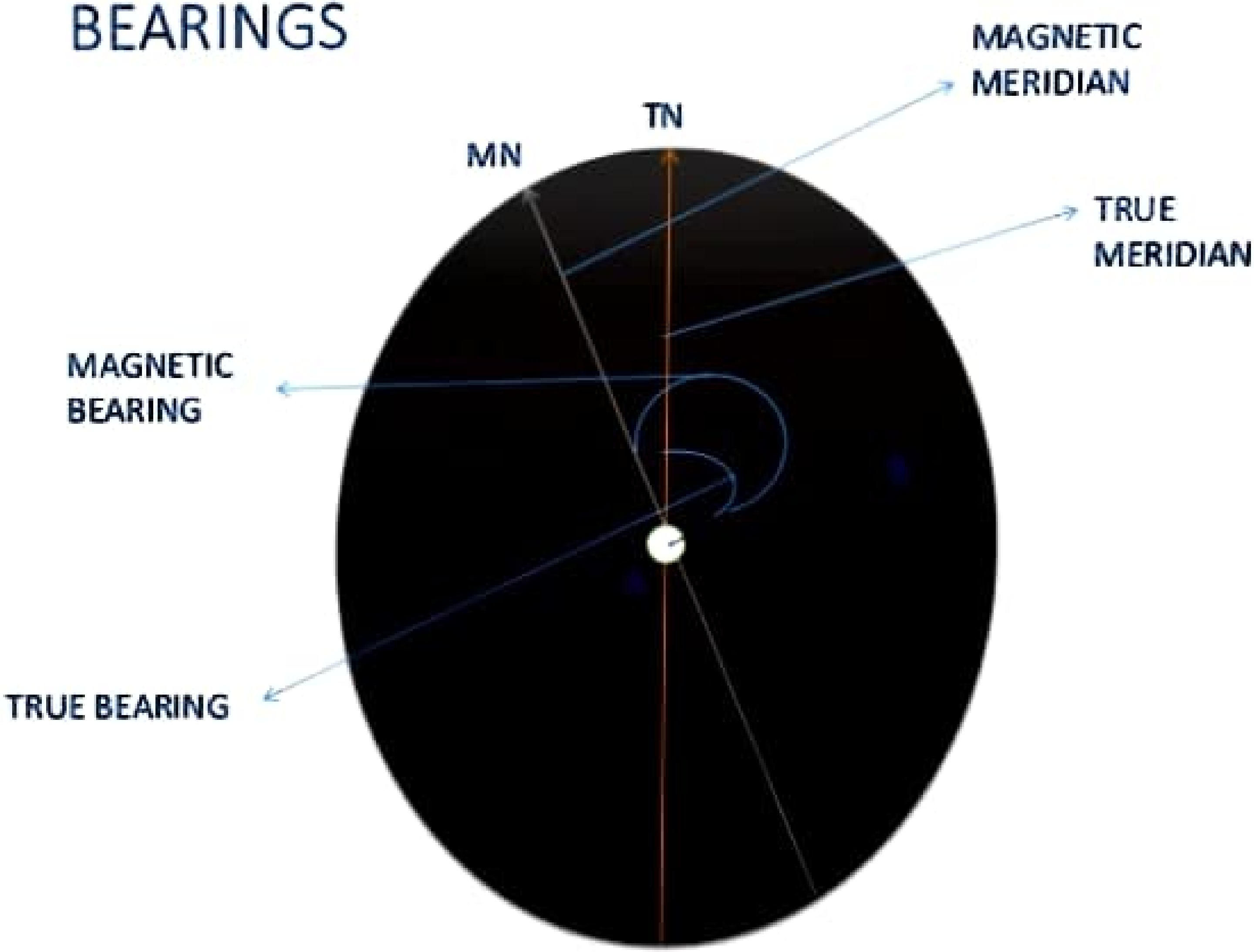
# BEARINGS

- The bearing of a line is the horizontal angle which it makes with a reference line(meridian).
- Depending upon the meridian , there are four type of bearings they are as follows:
- 1) **True Bearing:** The true bearing of a line is the horizontal angle between the true meridian and the survey line. The true bearing is measured from the true north in the clockwise direction.
- 2) **Magnetic Bearing:** the magnetic bearing of a line is the horizontal angle which the line makes with the magnetic north.
- 3) **Grid Bearing:** The grid bearing of a line is the horizontal angle which the line makes with the grid meridian.
- 4) **Arbitrary Bearing:** The arbitrary baring of a line is the horizontal angle which the line makes with the arbitrary meridian.

# Working of Surveyor`s Compass

- 1) Centering
- 2) LEVELING
- 3) OBSERVING THE BEARING OF A LINE
- First two observation are same as prismatic compass but third observation differs from that.
- 3) OBSERVING THE BEARING OF A LINE : in this compass ,the reading is taken from the top of glass and under the tip of north end of the magnetic needle directly. No prism is provided here.

# BEARINGS


MAGNETIC MERIDIAN
TN
MN
TRUE MERIDIAN
MAGNETIC BEARING
TRUE BEARING

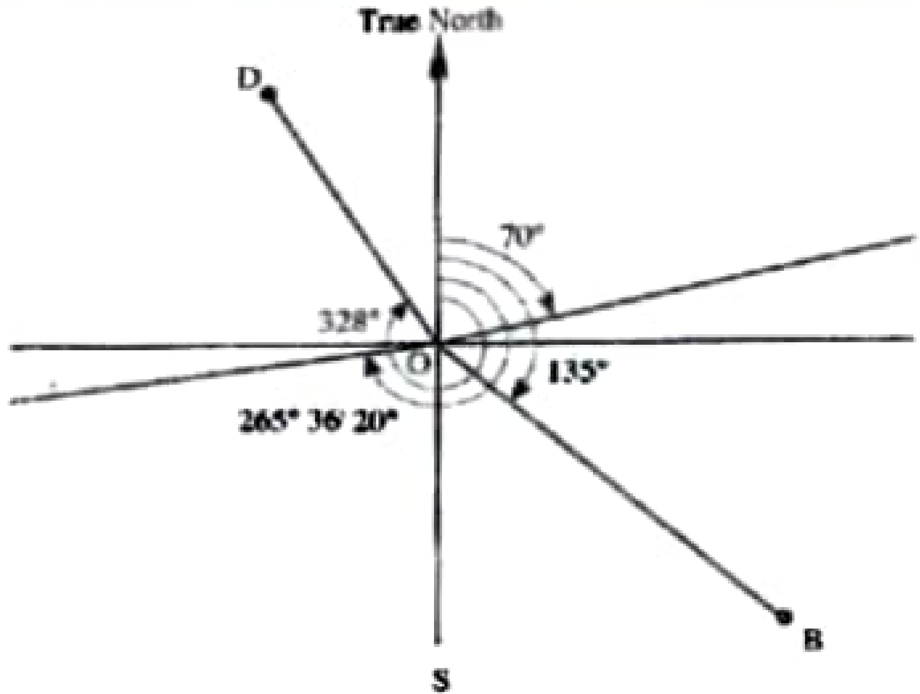
# Designation of bearing

- The bearing are designated in the following two system:-
- 1) Whole Circle Bearing System.(W.C.B)
- 2) Quadrantal Bearing System.(Q.B)

# Whole circle bearing system(W.C.B.)

- The bearing of a line measured with respect to magnetic meridian in clockwise direction is called magnetic bearing and its value varies between $0^{O}$ to $360^{O}$.
- The quadrant start from north an progress in a clockwise direction as the first quadrant is $0^{O}$ to $90^{O}$ in clockwise direction , 2nd $90^{O}$ to $180^{O}$ , 3rd $180^{O}$ to $270^{O}$, and up to $360^{O}$ is 4th one.

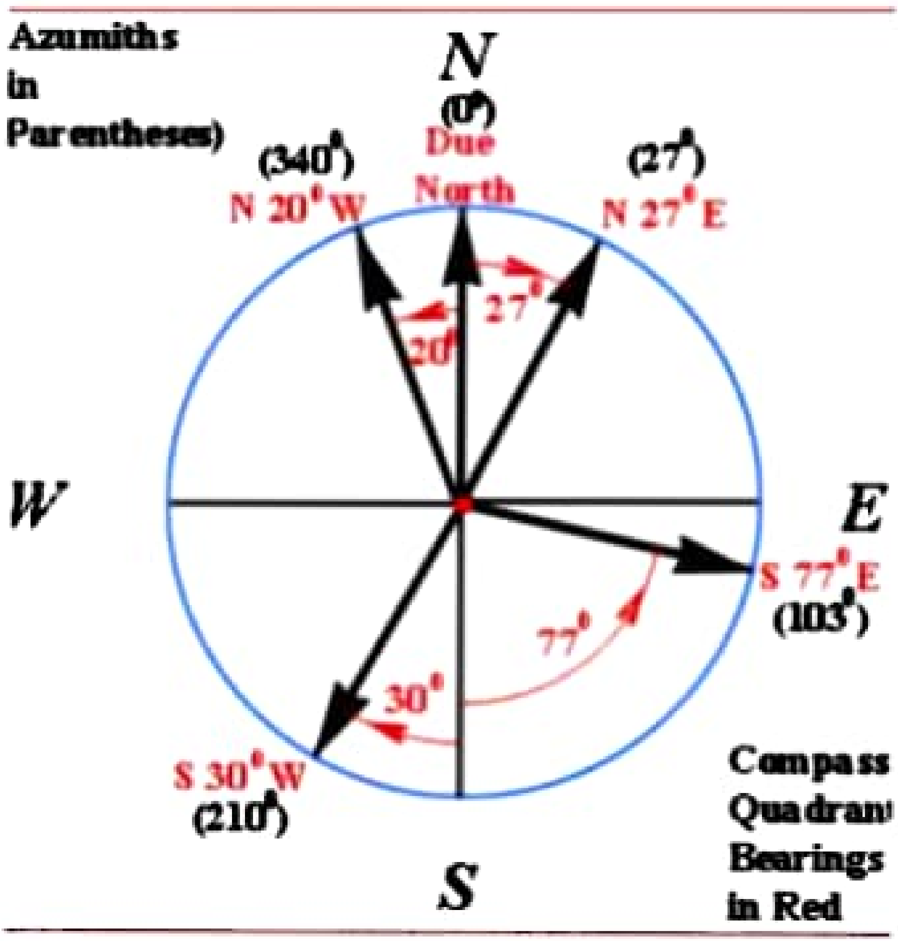
# WHOLE CIRCLE BEARING



# Quadrantal bearing system(Q.B.)

- In this system, the bearing of survey lines are measured wrt to north line or south line which ever is the nearest to the given survey line and either in clockwise direction or in anti clockwise direction.

QUADRANTAL BEARING



# Reduced bearing (R.B)

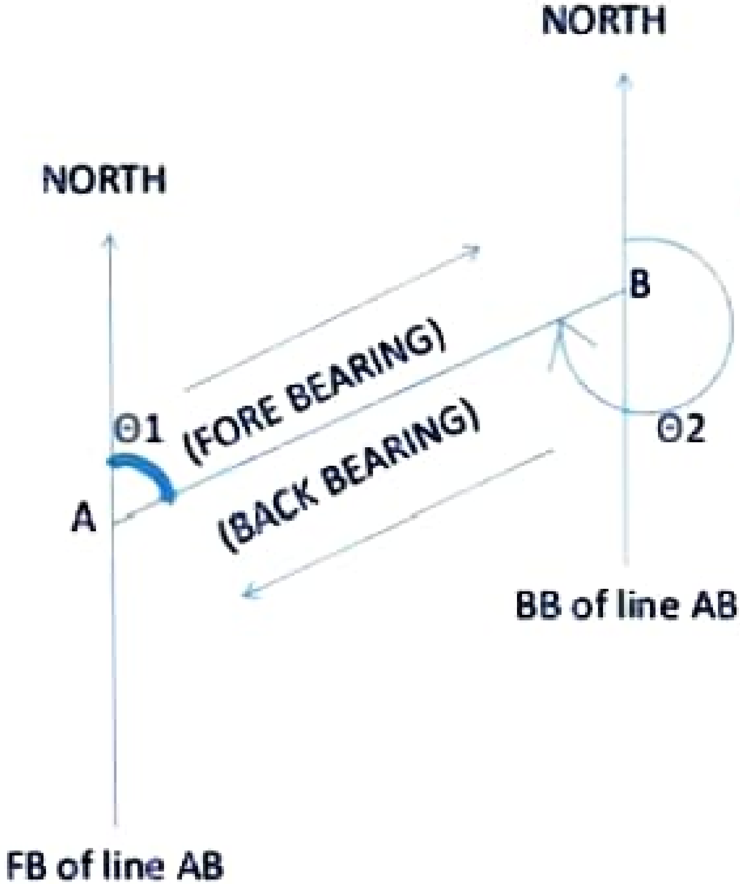
- When the whole circle bearing is converted into Quadrantal bearing , it is termed as “REDUCED BEARING”.
- Thus , the reduced bearing is similar to the Quadrantal bearing.
- Its values lies between $0^{O}$ to $90^{O}$, but the quadrant should be mentioned for proper designation.

- The following table should be remembered for conversion of WCB to RB.

| W.C.B OF ANY LINE | QUADRANT IN WHICH IT LIES | RULES FOR CONVERSION | QUADRANT |
|---|---|---|---|
| 0 TO 90 | I | RB=WCB | N-E |
| 90 TO 180 | II | RB=180-WCB | S-E |
| 180 TO 270 | III | RB =WCB-180$^\circ$ | S-W |
| 270 TO 360 | IV | RB=360$^\circ$ - WCB | N-W |

# Fore bearing and Back bearing

- The bearing of a line measured in the forward direction of the survey lines is called the 'fore bearing'(F.B.) of that line.
- The bearing of a line measured in direction backward to the direction of the progress of survey is called the 'back bearing'(B.B.) of the line.




FB of AB = Θ1(from A to B)
BB of AB= Θ2(from B to A)

---

Remembering following points:

1) In the WCB system ,the differences b/n the FB and BB should be exactly 180°. Remember the following relation :

   $$BB=FB+/-180^{o}$$

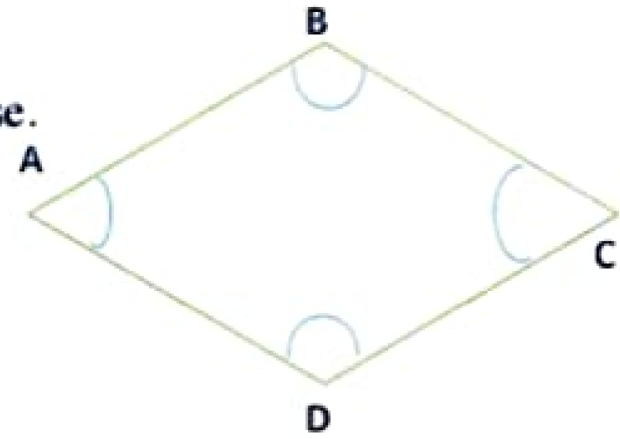
   + is applied when FB is <180°

   - is applied when BB is >180°

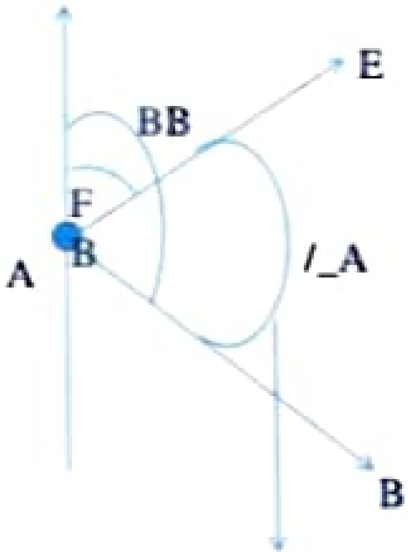
2) In the reduced bearing system the FB and BB are numerically equal but the quadrants are just opposite.

# Computation of Angles

- Observing the bearing of the lines of a closed traverse, it is possible to calculate the included angles, which can be used for plotting the traverse.
- At the station where two survey lines meet, two angles are formed-an exterior angles and an interior angles. The interior angles or included angle is generally the smaller angles(<180°).



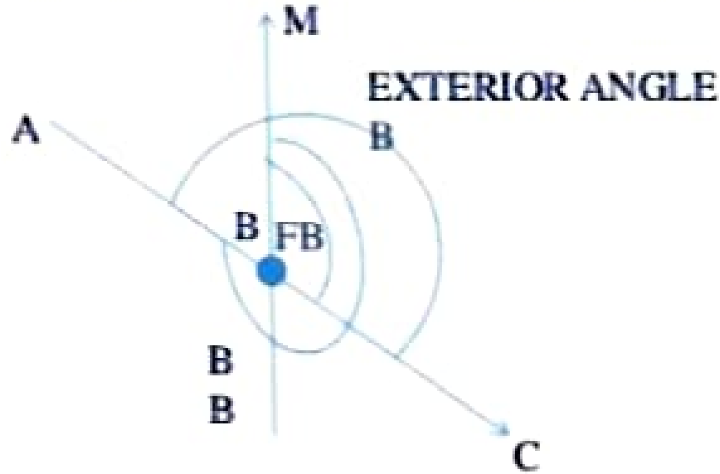
# EXAMPLES




INCLUDED ANGLE

AT STATION A,FB of AB and BB of EB were measured. Difference of these two bearing give interior angle A.

Angle A =FB OF AB – BB OF EA




AT STATION B ,FB of BB OF AB were measured . Difference of these two bearing will give you exterior angle B.

EXTERIOR ANGLE B=BB OF AB-FB OF BC
INTERIOR ANGLE B=360$^{o}$-EXTERIOR ANGLE

# Meridian

- Bearing of a line is always measured clockwise wrt some reference line or direction. This fixed line is known as meridian.
- There three types of meridian:
- 1) **Magnetic meridian**: The direction shown by a freely suspended needle which is magnetized and balanced properly without influenced by any other factors is known as magnetic meridian.
- 2) **True meridian** : True meridian is the line which passes through the true north and south. The direction of true meridian at any point can be determined by either observing the bearing of the sun at 12 noon or by sun's shadow.
- 3) **Arbitrary meridian:** In case of small works or in places where true meridian or magnetic meridian cannot be determined, then ,any direction of a prominent object is taken as a reference direction called as arbitrary meridian.

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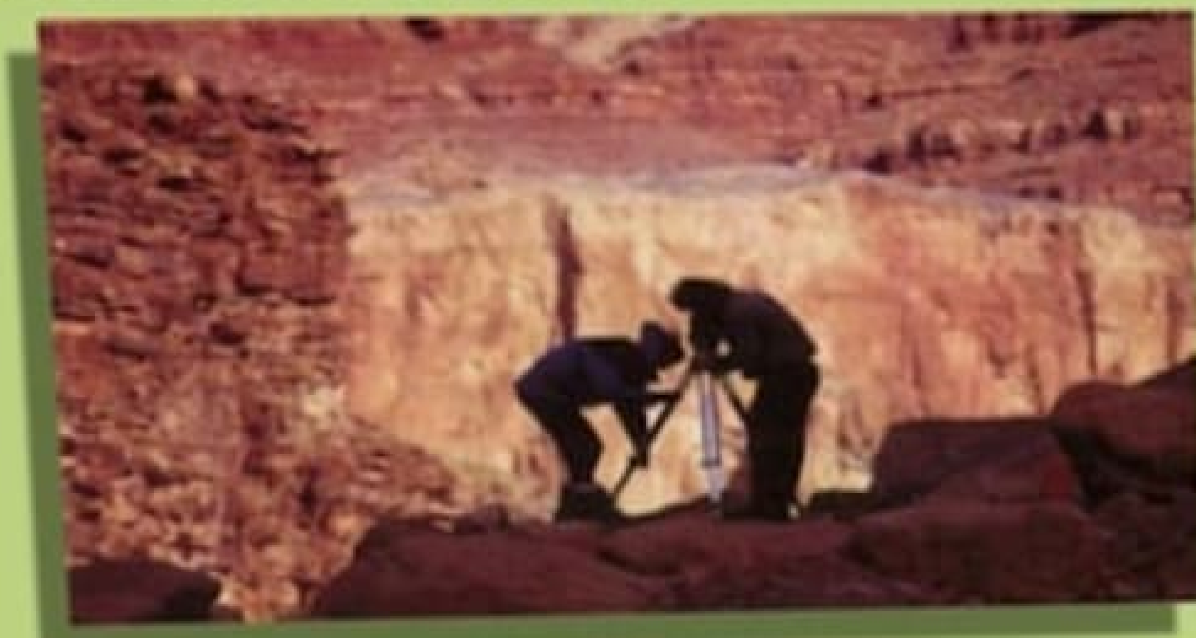
# LEVELLING

Unit-

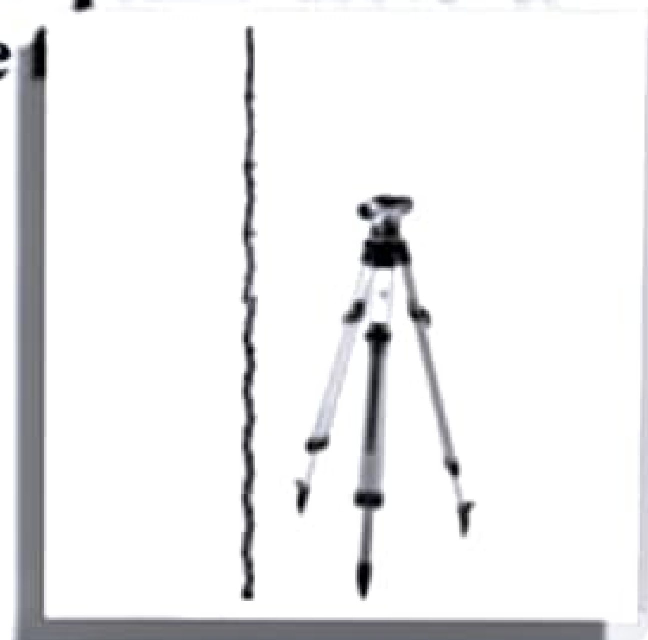
# Definition

- Levelling is defined as "**an art** of determining the relative height of different points **on, above** or **below** the surface".



# Principle of Levelling

- The principle of levelling is to obtain **horizontal line of sight** with respect to which **vertical distances of the points** above or below this **line of sight are**



# Object of levelling

**The objective of Levelling**

- To Find the **elevation** of given point with respect to some assumed reference line called datum.
- **To establish point at required elevation** respect to datum.

# Terms used in Levelling

**Level surface**

- It is the surface parallel to the mean spheroidal surface of the earth

**Level line**

- Line lying on level surface.

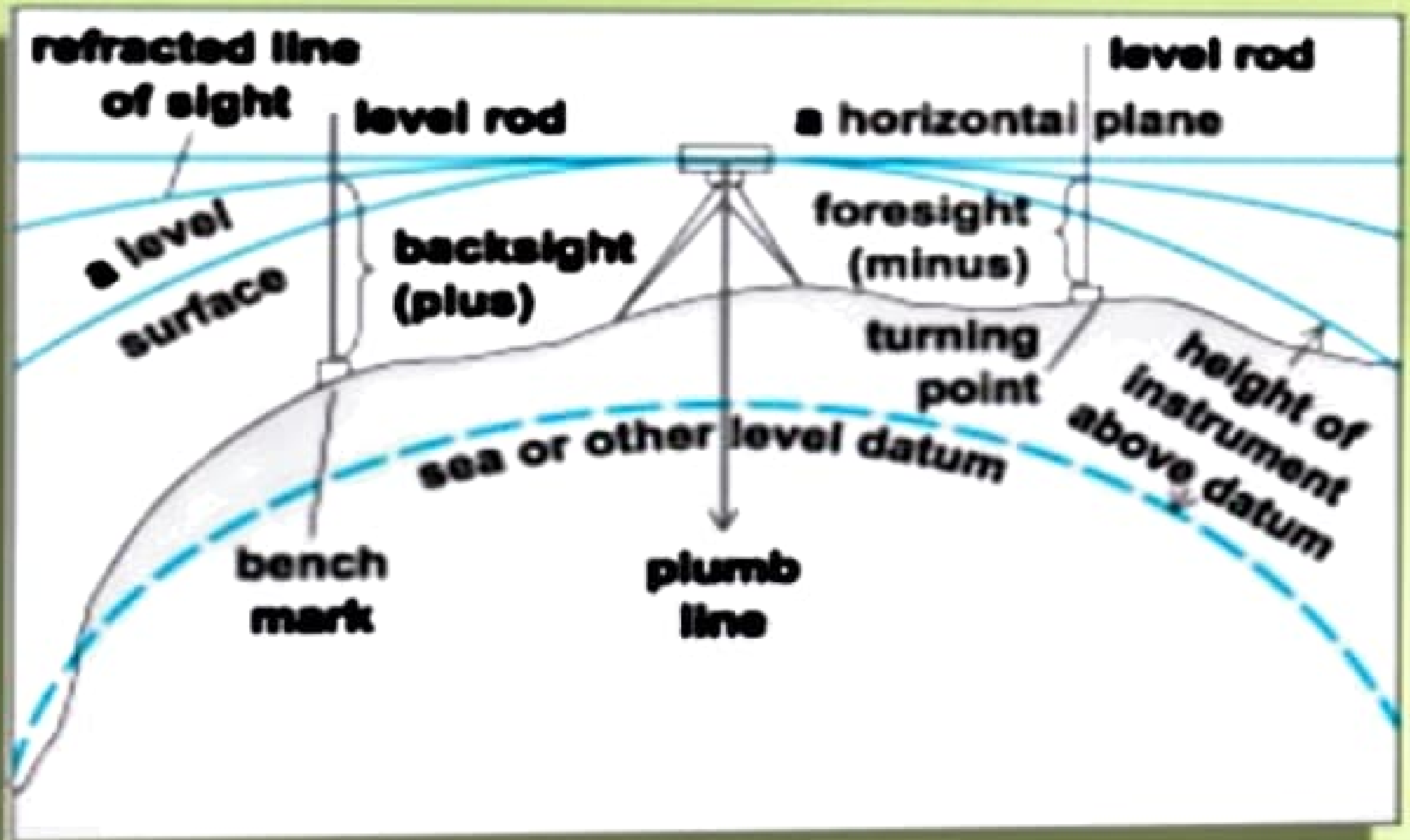
**Horizontal plane**

- Horizontal plane through a point is a plane tangential to level surface.

**Horizontal line**

- It is a straight line tangential to level line.

# Levelling


refracted line of sight
level rod
level rod
a horizontal plane
a level surface
backsight (plus)
foresight (minus)
turning point
height of instrument above datum
sea or other level datum
bench mark
plumb line

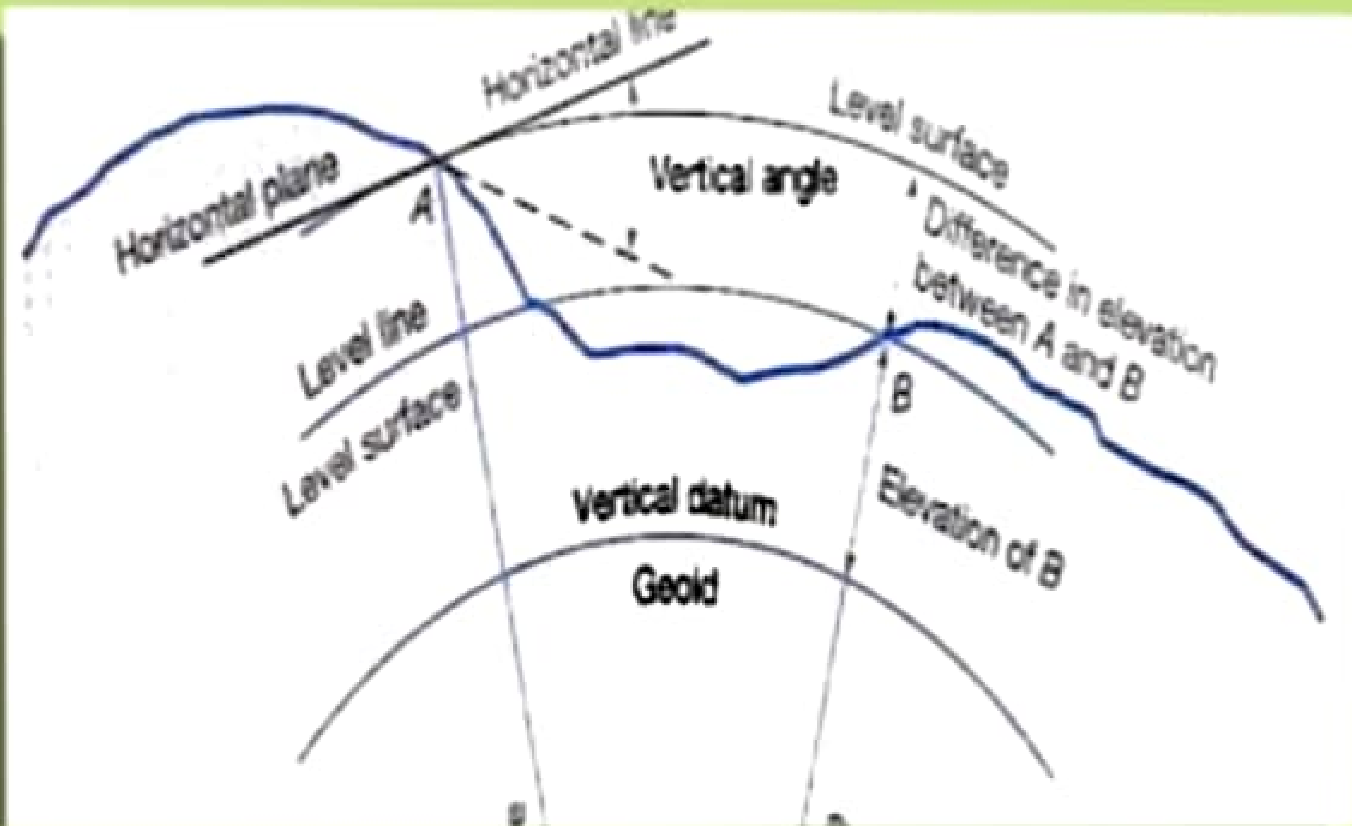
# Terms used in levelling

**Datum** "It is an arbitrary level surface from which elevation of points may be referred". In India mean sea level is considered as datum of zero elevation it is situated at Karachi.

**Mean Sea Level** is the average height of sea for all stages of tides it is derived by averaging the hourly tide height over a period of 19 years.

**Elevation or Reduced level** It is height or depth of any point above or below any datum. It is denoted as R.L.

# Terms used in levelling



# Terms used in Levelling

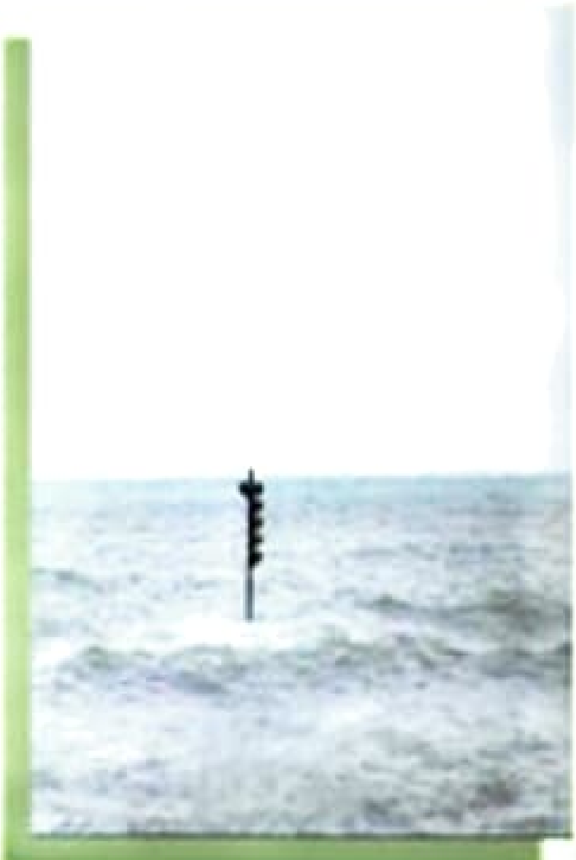
**Bench Mark (B.M.)** It is a fixed reference point of known elevation with respect to datum.

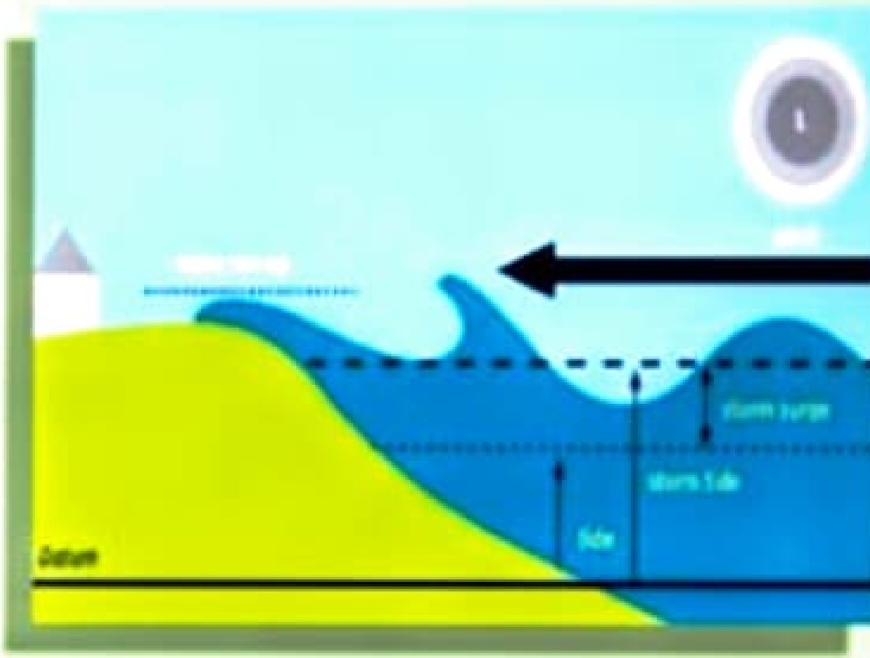
**Line of collimation** It is a line joining the intersection of cross hairs of diaphragm to the optical centre of object glass and its continuation. It is also known as line of sight.

**Height of instrument** It is the elevation of line of collimation with respect to datum

**Back sight** It is a staff reading taken at a known elevation. It is the first staff reading taken after setup of instrument.

# Mean Sea Level





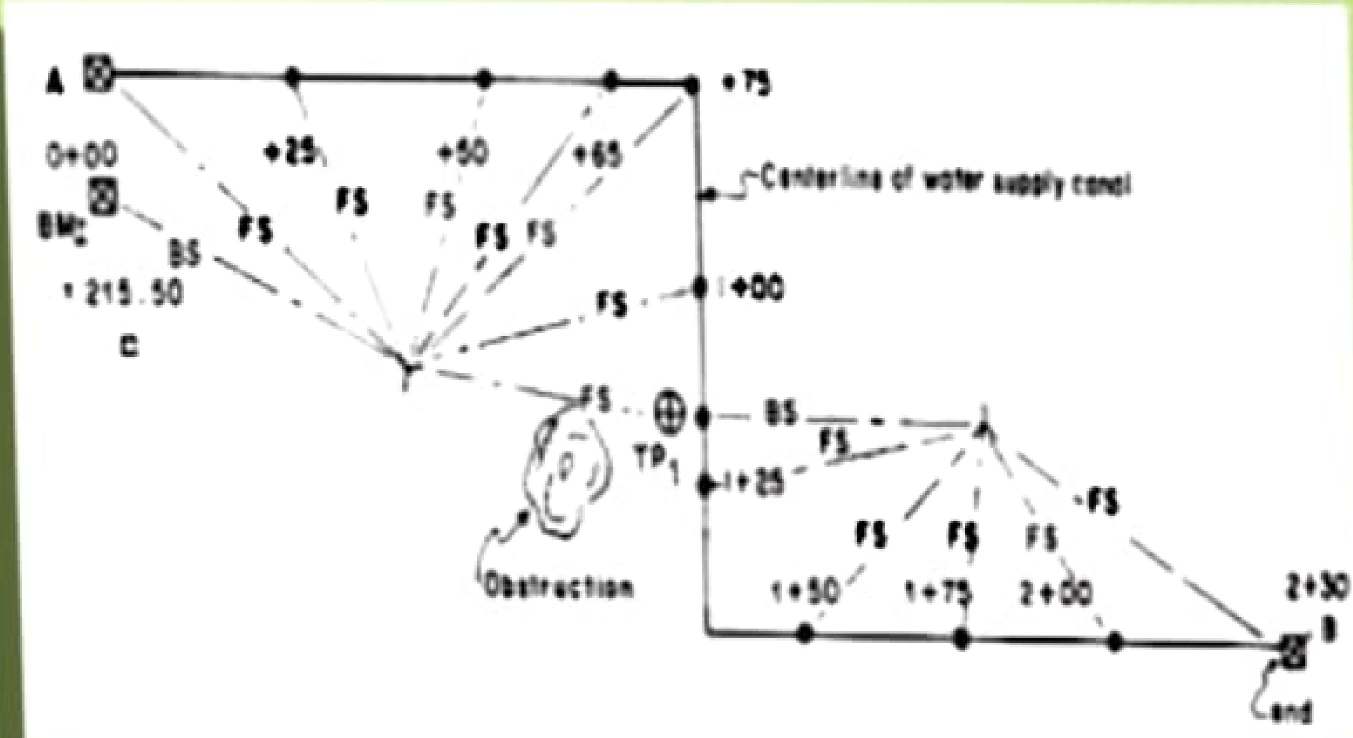
# Terms used in Levelling

**Fore sight( F.S.)** It is the last staff reading taken denoting the shifting of the instrument.

**Intermediate sight.(I.S.)** It is staff reading taken on a point whose elevation is to be determined. All staff reading between B.S. and F.S. are Intermediate sight.

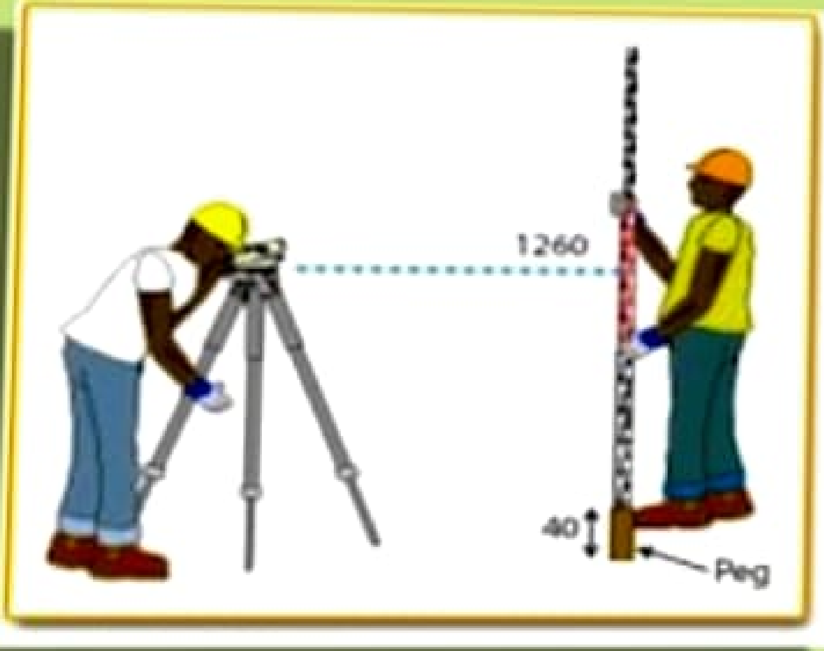
**Change Point (T.P)** It is a point on which both fore and back sight are taken.

# Terms used in Levelling



# Instruments for levelling

- The following instruments are essentially required for levelling
- Level
- Levelling Staff



# Instruments for levelling

- **Level and types of level**
- Level
- The instrument used to furnish horizontal line of sight for observing staff readings and determining R.L.s

# Types of Level

- Dumpy level
- Tilting level
- Wye level
- Automatic level

# Dumpy level

- The Dumpy level is a simple, compact and stable instrument. The telescope is rigidly fixed to its supports. Hence it cannot be rotated about horizontal axis.

# Dumpy level

# Tilting Level

- It is also known as I.O.P. level (**Indian office Pattern**).In this level the telescope tilts about its horizontal axis hence it is called tilting level

# Tilting Level

# Wye level

- The essential difference between wye level and other levels is that in wye level the telescope is carried by two vertical wye supports. The telescope can be rotated, moved or even raised in wyes.

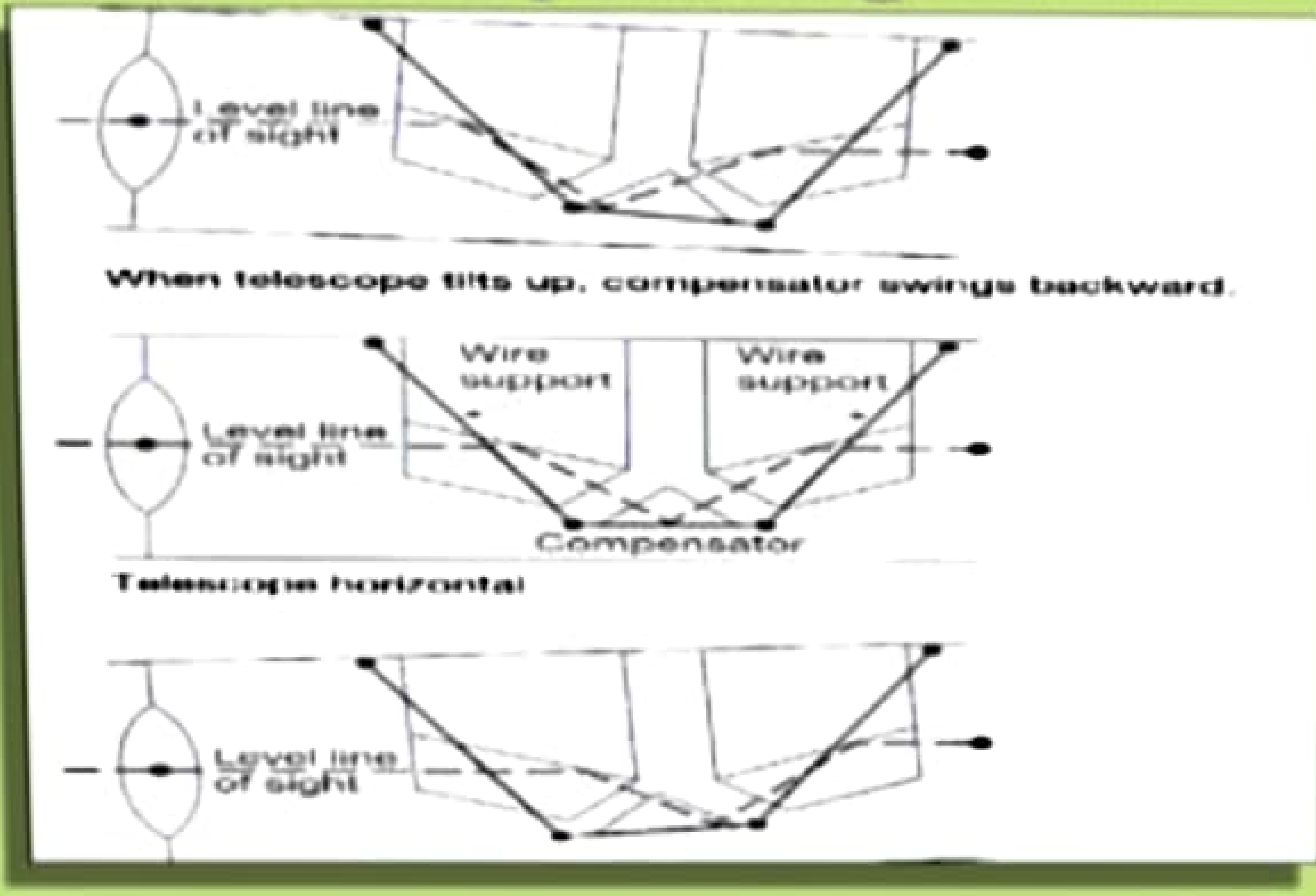
# Wye level

# Automatic level

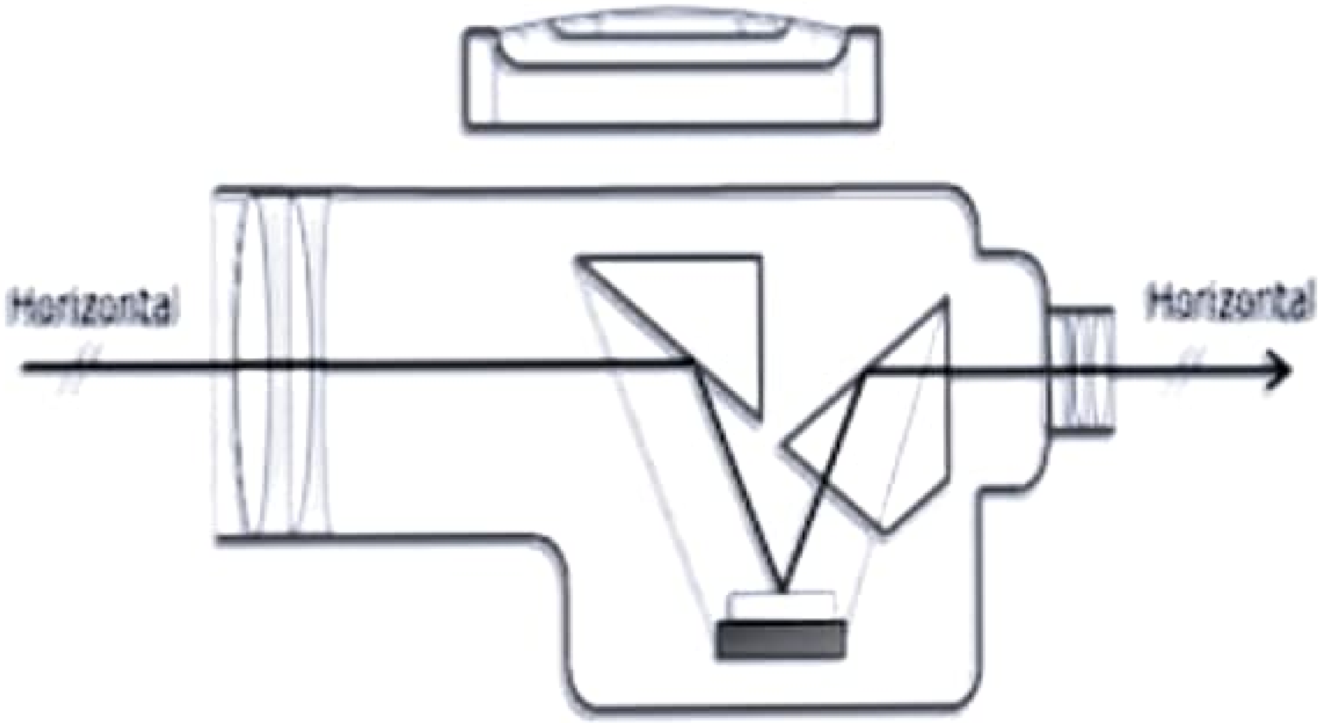
- It is also known as self aligning level. It is a recent development. The fundamental difference between auto level and other levels is that the levelling is not manually but it is levelled automatically. It is achieved by **inclination compensating device.**

# Automatic level

# Tilt Compensating Device



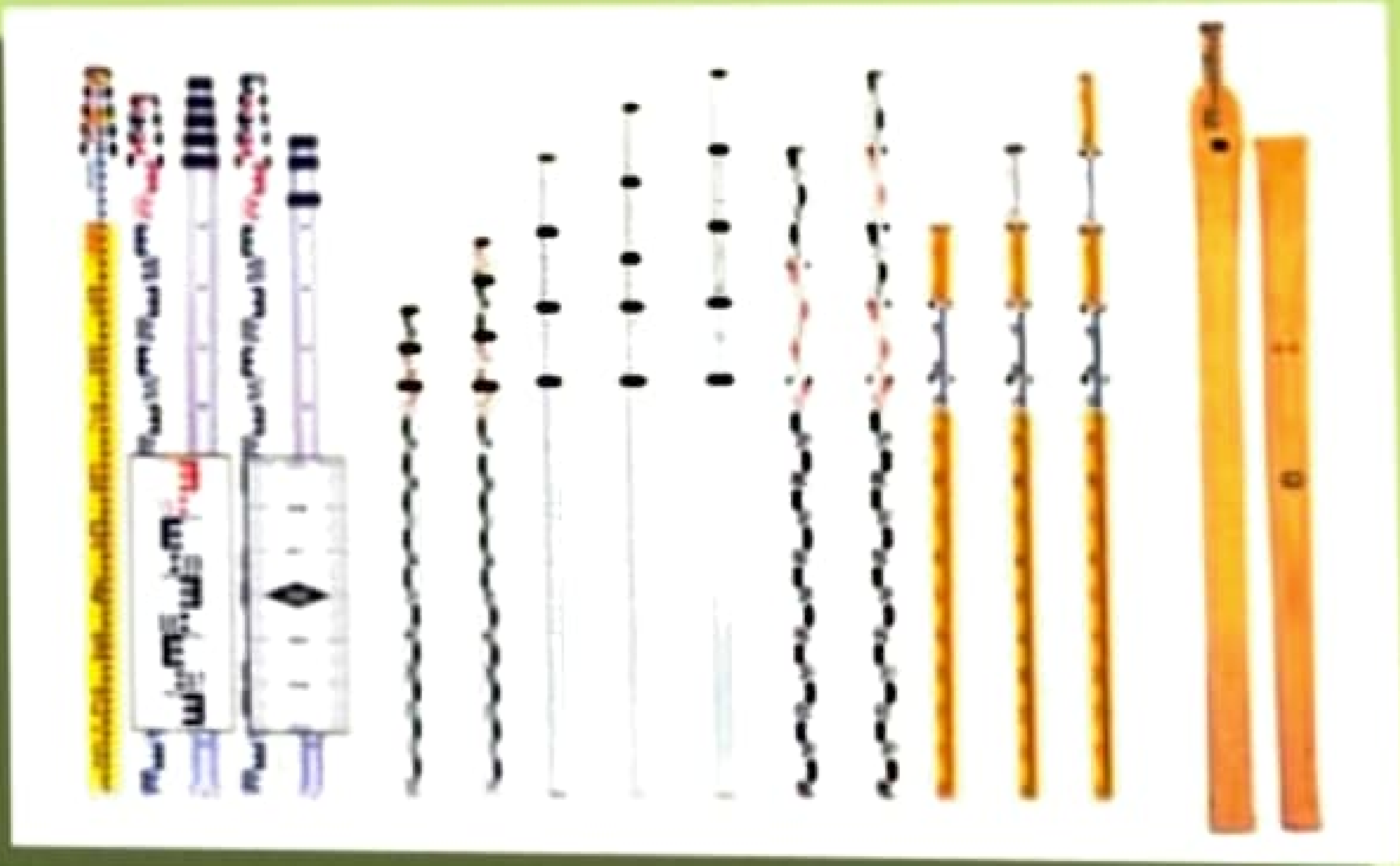
# Tilt Compensating Device



# Levelling Staffs

- Levelling staffs are scales on which these distances are measured.
- Levelling staffs are of two types
- Self Reading staff
- Target staff

# Levelling Staffs

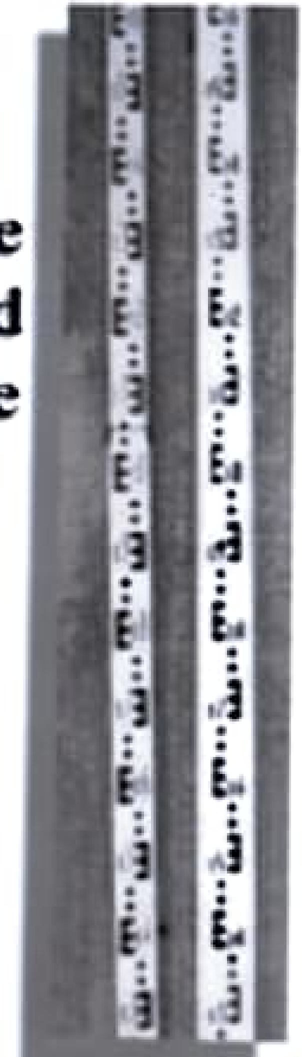


# Self Reading Staff

- The self reading staff can be read directly by the level man looking through the telescope.
- Common types of self reading staffs
- Ordinary staff
- Sop-with telescopic staff
- Folding Staff

# Ordinary Staff

- The one length staff, is solid and made of seasoned wood, it is 3 m long and graduated in the same way as the telescopic staff



# Folding Staff

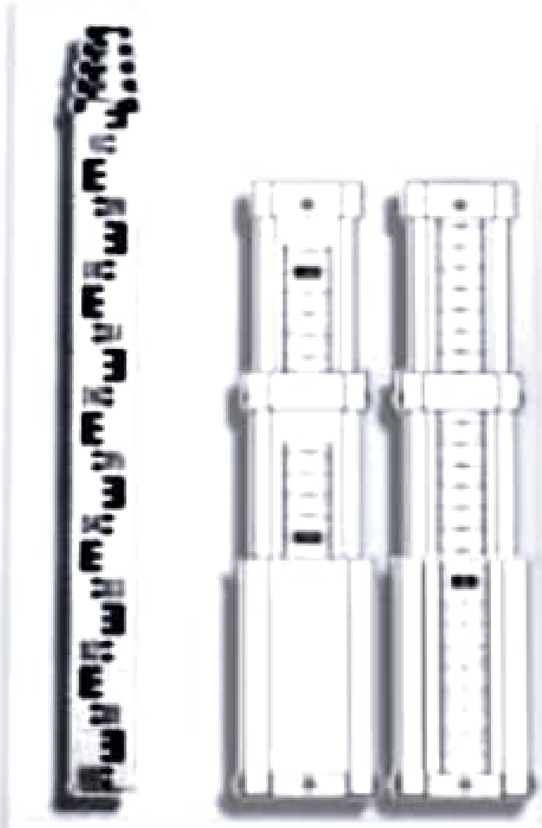
- The folding staff is made up of well seasoned timber such as Cyprus. It consists of two 2 m **wooden pieces with a joint assembly**. Each piece of the staff is made of one longitudinal strip without any joint. **The folding joint is of the detachable type with a locking device** at the back. The staff is joined together in such a way that the staff may be folded from one another when required.
- The staff has **brass cap at the bottom**. It has two folding handles, with spring action. It is provided with a circular bubble fitted at the back.

# Folding Staff

# Sop-with Telescopic Staff

- Such a staff is arranged in **three lengths placed one into the other.** It can be extended to its **full length by pulling**. The **top portion is solid** and the **central box is hollow** the total length of staff is 4 m.
- The staff is graduated in such a way that **smallest division is of 5 mm**. the value in m are marked in **red on the left and those in decimetre are in black on the right**.

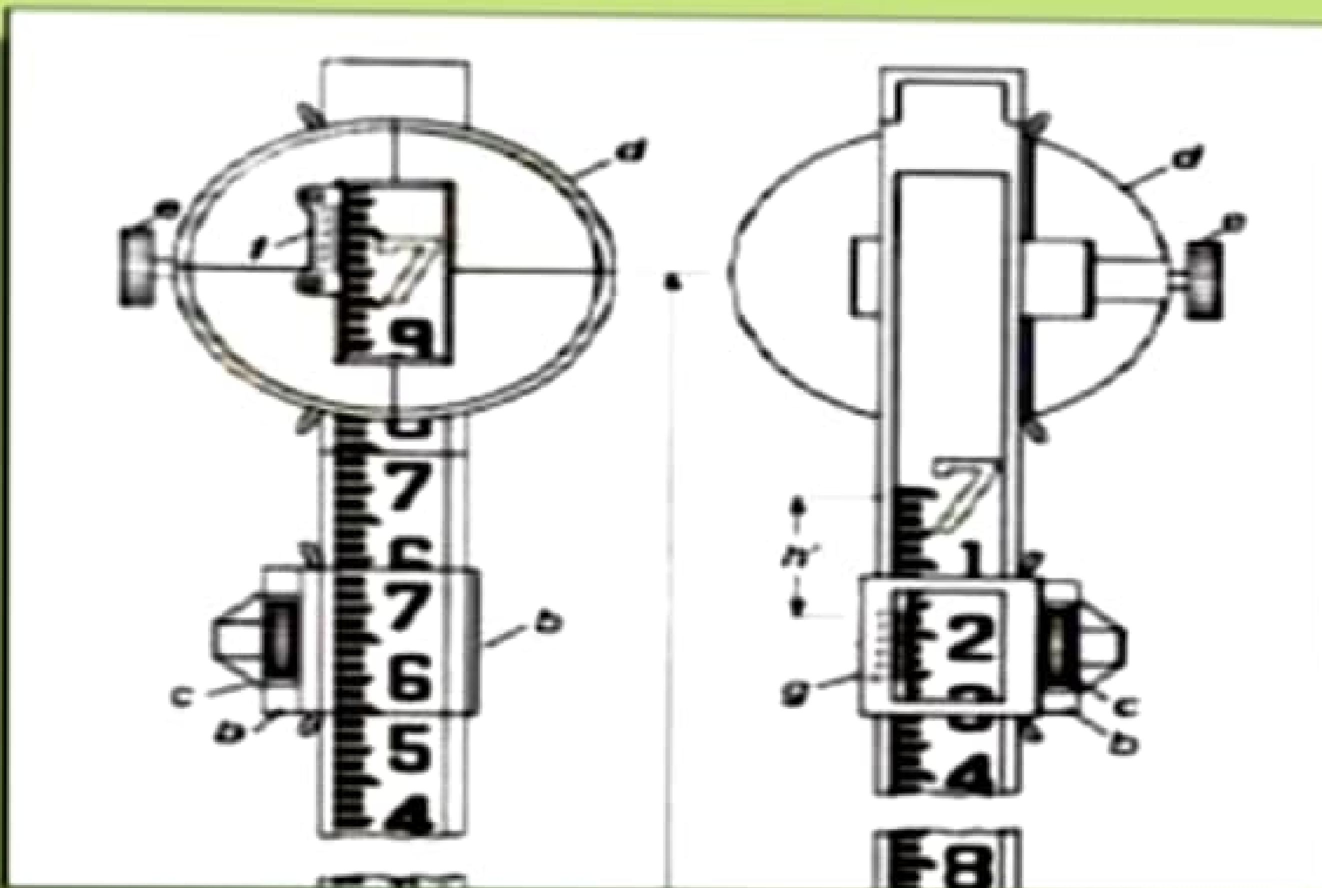
# Self Reading Staff



# Target Staff

- **For very precise works and sight target staff** are used. A movable target is provided in this staff.
- A vernier is provided on target to give precise reading. **In target staff level man directs the staff man to move the target up and down until it bisects by the line of sight.** The staff man observe the staff reading

# Target Staff



# Bench Marks

Bench mark is a point of known elevation

There are 4 kinds of bench marks

- GTS (Great trigonometrically survey bench mark)
- Permanent bench mark
- Arbitrary bench mark
- Temporary bench mark

# GTS Bench Mark

- They are the bench marks established with very high degree of precision at regular intervals by the survey of India Department all over the country Their position and R.Ls values above mean seal level which was earlier located at **Karachi** and now it is taken at **Bombay High, Mumbai** and is given in catalogue formed by the department.

# GTS Bench Mark


# Permanent Bench Mark

- Permanent bench marks are fixed in between GTS benchmarks by govt. agencies such as railways, PWD, etc. **This benchmarks are written on permanent objects** such as milestones, culverts, bridges etc their value are clearly written and their position are recorded for future reference.

# Permanent Bench Mark



# Permanent Bench Mark

# Bench Marks

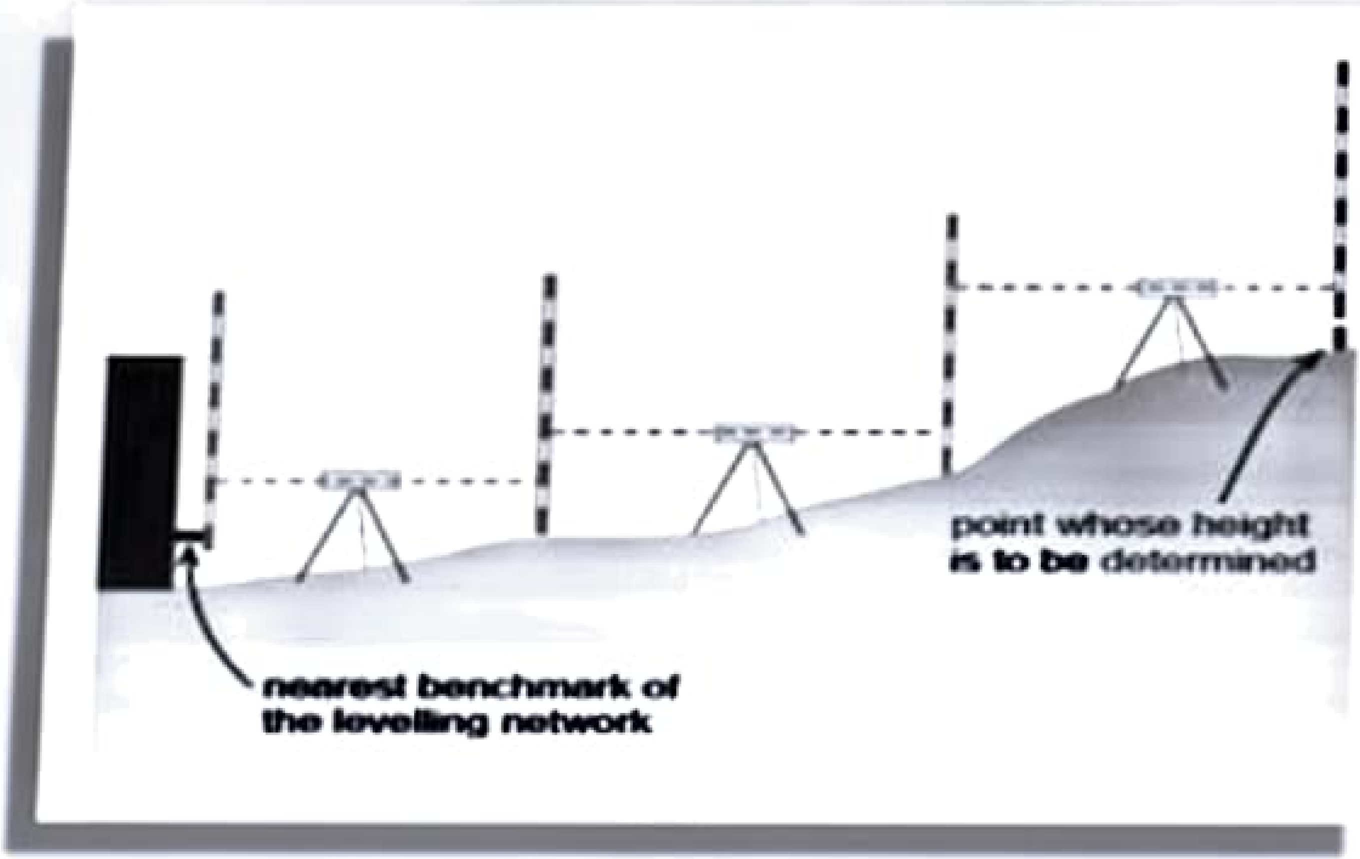
**Arbitrary Bench Marks**

- These are reference points whose R.L.s are arbitrarily assumed. They are used in small works such bench mark may be assumed as 100 or 50 m

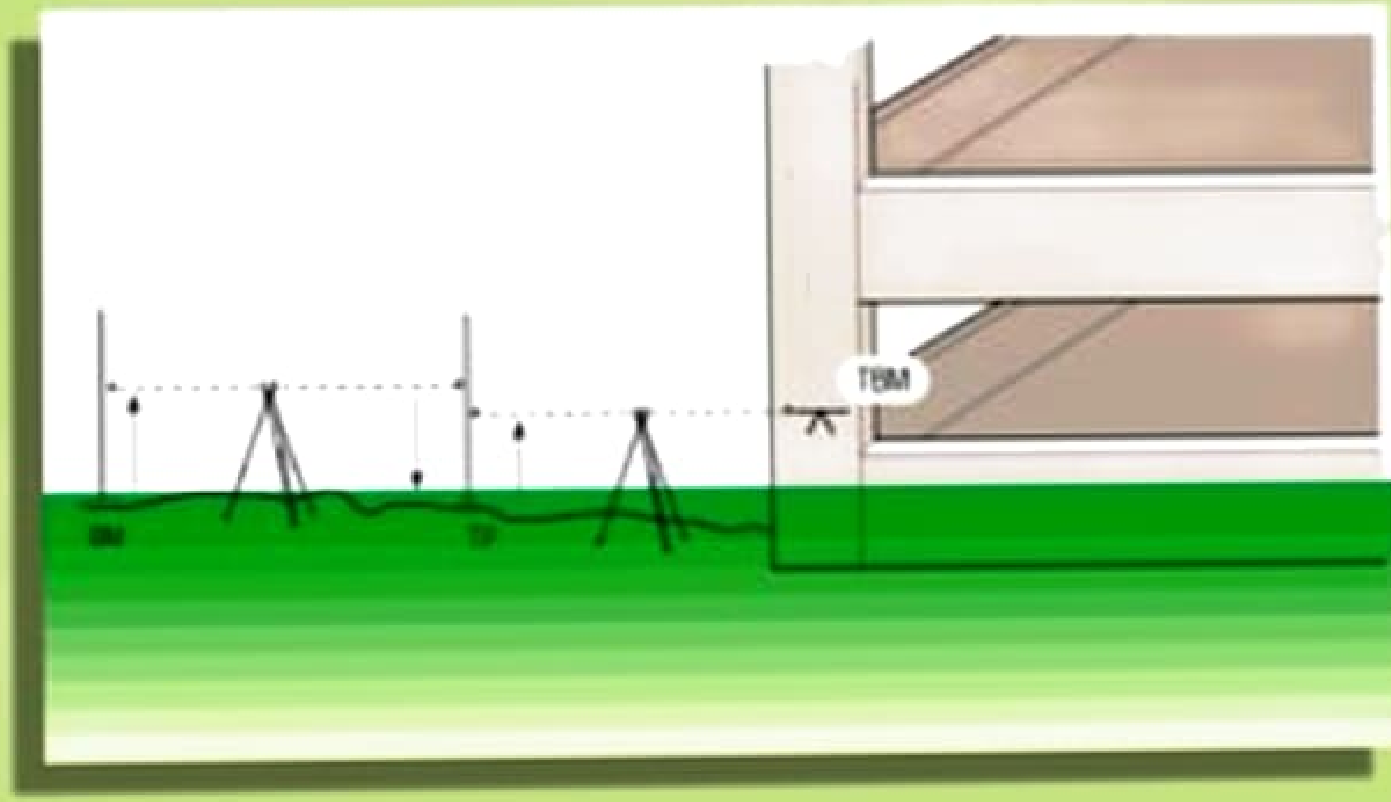
**Temporary Bench Marks**

- They are the reference points established during the levelling operations when there is a break in work, or at the end of day's work the value of reduced levels are marked on some permanent objects such as stones, trees etc.

# Arbitrary Bench Marks



# Temporary Bench Marks



# Temporary Adjustments of a level

- These adjustments are performed at every setup of instrument
- Setting up of level
- Levelling of telescope
- Focusing of the eye peace
- Focusing of object glass

# Temporary Adjustments of a level

**Setting up the level**

This includes

- A) Fixing the instrument on tripod
- B) Levelling the instrument approximately by Tripod

# Setting up the level

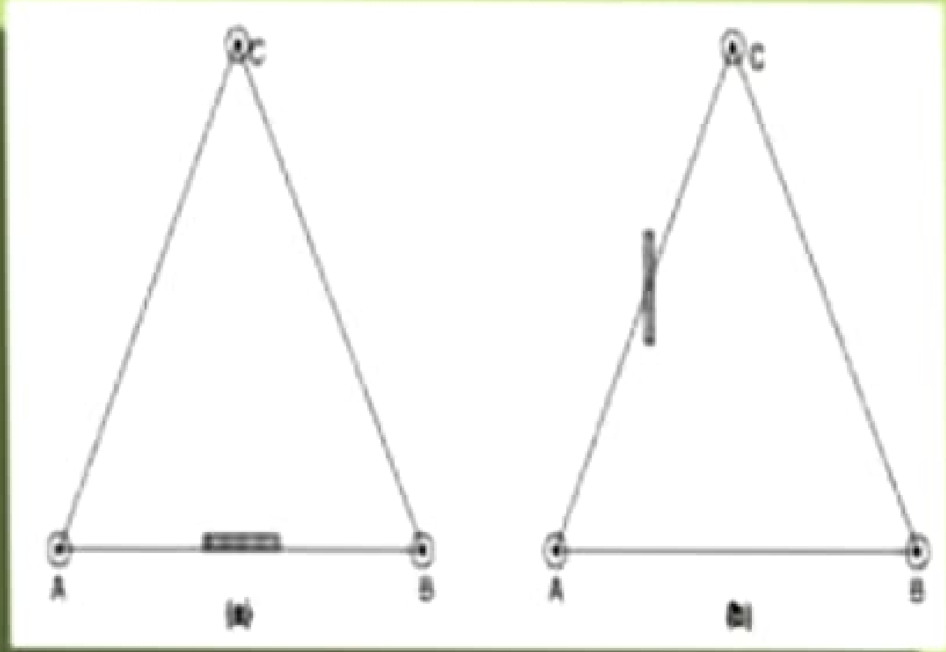
# Temporary Adjustments of a level

**Levelling**

Levelling is done with the help of foot screws. The purpose of levelling is to make vertical axis truly vertical. It is done with the help of foot screws

- A) Place the telescope parallel to a pair of foot screw then hold the foot screws between thumb and first finger and turn them either inward or outward until the longitudinal bubble comes in the centre.
- B)Turn the telescope through $90^0$ so that it lies parallel to third foot screw, turn the screw until the bubble comes in the centre.

# Temporary Adjustments of a level




# Temporary Adjustments of a level

**Focusing the eye piece**

- To focus the eye piece, hold a white paper in front of object glass, and move the eye piece in or out till the cross hair are distinctly seen.

**Focusing of object glass**

Direct the telescope to the levelling staff and on looking through the telescope, turn the focusing screw till the image appears clear and sharp.

# Temporary Adjustments of a level

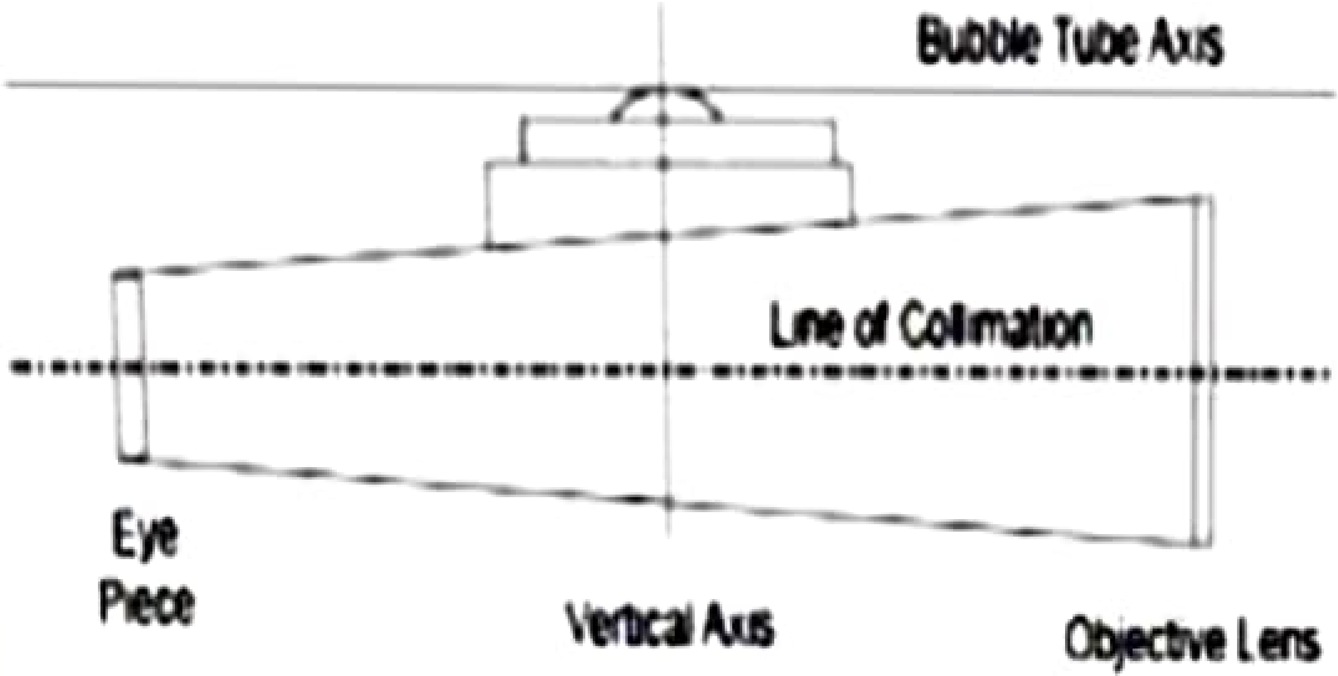
# Permanent adjustment of level

- The establishment of a desired relationship between the fundamental lines of a leveling instrument is termed permanent adjustment. So, permanent adjustment indicates the rectification of instrumental error.
- ***The fundamental lines***
- ***The line of collimation***
- ***The axis of the bubble tube***
- ***The vertical axis***
- ***The axis of the telescope***

# Permanent adjustment of level

- The following relationship between the lines are desirable
- ***The line of collimation should be parallel to the axis of the bubble***
- ***The line of collimation should coincide with the axis of the telescope***
- ***The axis of the bubble should be perpendicular to the vertical axis. That is, the bubble should remain in the central position for all the directions of the telescope.***

# Permanent adjustment of level



# Permanent adjustment of level

- Two adjustment are required in the dumpy level
- **The first adjustment, to make the axis of the bubble tube perpendicular to the vertical axis**
- **The second adjustment, to make the line of collimation parallel to the axis of the bubble tube.**

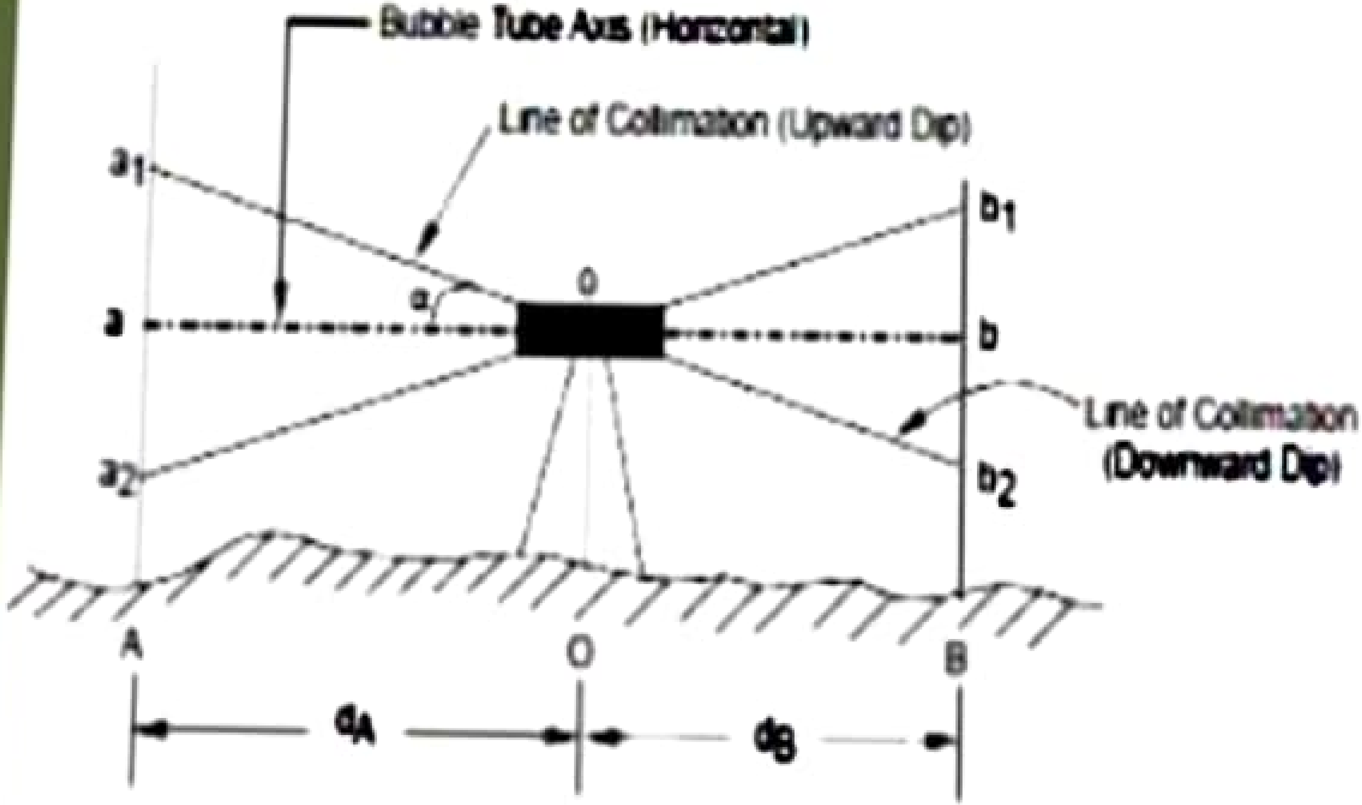
# Permanent adjustment of level

- Following procedure is adopted to make the line of collimation parallel to the axis of the bubble tube.
- The level is set up on fairly level ground, with its legs well apart, It is **firmly fixed to the ground**.
- The telescope is placed parallel to any pair of foot screws and, by turning the foot screw either inward or outward, the **bubble is brought to the centre.**
- The **telescope is then turned through 90 $^{0}$**, so that it lies over the **third foot screw**. Then by turning the third foot screw the bubble is brought to the centre.
- The process is repeated several times until the bubble is in the central position in both the direction.

# Permanent adjustment of level

- Now the **telescope is turned through 180 °** and the position of the bubble is noted.
- **If the bubble still remains in the central position, the desired relationship is perfect**. If not, the amount of deviation of the bubble is noted.
- Suppose the deviation is 2n division. Now by turning **capstan headed nut (which is at one end of the tube), the bubble is brought half-way back (i.e. n division) the remaining half-deviation is adjusted by foot screws just below the telescope.**
- The procedure of adjustment is continued till the bubble remain in the central position of the telescope.

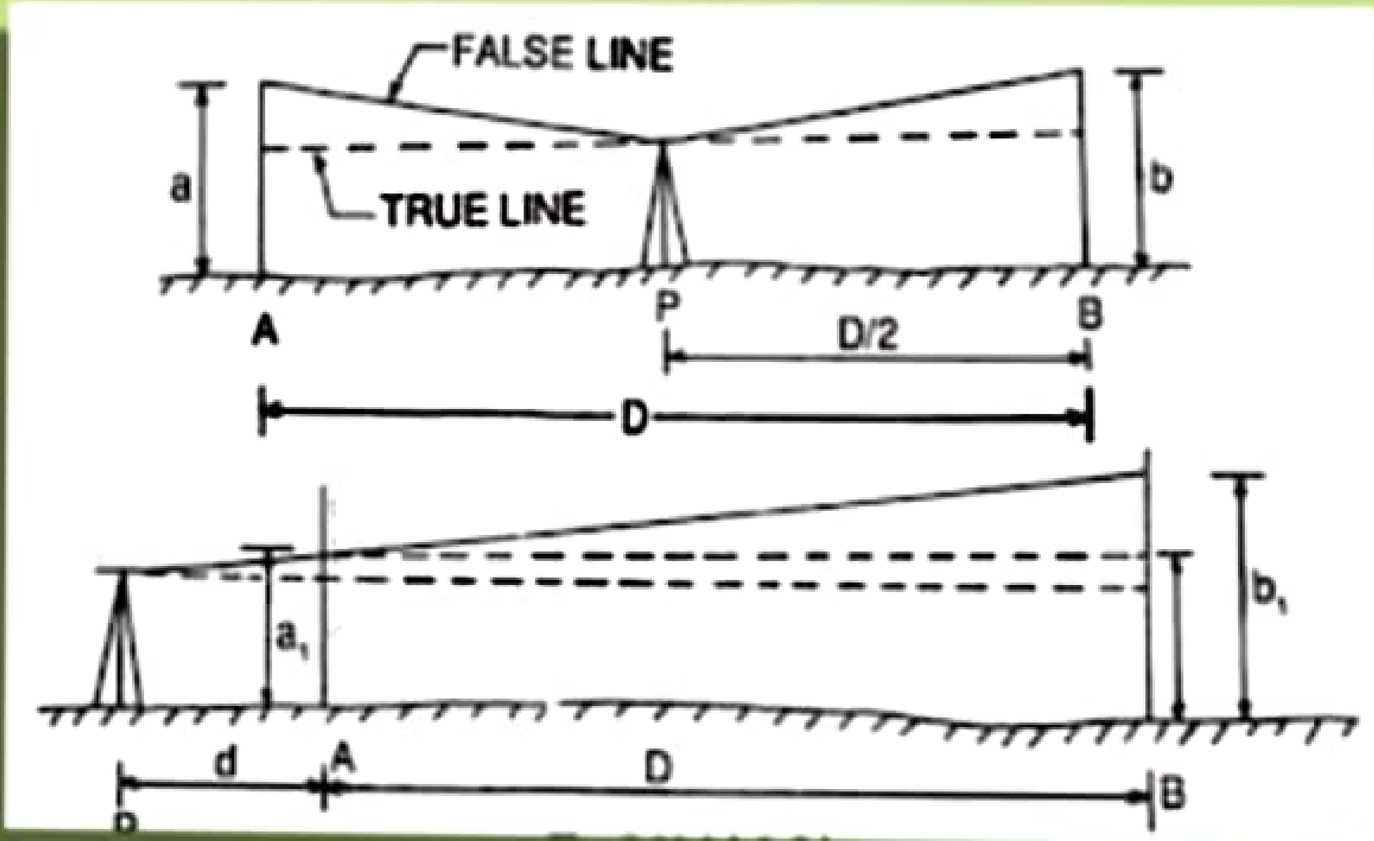
# Permanent adjustment of level



# Permanent adjustment of level

- The second adjustment is done by **two peg method**
- Two pegs A & B are driven at a distance apart on level and firm ground. The level is set up at P, just mid-way between A & B. After bringing the bubble to the centre of its run, the staff readings on A & B are taken. Suppose the reading are a & b
- Now the difference of level between A & B is calculated , this difference is true difference, as the level is set up just mid-way between BS and FS
- Then the rise or fall is determined by comparing the staff reading.

# Permanent adjustment of level



# Permanent adjustment of level

- The level is shifted and set up at $P_1$ (very near to A), say at a distance d from A. Then after proper leveling, staff reading at A & B are taken. Suppose the reading are $a_1$ and $b_1$
- Then the apparent difference of level is calculated
- If the true difference and apparent difference are equal, the line of collimation is in adjustment, if not the line of collimation is inclined.
- Let e be the staff reading on B at the same level of the staff reading $a_1$
- **Then e= $a_1 \pm$ true difference**

# Permanent adjustment of level

- Use positive sign in case of fall and negative sign when it is rise
- If $b_1$ is greater than e, the line of collimation is inclined upwards and if $b_1$ is less than e, it is inclined downwards.
- **Collimation error= $b_1$-e (in distance D)**
- By applying the principle of similar triangle
- Correction to near peg
- $C_1 = \frac{d\,(b_1 - e)}{D}$

And correction to far peg

$C_2 = \frac{D + d\,(b_1 - e)}{D}$

# Permanent adjustment of level

Correct staff reading on **A**= **$a_1$** ± **$C_1$**

Correct Staff reading on **B**= **$b_1$** ± **$C_2$**

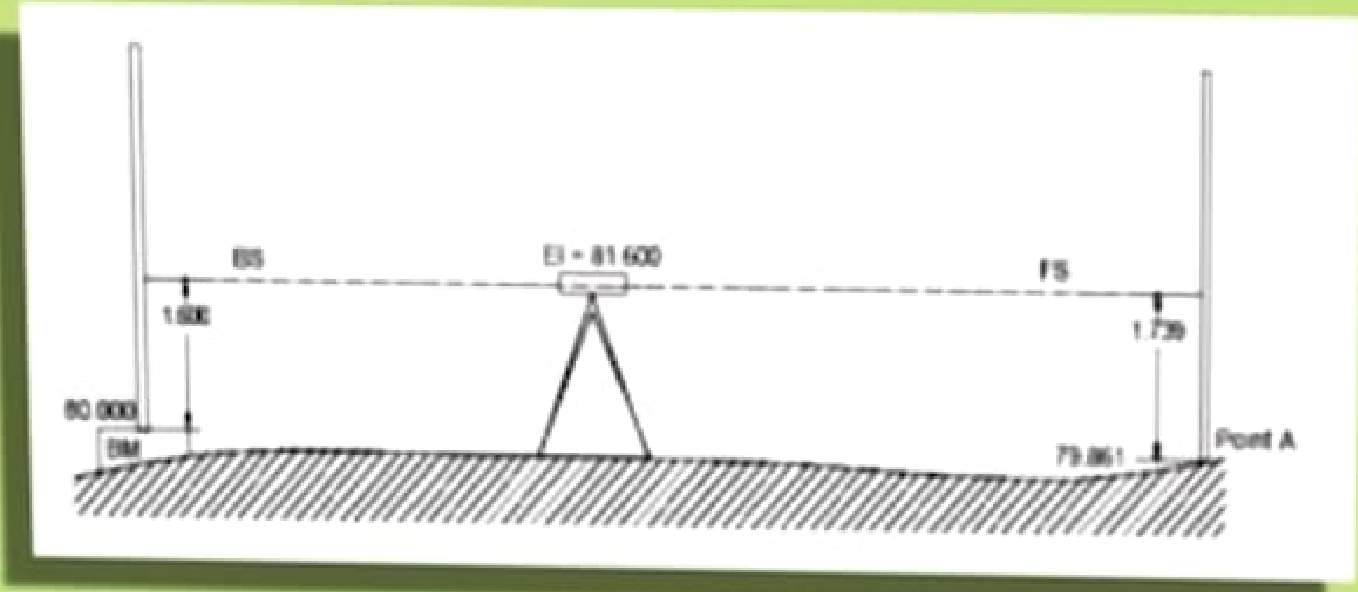
Then the cross-hair is brought to the calculated correct reading by raising or lowering the diaphagram by means of diphagram screw.

# Classification of Levelling

- Simple Levelling
- Differential Levelling
- Fly Levelling
- Check Levelling
- Profile Levelling
- Cross Levelling
- Reciprocal Levelling
- Precise Levelling
- Trigonometric Levelling
- Barometric Levelling
- Hypersometric Levelling

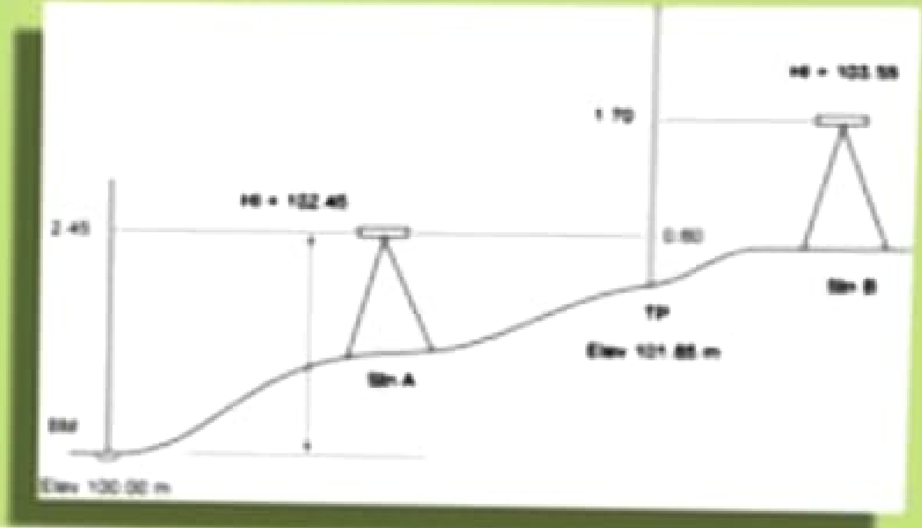
# Simple Levelling

- It is the simplest method used, when it is required to find the difference in elevation between 2 points.

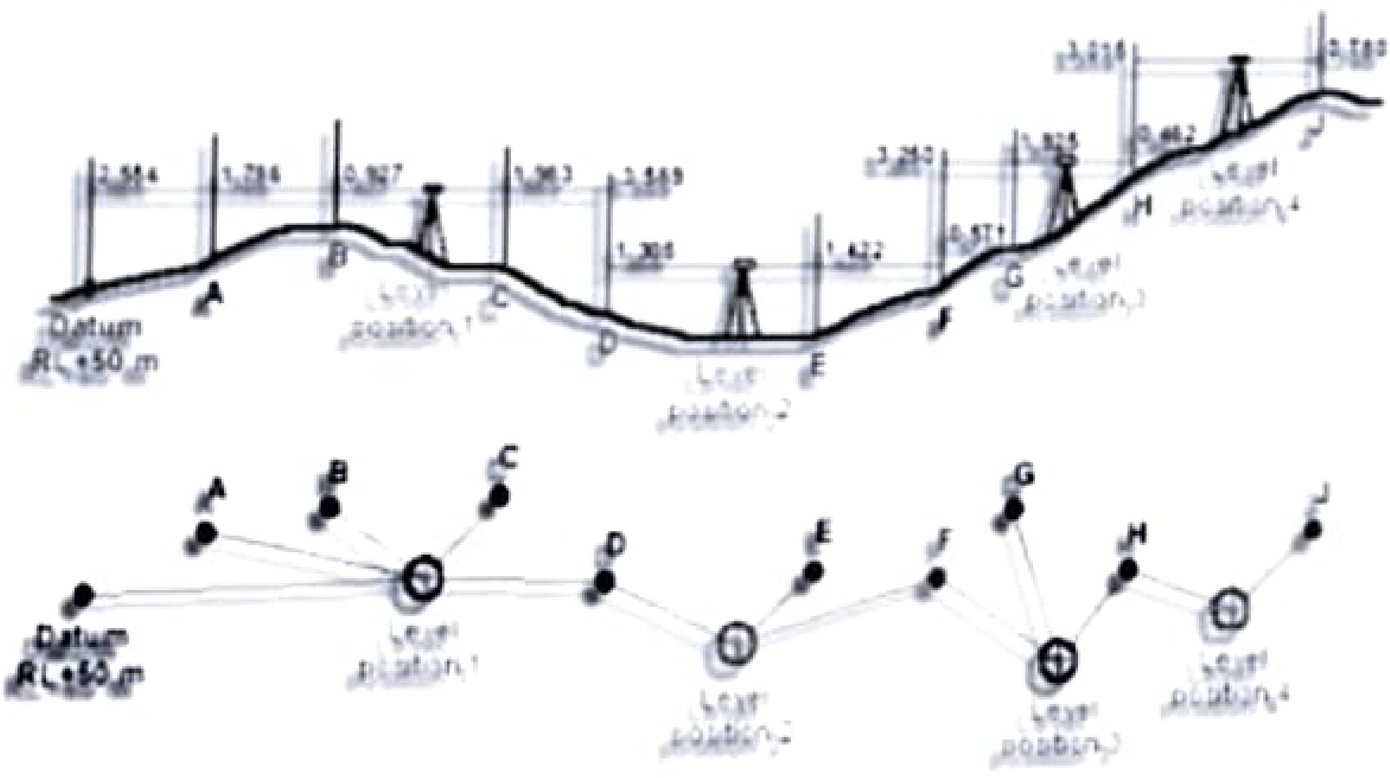


# Differential Levelling

- This method is used to find the difference in the elevation between points if they are too far apart or the difference in elevation between them is too much.



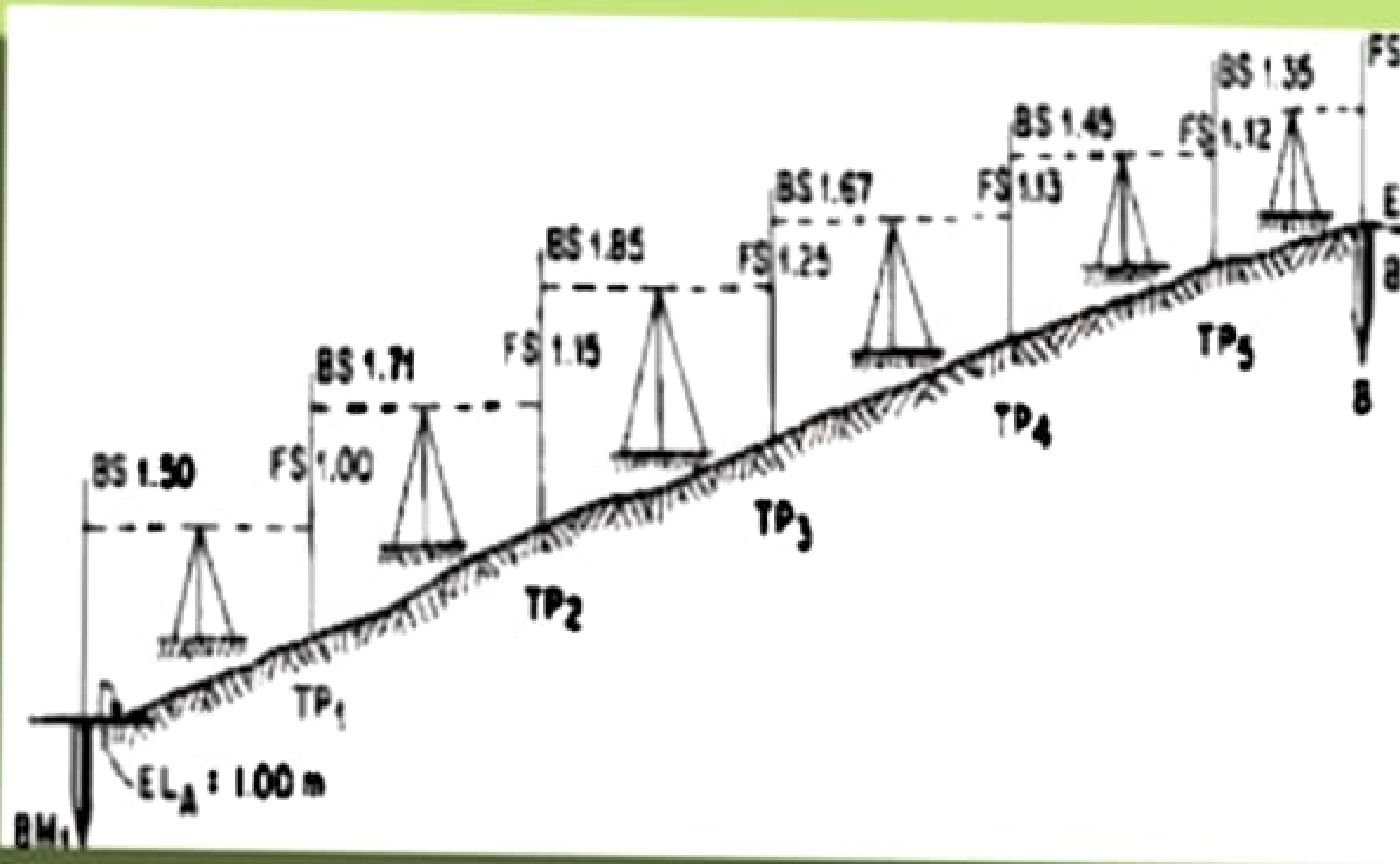
# Differential Levelling



# Fly Levelling

- Fly levelling is just like differential levelling carried out to check the accuracy of levelling work. In fly levelling only B.S. and F.S. are taken

# Fly Levelling



# Classification of Levelling

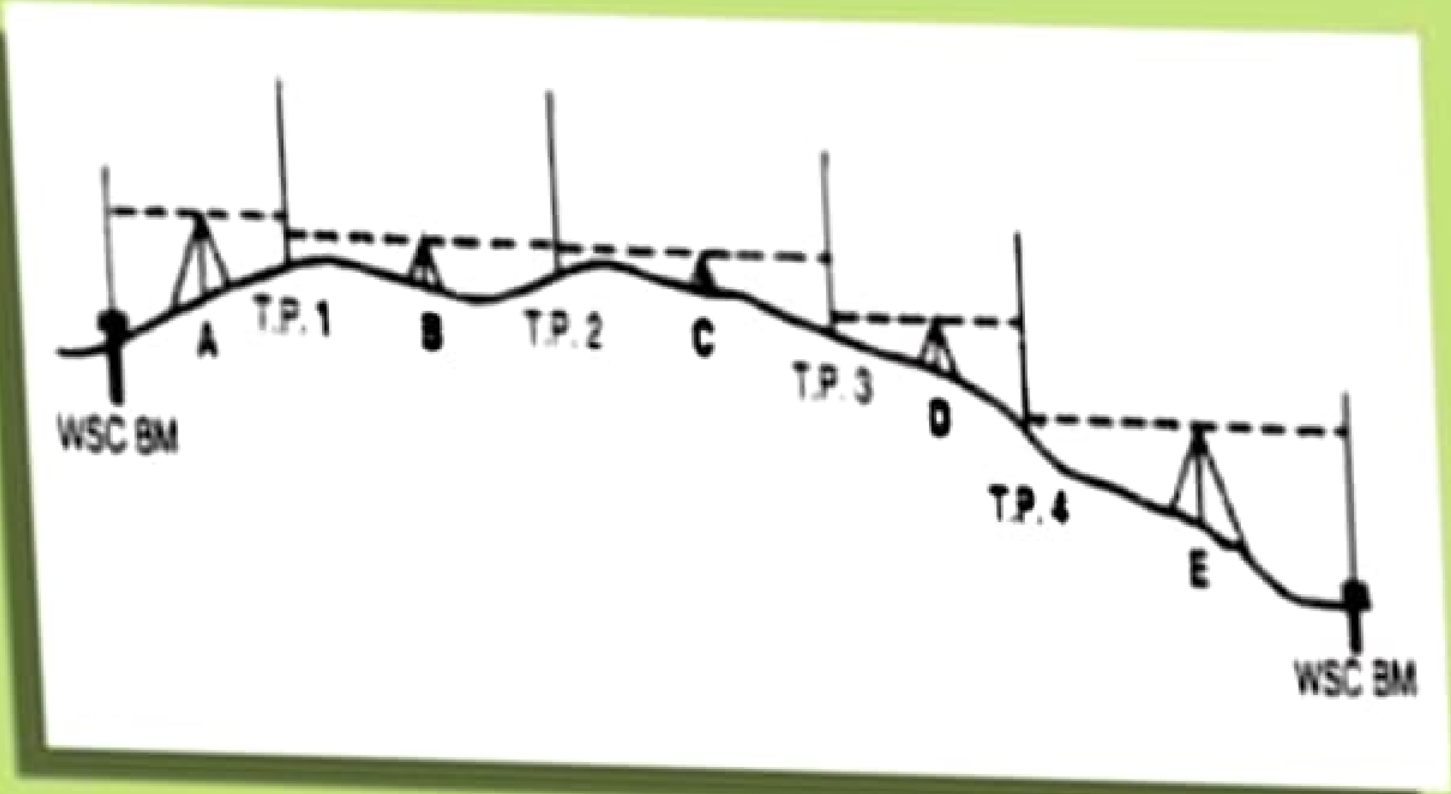
**Check levelling**

- This kind of levelling is carried out to check the accuracy of work. It is done at the end of the days work in the form of fly levelling to connect the finishing point and starting point.

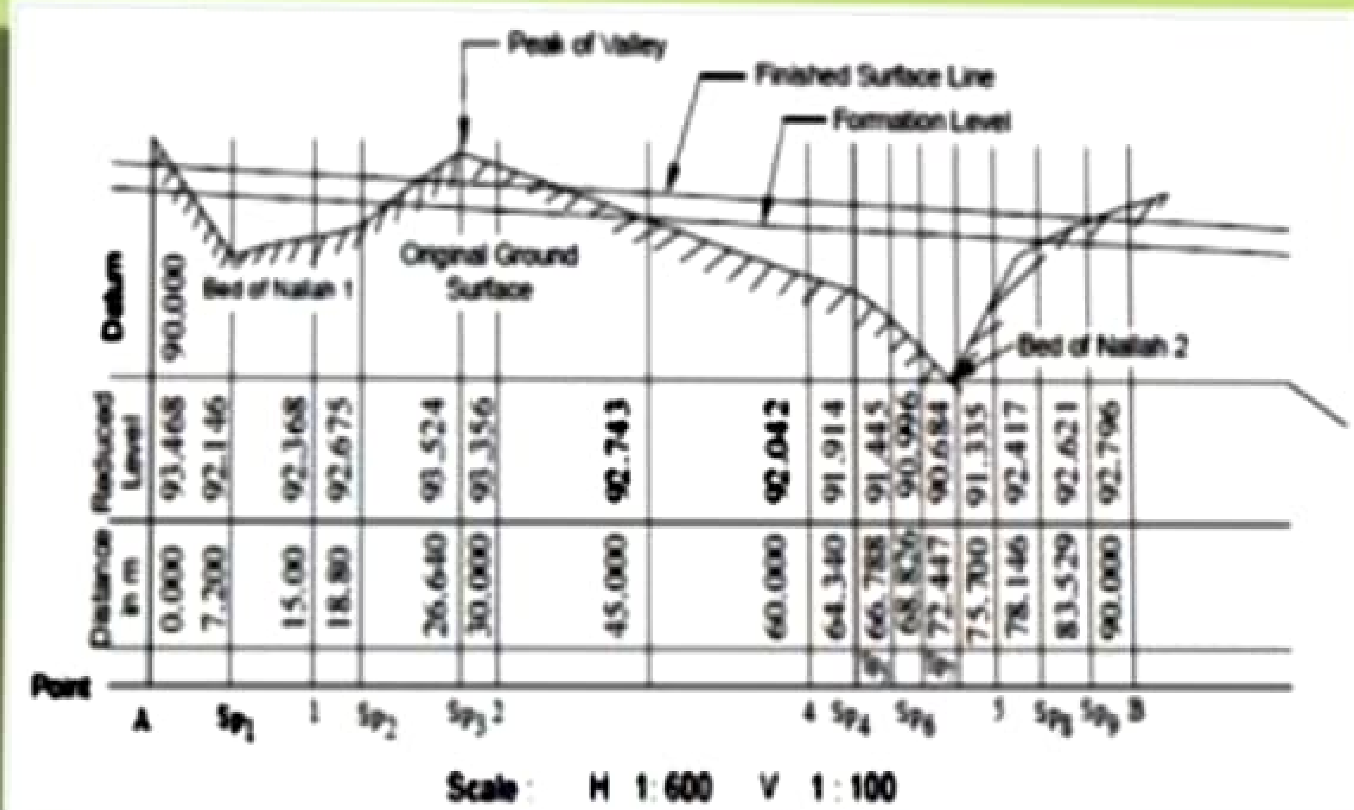
**Profile levelling or L-Section**

- This method is used for taking levels along the centre line of any alignment like road, railway canal etc. The object is to determine the undulations of the ground surface along the alignment

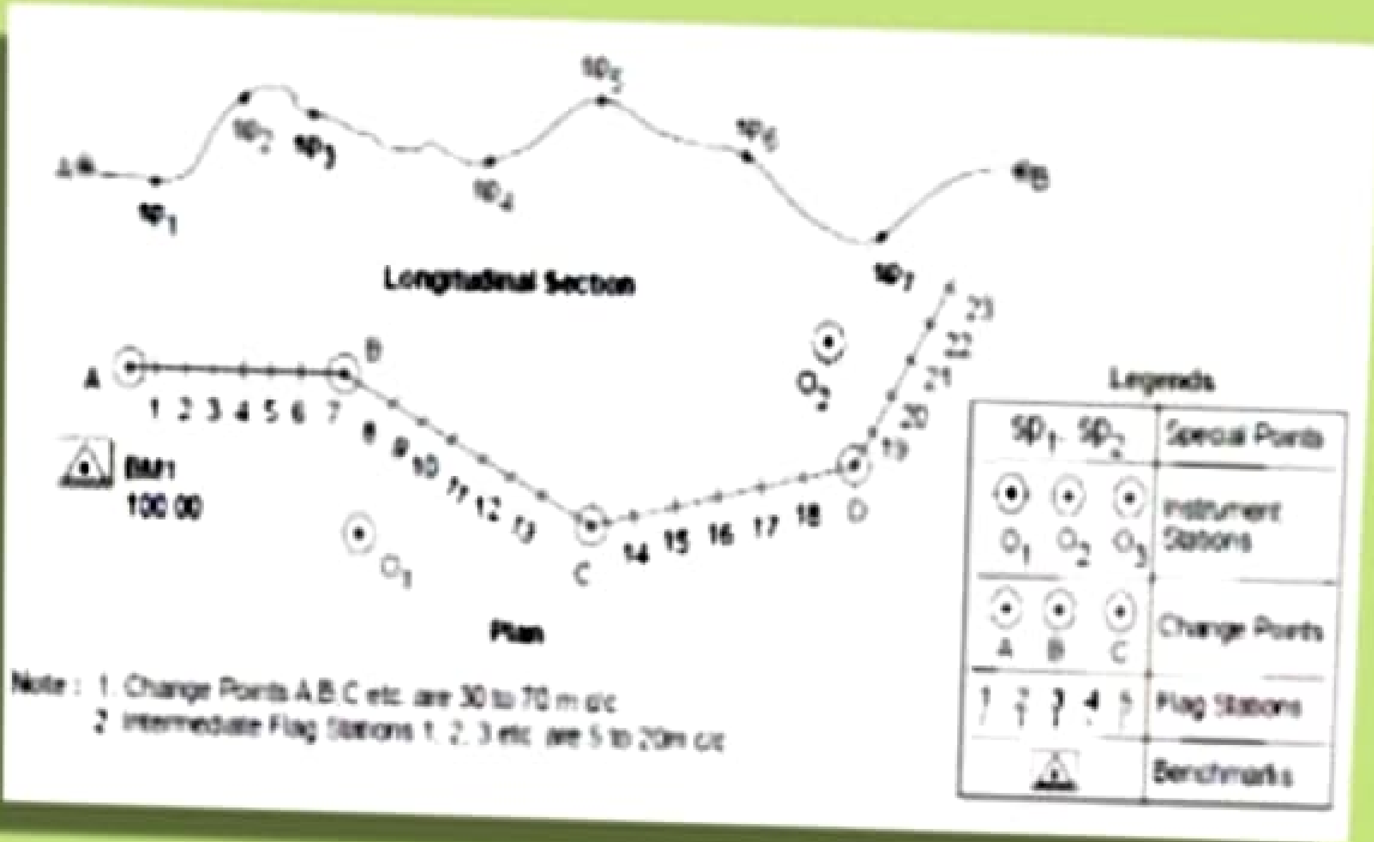
# Check levelling



# Profile levelling or L-Section



# Profile levelling or L-Section



# Classification of Levelling

**Cross-Sectioning**

- This operation is carried out perpendicular to alignment at an interval of 10, 20 ,30, 40 m. The idea is to make an estimate of earthwork.

**Precise Levelling**

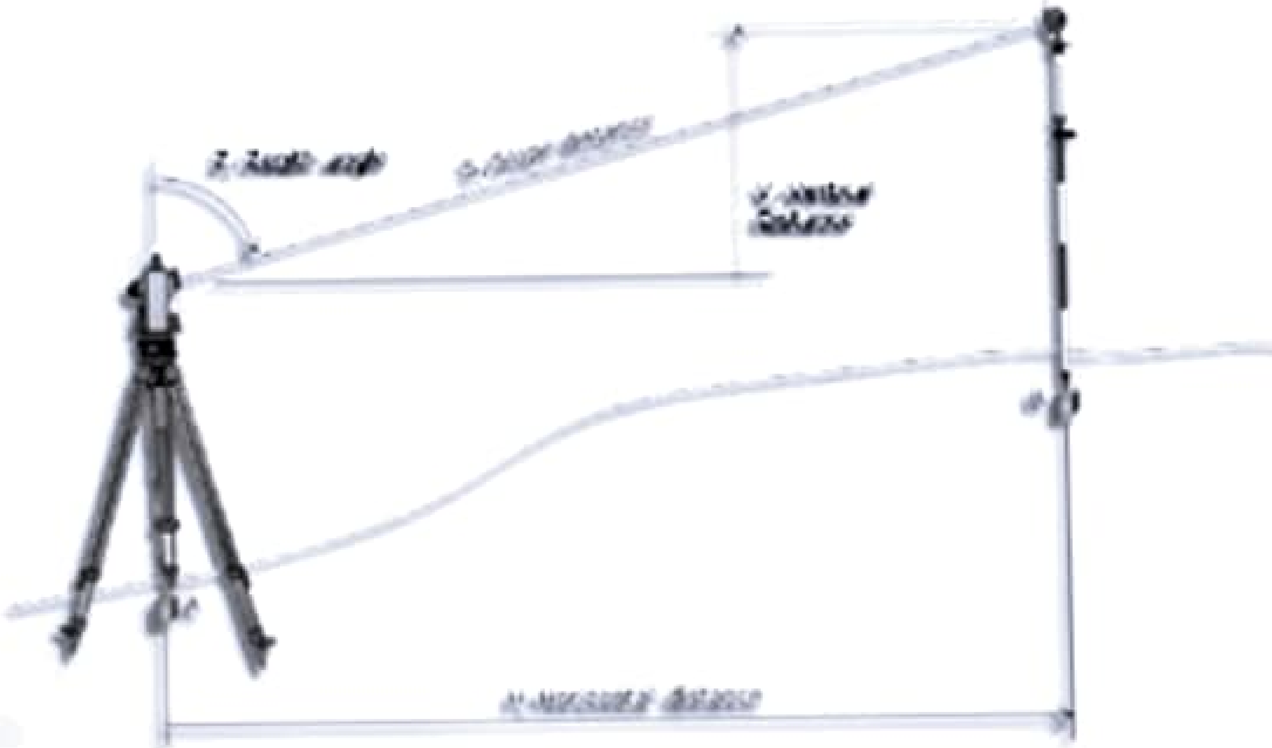
- It is used for establishing bench marks for future public use. It is carried out with high degree of accuracy using advanced instruments

**Trigonometric Levelling**

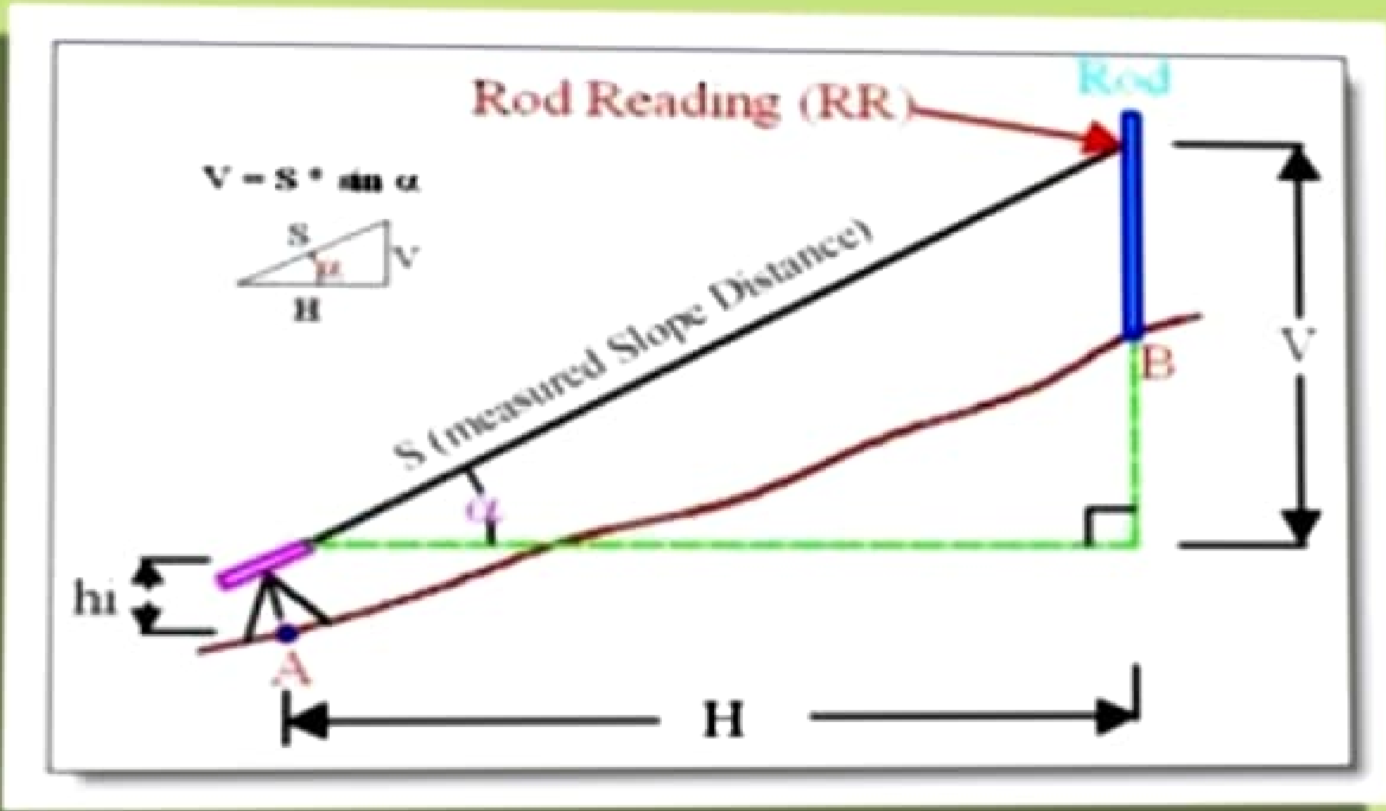
- In this method vertical distances between points are computed by observing horizontal distances and vertical angle between points.

# Cross-Sectioning

# Trigonometric Levelling



# Trigonometric Levelling



# Classification of Levelling

**Barometric Levelling**

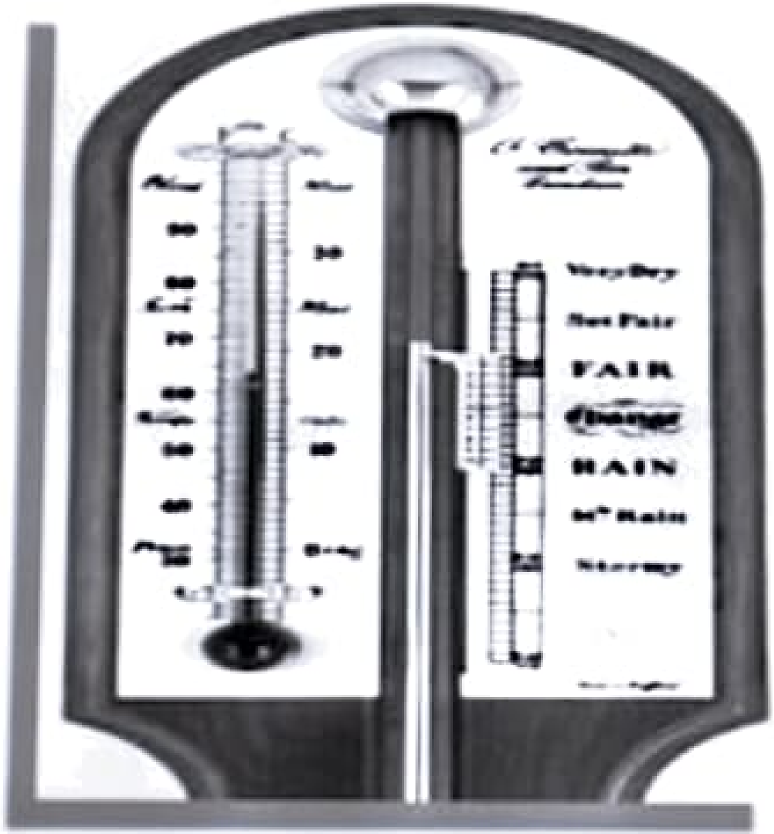
- In this method the **altitude difference is determined by means of a barometer.**
- Barometric leveling is based on the fact that the atmospheric pressure varies inversely with height. In this method a barometer is used to determine the differences in elevation of points, which differ considerably in heights as in a hilly area or mountainous country.

# Classification of Levelling

- It is chiefly used on **exploratory or reconnaissance surveys.** Since the pressure of the atmospheric at any point is constantly changing and **barometer reading are affected by the temperature of the air**
- Types of barometer in use are
- **Mercury Barometer**
- **Aneroid Barometer**

# Aneroid Barometer

# Mercury Barometer

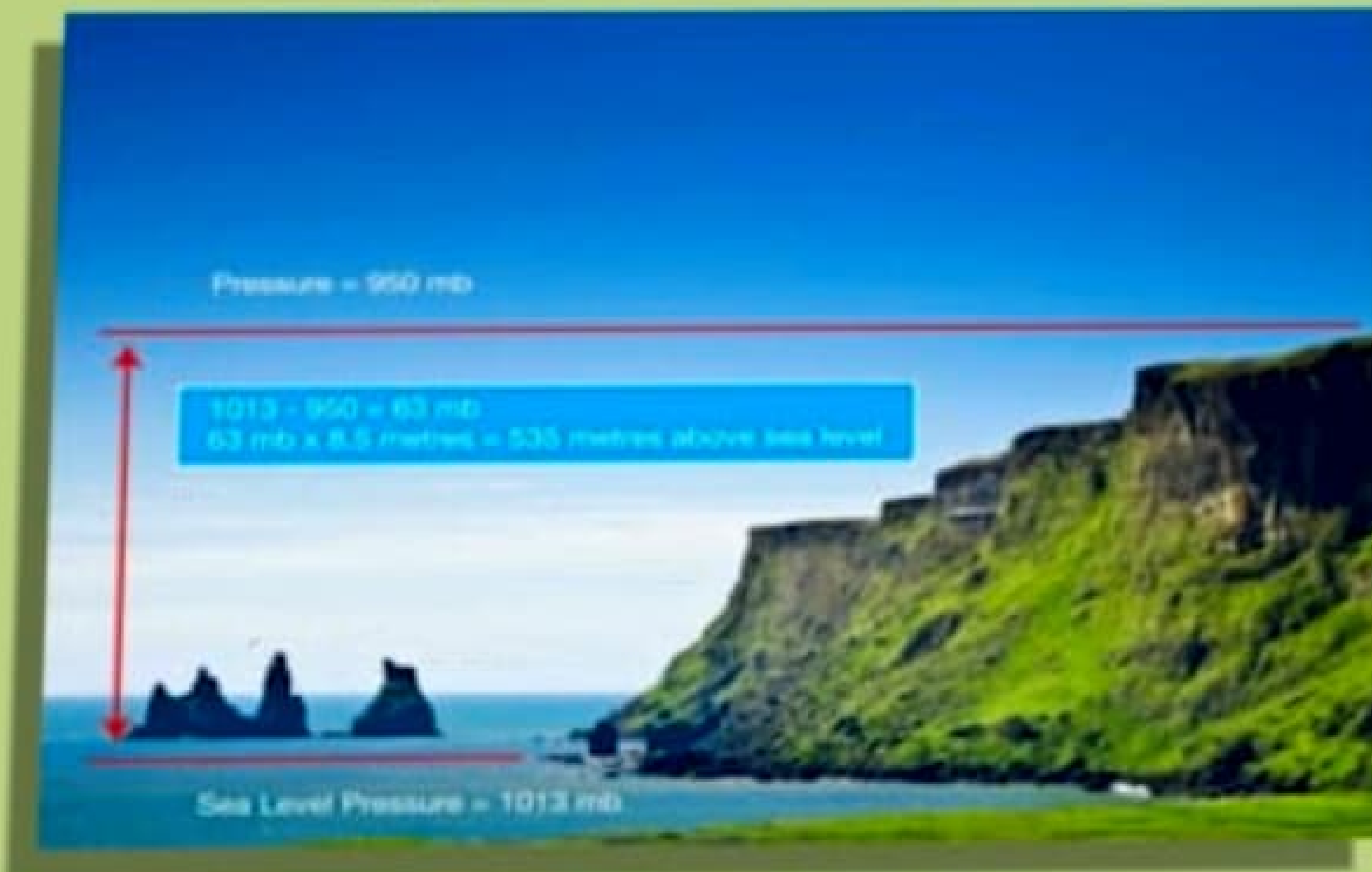
# Hypsometric Levelling

The working of Hypsometry for determining the elevation depends upon the fact that the temperature at which water boils varies with the atmospheric pressure. The boiling point of water reduces at higher altitude thus knowing the boiling point of water, the atmospheric pressure can be calculated and knowing the atmospheric pressure altitude or elevation can be determined.

# Hypsometric Levelling

- The altitudes of various points may be determined by using hypsometer, also called as thermo-barometer.

# Hypsometric Levelling



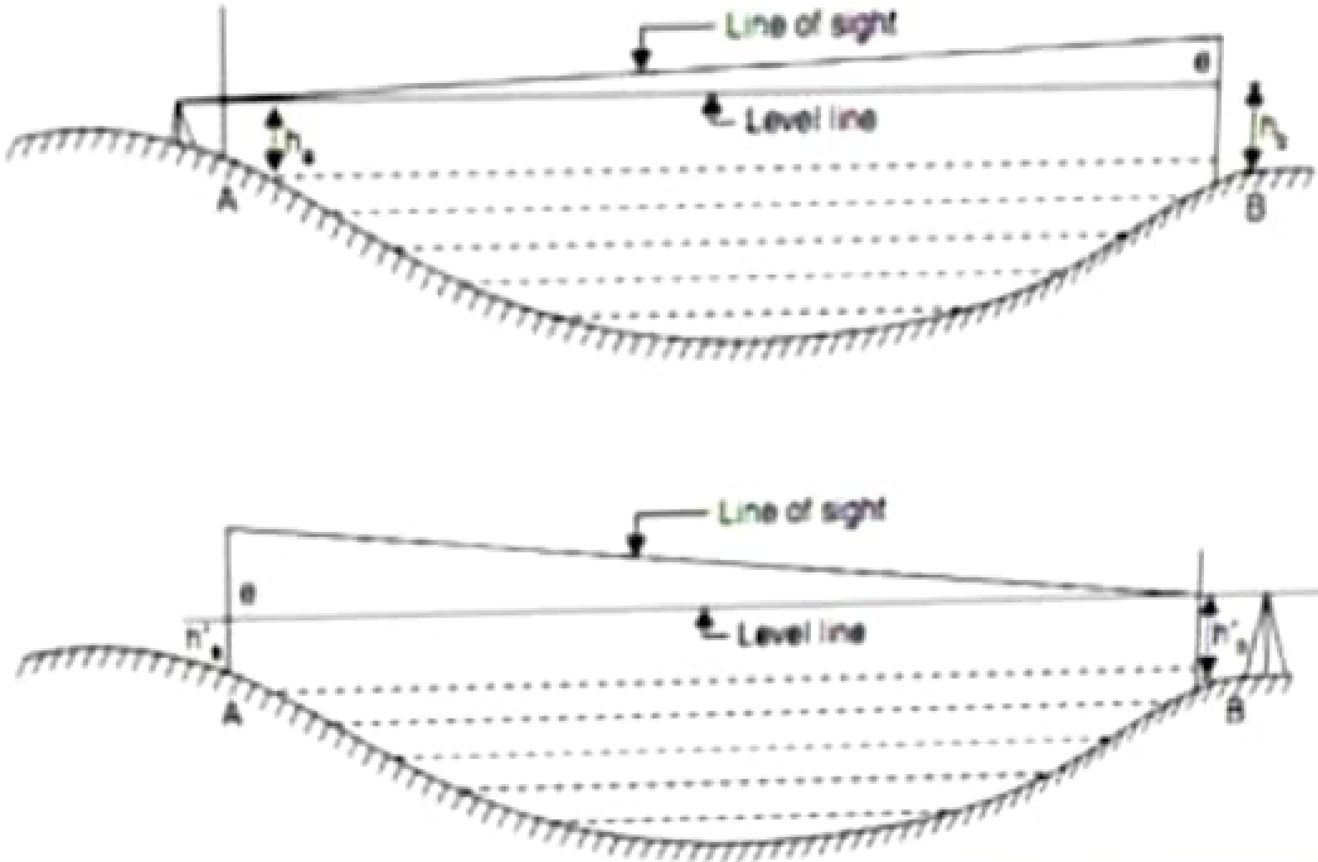
# Hypsometric Levelling

# Hypsometric Levelling

# Reciprocal levelling

- **Reciprocal Levelling:-**
- **This method is adopted to accurately determine the difference of level between two points which are far apart. It is also used when it is not possible to setup level in midway between two points**
- Let A and B be the two points on opposite banks of a river. It is required to find out the level difference between A&B
- Setup the level very near to A and take the reading at A and B let the reading be $a_1$ and $b_1$
- Shift the level and setup very near to B and observe A and B to get reading $a_2$ and $b_2$
- Let d is the true difference of level between A and B, and e=error due to curvature, refraction and imperfect adjustment.

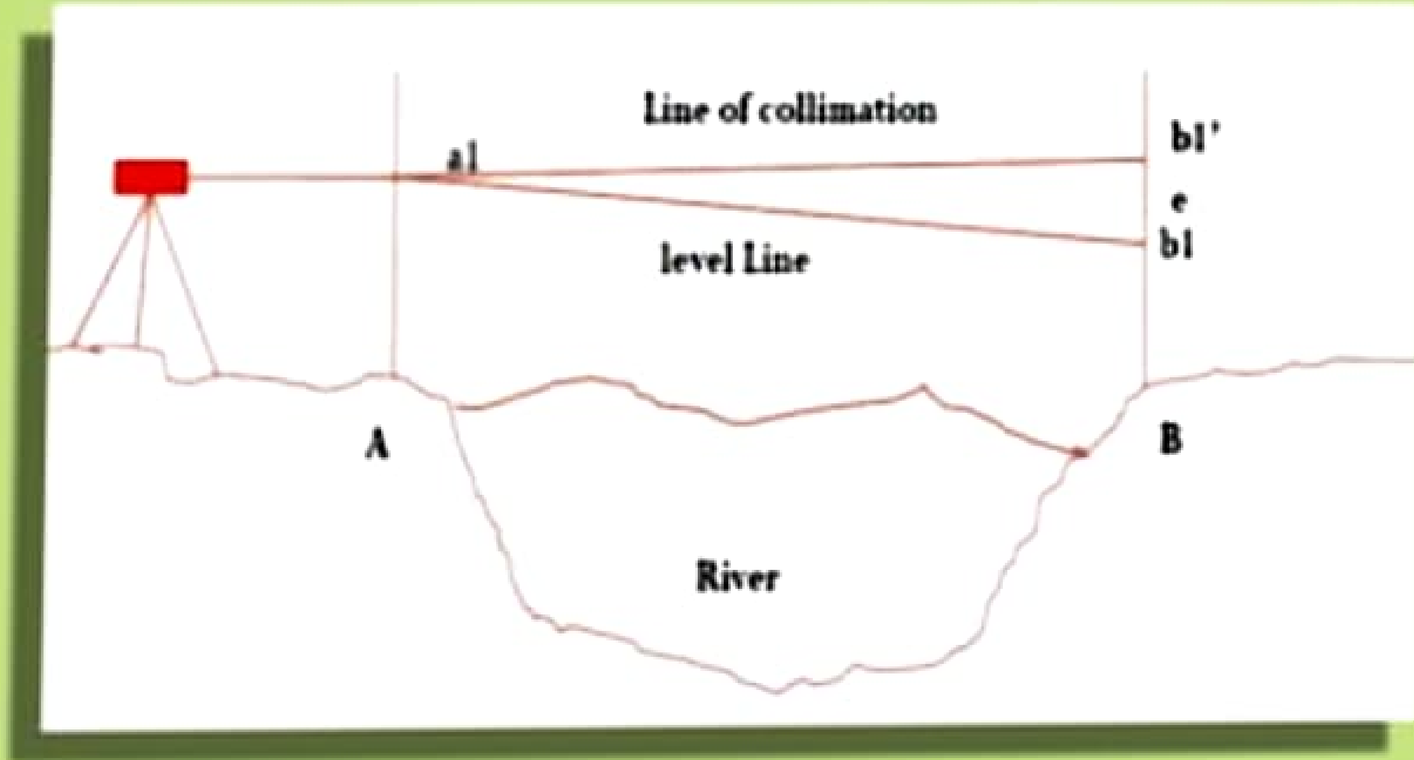
# Reciprocal levelling



# Reciprocal Levelling

- Thus to eliminate the error take an average of the difference in elevation taken from 2 points
- i.e. from A the true difference will be
- $=(b_1-e)-a_1$
- **Or $d=(b_1-a_1)-e$**
- From B the difference will be $= b_2-(a_2-e)$
- **Or $d=(b_2-a_2)+e$**
- Adding these two $eq^n$ to eliminate e, we get
- Therefore **$d=\{(b_1-a_1)+(b_2-a_2)\}/2$**

# Reciprocal Levelling

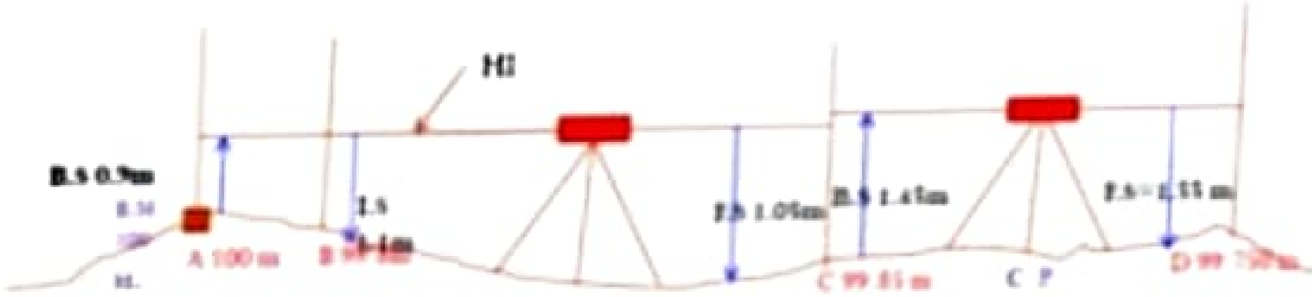


# Methods of Reducing Levels

**Height of Instrument Method**

- This method consist of finding H.I. for every setup of instrument, and then obtaining the R.L. of point of reference with respect to H.I

# Height of Instrument Method

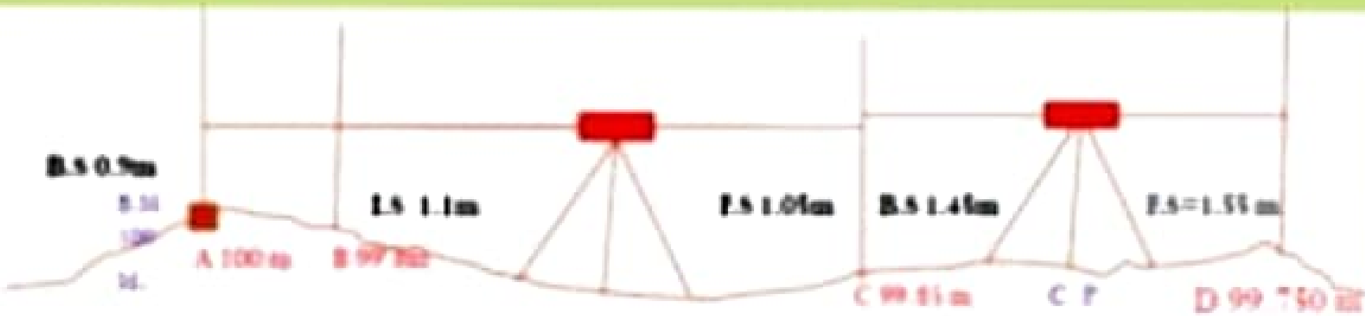



| Station | B.S | I.S | F.S | H.I | R.L | Remark |
|---|---|---|---|---|---|---|
| A | 0.9 | | | 100.9 | 100.00 | B.M |
| B | | 1.1 | | | 99.800 | |
| C | 1.450 | | 1.05 | 101.3 | 99.850 | C.P. |
| D | | | 1.550 | | 99.750 | |
| | | | | | | |

# Rise and Fall Method

- This method consist of determining the difference of level between consecutive points by comparing each point with immediate preceding point.

# Rise and Fall Method




| Station | B.S | I.S | F.S | Rise | Fall | R.L | Remark |
|---|---|---|---|---|---|---|---|
| A | 0.9 | | | | | 100.00 | B.M |
| B | | 1.1 | | | 0.2 | 99.800 | |
| C | 1.450 | | 1.05 | 0.05 | | 99.850 | C.P. |
| D | | | 1.550 | | 0.1 | 99.750 | |
| | | | | | | | |

# Errors in Levelling

The following are the different sources of Errors

- **Personal Error**
- The Instruments may not be levelled
- The focusing of eye piece and objective glass may not be perfect
- The parallax may not be eliminated
- The position of staff may have changed
- Entry and recording in the field book may not be correct
- The staff may not be fully extended, may not be held vertical.

# Errors in Levelling

**Instrumental Error**

- The Permanent adjustment of the instrument may not be perfect. That is the line of collimation may not be horizontal line.
- The internal arrangement of focusing tube may not be correct
- The graduation of the staff may not be perfect
- Defective bubble tube, if the bubble tube is sluggish, it may apparently be in the mid-position even though the bubble line is not horizontal.

# Errors in Levelling

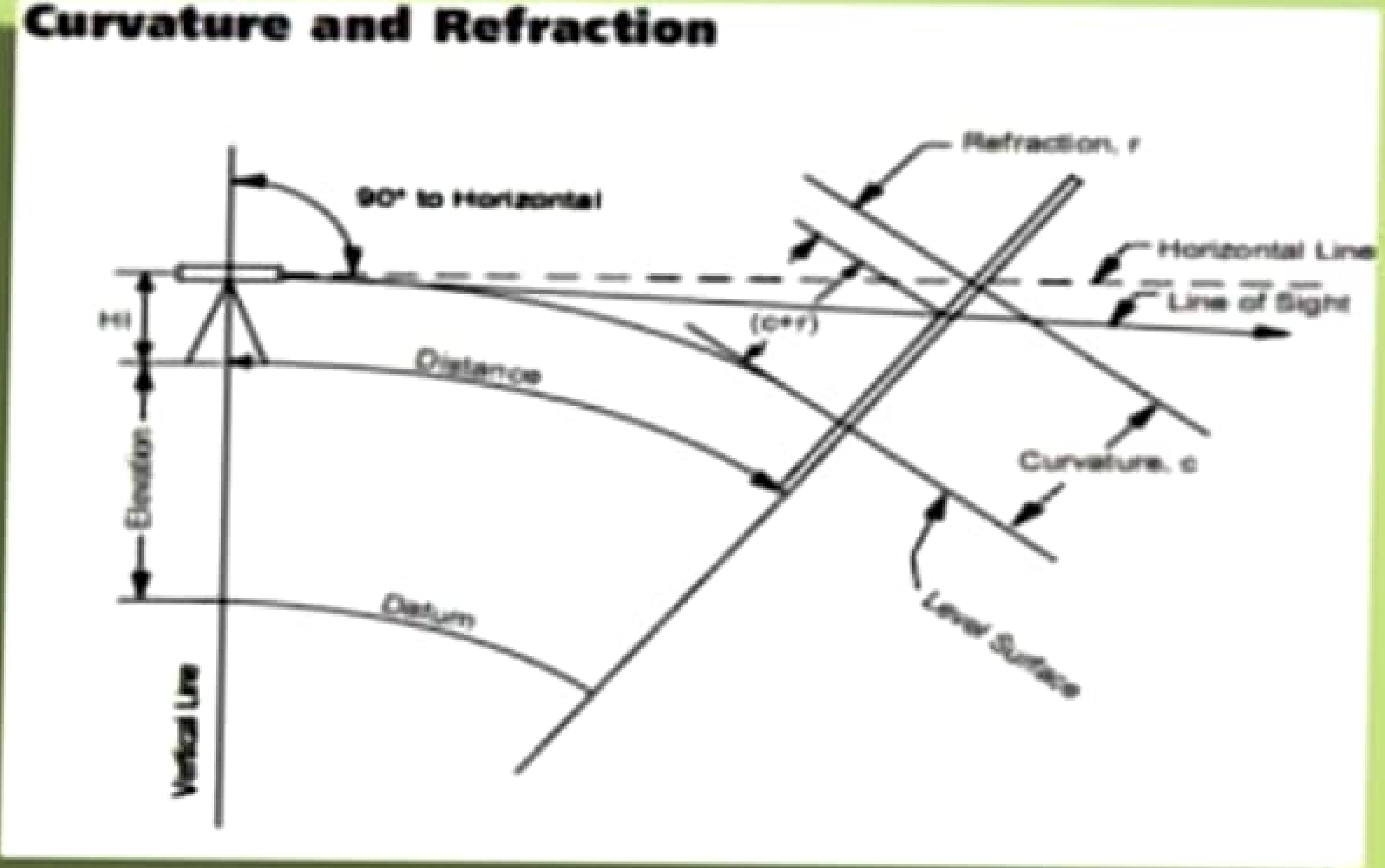
**Errors due to Natural Causes**

- The Curvature of the Earth may affect the staff readings when the distance of sight is long.
- The effect of refraction may cause a wrong staff reading
- There are some errors in staff readings due to high velocity wind

# Common errors in Leveling

- Foresight and back sight not being taken on exactly the same point
- Reading the staff upward instead of downward
- Reading of stadia hair
- Reading of wrong number of metre and decimeter
- Entering backsight in F.S and vice versa
- Transposing the figures
- Omitting an entry
- The leveling staff not being fully extended.

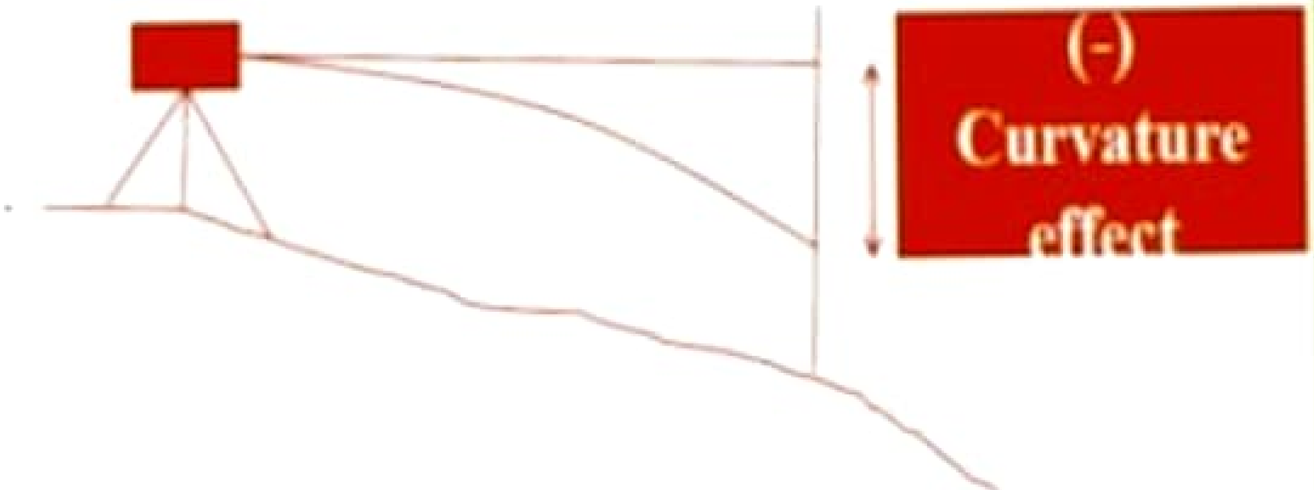
# Curvature & Refraction Correction



# Curvature Correction

- For long sights the curvature of earth can effect staff readings. The line of sight is horizontal but the level line is curved and parallel to the mean spheroidal surface of the earth.
- The vertical distance between the line of sight and level line at particular place is called the curvature correction
- The effect of curvature is to cause the object sighted to appear lower than they really are.
- Curvature correction is always **Subtractive(-)**
- **True staff reading=(Observed staff reading-0.0785$D^2$)m**
- Where D= distance in Km.

# Curvature Correction



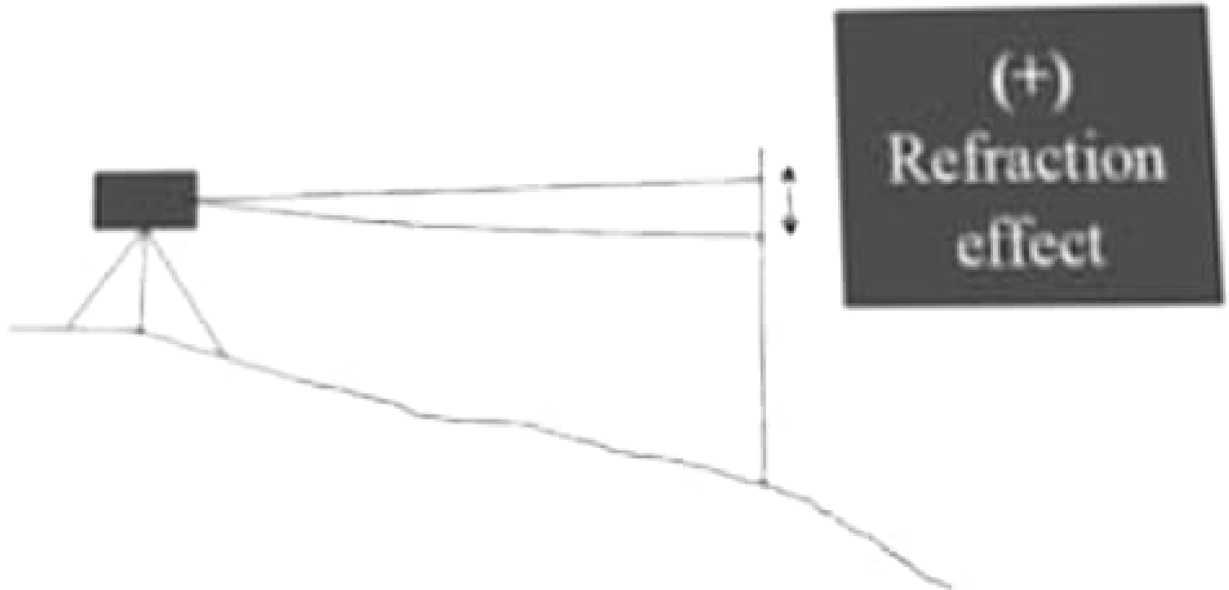
# Refraction

- The ray of light pass through layers of air of different densities and refractor bent down. The effect of refraction is to make the object appear higher then they really are. Refraction varies considerably with climate conditions.

However it is taken as,

- **$C_r = 0.0112\ D^2 m (+)$**
- Refraction is always additive
- **True staff reading**
- **=Observed staff Reading+ Refraction correction.**

# Refraction



# Leveling Examples

# Example

- The following staff readings were observed successively with a level the instrument is moved by **third, sixth and eighth readings.**
- 2.228 :1.606 :0.988 :2.090 :2.864 :1.262 0.602 :1.982 :1.044 :2.684 m
- enter the reading in record book and calculate R.L. if the first reading was taken at a **B.M of 432.383m**

# H.I. Method

| Station | B.S | I.S | F.S | HI | RL | REMARKS |
|---|---|---|---|---|---|---|
| 1 | 2.228 | | | 434.612 | 432.384 M | B.M. |
| 2 | | 1.606 | | | 433.006 | |
| 3 | 2.090 | | 0.988 | 435.714 | 433.624 | $3^{RD}$ C.P. |
| 4 | | 2.864 | | | 432.850 | |
| 5 | 0.602 | | 1.262 | 435.054 | 434.452 | $6^{TH}$ C.P |
| 6 | 1.044 | | 1.982 | 434.116 | 433.072 | $8^{TH}$ C.P |
| 7 | | | 2.684 | | 431.432 | |
| | 5.964 | | 6.916 | | | |

CHECK Σ B.S-Σ F.S = 5.964-6.916= -0.952 = LAST R.L-FIRST R.L= 431.432-432.384= -0.952

# Rise and Fall Method

| Station | B.S | I.S | F.S | Rise | Fall | R.L | REMARKS |
|---|---|---|---|---|---|---|---|
| 1 | 2.228 | | | | | 432.384 M | B.M. |
| 2 | | 1.606 | | 0.622 | | 433.006 | |
| 3 | 2.090 | | 0.988 | 0.618 | | 433.624 | 3RD C.P. |
| 4 | | 2.864 | | | 0.774 | 432.850 | |
| 5 | 0.602 | | 1.262 | 1.602 | | 434.452 | 6TH C.P |
| 6 | 1.044 | | 1.982 | | 1.38 | 433.072 | 8TH C.P |
| 7 | | | 2.684 | | 1.64 | 431.432 | |
| | 5.964 | | 6.916 | | | | |

CHECK Σ B.S-Σ F.S= 5.964-6.916= -0.952 = LAST R.L-FIRST R.L= 431.432-432.384=-0.952
ΣRISE-Σ FALL= 2.842-3.794=-0.952

- The following readings were taken with a dumpy level and **4m leveling staff.** The instrument was shifted after **3rd and 6th readings**. The readings are **2.665, 3.225, 2.905, 1.85, 0.98, 2.62, 1.585, 0.96, 0.425. m** Enter the above readings in a page of level book and calculate R.L. of points, if the first reading was taken with a staff held on **B.M. of 240 m**. use **rise and fall method**. Apply arithmetic checks

# Rise and Fall Method

| Station | B.S. | I.S. | F.S | Rise (+) | Fall (-) | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 2.665 | | | | | 240 | BM |
| B | | 3.225 | | | 0.56 | 239.44 | |
| C | 1.85 | | 2.905 | 0.32 | | 239.76 | 3rd CP |
| D | | 0.98 | | 0.87 | | 240.63 | |
| E | 1.585 | | 2.62 | | 1.64 | 238.99 | 6th CP |
| F | | 0.96 | | 0.625 | | 239.615 | |
| G | | | 0.425 | 0.535 | | 240.15 | |
| CHECK | | ∑ BS- ∑ FS | | ∑RISE- ∑ FALL | | L.RL -F. RL | |
| | 6.1 | | 5.95 | 2.35 | 2.2 | | |
| | ∑ BS- ∑ FS= 0.15 | | | ∑RISE- ∑ FALL =0.15 | | L.RL -F. RL= 0.15 | |

# HI Method

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 2.665 | | | 242.665 | 240 .00 | BM |
| B | | 3.225 | | | 239.44 | |
| C | 1.85 | | 2.905 | 241.61 | 239.76 | 3rd CP |
| D | | 0.98 | | | 240.63 | |
| E | 1.585 | | 2.62 | 240.575 | 238.99 | 6th CP |
| F | | 0.96 | | | 239.615 | |
| G | | | 0.425 | | 240.15 | |
| CHECK | | $\sum$ BS- $\sum$ FS | | | L.RL –F. RL | |
| | 6.1 | | 5.95 | | | |
| | $\sum$ BS- $\sum$ FS= 0.15 | | | | L.RL –F. RL= 0.15 | |

# HI Method

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 2.665 | | | **242.665** | 240.00 | BM |
| B | | 3.225 | | | 239.44 | |
| C | 1.85 | | 2.905 | **241.61** | **239.76** | 3rd CP |
| D | | 0.98 | | | 240.63 | |
| E | 1.585 | | 2.62 | 240.575 | 238.99 | 6th CP |
| F | | 0.96 | | | 239.615 | |
| G | | | 0.425 | | 240.15 | |
| CHECK | | $\sum$ BS- $\sum$ FS | | | L.RL –F. RL | |
| | 6.1 | | 5.95 | | | |
| | $\sum$ BS- $\sum$ FS= 0.15 | | | | L.RL –F. RL= 0.15 | |

# Example

- The Following observations were taken with dumpy level and **4 m leveling staff**. The instrument were shifted after the 4th and 7th reading. The first reading was taken on a bench mark whose **R.L. was 15.575 m**. prepare a page of level book and calculate RL of all the points. The observations were taken at every **30 m interval**. Also find out the gradient between first and last point. Also draw the profile of ground. **Use H.I. Method**. Observations are: **0.565, 1.250, 1.675, 3.695,0.125, 2.345, 0.500, 1.785, 2.535.**

# Observations are: 0.565, 1.250, 1.675, 3.695 (CP),0.125, 2.345, 0.500 (CP), 1.785, 2.535.

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 0.565 | | | 16.14 | 15.575 | BM |
| B | | 1.250 | | | 14.89 | |
| C | | 1.675 | | | 14.46 | |
| D | 0.125 | | 3.695 | 12.565 | 12.44 | CP |
| E | | 2.345 | | | 10.22 | |
| F | 1.785 | | 0.500 | 13.85 | 12.065 | CP |
| G | | | 2.535 | | 11.315 | |
| CHECK | | ∑ BS- ∑ FS | | | L.RL –F. RL | |
| | 2.47 | | 6.73 | | | |
| | ∑ BS- ∑ FS= -4.26 | | | | L.RL –F. RL= -4.255 | |

## Observations are: 0.565, 1.250, 1.675, 3.695 (CP),0.125, 2.345, 0.500 (CP), 1.785, 2.535.

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 0.565 | | | | | 15.575 | BM |
| B | | 1.250 | | | 0.685 | 14.89 | |
| C | | 1.675 | | | 0.425 | 14.46 | |
| D | 0.125 | | 3.695 | | 2.02 | 12.44 | CP |
| E | | 2.345 | | | 2.22 | 10.22 | |
| F | 1.785 | | 0.500 | 1.845 | | 12.065 | CP |
| G | | | 2.535 | | 0.75 | 11.315 | |
| CHECK | | ∑ BS- ∑ FS | | | | L.RL -F. RL | |
| | 2.47 | | 6.73 | | | | |
| | ∑ BS- ∑ FS= -4.26 | | | ∑RISE- ∑ FALL =-4.26 | | L.RL -F. RL= -4.26 | |

**Observations are: 0.565, 1.250, 1.675, 3.695 (CP),0.125, 2.345, 0.500 (CP), 1.785, 2.535.**

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A (0 m) | 0.565 | | | | | 15.575 | BM |
| B (30 m ) | | 1.250 | | | 0.685 | 14.89 | |
| C (60 m) | | 1.675 | | | 0.425 | 14.46 | |
| D (90 m) | 0.125 | | 3.695 | | 2.02 | 12.44 | CP |
| E (120 m) | | 2.345 | | | 2.22 | 10.22 | |
| F (150 m) | 1.785 | | 0.500 | 1.845 | | 12.065 | CP |
| G (180 m) | | | 2.535 | | 0.75 | 11.315 | |
| CHECK | | $\sum$ BS- $\sum$ FS | | | | I. RL. –F. RL | |
| | 2.47 | | 6.73 | | | | |
| | $\sum$ BS- $\sum$ FS= -4.26 | | | $\sum$RISE- $\sum$ FALL =-4.26 | | I. RL. –F. RL= -4.26 | |

# GRADIENT

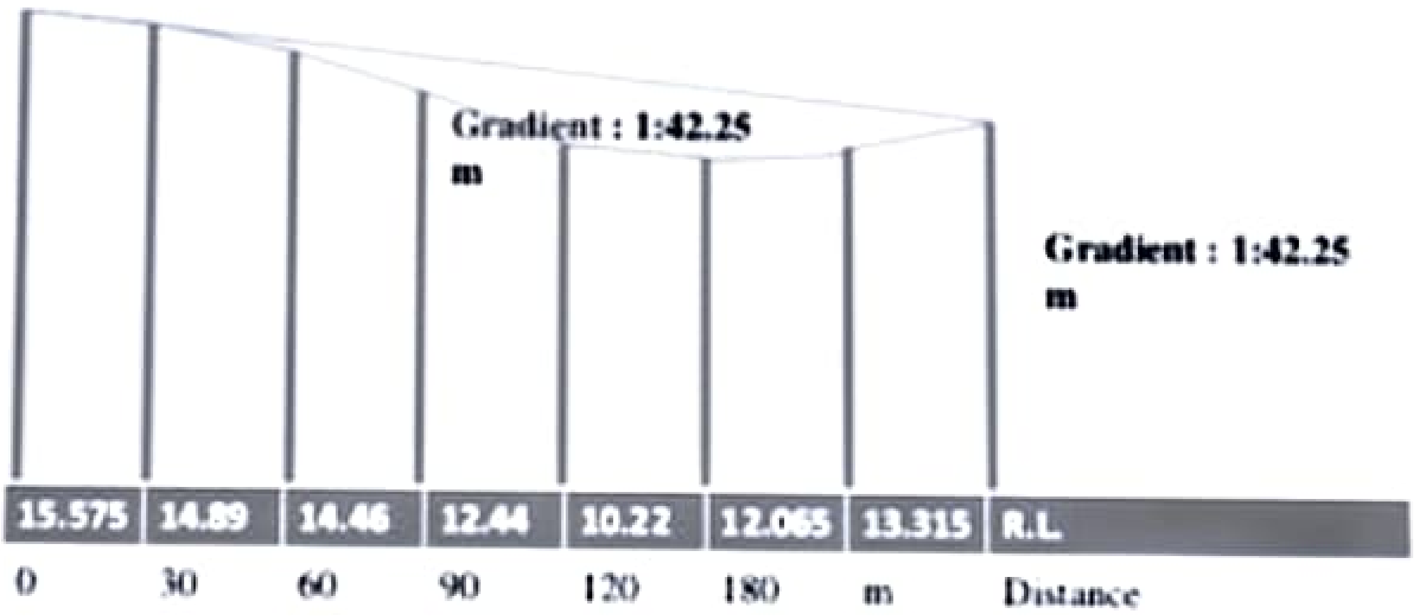
- Gradient of line AG = $\dfrac{\text{Diff of RLs}}{\text{Length}}$

- Gradient of line AG = $\dfrac{4.260}{180}$

$$= \frac{1}{42.25}$$

= 1 in 42.25 Gradient.

# Profile



Gradient : 1:42.25
m
Gradient : 1:42.25
m
15.575
14.89
14.46
12.44
10.22
12.065
13.315
R.L
0
30
60
90
120
180
m
Distance

# Example

The following readings are taken on continuous falling ground with staff of **4 m** the **are 0.4 m, 0.765, 1.270, 2.56, 3.22, 3.95, 0.390, 1.690, 3.5, 0.8, 1.920, 2.45, 3.98**. Enter the reading in the page of level book and calculate the RLs of all point if the first reading was taken on **Benchmark of 100m.**

**0.400, 0.765, 1.270, 2.560, 3.220, 3.950, 0.390,1.690,3.500,0.800,1.920, 2.450,3.980**
**(Continuous Sloping Ground) 4m staff**

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 0.400 | | | 100.4 | 100.00 | BM |
| B | | 0.765 | | | 99.635 | |
| C | | 1.270 | | | 99.13 | |
| D | | 2.560 | | | 97.84 | |
| E | | 3.220 | | | 97.18 | |
| F | 0.390 | | 3.950 | 96.84 | 96.45 | CP |
| G | | 1.690 | | | 95.15 | |
| H | 0.800 | | 3.500 | 94.14 | 93.34 | CP |
| I | | 1.920 | | | 92.22 | CP |
| J | | 2.450 | | | 91.69 | |
| K | | | 3.98 | | 90.16 | |
| ∑ | 1.59 | | 11.43 | | | |
| CHECK | ∑ BS- ∑ FS= -9.84 m | | | | L.RL –F. RL= -9.84 m | |

**0.400, 0.765, 1.270, 2.560, 3.220, 3.950, 0.390,1.690,3.500,0.800,1.920, 2.450,3.980**
**(Continuous Sloping Ground) 4m staff**

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 0.400 | | | | | 100.00 | BM |
| B | | 0.765 | | | 0.365 | 99.635 | |
| C | | 1.270 | | | 0.505 | 99.13 | |
| D | | 2.560 | | | 1.29 | 97.84 | |
| E | | 3.220 | | | 0.66 | 97.18 | |
| F | 0.390 | | 3.950 | | 0.73 | 96.45 | CP |
| G | | 1.690 | | | 1.30 | 95.15 | |
| H | 0.800 | | 3.500 | | 1.81 | 93.34 | CP |
| I | | 1.920 | | | 1.12 | 92.22 | CP |
| J | | 2.450 | | | 0.53 | 91.69 | |
| K | | | 3.98 | | 1.53 | 90.16 | |
| Σ | 1.59 | | 11.43 | 0 | 9.84 | | |
| CHECK | ∑ BS- ∑ FS= -9.84 m | | | ∑RISE- ∑ FALL =-9.84 | | L.RL –F. RL= -9.84 m | |

- The following is an incomplete page of level book in which X indicates missing Entry line. Calculate all the missing entries and complete the page of level book .also give the usual arithmetical checks.

# MISSING READINGS

| Station | BS | IS | FS | Rise | Fall | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 2.560 | | | | | 100.0 | BM |
| B | | 3.540 | | | X | X | |
| C | | 3.200 | | X | | X | |
| D | | 2.340 | | X | | X | |
| E | 1.950 | | X | 1.08 | | X | CP1 |
| F | | 2.440 | | | X | X | |
| G | | | 3.465 | | X | X | |

# MISSING READINGS

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 2.560 | | | | | 100 | |
| B | | 3.54 | | | X | X | |
| C | | 3.20 | | X | | X | |
| D | | 2.34 | | X | | X | |
| E | 1.95 | | X | 1.08 | | X | CP |
| F | | 2.44 | | | X | X | |
| G | | | 3.46 | | X | X | |
| CHECK | | ∑ BS- ∑ FS | | | | L.RL. –F. RL | |
| | | | | | | | |
| | ∑ BS- ∑ FS= | | | | | L.RL. –F. RL= | |

# MISSING READINGS

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 2.560 | | | | | 100 | |
| B | | 3.54 | | | 0.98 | 99.02 | |
| C | | 3.20 | | 0.34 | | 99.36 | |
| D | | 2.34 | | 0.86 | | 100.22 | |
| E | 1.95 | | 1.26 | 1.08 | | 101.3 | CP |
| F | | 2.44 | | | 0.49 | 100.81 | |
| G | | | 3.46 | | 1.02 | 99.79 | |
| CHECK | | $\sum$ BS- $\sum$ FS | | | | L..RL. –F. RL | |
| | 4.51 | | 4.72 | | | | |
| | $\sum$ BS- $\sum$ FS= -0.21 | | | $\sum$RISE- $\sum$ FALL =-0.21 | | L..RL. –F. RL= -0.21 | |

# Example

- The following consecutive readings were taken with a level and a **4m staff** at a common **interval of 30m**; The first reading was taken at **B.M. having R.L.. =100m**. The instrument were shifted after the **4th and 9th readings**. Rule out a page of a level book, enter the readings given and also calculate the reduced levels of the points by the collimation method. Also apply arithmetic checks.
- Consecutive readings are: **2.650, 1.745, 0.625, 0.260, 2.525, 2.160, 1.235, 0.870, 1.365, 0.625, 1.790, and 2.535.**

**Consecutive readings are: 2.650, 1.745, 0.625, 0.260 (CP), 2.525, 2.160, 1.235, 0.870, 1.365 (CP), 0.625, 1.790, and 2.535.**

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 2.65 | | | | | 100 m | BM |
| B | | 1.745 | | 0.905 | | 100.905 | |
| C | | 0.625 | | 1.12 | | 102.025 | |
| D | 2.525 | | 0.260 | 0.365 | | 102.39 | CP |
| E | | 2.160 | | 0.365 | | 102.755 | |
| F | | 1.235 | | 0.925 | | 103.68 | |
| G | | 0.87 | | 0.365 | | 104.045 | |
| H | 0.625 | | 1.365 | | 0.495 | 103.55 | CP |
| I | | 1.79 | | | 1.165 | 102.385 | |
| J | | | 2.535 | | 0.745 | 101.64 | |
| K | 5.8 | | 4.16 | 4.045 | 2.405 | | |
| ∑ | | | | | | | |
| CHECK | ∑ BS- ∑ FS= 1.64 m | | | ∑RISE- ∑ FALL = 1.64 m | | L.RL -F. RL= 1.64 m | |

**Consecutive readings are: 2.650, 1.745, 0.625, 0.260 (CP), 2.525, 2.160, 1.235, 0.870, 1.365 (CP), 0.625, 1.790, and 2.535.**

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 2.65 | | | 102.65 | 100 m | BM |
| B | | 1.745 | | | 100.905 | |
| C | | 0.625 | | | 102.025 | |
| D | 2.525 | | 0.260 | 104.915 | 102.39 | CP |
| E | | 2.160 | | | 102.755 | |
| F | | 1.235 | | | 103.68 | |
| G | | 0.87 | | | 104.045 | |
| H | 0.625 | | 1.365 | 104.175 | 103.55 | CP |
| I | | 1.79 | | | 102.385 | |
| J | | | 2.535 | | 101.64 | |
| K | 5.8 | | 4.16 | | | |
| Σ | | | | | | |
| CHECK | $\sum BS - \sum FS = 1.64$ m | | | | L.RL – F. RL= 1.64 m | |

# EXAMPLE

- **The following consecutive readings were taken with a level and a 4m leveling staff on a continuously sloping ground at a common interval of 30 m on line AB.**

| Chainage | 0 | 30 | 60 | 90 | 120 | 150 |
|---|---|---|---|---|---|---|
| Level | 0.585 | 0.930 | 1.95 | 2.845 | 3.645 | 3.93 |
| Station | A | | | | | B |

**The reduced level (RL) of station A is 50.00**. Calculate the reduced levels at all the points where the leveling staff is placed. Tabulate the results and apply usual checks. Also determine the gradient of line AB.

# EXAMPLE (Rise and Fall Method)

| Station | B.S. | I.S. | F.S | RISE | FALL | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A (0 m) | 0.585 | | | | | 50.00 | BM |
| B (30 m ) | | 0.930 | | | 0.345 | 49.655 | |
| C (60 m) | | 1.950 | | | 1.02 | 48.635 | |
| D (90 m) | | 2.840 | | | 0.89 | 47.745 | |
| E (120 m) | | 3.645 | | | 0.805 | 46.94 | |
| F (150 m) | | | 3.930 | | 0.285 | 46.655 | |
| G (180 m) | | | | | | | |
| CHECK | | $\sum$ BS- $\sum$ FS | | | | L.RL. –F. RL | |
| | 0.585 | | 3.930 | 0 | 3.345 | 3.345 | |
| | $\sum$ BS- $\sum$ FS= -3.345 m | | | $\sum$RISE- $\sum$ FALL = 3.345 m | | L.RL. –F. RL= 3.345 m | |

# EXAMPLE (HI Method)

| Station | B.S. | I.S. | F.S | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A (0 m) | 0.585 | | | 50.585 | 50.00 | BM |
| B (30 m ) | | 0.930 | | | 49.655 | |
| C (60 m) | | 1.950 | | | 48.635 | |
| D (90 m) | | 2.840 | | | 47.745 | |
| E (120 m) | | 3.645 | | | 46.94 | |
| F (150 m) | | | 3.930 | | 46.655 | |
| G (180 m) | | | | | | |
| CHECK | | ∑ BS- ∑ FS | | | L.RL. –F. RL. | |
| | 0.585 | | 3.930 | | 3.345 | |
| | ∑ BS- ∑ FS= -3.345 m | | | | L.RL. –F. RL.= 3.345 m | |

# Plane Table Surveying

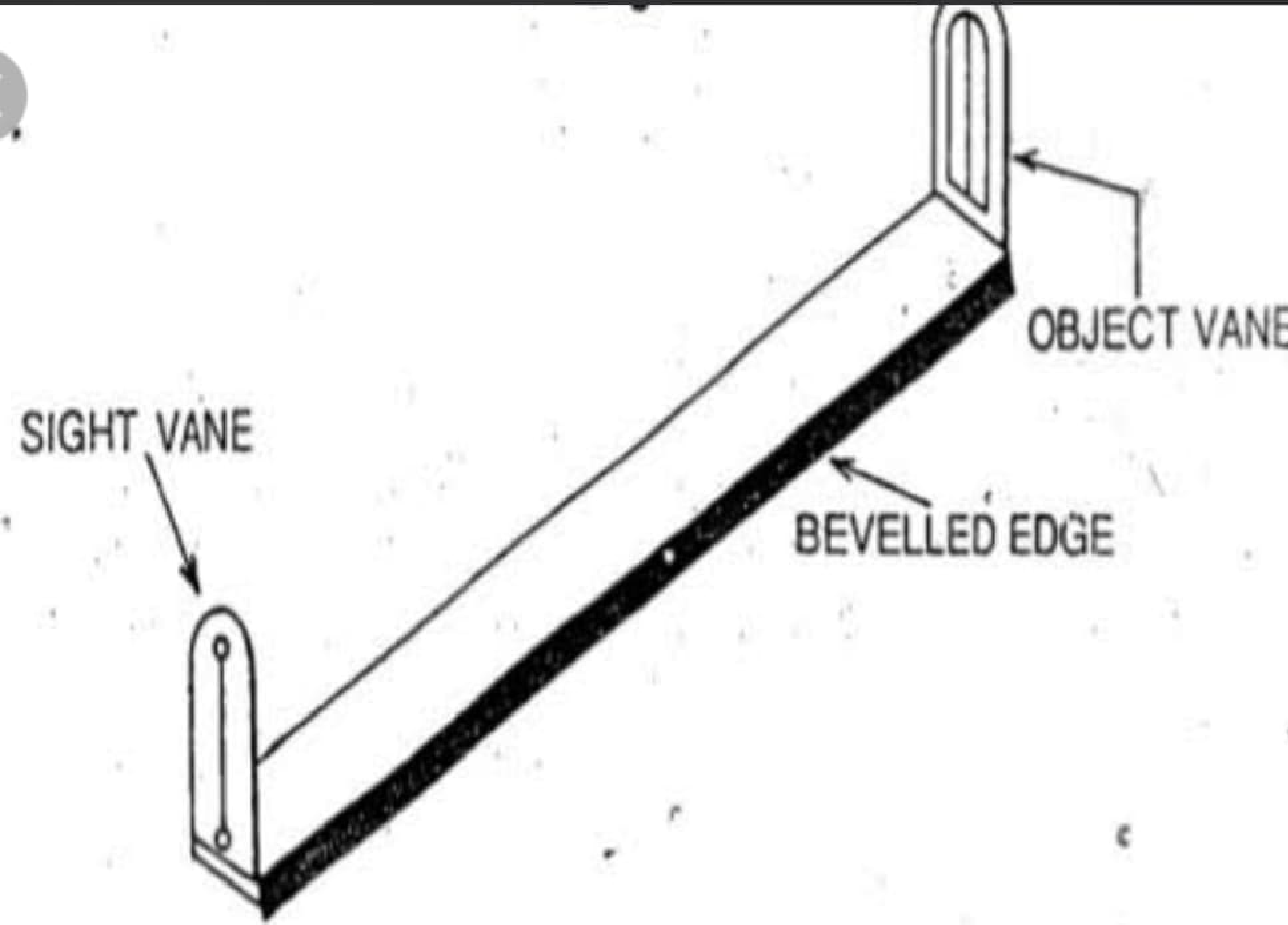
- Plane table is a graphical methodof surveying in which the field work and the plotting is done simultaneously.
- It is adopted in small mapping.
- It is also ideally suited to filling detail on a map already prepare and available on the drawing sheets.
- It can also be used to prepare a fresh map with the linear measurements being taken with a chain or tape.

# Plane Table And Tripod

- A simple plane table is a drawing board provided with a ball and socket arrangement for leveling the table ,with an arrangement to fix the table to a tripod.

# Alidade

- a plane alidade consists of a metallic rule with a fine beveled edge called the fiduucial edge.
- This edge used for drawing line.
- For sighting-by placing the ruling edge along the points or lines marked on the sheet.
- Two frame are attached vertically at its end.
- The eye vane-a small metal frame with a silt.
- The object vane-a frame with a fine hair placed vertically ,for bisecting – the part directed towards the object.
- The center of the eye vane and hair of the object vane provides the line of site.


OBJECT VANE
SIGHT VANE
BEVELLED EDGE

# Telescopic Alidade

- The alidade which is fitted with a telescope is known as a ***telescopic alidade***.
- It is used to take inclined sights.
- It increases the range and accuracy of the sights.
- It consists of a small telescope with a level tube.
- A graduated scale is mounted on the horizontal axis.
- One side of the metal ruler is used as the working edge along which lines are drawn.
- The angles of elevation or depression can be read on the vertical circle.

# Trough Compass

- A compass is used for orienting the plane table when it has to be used in more than one station.
- When the table is shifted to another station ,the compass is placed along the meridian previously drawn and the table is rotated to make the needle read zero.
- The table is then oriented to the same position it occupied at the previous station.

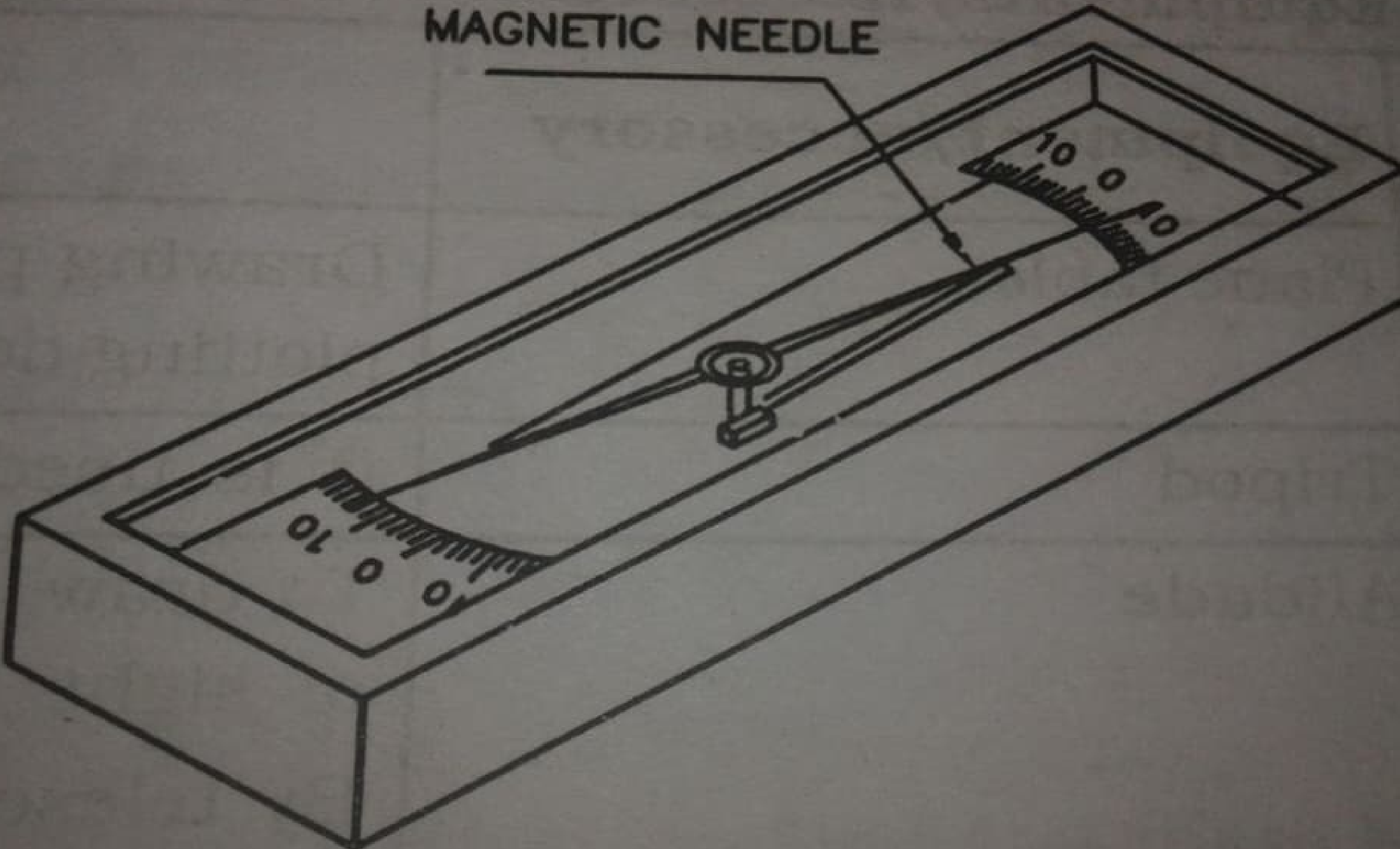


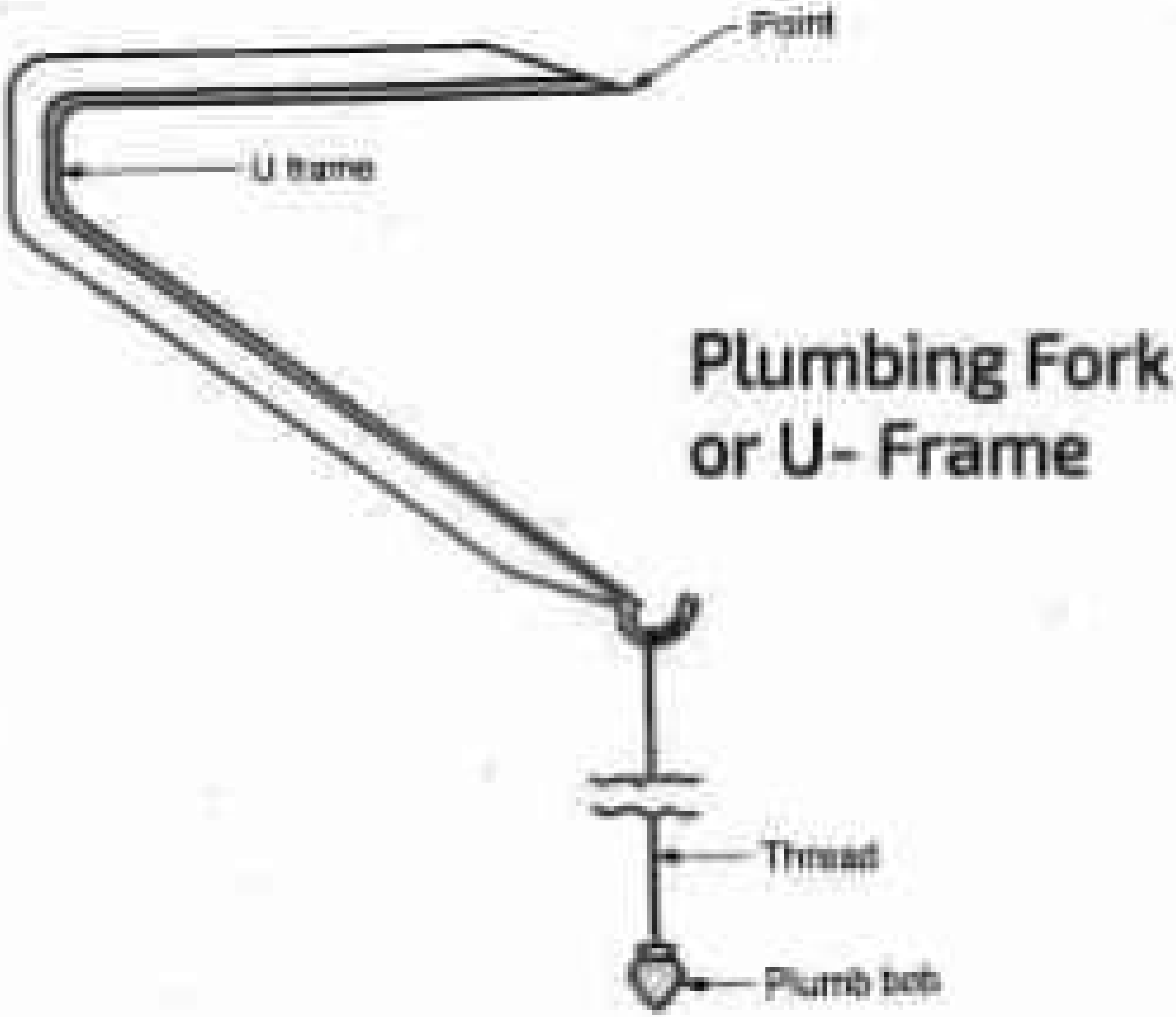

FIG. 1.3 TROUGH COMPASS

# Spirit Level

- Spirit level can be used  to level the plane table.
- It can be tubular level which can be placed in two perpendicular positions and leveled.

# Plumbing fork

- The plumb bob is fitted on to a folded frame (fork).
- The straight edge can be placed on the table and the bottom leg on the frame is under the table.
- The top leg has a fine point which can be kept on a plotted point.


Point
U frame
Plumbing Fork
or U- Frame
Thread
Plumb bob

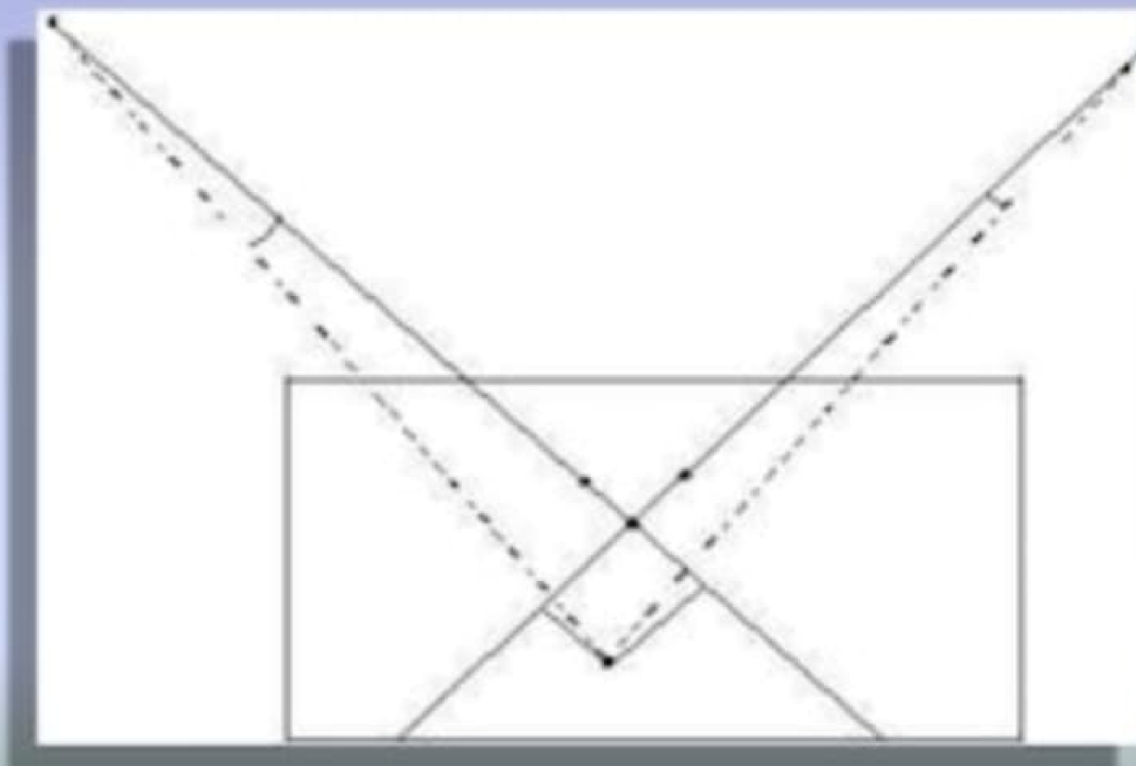
# WATER PROOF COVER & DRAWING PAPER

- An umbrella is used to protect the drawing paper from rain.
- Drawing paper is used for plotting the ground details.

# Principle Of Plane Table Survey

- **The principle of plane tabling is parallelism means,**
- **Principle: "All the rays drawn through various details should pass through the survey station.**"
- The Position of plane table at each station must be identical, i.e. at each survey station the table must be oriented in the direction of magnetic north.

# Principle Of Plane Table Survey



# Advantage Of Plane Table Surveying

- It is suitable for location of details as well as contouring for large scale maps directly in the field.
- As surveying and plotting are done simultaneously in the field, chances of getting omission of any detail get less.
- The plotting details can immediately get compared with the actual objects present in the field. Thus errors as well as accuracy of the plot can be ascertained as the work progresses in the field.
- Contours and specific features can be represented and checked conveniently as the whole area is in view at the time of plotting.
- Only relevant details are located because the map is drawn as the survey progresses. Irrelevant details get omitted in the field itself.
- The plane table survey is generally more rapid and less costly than most other types of survey.
- As the instruments used are simple, not much skill for operation of instruments is required. This method of survey requires no field book.

# Disadvantage Of Plane Table Surveying

- The plane table survey is not possible in unfavourable climates such as rain, fog etc.
- This method of survey is not very accurate and thus unsuitable for large scale or precise work.
- As no field book is maintained, plotting at different scale require full exercise.
- The method requires large amount of time to be spent in the field.
- Quality of the final map depends largely on the drafting capability of the surveyor.
- This method is effective in relatively open country where stations can be sighted easily .

# Method Of Setting Up The Plane Table

- Three processes are involved in setting up the plane table over the station.
- Leveling
- Centering
- Orientation

# Leveling and Centering

- The Table should be set up at convenient height for working on the board, say about 1 m. The legs of Tripod should be spread well apart and firmly into the ground.

# Leveling

# Leveling and Centering

- **The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground.** The operation is known as centering the plane table. **It is done by U-fork and plumb bob**.
- For leveling the table ordinary spirit level may be used. The table is leveled by placing the level on the board in two positions at right angles and getting the bubble central in both directions.

# Centering

# Orientation

- The **Process by which the positions occupied by the board at various survey stations are kept parallel** is known **as the orientation**. Thus, when a plane table is properly oriented, the lines on the board are parallel to the lines on ground which they represent.
- There are two methods of orientation:
- By magnetic needle
- By back sighting

# Orientation

## By Magnetic Needle

- In this method, **the magnetic north is drawn on paper at a particular station.** At the next station, the trough compass is placed along the line of magnetic north and the table is turned in such a way that the ends of magnetic needle are opposite to zeros of the scale. The board is then fixed in position by clamps. This method is inaccurate in the since that the results are likely to be affected by the local attraction.

**By Back Sighting**

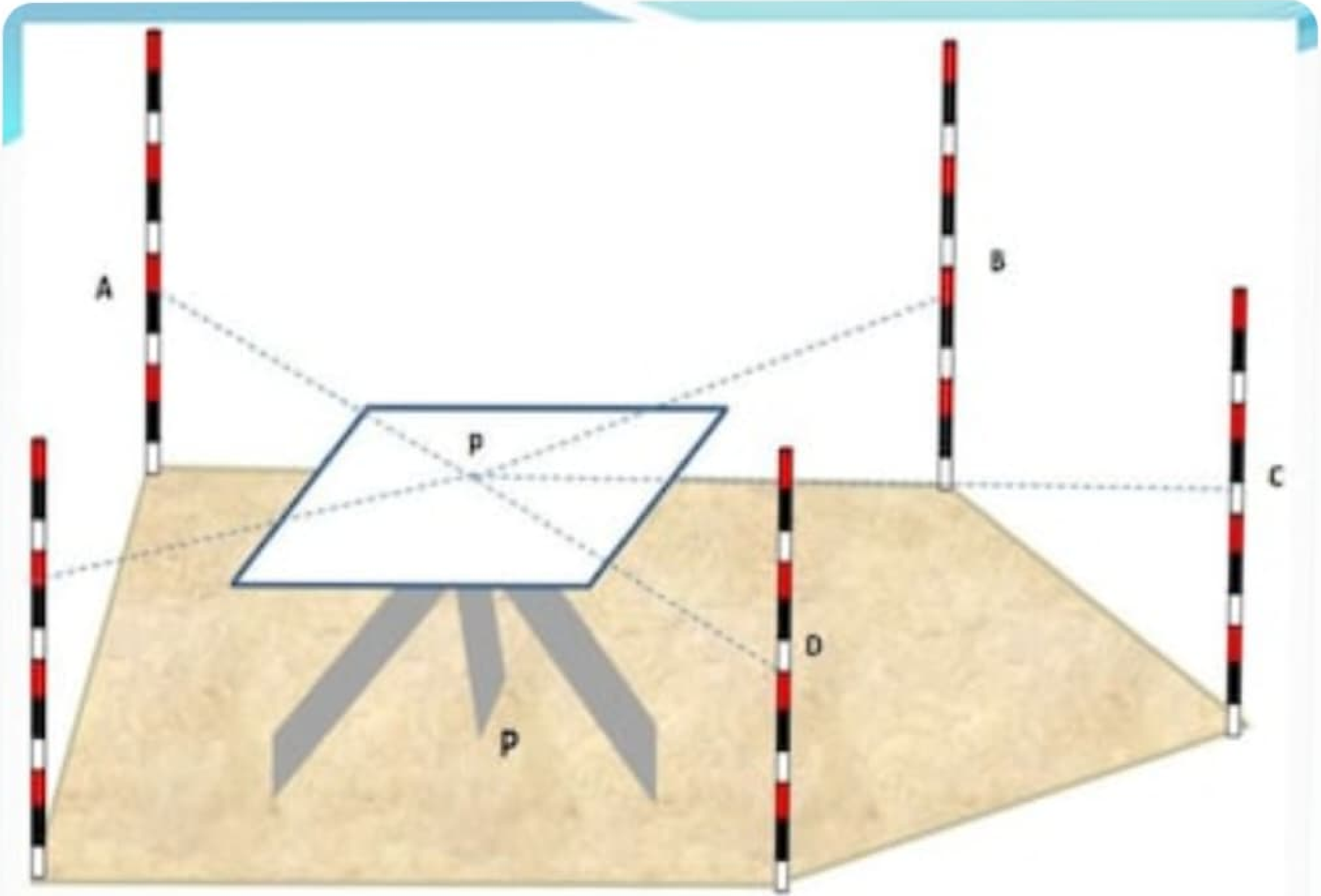
- A= First survey station
- B= Second survey station
- Suppose a line is drawn from station A on paper as ab, representing line AB on ground
- The table is turned till the line of sight bisects the ranging rod at A. The board is then clamped in this position.
- This method is better than the previous one and it gives perfect orientation.

# Plane Tabling Methods

- The plane table can be used in four ways-
  - i) radiation
  - ii) intersection
  - iii) traversing
  - iv) resection
- Plane table is generally used with the traverse drawn on a sheet for filling details or
- Can also be used for doing a fresh survey.
- These methods cover both these aspects of surveying with the plane table.

# Radiation Method

- It requires the plane table to occupy a single station .
- Orientation table is not required.
- To conduct the survey of an area ,the table is kept at a convenient station P commanding a full view of the area to be surveyed.


A
B
P
C
D
P

# Intersection Method

- This method requires setting the table up at minimum of two stations.
- Orientation is essential and be can done by back sighting.
- Two station A and B are selected so that they command a full view of the area to be surveyed.

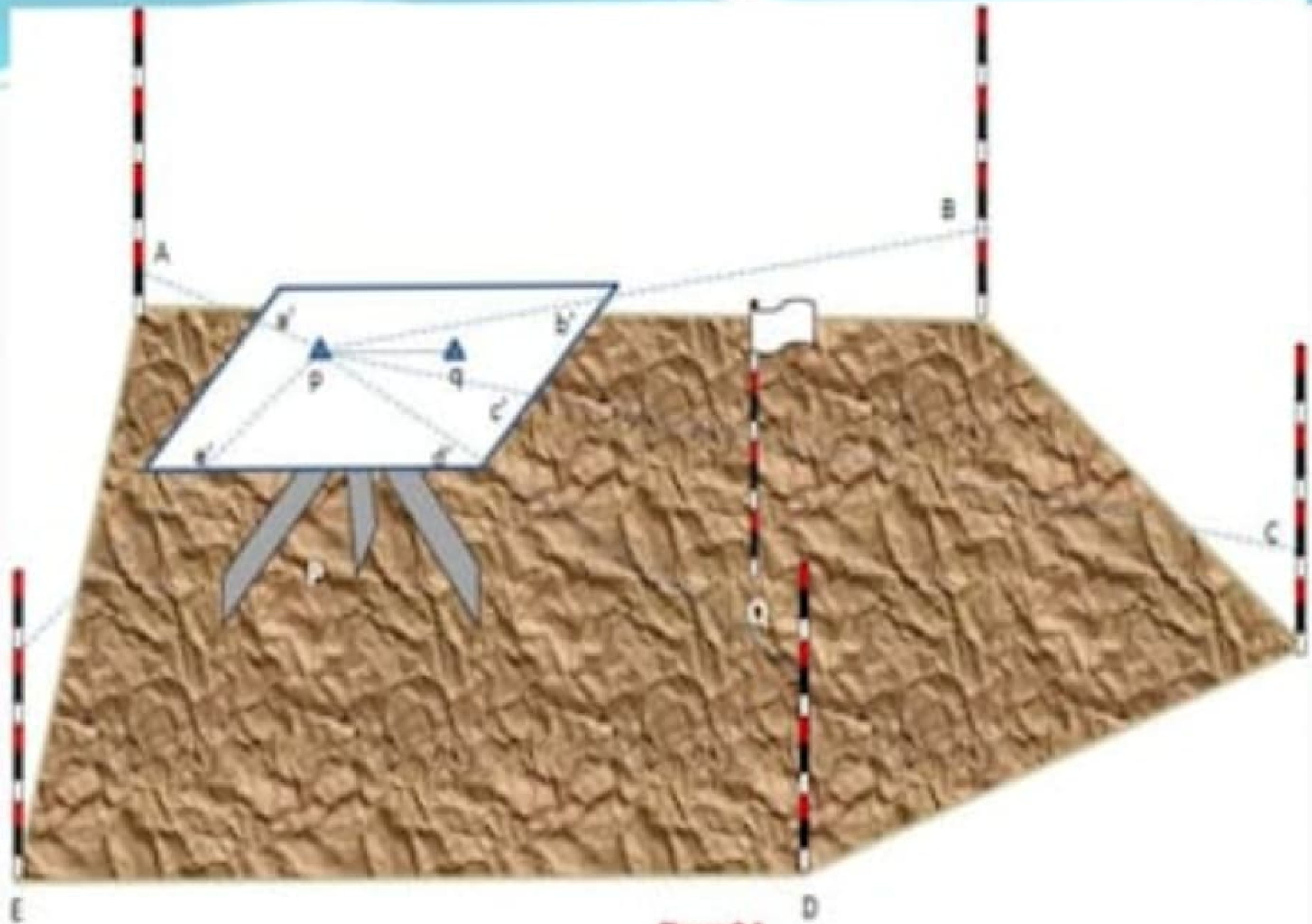
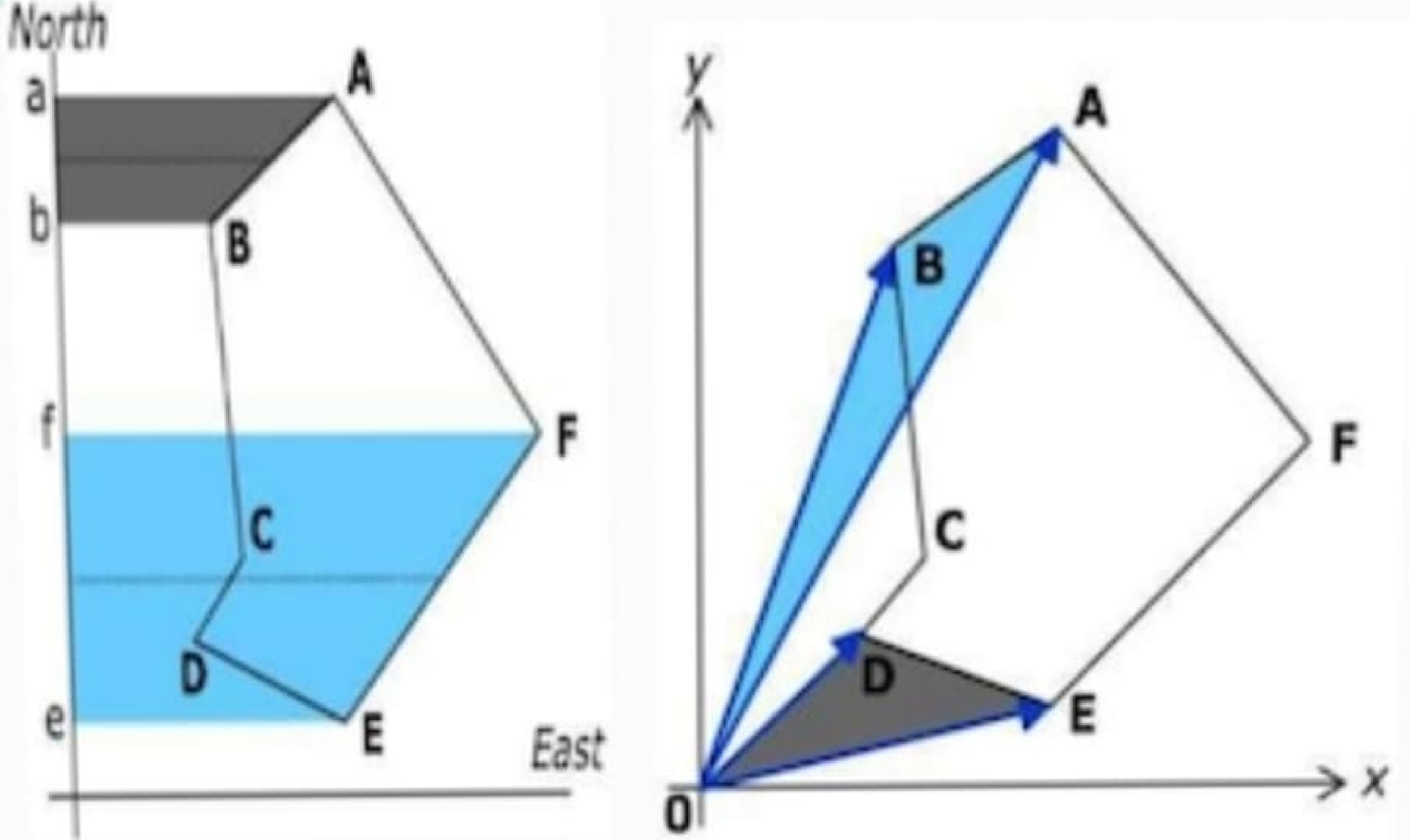



Figure 0-1

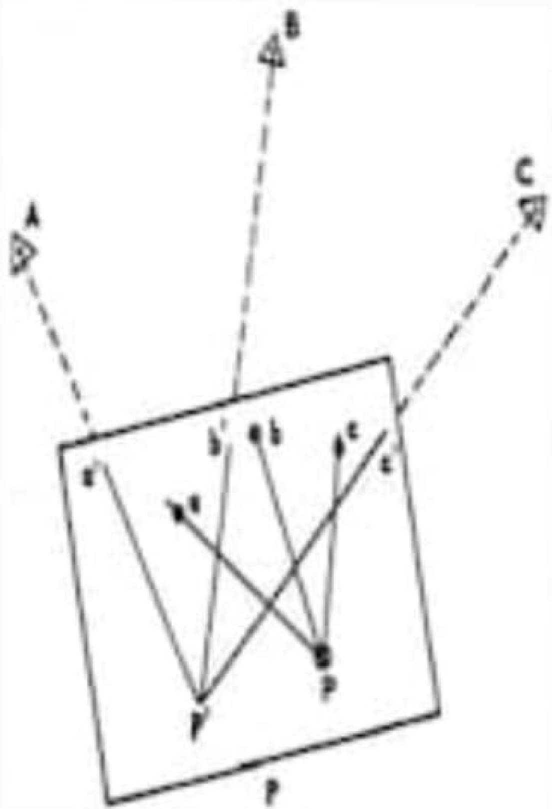
# Traversing Method

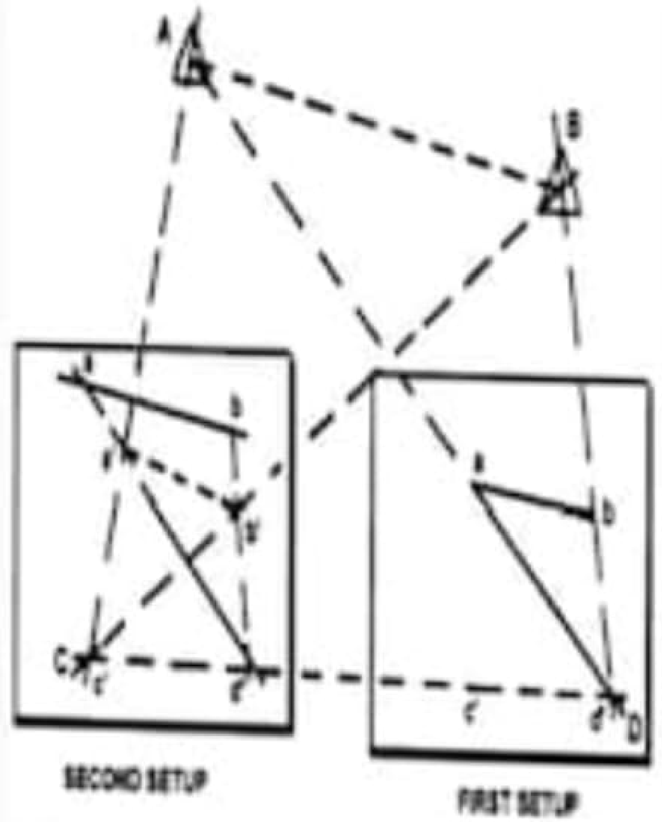
- This method is used to connect the two or more stations , however it is similar to the compass traversing but are done simultaneously.
- Traversing is a method of surveying where by a series of lines are surveyed.
- Traverse may be open or closed one.


North
a
b
f
e
A
B
C
D
E
F
East
y
A
B
C
D
E
F
O
x

# Re-Section Method

- This is the method of orienting the table . a characteristic feature of resection is that the objective is to plot the station occupied by the table on the sheet rather than obtaining the other stations or plotting details.
- Two method of orienting the table
- Method of back sighting
- Method using trough compass


A
B
C
P


A
B
C
D
SECOND SETUP
FIRST SETUP

# Two-Point Problem

- This is a special case of resection to obtain the position of station occupied by the table ,given the plotted position of the two points.
- State – to determine the position s of the station S occupied by the plane table, given the accurately plotted position ,p and q of the two points P and Q visible from the instrument station without occupying these two stations.

# Three-Point Problem

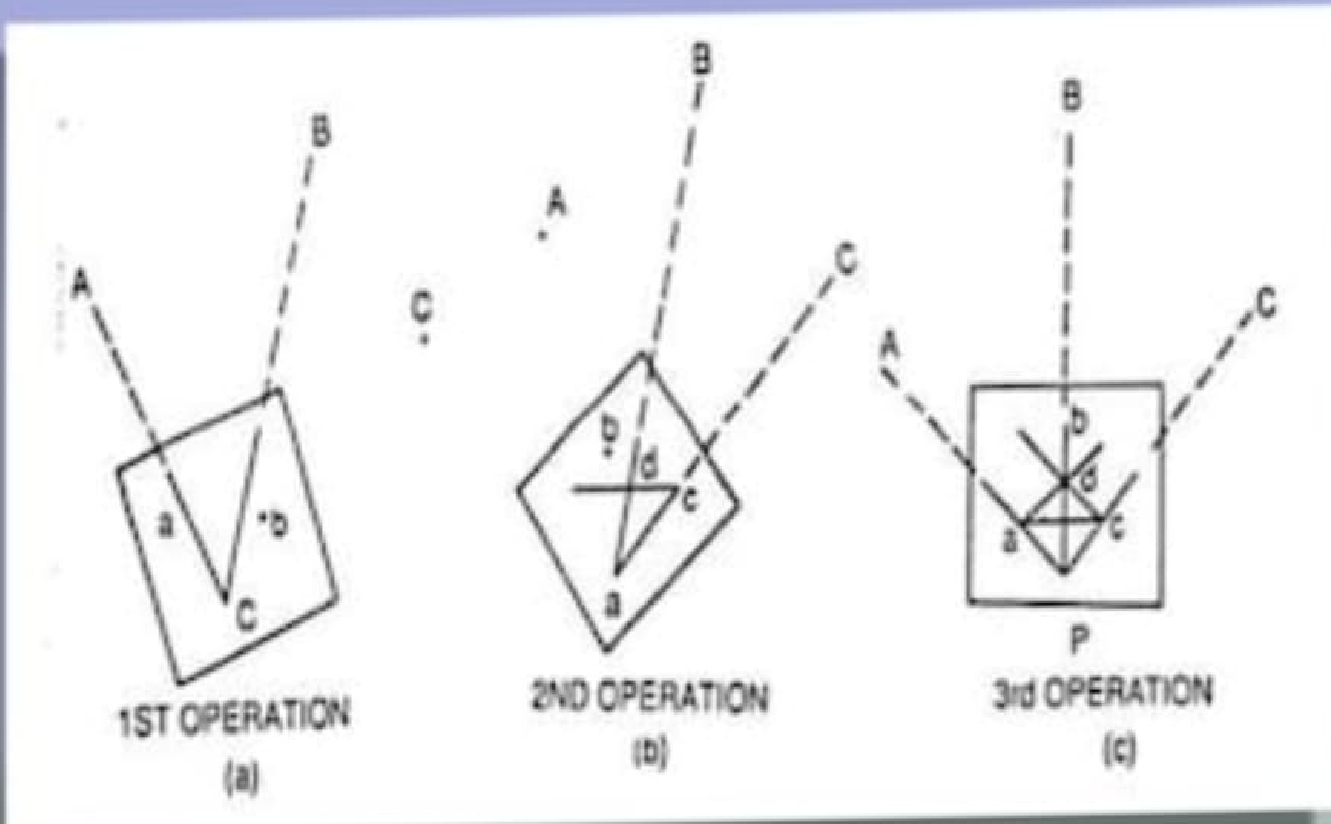
- This is also a problem of resection.
- Objective is to obtain the position of the occupied the table after orientation.
- State – given three visible stations and their plotted positions, to plot the station occupied by the plane table with the table correctly oriented with respect to the three points already plotted.

# The Three Point Problem

## The graphical method or Bessel's method

- (i) suppose A,B, and C are three well-defined points which have been plotted as a, b and c. Now it is required to locate a station at P.
- (ii) The table is placed at the required station P and leveled. The alidade is placed along the line ca and the point A is bisected. The table is clamped. With the alidade in centre on C, the point B is bisected and rays is drawn

# Bessel's Method

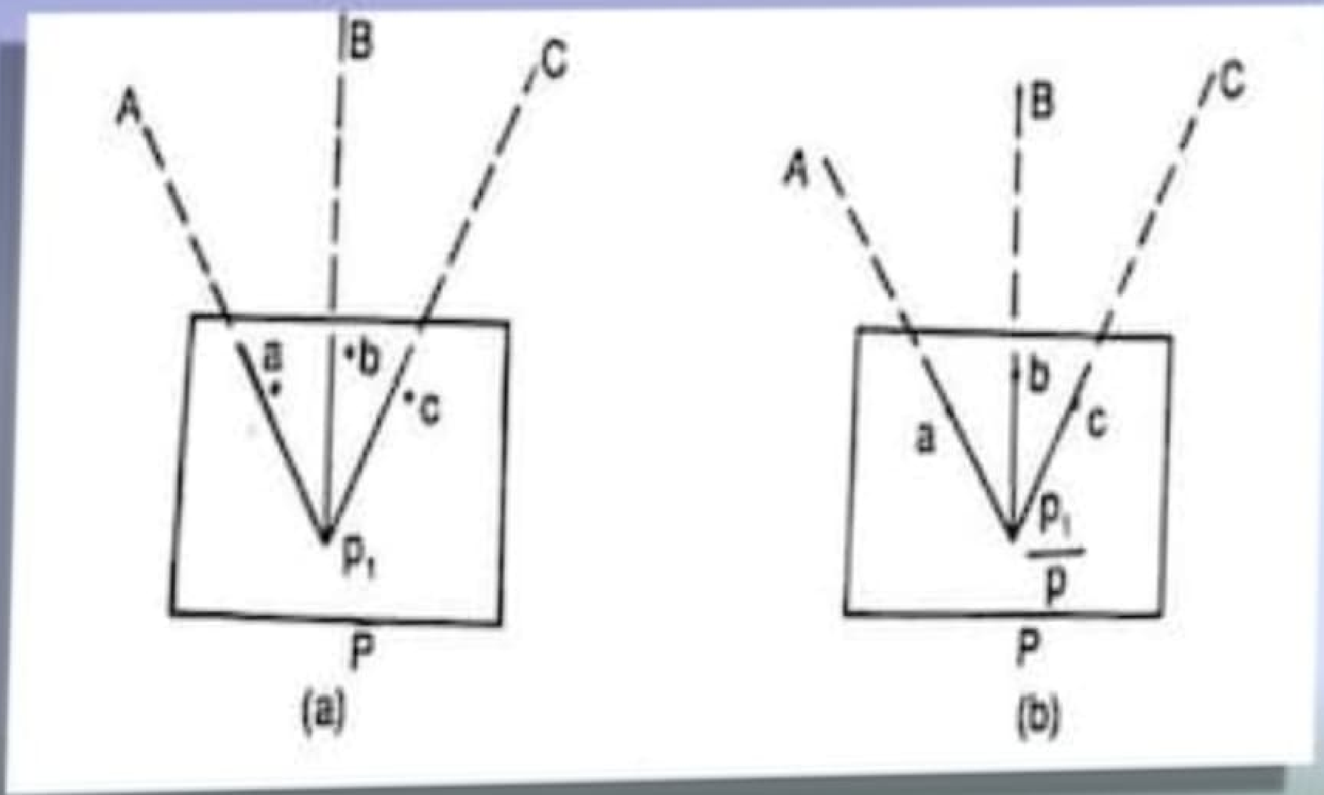


# The Three Point Problem

## The Mechanical Method

- Suppose A, B and C are the three well-defined points which have been plotted on the map as a, b and c. It is required to locate a station at P.
- The table is placed at P and leveled. A tracing paper is fixed on the map and a point p is marked on it.
- With the alidade centered on P the points A, B and C are bisected and rays are drawn. These rays may not pass through the points a, b and c as the orientation is done approximately

# The Mechanical Method

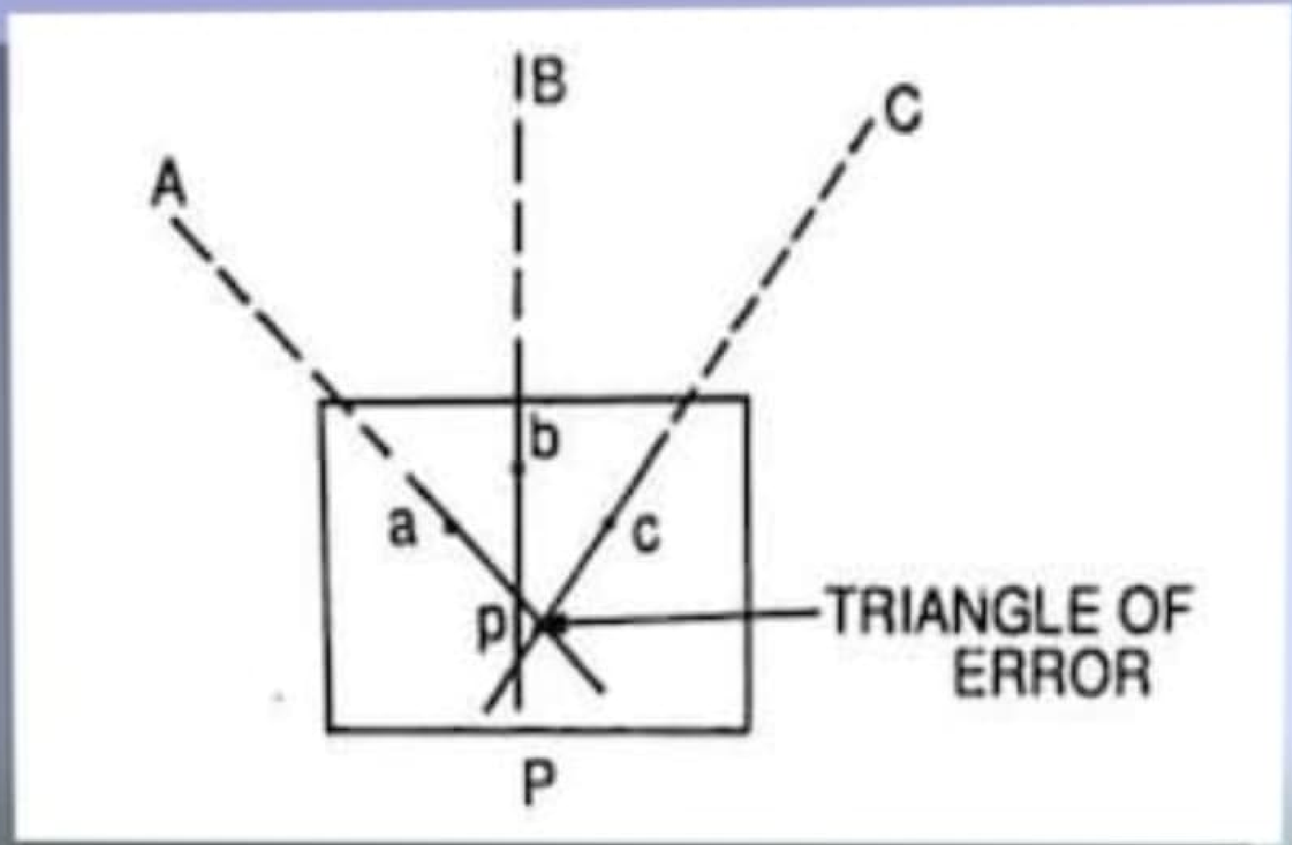


# The Three Point Problem

**The method of Trial and error**

- Suppose a, B and C are the three well-defined points which have been plotted as a, b and c on the map. Now it is required to establish a station at P.
- The table is set up at P and leveled. Orientation is done by eye estimation
- With the alidade, rays Aa, Bb and Cc are drawn. As the orientation is approximately, the rays may not intersect at a point, but may form a small triangle the triangle of error.
- To get the actual point, this triangle of error is to be eliminated. By repeatedly turning the table clockwise or anticlockwise. The triangle is eliminated in such a way that the rays Aa, Bb and Cc finally meet at a point p. This is the required point on the map. This point is transferred to the ground by U-fork and plumb bob.

# The method of Trial and Error



# Error In Plane Tabling

- The various sources of error may be classified as :
- Instrumental errors
- Errors in manipulation and sighting
- Errors in plotting

# Instrumental Errors

- The surface of drawing board is not plane
- The edge of alidade is not straight.
- The object vane and sight vane are not perpendicular to the alidade.
- The edge of alidade is not is not parallel to the line of sight.
- The fixing clamp is not proper.

# Errors In Manipulation And Sighting

- Defective Leveling
- Defective Sighting
- Defective Orientation
- Defective Centering
- Movement of Board between sights

# Errors in Plotting

- Defective scale of map
- Wrongly intersecting the rays drawn from two different stations.

# Plane Table Surveying

## What is Plane Table Surveying?

The plane table surveying is the fast method of surveying. In this type of surveying plotting of the plan and field observations can be done simultaneously.
In case of plane table surveying Geometrical conditions of site are manuscript in the map sheet using plane table and alidade after that topographic details are arranged on the map.

**Principle of Plane Table Surveying**

The rays drawn from different points should pass through a single point i.e. a position of station point.
And the position of the table at any station should be same as that at previous station i.e the table should be accurately oriented at all subsequent stations.

## Equipment Used in Plane Table Survey

1. Plane table
2. Alidade for sighting (telescopic or simple)
3. Plumb bob and plumb fork
4. Compass
5. Spirit level
6. Chain/Tape
7. Ranging rods
8. Tripod
9. Drawing sheet and drawing tools
10. Paper clips or screws

In a **plane table surveying a table top**, similar to drawing board fitted onto a tripod is the main instrument.
A drawing sheet is fixed on to the table top, the observations are made to the objects, distances are scaled down and the objects are plotted in the field itself.

Since the plotting is made in the field itself, there is no chance of omitting any necessary measurement in this surveying. However the accuracy achieved in this type of surveying is less.
The most commonly used **plane table** is shown in Fig.1 It consists of a well seasoned wooden table top mounted on a tripod. (**Sizes 40x30x15cm,60x75x15cm or 50x60x15cm)**
The table top can rotate about vertical axis freely. Whenever necessary table can be clamped in the desired orientation. The table can be leveled by adjusting tripod legs.

**Bottom Surface**

**Top Surface**

## Alidade

It is a straight edge ruler having some form of sighting device. One edge of the ruler is beveled and is graduated. Always this edge is used for drawing line of sight. Depending on the type of line of sight there are two types of alidade:

1) Plane Alidade
2) Telescopic Alidade

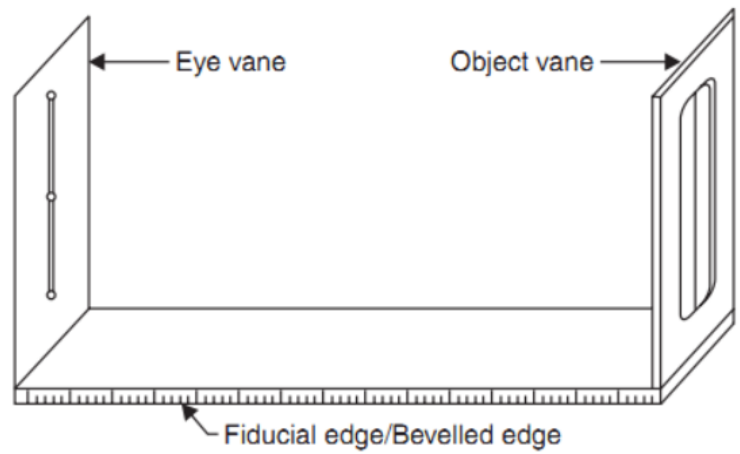
**1) Plane Alidade**

**2) Telescopic Alidade**

**Plain Alidade:**

A sight vane is provided at each end of the ruler. The vane with narrow slit serves as eye vane and the other with wide slit and having a thin wire at its center serves as object vane.

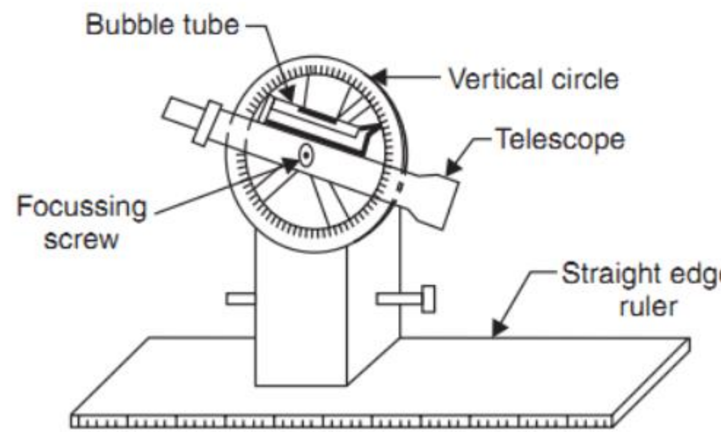
The two vanes are provided with hinges at the ends of ruler so that when not in use they can be folded on the ruler. Plain alidade is not suitable in surveying hilly areas as the inclination of line of sight in this case is limited.



**Telescopic Alidade:**

It consists of a telescope mounted on a column fixed to the ruler . The line of sight through the telescope is kept parallel to the beveled edge of the ruler. The telescope is provided with a level tube and vertical graduation arc. If horizontal sight is required bubble in the level tube is kept at the center.

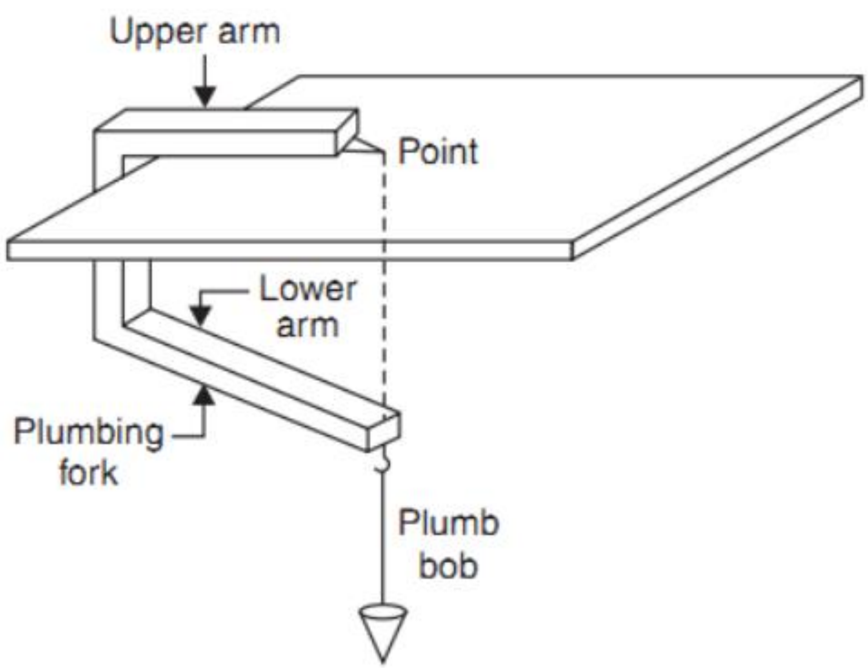
If inclined sights are required vertical graduation helps in noting the inclination of the line of sight. By providing telescope the range and the accuracy of line of sight is increased.



**Plumbing Fork and Plumb Bob**

Figure shows a typical plumbing fork with a plum bob. Plumbing fork is a U-shaped metal frame with a upper horizontal arm and a lower inclined arm. The upper arm is provided with a pointer at the end while the lower arm is provided with a hook to suspend plumb bob.

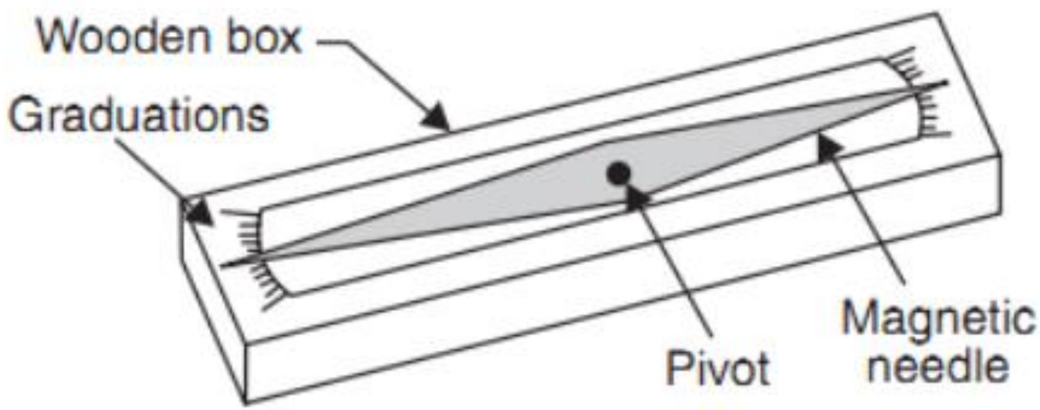
When the plumbing fork is kept on the plane table the vertical line (line of plumb bob) passes through the pointed edge of upper arm. The plumb bob helps in transferring the ground point to the drawing sheet and vice versa also.



**Trough Compass**

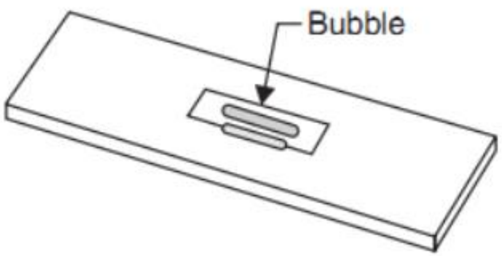
It consists of a 80 to 150 mm long and 30 mm wide box carrying a freely suspended needle at its center .At the ends of the needle graduations are marked on the box to indicate zero to five degrees on either side of the center. The box is provided with glass top to prevent oscillation of the needle by wind.

When needle is centered (reading 0–0), the line of needle is parallel to the edge of the box. Hence marking on the edges in this state indicates magnetic north–south direction.



**Spirit Level**

A flat based spirit level is used to level the plane table during surveying To get perfect level, spirit level should show central position for bubble tube when checked with its positions in any two mutually perpendicular directions.




**Drawing Sheet and Accessories for Drawing**

A good quality, seasoned drawing sheet should be used for plane table surveying.
The drawing sheet may be rolled when not in use, but should never is folded.
For important works fibre  glass sheets or paper backed with thin aluminium sheets are used.
Clips clamps, adhesive tapes may be used for fixing drawing sheet to the plane table. Sharp hard pencil, good quality eraser, pencil cutter and sand paper to keep pencil point sharp are other accessories required for the drawing work. If necessary, plastic sheet should be carried to cover the drawing sheet from rain and dust.

## Plane table survey equipment is arranged in 4 steps as follows

**Fixing of Plane Table**

Fix the plane table to the tripod stand. Arrange the drawing sheet on the plane table using paper clips or thumb screws. The sheet should be in one position from first to last.

**Leveling of Plane Table**

Plane table should be leveled using spirit level. For small works, eye estimation can be ok.

**Centering of Plane Table**

The table should be centered by using plumbing fork. By which we can arrange the plotted point exactly over the ground point.

**Orientation of Plane Table**

Whenever we are using more than one instrument station, orientation is essential. It can be done by using compass or back sighting. In this case, the plane table is rotated such that plotted lines in the drawing sheet are parallel to corresponding lines on the ground.

## Orientation

The process by which the position occupied by the board at various survey stations are kept parallel is known as the orientation. In the plane table surveying, the whole table needs to be moved at several stations to complete a survey. Every time the table is moved one has to make sure that the new station is parallel to the previous one otherwise the lines drawn on paper will not represent the same lines on the field. Methods of orientation are:-

**Orientation by Magnetic Needle:**

This method is used when it is not possible to bisect the previous station from the new station. This method is not much reliable and prone to errors due to variations of the magnetic field.

**Orientation by Back Sighting:**

This is a more reliable method. In this method, a particular line drawn from the previous station is drawn again from the new station. This process is called back-sighting. One does not necessarily have to draw the line the second time rather check if the new line superposes over the previous one or not.

**Methods of Plane Table Surveying**

Generally there are three methods are available to perform plane table surveying. They are

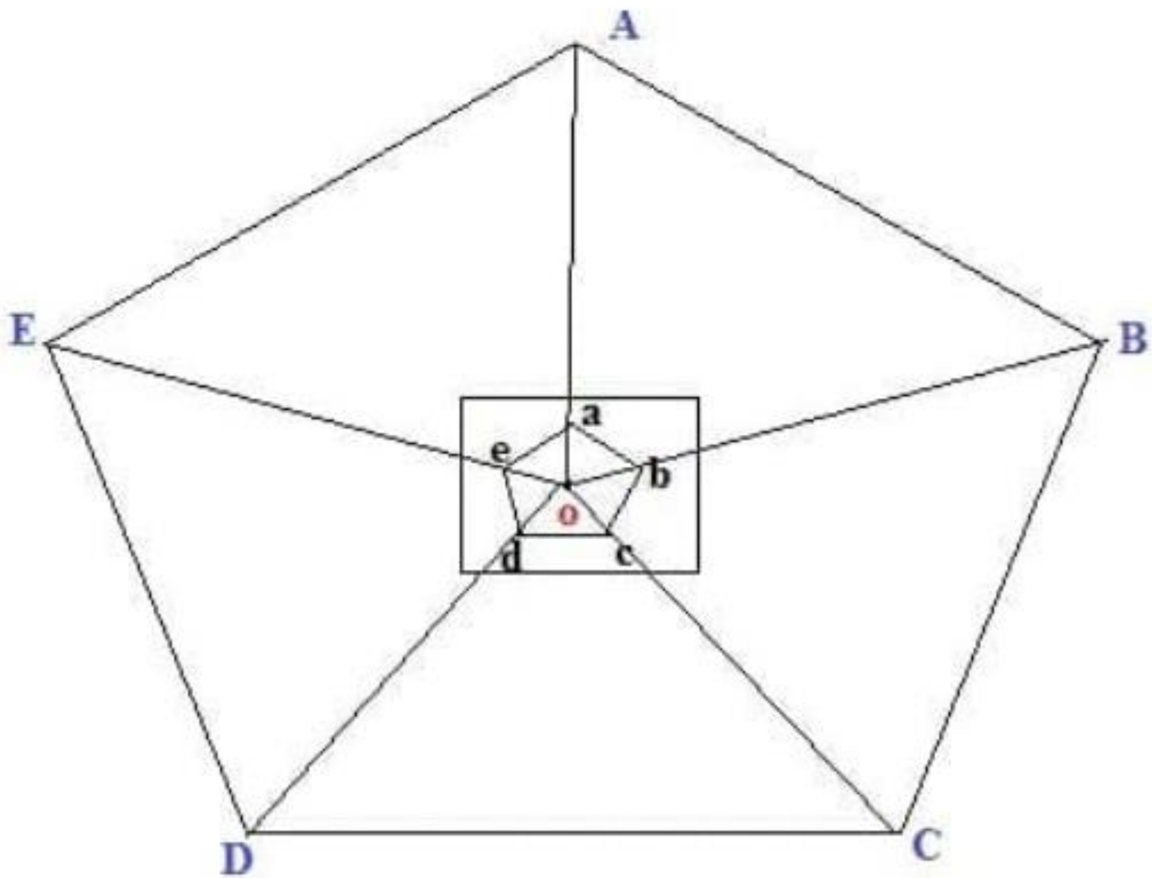
1. Radiation

2. Intersection

3. Traversing

**Radiation**

In this method, plane table is located at one point "o" as shown in fig. and perform the whole from that point. From point O, sight the points A,B,C,D and E using alidade, locate and plot the points as a,b,c,d and e in the drawing sheet.



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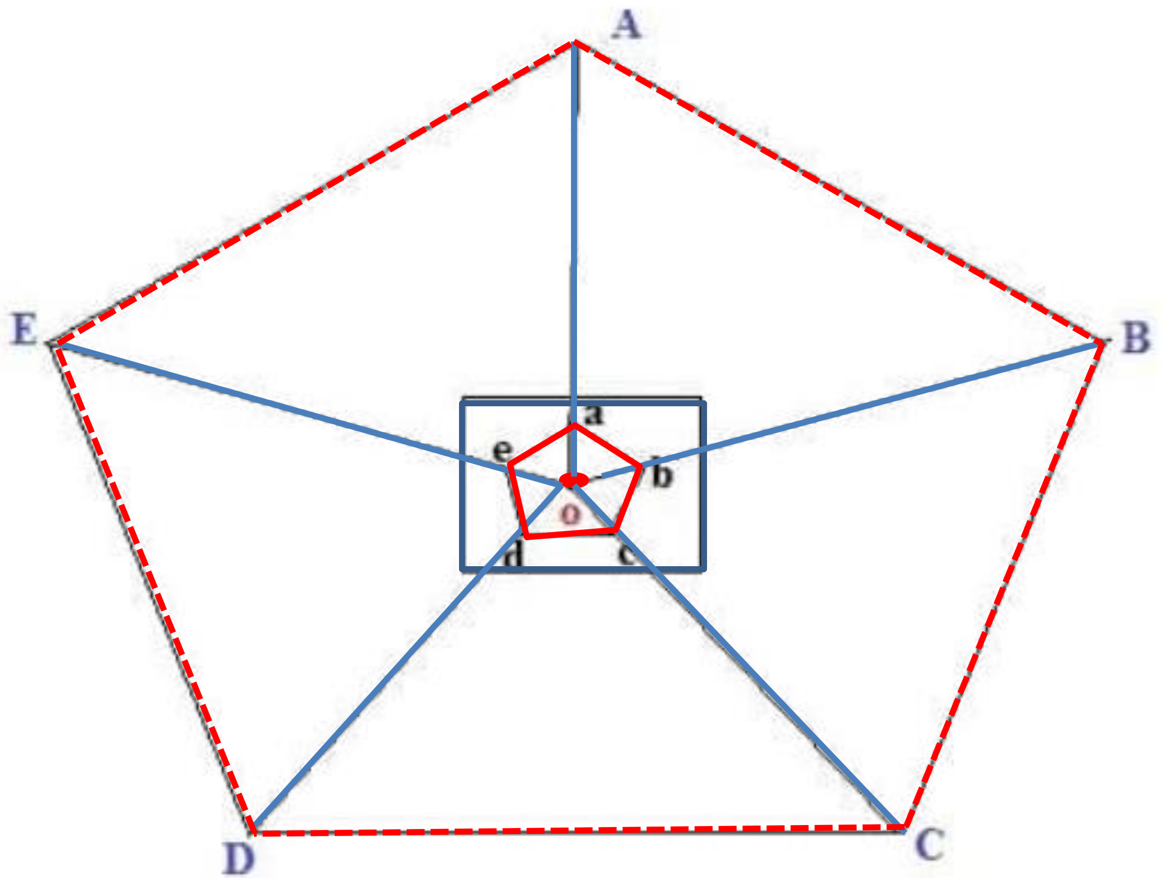
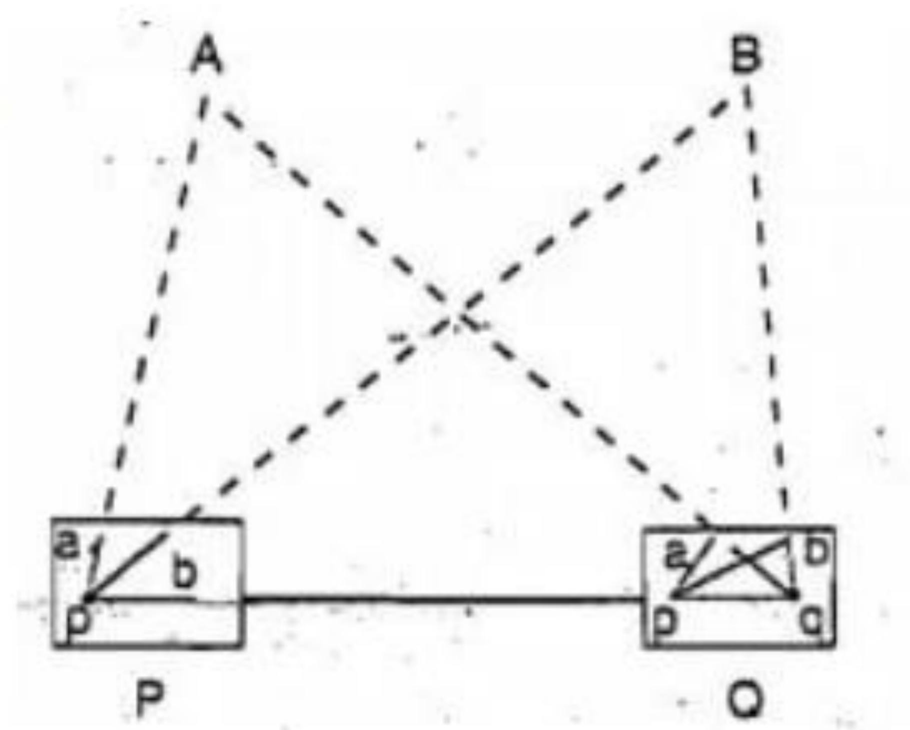


**Intersection**

In this method we can locate the point by plotting two rays from two known stations. As shown in figure, P and Q are the known station. First the equipment is placed on P and plot the lines by sighting the stations A, B and Q. then shift the equipment to station Q and plot the lines by sighting stations A, B and P. Finally, the intersection of A and B rays is the required location of point of intersection.



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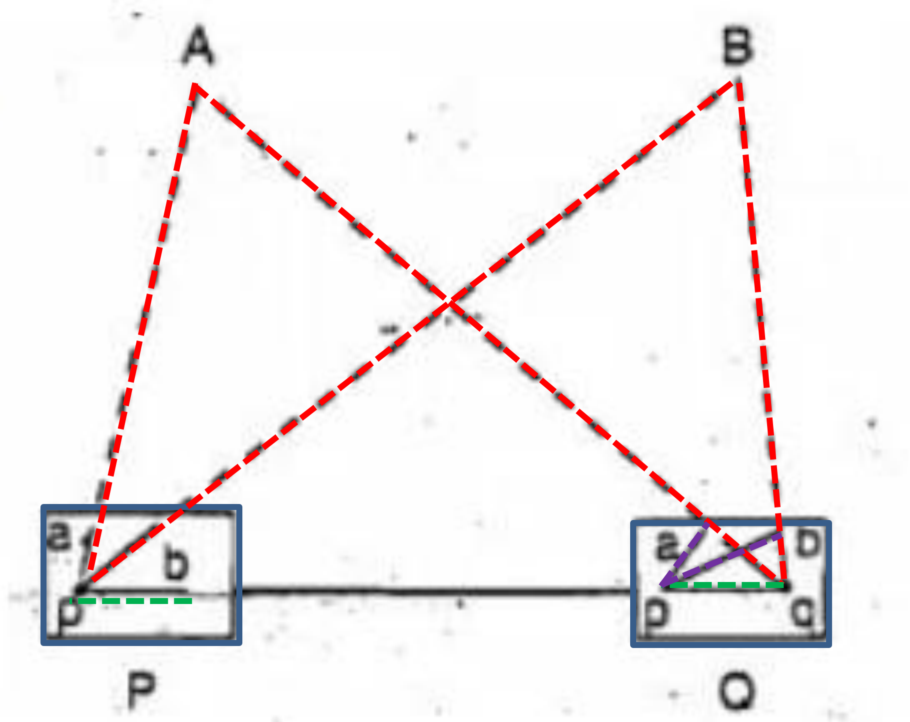
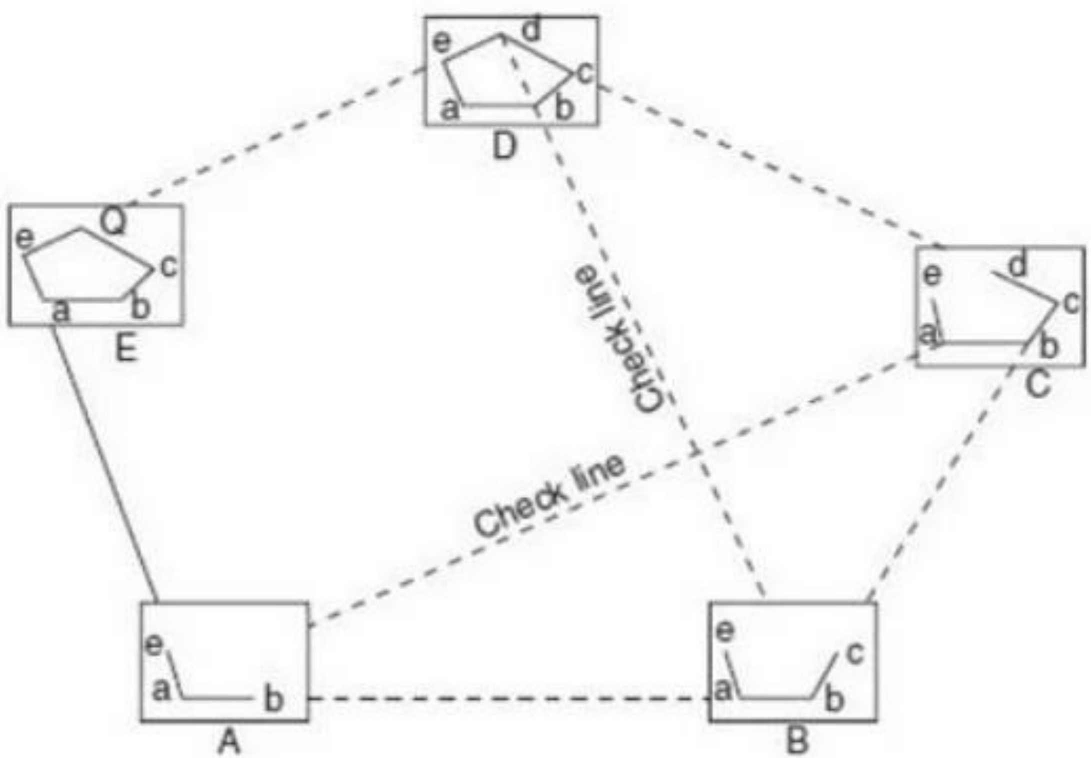


**Traversing**

Traversing is the connection of series of straight lines. In case of traversing, plane table is located at one point for suppose A as shown below. From that point sight towards B and measure the distance AB. Then shift the plane table to point B and sight towards A and measure BA. Average distance of AB and Ba are plotted to scale in drawing sheet. Then Sight the point C from B and measure BC and repeat the same procedure until last point. Conduct some checks at some points. Finally traverse lines are plotted on the drawing sheet.



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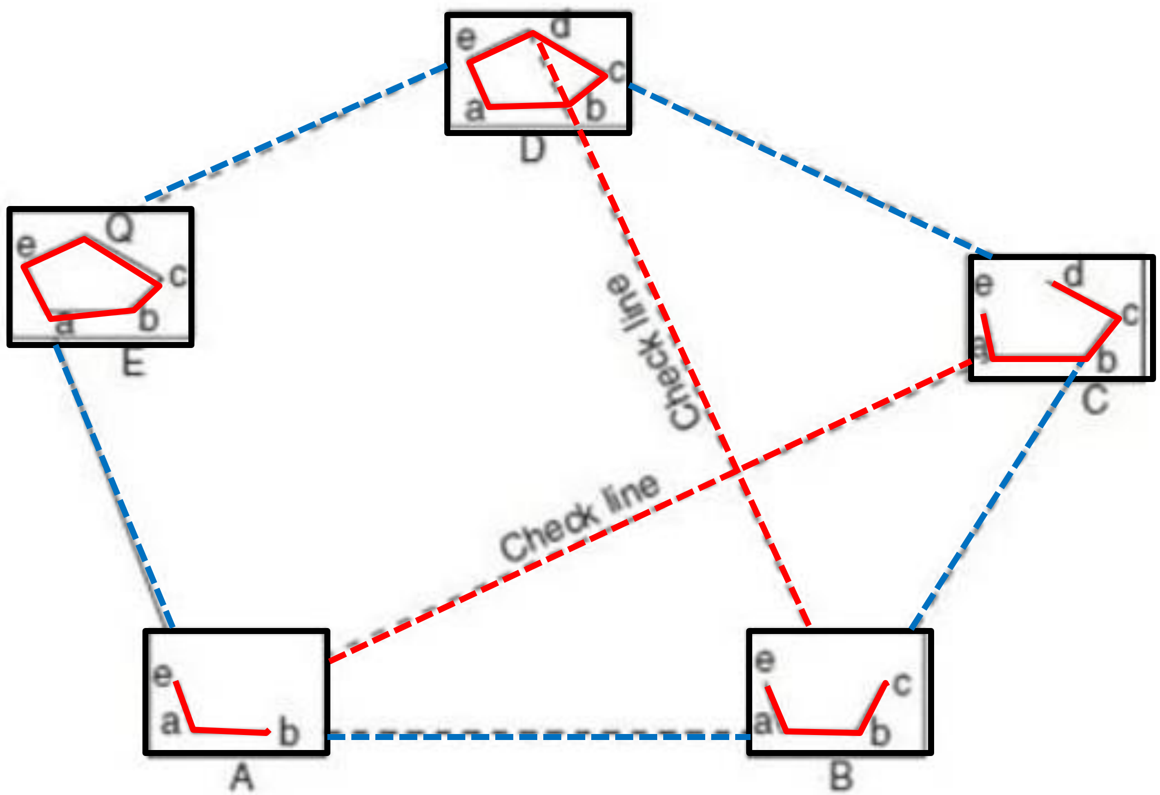


**Advantages of Plane Table Survey**
The advantages of use of plane table in surveying are-

- It is the most used and suitable method for surveying and preparing small scale maps.

- All possible human and machine errors can be eliminated as the surveying and plotting are done simultaneously in the field.

- Plane table surveying finds its importance in the places with high magnetic fluctuations where compass survey is not reliable.

- As this type of survey does not use the machine, it is less costly than most of the type of surveying techniques.

- It is one of the most rapid surveying techniques.

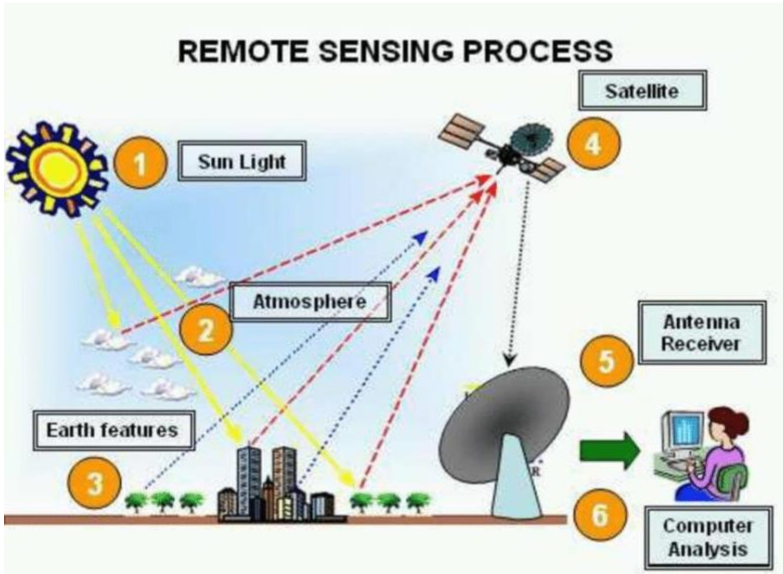
- Errors occurring due to mistakes in the field book entry are eliminated.

- Contours and other irregular objects may be accurately represented on the map since the tract is in view.
- It does not require skilled personal to plot the map.
- The errors and mistakes in plotting can be checked by drawing check lines.

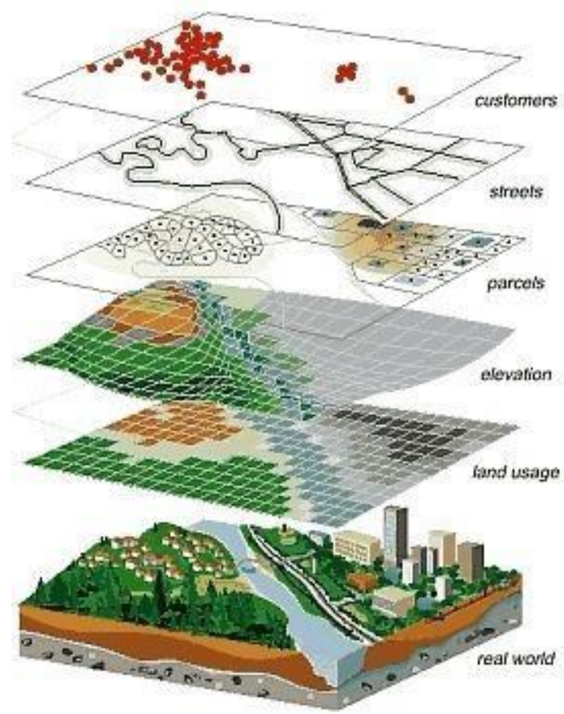
**Disadvantages of Plane Table Survey**

- The disadvantages of use of plane table in surveying are
- The process of shifting and re-orienting the plane table from one place to another is very lengthy.
- This type of surveying is not feasible in raining and windy areas as the plotting work are done in the field itself.
- The plane table and its accessories are heavy and difficult to carry
- The accuracy achieved in other types of surveying is higher than the accuracy achieved by plane table surveying.
- If the survey is to be repotted to a different scale or quantities are to be computed, it is a great inconvenience in the absence of the field notes.
- It is not suitable for surveying large areas.
- This method of surveying is not suitable in dense forest areas as the trees block the view of other important components of the field.
- This method of surveying can only be done in the day time.

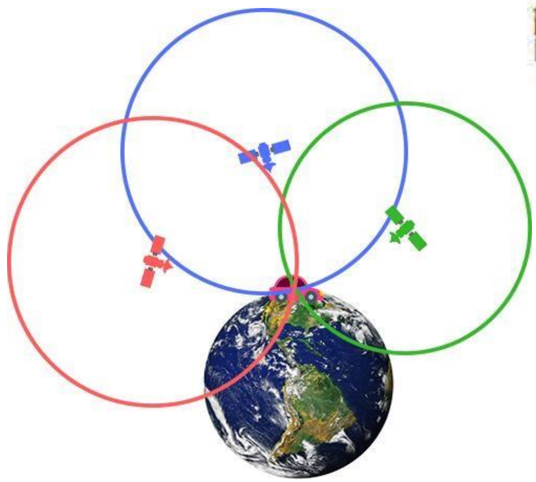
# Remote Sensing, GIS & GPS




Remote Sensing




Geographical information System



Global Positioning System

# Unit outcomes

1. **Describe the method of taking the images of the given object/area from the remote place.**

2. **Propose the relevant system of remote sensing to be used for given situation.**

3. **Describe the procedure to find the coordinates of the given station using GPS.**

4. **Explain the utility of GIS applications in given civil engineering problem.**

## Remote Sensing

**What is the remote sensing?**

Remote sensing is a method of **collecting and interpreting information about terrain and other objects from a distance <u>without being in physical contact with the objects.</u>**

Remote sensing is advanced technique of obtaining the information (Spectral,spatial,Temporal) about material objects, area or phenomenon without coming in to physical contact with objects or area, under investigation.

The remote sensing ,information transfer is accomplished by use of **electromagnetic radiation (EMR)**

*Remote sensing is the practice of **<u>deriving information</u>** about the **<u>Earth's land</u>** and water surfaces using images acquired from an **<u>overhead perspective</u>**, using* **<u>electromagnetic radiation</u>** *in one or more regions of the electromagnetic spectrum, **<u>reflected or emitted</u>** from the Earth's surface.*

## Necessity of Remote Sensing System

Earlier days the information collected through standard maps , books and the actual field visits to the site collecting ground information with the photographs and notes.

Each one having some disadvantage to collect the information about the site or field, like
1.Books- Subjective information and not up to date

2.Maps-Better than the books but have an scale problems, like small scale map doesn't give the details, and lager area details in single sheet.

3.Photographs- coverage area of the picture frame altitude and other limitations.
4. Filed visits- limitations to do field visit

To overcome all these problems Remote Sensing is used to collect the detail information of the terrain without being in physical contact with the objects.

## Necessity of Remote Sensing System

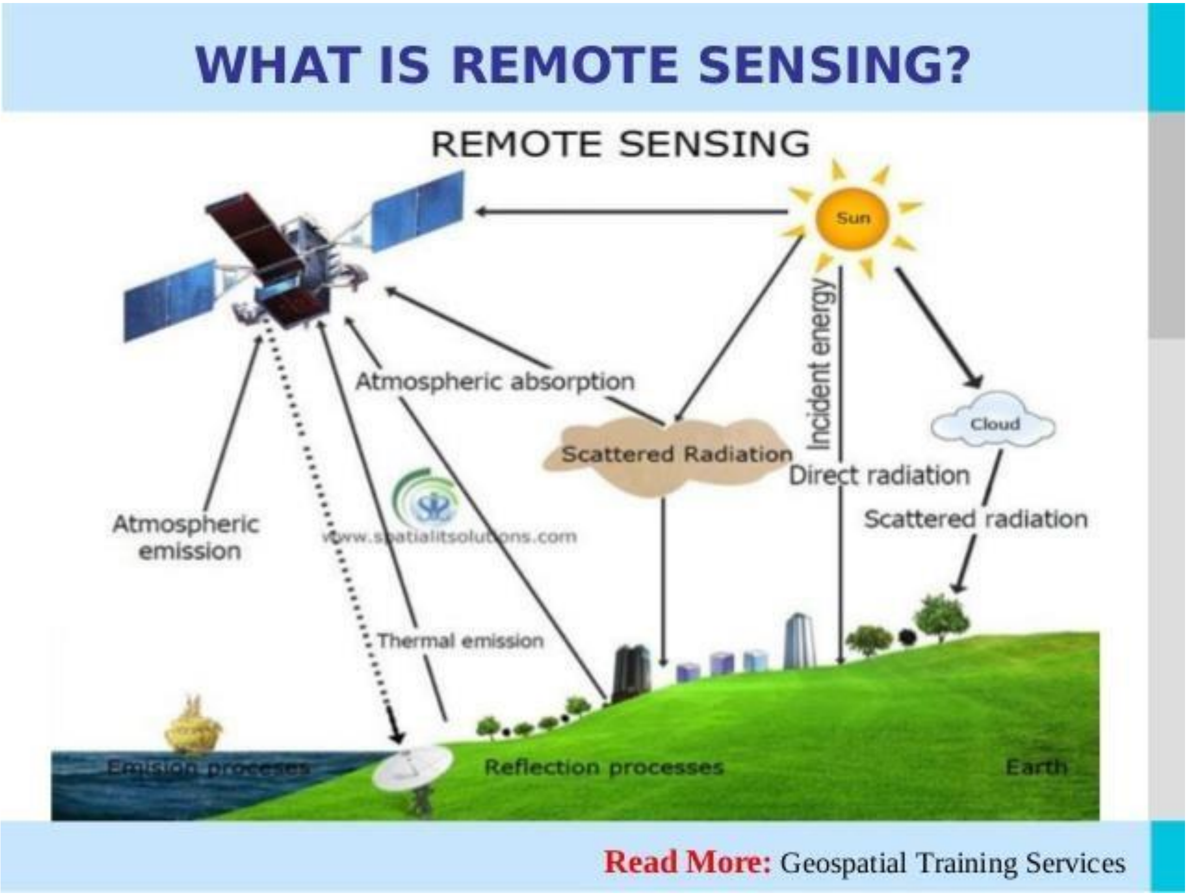
- Systematic data collection
- Information about three dimensions of real objects
- Repeatability

- Global Coverage
- The only solution sometimes for the otherwise in accessible areas.(e.g-

  Natural Disaster)
- Multipurpose information

**Principle of Remote Sensing**

"Sensing the earth's surface from space by making use of the properties **of electromagnetic waves emitted**, reflected or diffracted by the sensed objects by using natural resource management, land use and artificial resources".

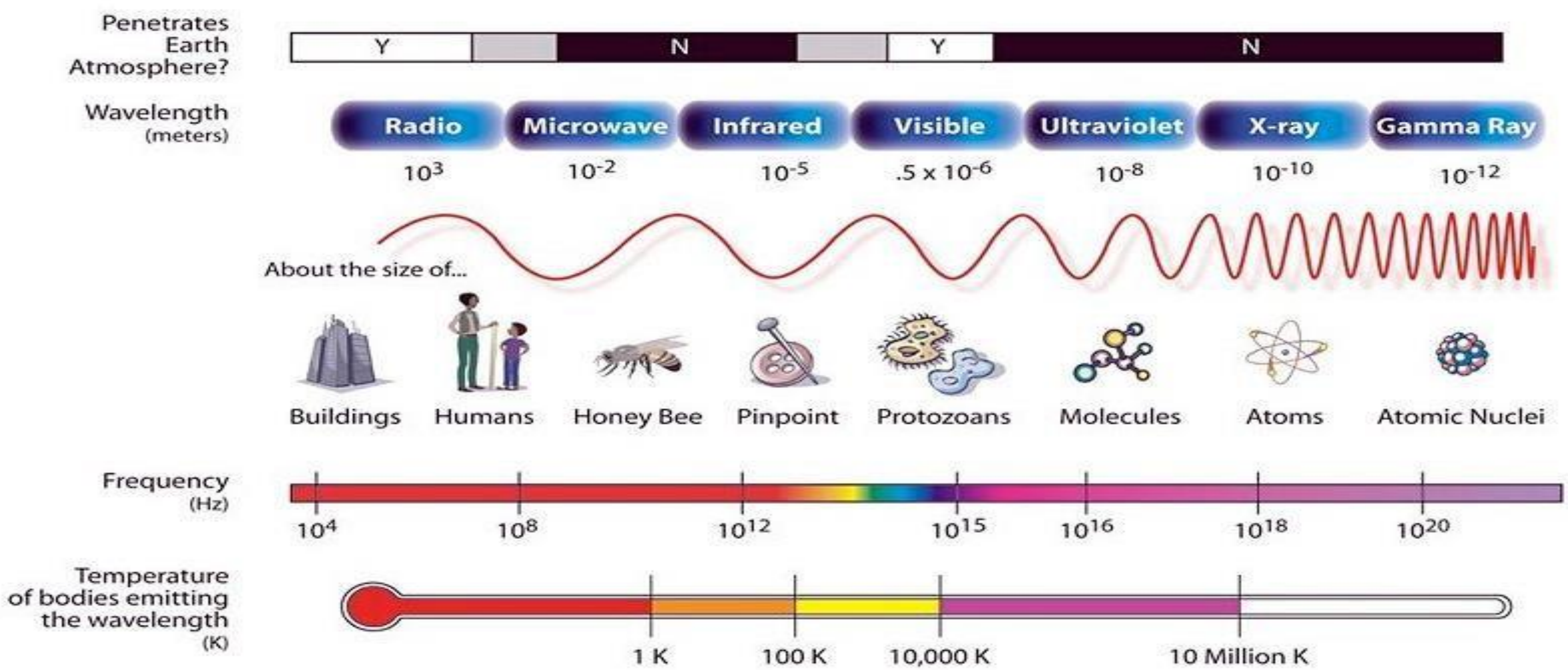



The electromagnetic energy from the **source passes through atmosphere** to the earths surface and it get reflected from the earths surface and it again pass through the atmosphere to the sensors.

This is the principle of **energy interaction in atmosphere and earths surface features.**

The **wave length and spectral distribution of energy is modified by the atmosphere to some extent** and this modification varies with respect to wave length.

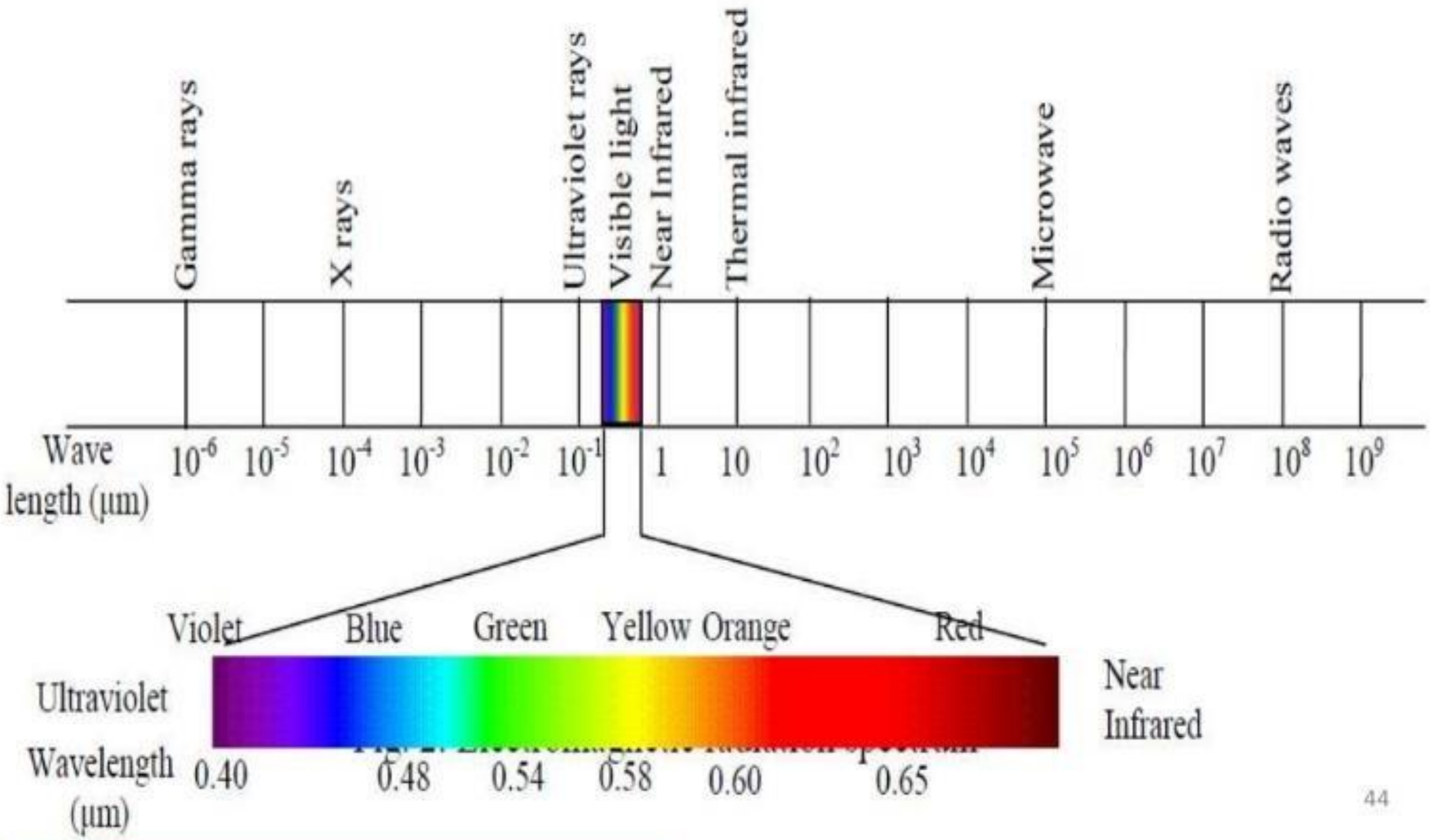
## Electromagnetic Spectrum




**The most familiar form of EMR is visible light, which forms only a small (but very important) portion of the full EM spectrum. The large segments of this spectrum that lie outside the visible range require our special attention because they**

**may behave in ways that are quite foreign to our everyday experience with visible radiation.**

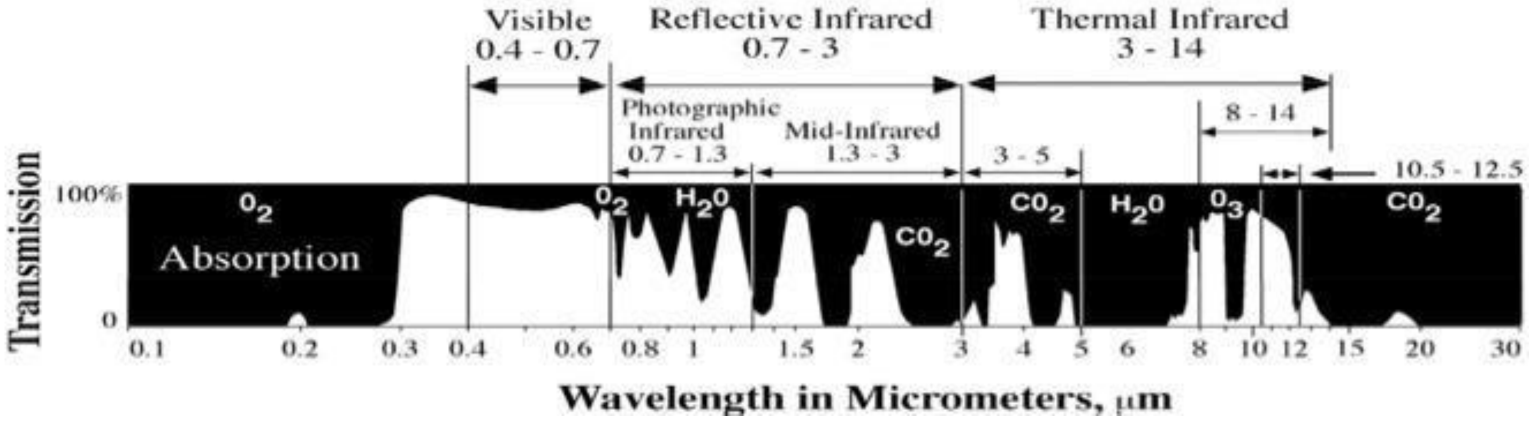
# ELECTROMAGNETIC SPECTRUM



## Atmospheric Window-

Earth's atmosphere is by no means completely transparent to electromagnetic radiation because the gases ($O_3$, $O_2$, $CO_2$ & $H_2O$ ) together form important barriers to transmission of electromagnetic radiation through the atmosphere

Atmosphere selectively transmits energy of certain wavelengths; those wavelengths that are relatively easily transmitted through the atmosphere are referred to as *atmospheric windows*




**Atmospheric windows are vitally important to the development of sensors for remote sensing**

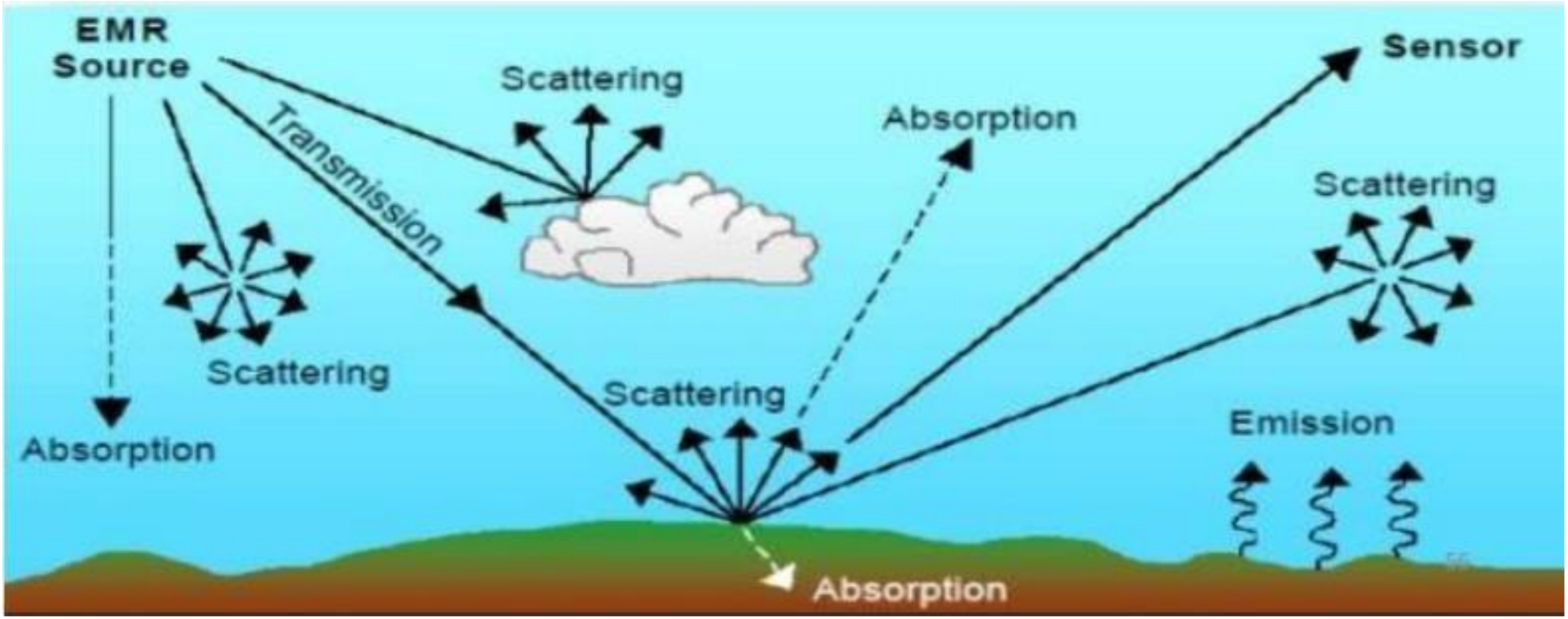
## Atmosphere affects the electromagnetic radiation

1. **Scattering**- Scattering of the electromagnetic radiation is caused by the molecules of gases, dust and smoke in the atmosphere.
2. **Absorption**- molecules of ozone , $CO_2$, and water vapour in the atmosphere absorb some of the electromagnetic radiation.

## Interaction of electromagnetic radiation with matter

- **Transmission- Incident radiation which passes through matter**
- **Absorption- Incident radiation absorbed by matter.**
- **Emission- Emission is energy emitted by the matter.**
- **Scattering – rough surface cause scattering.**
- **Reflection-some of the electromagnetic energy is reflected from the surface of the matter.**

## Interaction of electromagnetic radiation with matter

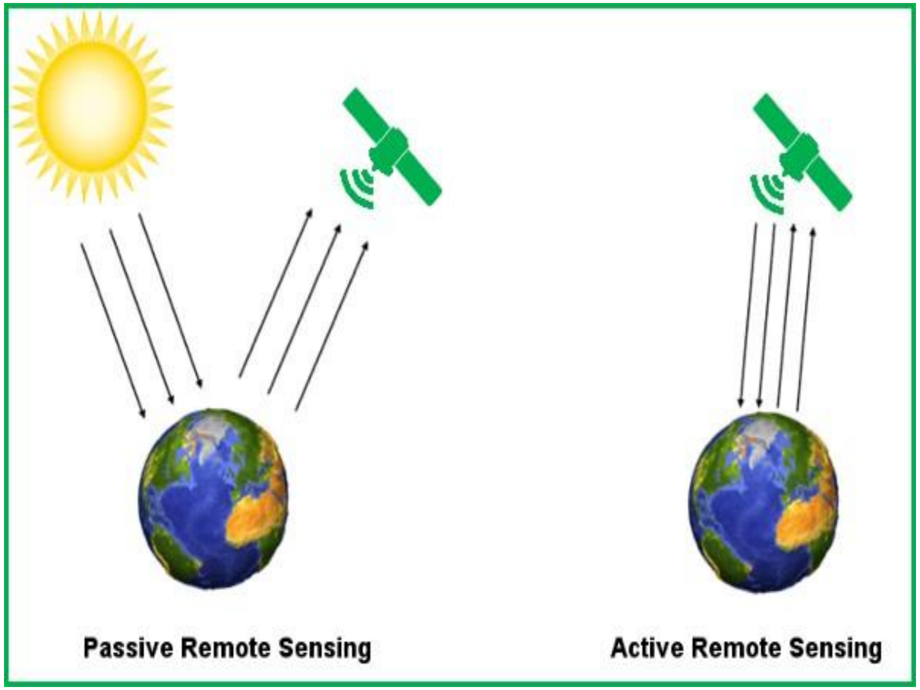



## Types of remote Sensing- Based on Energy Source

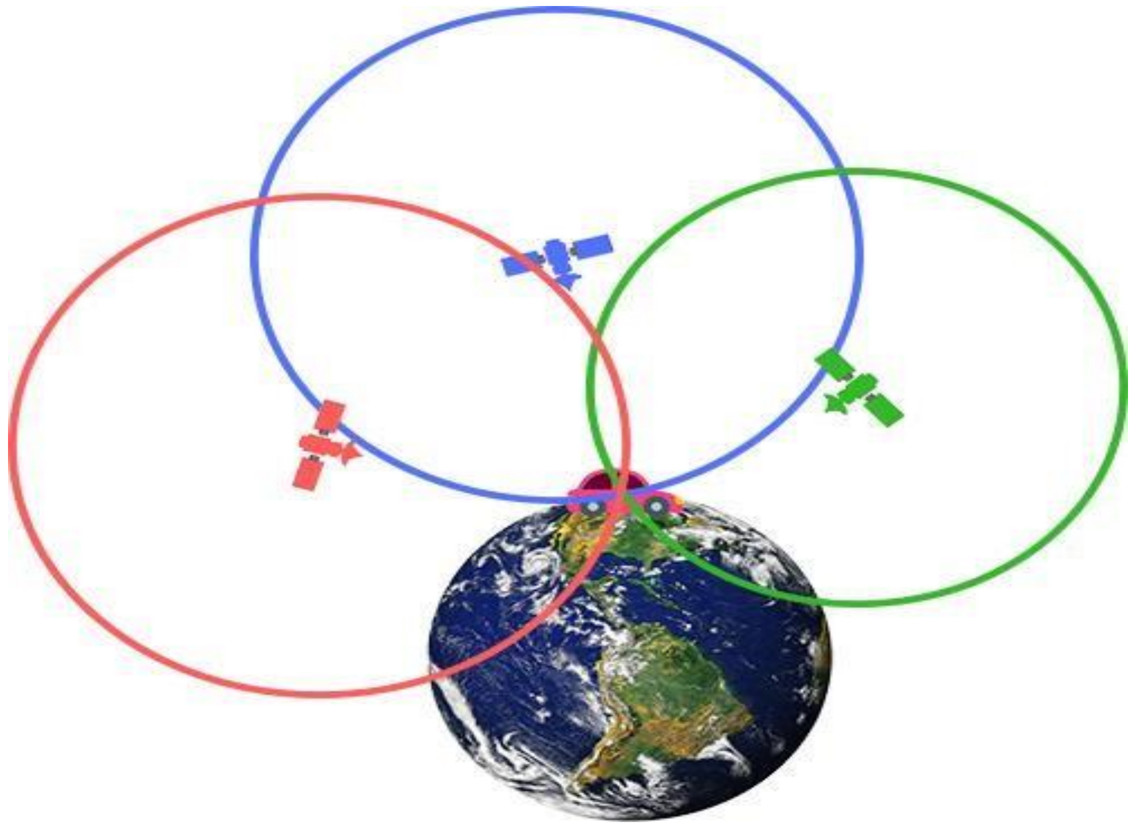
1. **<u>Active Remote Sensing</u>**- An Active remote sensing system, has its own energy source for illumination. Remote sensing data is available any time, day or night, for all the sensors. (e.g <u>Radar</u>)

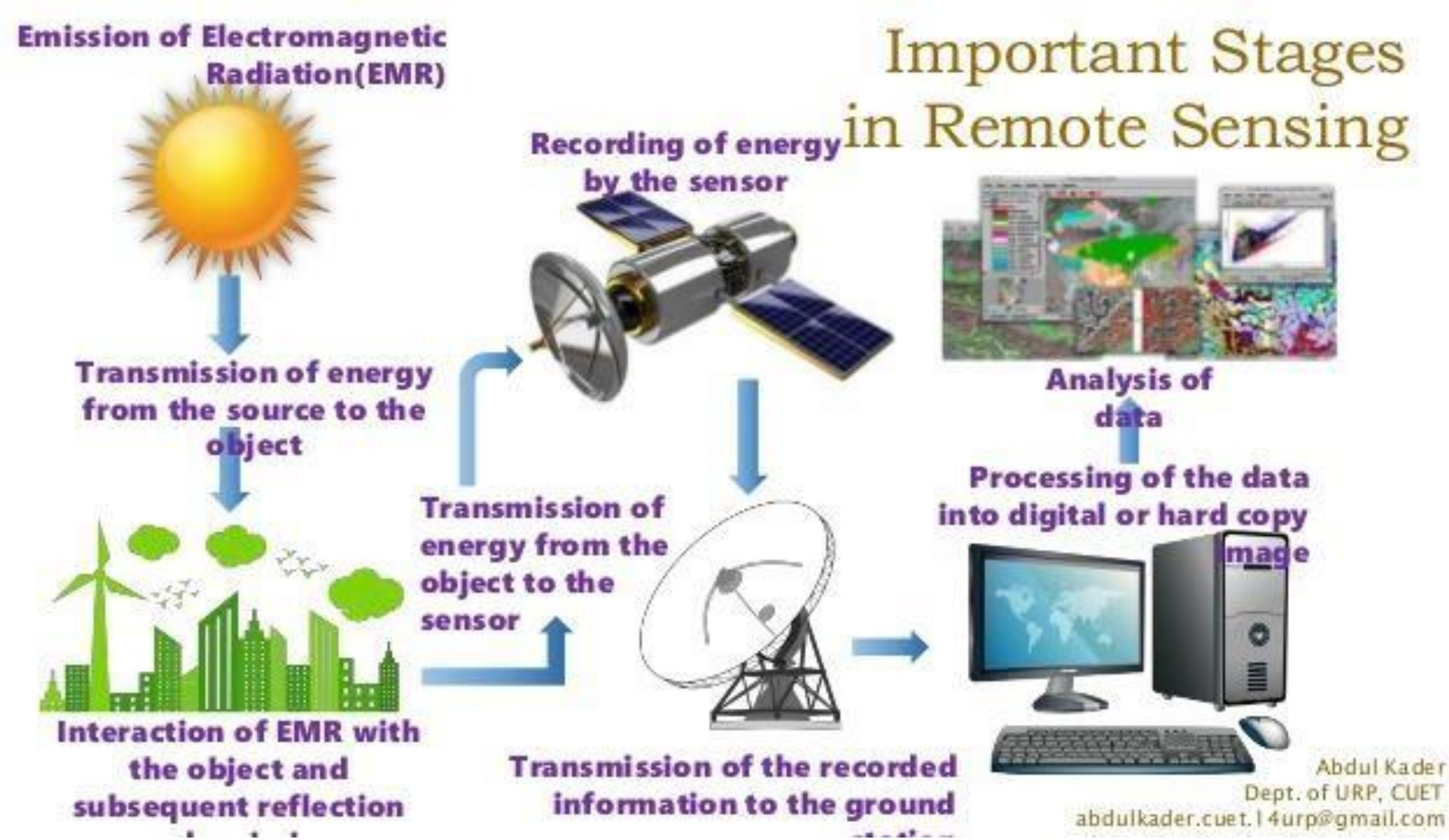
2. **Passive Remote Sensing**- Remote sensing work where system has no energy source of its own is called passive remote sensing. In this system, remote sensing work generally depends on an external energy source like the Sun.

**Stages in Remote Sensing System**



1. **Energy source**
2. **Propagation of energy**
3. **Interaction with matter**
4. **Return signal**
5. **Recording**
6. **Supply of information**





Important Stages in Remote Sensing
Emission of Electromagnetic Radiation(EMR)
Transmission of energy from the source to the object
Interaction of EMR with the object and subsequent reflection
Transmission of energy from the object to the sensor
Recording of energy by the sensor
Transmission of the recorded information to the ground
Processing of the data into digital or hard copy image
Analysis of data
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**Application of Remote Sensing in Various Fields**

1. Application of remote sensing in resource exploration (mining)
2. Environmental application
3. Land use and Land cover analysis
4. Locating natural Hazards( Disaster management)
5. Archaeology
6. Mineral Exploration
7. Mapping

**Application of Remote Sensing in <u>Civil Engineering</u>**

1. Silting of storage reservoirs and harbors-

2. Location of percolation Tanks- 3. Revision of existing toposheets - 4. Alignment of new highways and rail routes-

5. Location of bridge site-

6. Location of dam sites-

7. Tunneling-

8. Seepages losses in canals-

**Limitations of Remote sensing –**

1. Too costly to build and operate.

2. Needs Sound Knowledge and understanding of how the instrument is making the measurements.

3. Also requires knowledge of the phenomena you are sampling

4. Data interpretation is difficult.

**<u>Questions From Remote Sensing</u>**

1. Define Remote Sensing.
2. What is Remote sensing?
3. State the meaning of active and Passive remote sensing?
4. Difference between active and Passive remote sensing.
5. State with sketch the principle of remote sensing.
6. State the stages in remote Sensing.
7. State the applications of Remote sensing.
8. What are the field application of remote sensing in engineering science?

9. State the application of Remote sensing in civil engineering.

10. State any two advantages of remote sensing.

11. State the limitations of remote sensing.

**Application of GIS in Civil Engineering**

1. Street and Highway data

2. Land information system

3. Planning information System

4. Environmental Information System

5. Field of Surveying

# GEOGRAPHICAL INFORMATION SYSTEM (GIS)


**Definition of GIS**

A geographical information system refers to a system of capturing, storing and manipulating spatial( specific information of specific object) information in digital form with the help of computer hardware and software to analyse and present the features of the earth.

A **geographical Information system(GIS) is not one thing nor a single analysis, but rather a collection of hardware, software, data organization and professionals that together help people to represent and analyze geographic data**.

**GIS Components**

A successful GIS operation needs computer hardware, GIS software, spatial data and attributes, people and a well-defined , disciplined methodology of operation.

A integration of all five components simultaneously develops a GIS.

GIS Components are-

1. GIS Hardware
2. GIS Software- 3. Data- 4. People- 5. Methodology-


**Representation of Geospatial Data**

The geospatial object is represented in the form of either a point, line or a polygon in grid pattern or in vector form.

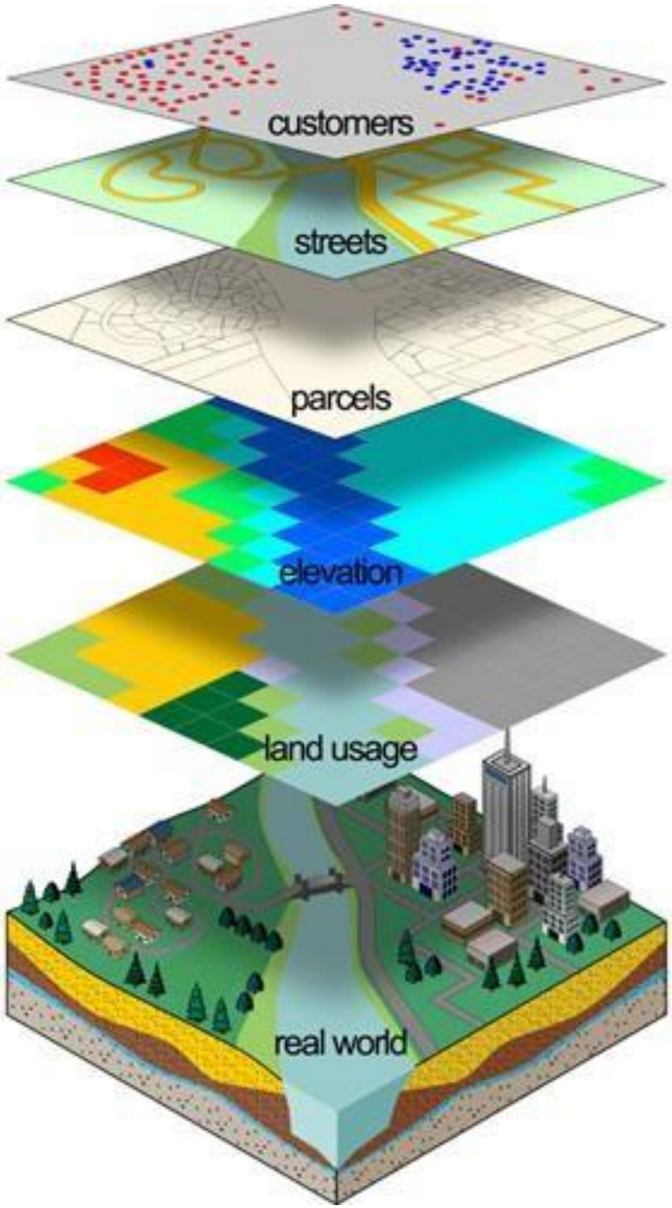
1. Point represents a spatial object having no area only with reference to a certain coordinate system, i.e latitude, longitude, etc.
2. Line represents the spatial object with no width and located from any one side.
3. Polygon represents spatial information of a closed area.

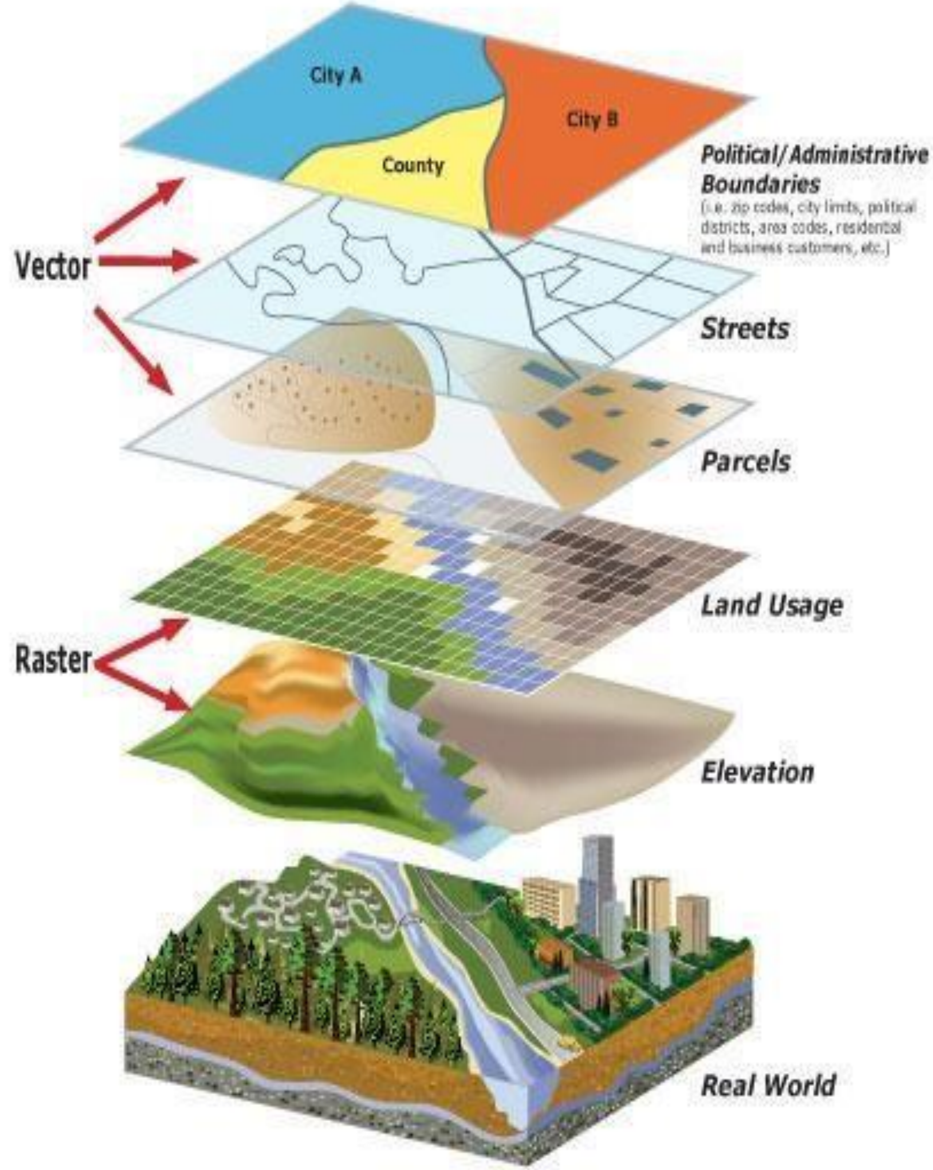
Modeling of Data –

**1.Raster mode**l- number of cells having definite coordinates are used.

**2. Vector Data**- Representation of objects in this model is either in point or line form with a definite coordinate system

## Layering of Data-

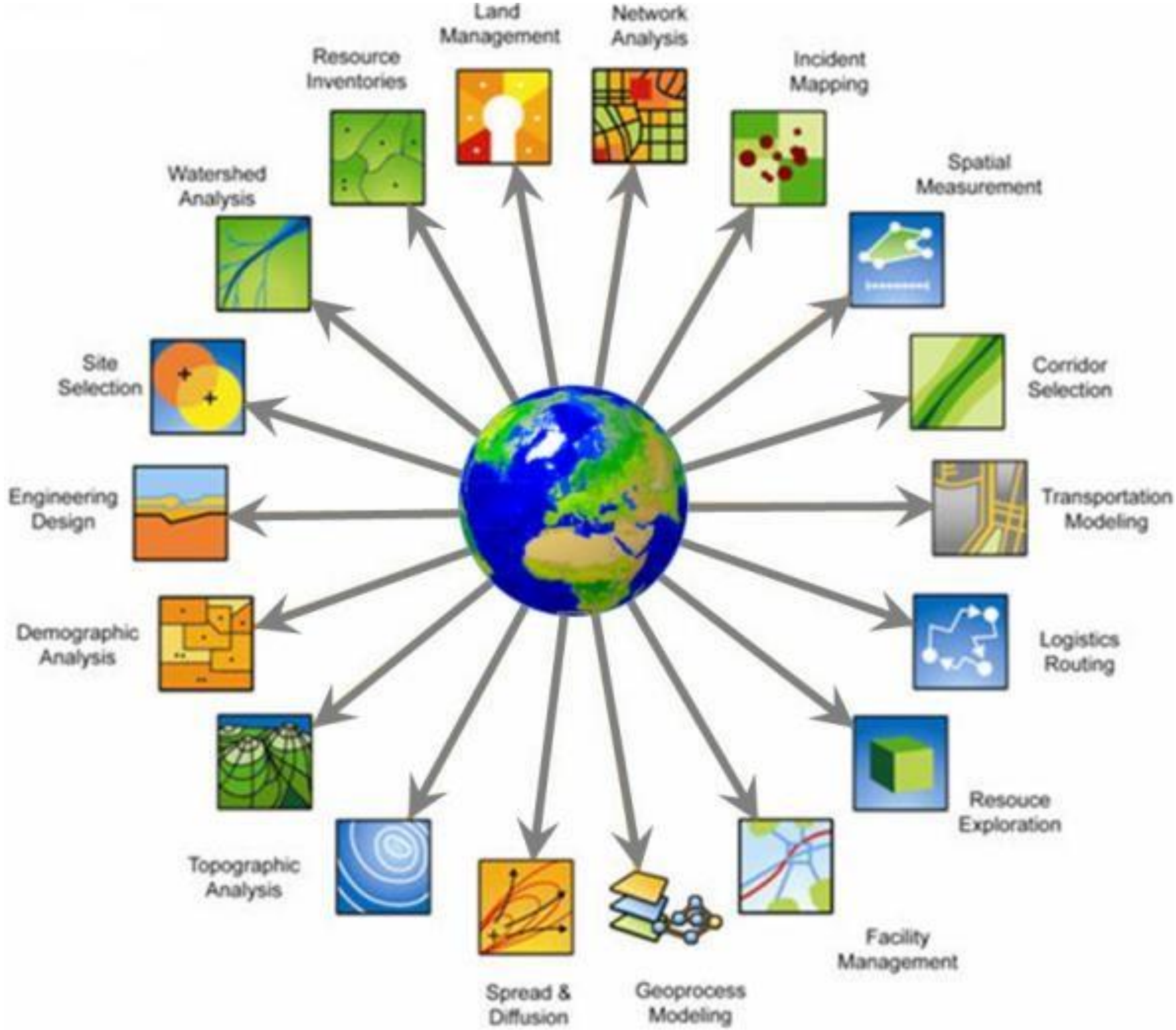


**Application of GIS**

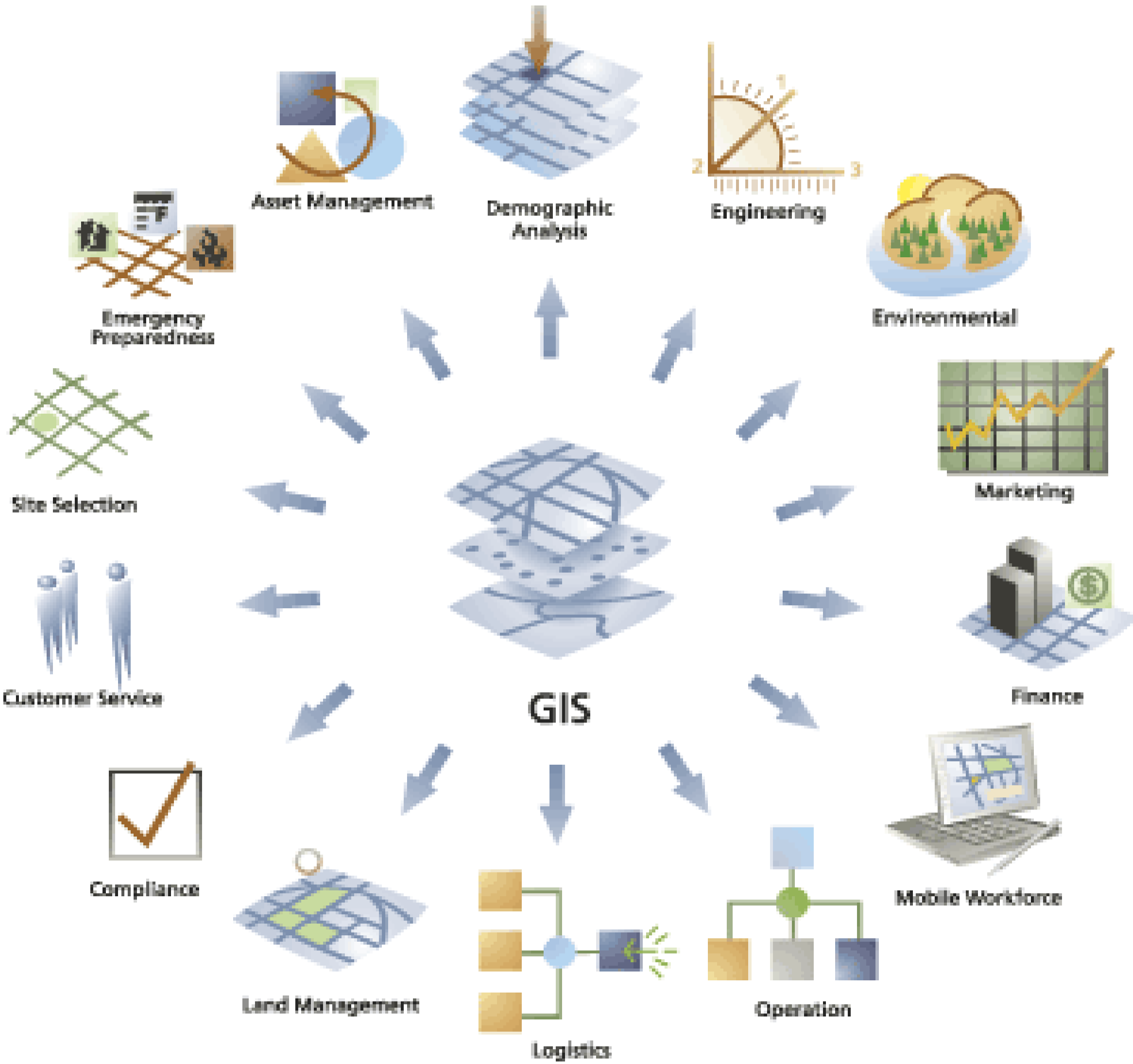
1. Land information
2. Environmental field
3. Map making
4. Site Selection
5. Network Analysis
6. Environmental Applications

# GIS Application in Civil Engineering



Land Management
Network Analysis
Resource Inventories
Incident Mapping
Watershed Analysis
Spatial Measurement
Site Selection
Corridor Selection
Engineering Design
Transportation Modeling
Demographic Analysis
Logistics Routing
Resouce Exploration
Topographic Analysis
Facility Management
Spread & Diffusion
Geoprocess Modeling

# GIS Application in Various Fields



**Limitations of GIS**

1. Cost
2. Hardware limitations
3. Ease of use of GIS
4. GIS is new
5. Data Availability

**Name of the GIS Software's –**

1. **Arc GIS**
2. **Geo-media**
3. **Map-Info**
4. **Idrisi**

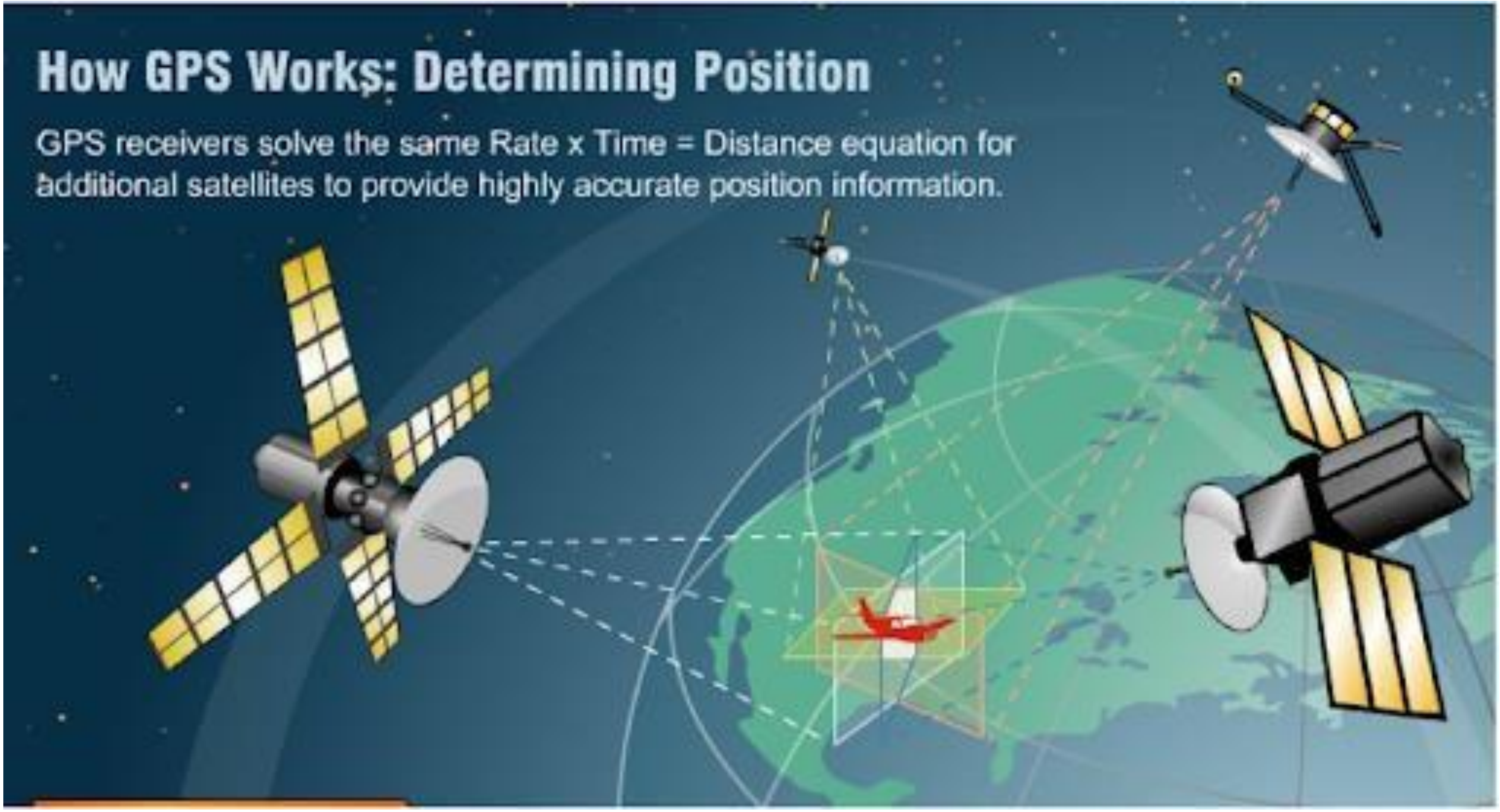
5. **ERDAS**

6. **Autocad Map**

7. **Microimages**

8. **Other Softwares**

# GPS (Global Positioning System)




**GPS**- Defined as a radio navigation system involving satellites computers

that can determine the latitude and longitude of receiver on the earth, by computing the time difference for signals reaching from different satellites to the receiver.

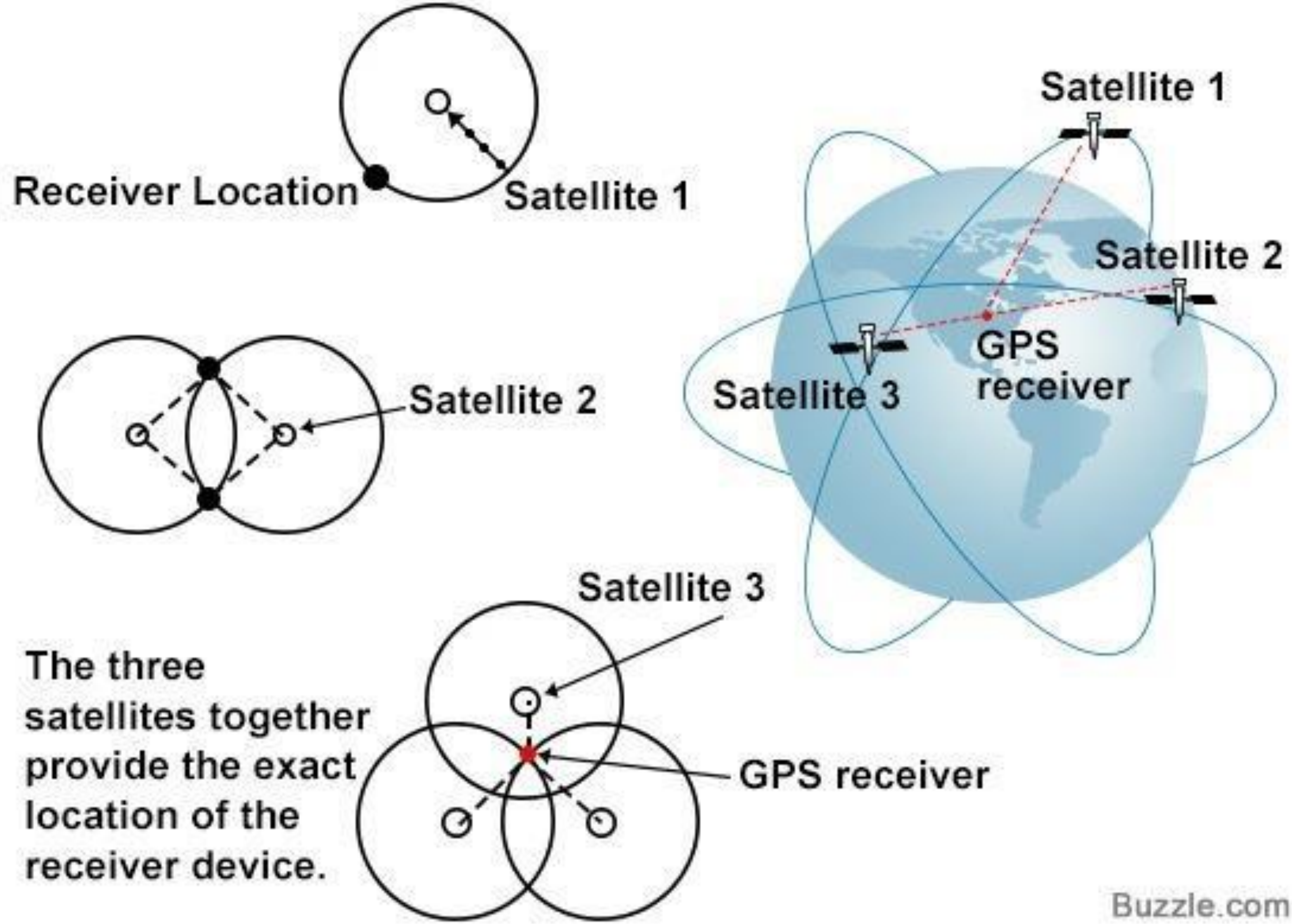
The Components of GPS system

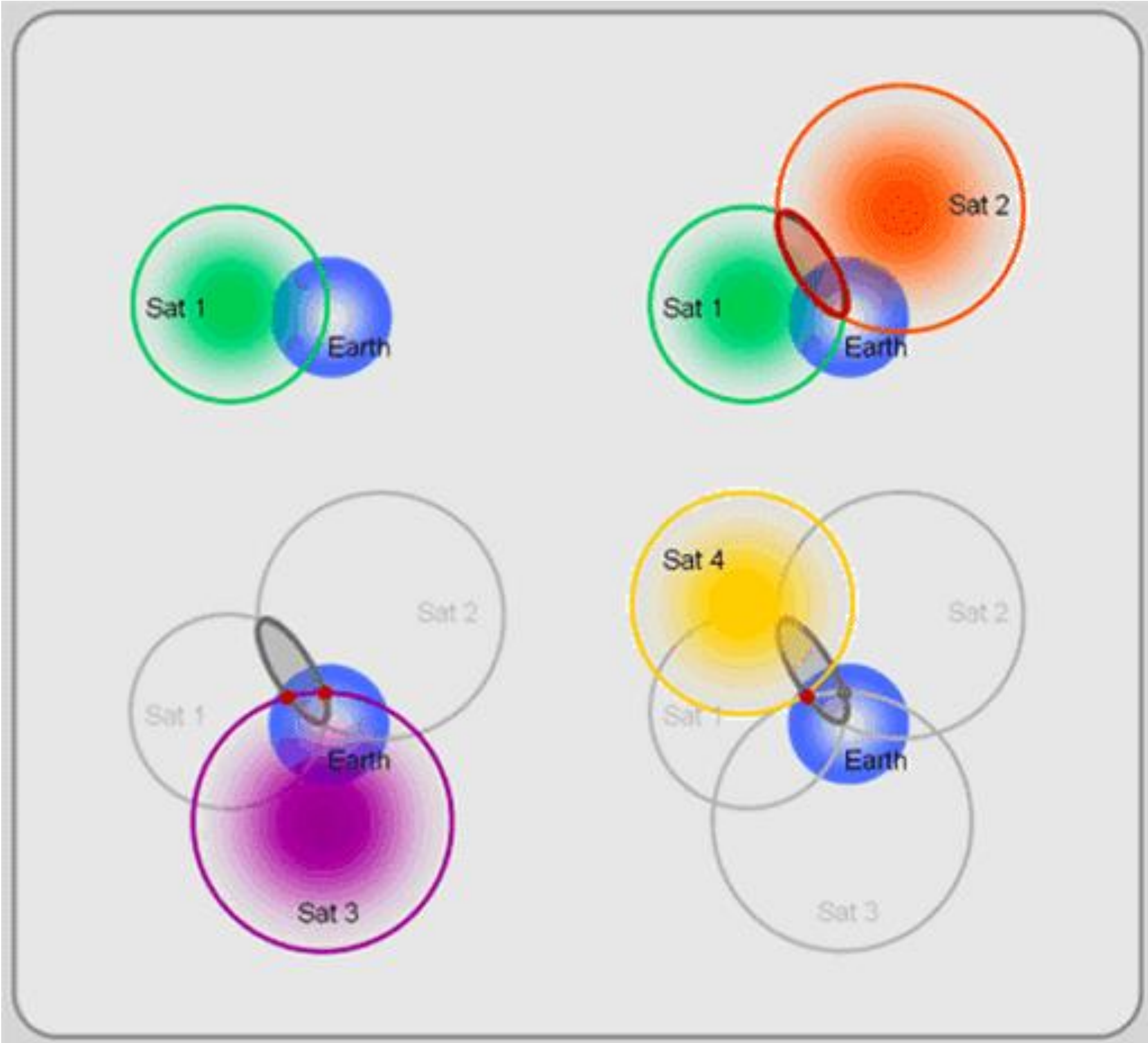
1. Space Segment
2. Control Segment
3. User Segment

- **Space Segment-**
- 30 GPS satellites inclined at 55degree and orbiting around in every 12 hour from height 10660miles.
- 27 satellites are active rest are spares rotating around 6 orbits.
- Due to earths rotation on its own axis satellite will take 24 hrs for a complete rotation.

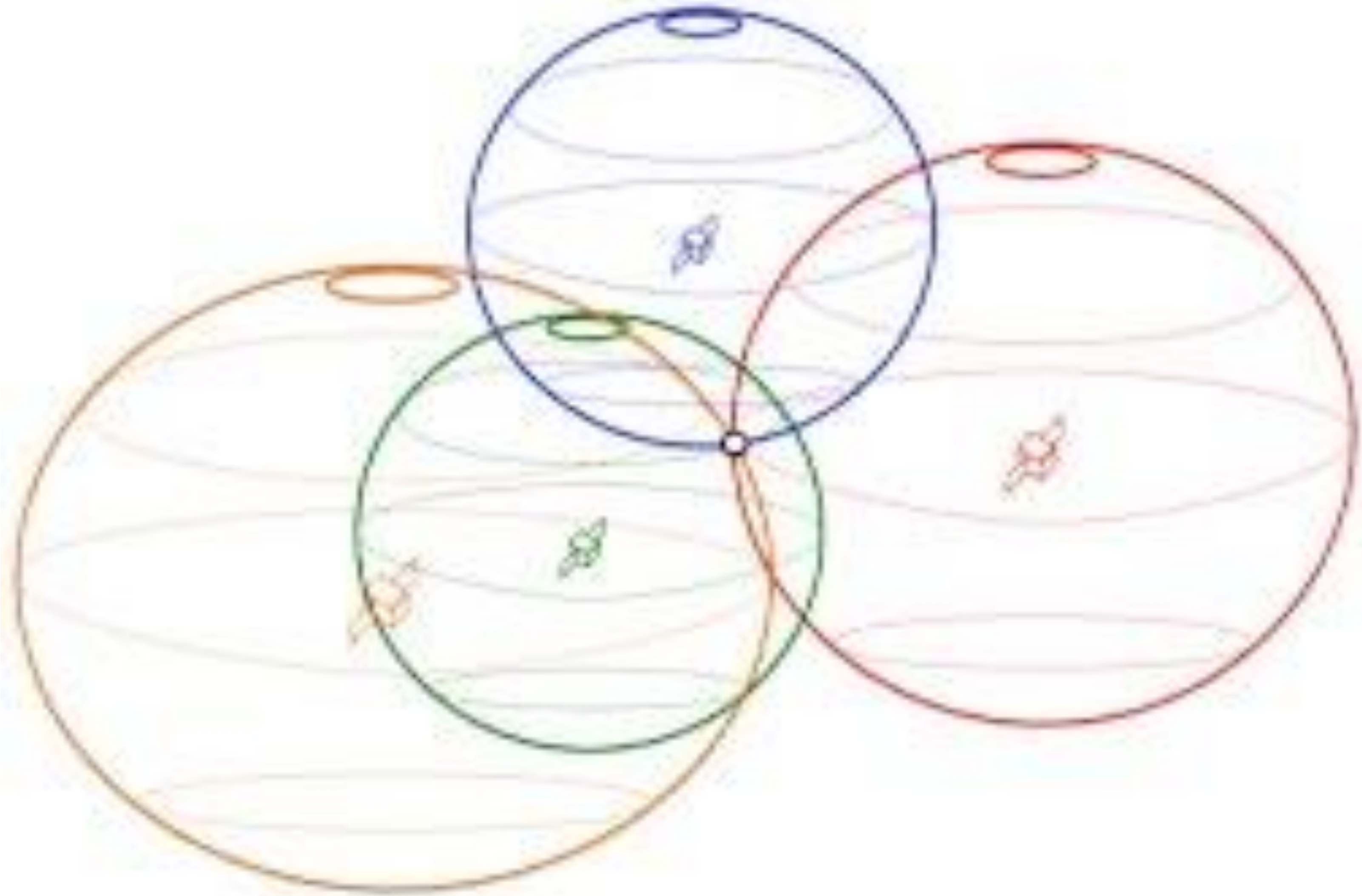
- **Control Segment**
- Monitor Station and Master Station to monitor signals and done neccesary corrections on time and orbital location.

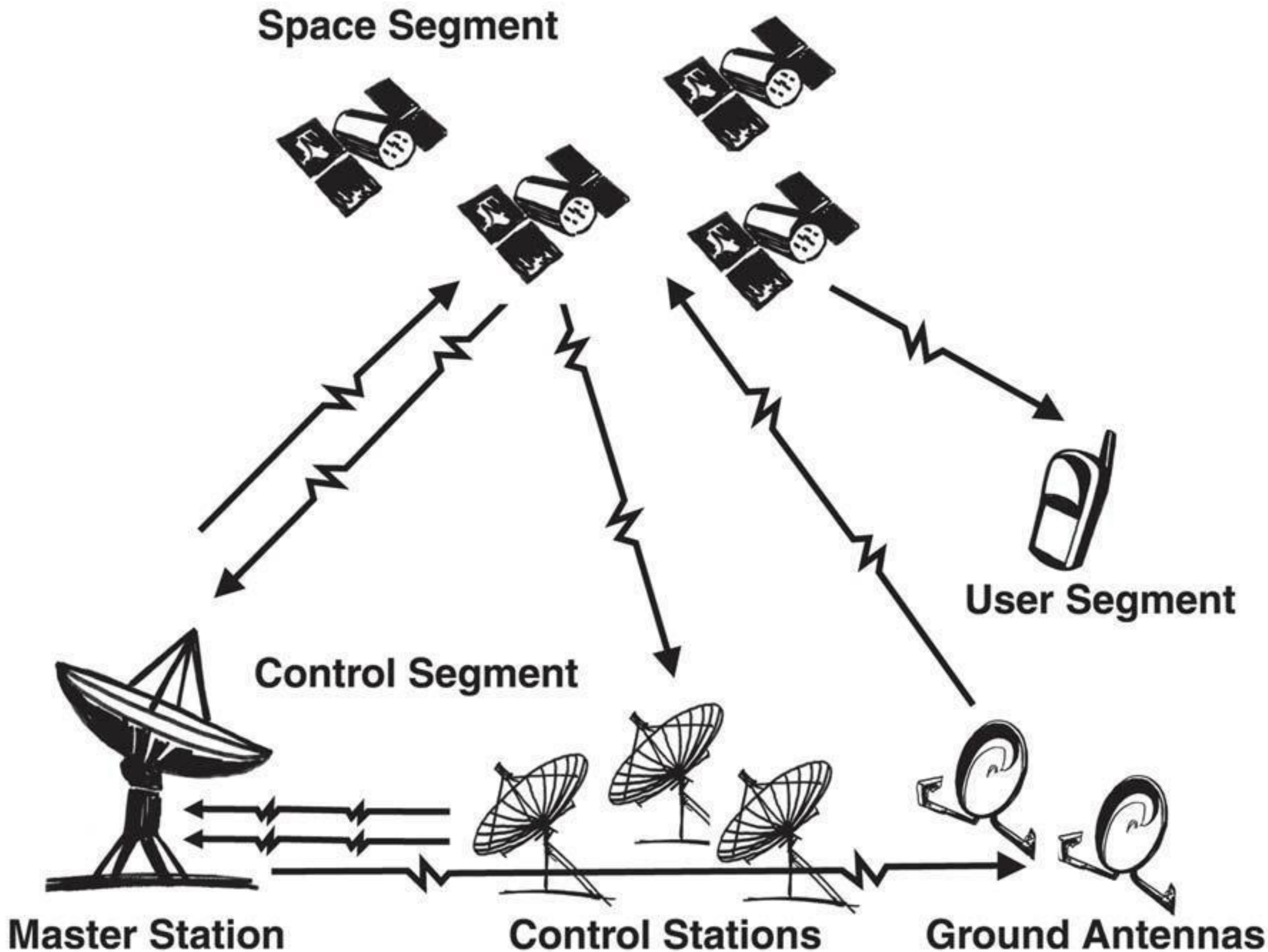
- **User Segments-** Different receivers at the end


Receiver Location
Satellite 1
Satellite 2
Satellite 3
The three satellites together provide the exact location of the receiver device.
GPS receiver
Satellite 1
Satellite 2
GPS receiver
Satellite 3
Buzzle.com



Sat 1
Earth
Sat 1
Sat 2
Earth
Sat 2
Sat 1
Earth
Sat 3
Sat 4
Sat 2
Sat 1
Earth
Sat 3




Space Segment
User Segment
Control Segment
Master Station
Control Stations
Ground Antennas


Agriculture
Space
Aviation
GPS
Timing
Environment
Space
Marine
Surveying &
Mapping