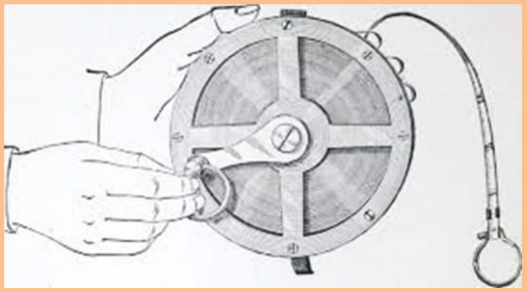
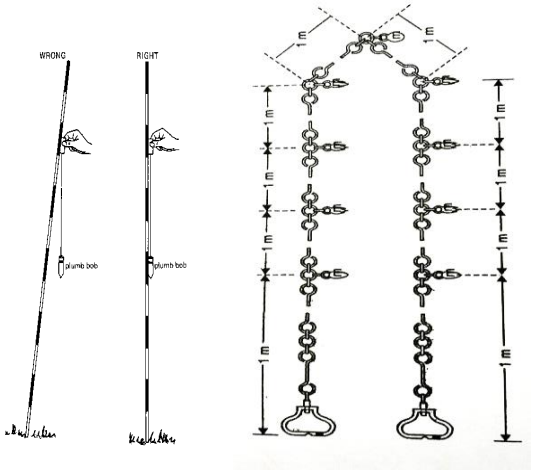
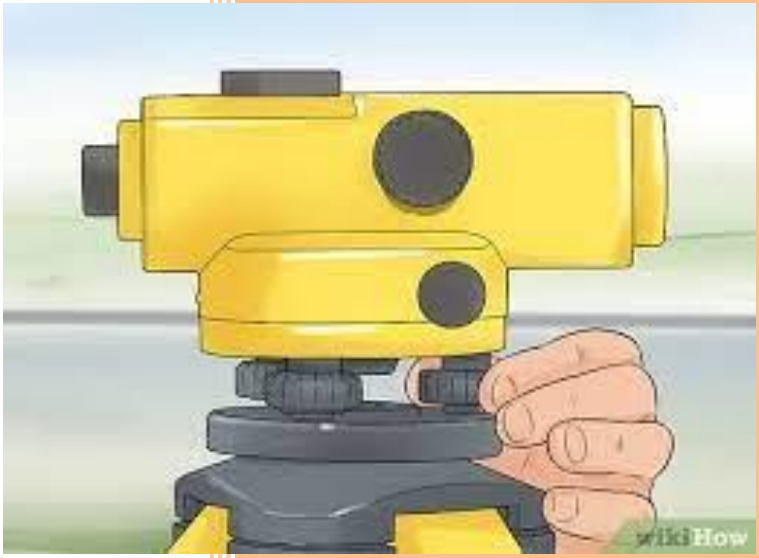
For 2nd Sem, Diploma in Civil Engineering

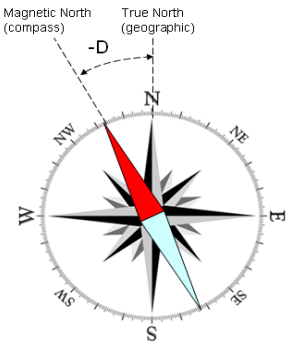


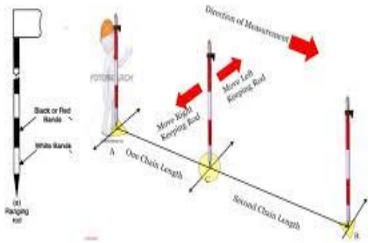
BASIC SURVEYING - 20CE22P

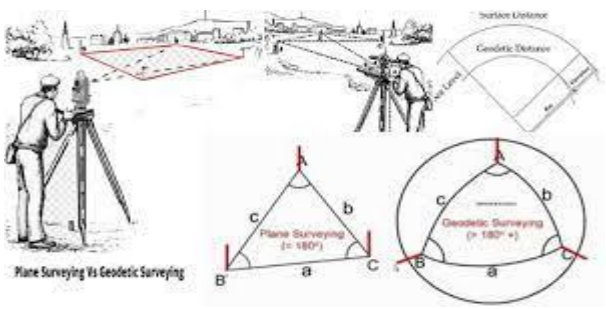
2021-22











NAGESHA M R

HEAD OF THE DEPARTMENT

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GOVERNMENT POLYTECHNIC SIDDAPURA

INTRODUCTION TO SURVEYING

UNIT 01: INTRODUCTION

Surveying is an art of determining the relative positions of various points on, above or below the surface of the earth by means of direct or indirect measurement of distance, direction and elevation. It also includes the art of establishing points by predetermined angular and linear measurements. The application of surveying requires skill as well as the knowledge of mathematics, physics and to some extent astronomy.

OBJECTIVES AND PURPOSE OF SURVEYING:

Following are the different objectives or Purpose of surveying.

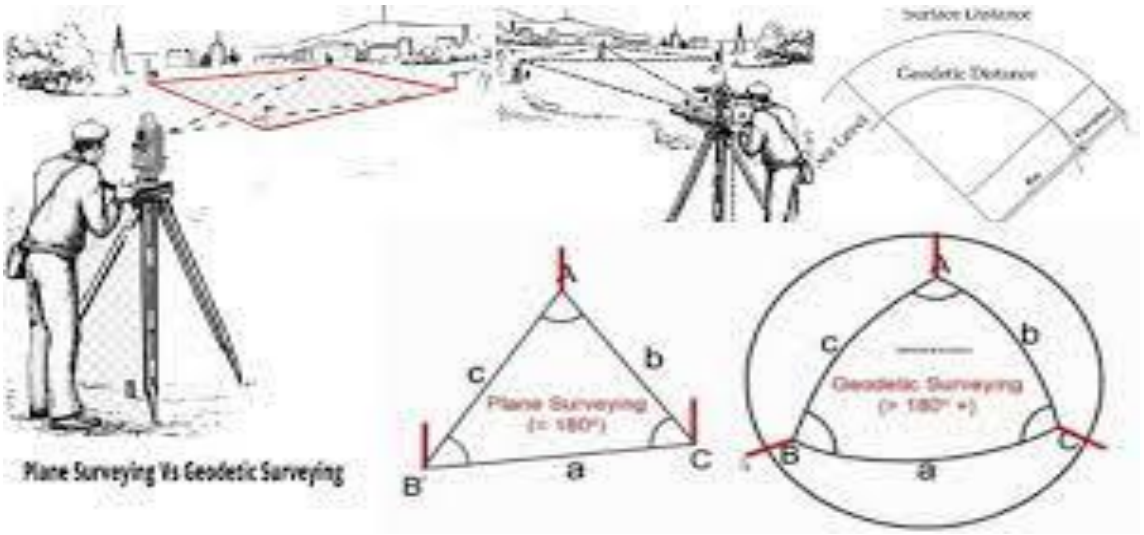
- ✓ To determine the relative position of any objects or points of the earth.
- ✓ To determine the distance and angle between different objects.
- ✓ To prepare a map or plan to represent an area on a horizontal plan.
- ✓ To develop methods through the knowledge of modern science and the technology and use them in the field.
- ✓ To solve measurement problems in an optimal way.
- ✓ To determine areas and volumes.
- ✓ To fix and measure the property lines.
- ✓ To find out the suitability of site for engineering works.

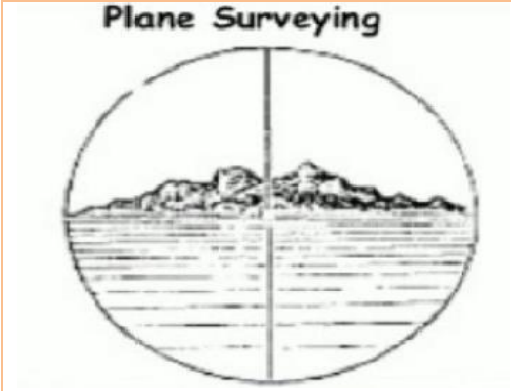
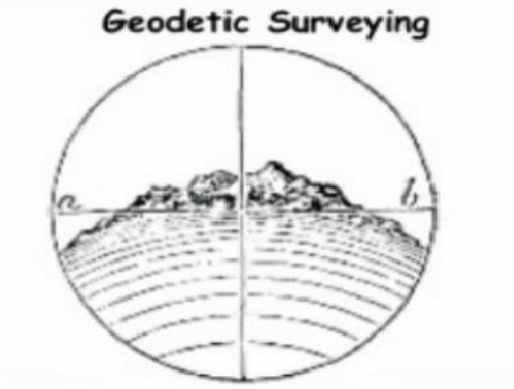
PRIMARY DIVISIONS OF SURVEYING:

The earth is an oblate spheroid of revolutions, the length of its polar axis 12713800 Metres being somewhat less than that of its equatorial axis 12756750 Metres. Thus the polar axis is shorter than the equatorial axis by 42.95Kilometres. relative to the diameter of the earth this is less than 0.34%. if we neglect the irregularities of the earth the surface of the imaginary spheroid is a curved surface. Every element of which is normal to the plumb line. The intersection of such a surface with a plane passing through the centre of the earth will form a line continuous around the earth. Surveying is primarily divided into two classes.

- ❖ **PLANE SURVEYING:** Plane surveying is that type of surveying in which the mean surface of the earth is considered as a plane and the spheroidal shape is neglected. All triangles formed by survey lines are considered as plane triangles. The level line is considered as straight and all plumb lines are considered as parallel. In everyday life we are concerned with small portions of earth's surface and above assumptions seem to be reasonable in light of the fact that the length of an arc 12kilometers long lying in the earth's surface is only 1cm greater than the subtended chord.

- **GEODETIC SURVEYING:** Geodetic surveying is that type of surveying in which shape of the earth is taken into consideration. All lines lying in the surface are curved lines and the triangles are spherical triangles. It involves spherical trigonometry. All geodetic survey includes work of larger magnitude and high degree of precision. The object of geodetic survey is to determine the precise positions on the surface of the earth of a system of widely distant points which form control stations to which survey of less precision may be referred.



Plane Surveying	Geodetic surveying
Effects of curvature of earth is ignored	Effects of curvature of earth is included
The earth surface is assumed to be plane i.e., two dimensional	The earth surface is assumed to be spherical i.e., Three dimensional
Involve smaller area less than 260km^2	Involve large area more than 260km^2
Less degree of accuracy	Higher degree of accuracy
Done locally by the individual organization	Done by the concerned state or Government department
	

CLASSIFICATION OF SURVEYING:

Surveying may be classified under headings which define the uses or purpose of the resulting maps.

1. **Classification based upon the Nature of the field of survey.**
    a. **Land Surveying:**
        i. ***Topographic survey:*** This consists of horizontal and vertical location of certain points by linear and angular measurements and is made to determine the natural features of a country such ass rivers, streams, lakes, woods, hills etc., and such artificial features ass roads, railways, canals, towns and villages.
        ii. ***Cadastral survey:*** Cadastral survey are made incident to the fixing of property lines, calculation of area or the transfer of land property from one owner to another. They are also made to fix the boundaries of municipalities and of state and federal judistrictions.
        iii. ***City survey:*** They are made in connection with the construction of streets, water supply systems, sewers and other works.
    b. **Marine or Hydrographic Surveying:** Marine or Hydrographic survey deals with bodies of water for purpose of navigation, water supply, harbour works or for the determination of mean sea level. The work consists in measurements of discharge of streams, making topographical survey for shores and banks, taking and locating surroundings to determine the depth of water and observing the fluctuations of the ocean tide.
    c. **Astronomical surveying:** The astronomical survey offers the surveyor means of determining the absolute location of any point or the absolute location and direction of any line on the surface of the earth. This consists in observation to the heavenly bodies such as Sun or any fixed star.
2. **Classification based on the Objects of survey.**
    a. **Engineering Survey:** This is undertaken for the determination of quantities or to afford sufficient data for the designing of engineering works such as roads and reservoirs or those connected with sewage disposal or water supply.
    b. **Military Survey:** This is used for determining points of strategic importance.
    c. **Mine survey:** This is used for the exploring mineral wealth.
    d. **Geological Survey:** This is used for determining different strata in the earth's crust.
    e. **Archaeological Survey:** This is used for unearthing relics of antiquity.

3. Classification based on Instrument used

An alternative classification may be based upon the instruments or methods employed, the chief types being.

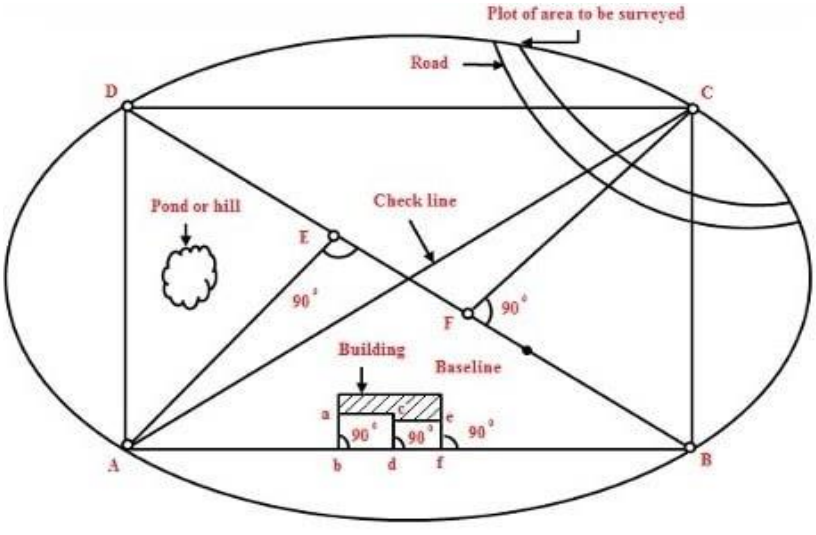
A. Chain survey.
B. Compass survey.
C. Theodolite survey.
D. Traverse survey.
E. Triangulation survey.
F. Tachometric survey.
G. Plane table survey.
H. Photogrammetric survey.
I. Aerial survey.

PRINCIPLES OF SURVEYING:

The fundamental principles upon which the various methods of plane surveying are based are of very simple nature and can be stated under the following two aspects.

- ***WORKING FROM WHOLE TO PART:***

The first ruling principle of surveying, weather geodetic or plane is to work from whole to part. It is essential to establish first a system of control points and to fix them with higher precision. Minor control points can be established by less precise methods and details can then located using this minor control points by running minor traverse. The idea of working in this way is to prevent the accumulation of errors and to control and localise minor errors which otherwise would expand to greater magnitudes if the reverse process is followed, thus making the work uncontrollable at the end.



A simple networks of triangle in a plot of land to be surveyed

➢ ***LOCATION OF A POINT BY MEASUREMENT FROM TWO POINTS OF REFERENCE:***

The relative positions of the points to be surveyed should be located by measurements from at least two points of reference, the positions of which have already been fixed. Let P and Q be the reference points on the ground. The distance PQ can be measured accurately and the relative positions of P & Q can be plotted on the sheet to some scale. The points P & Q will serve as reference points for fixing the relative positions of other points. Any other point such as R can be located by any of the following direct methods.

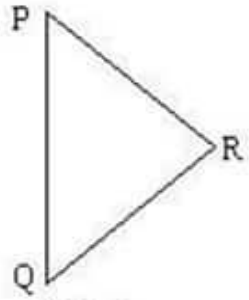


Fig. a

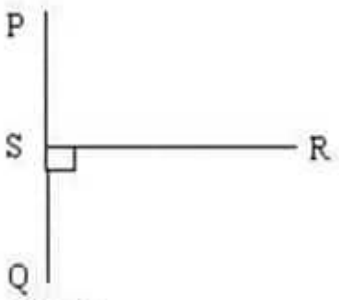


Fig. b

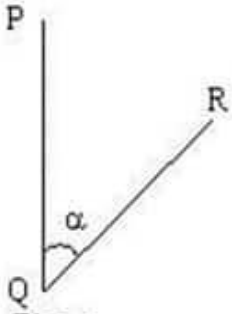


Fig. c

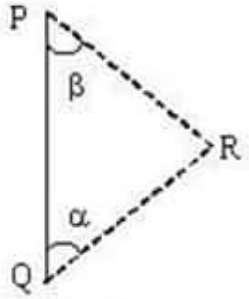


Fig. d

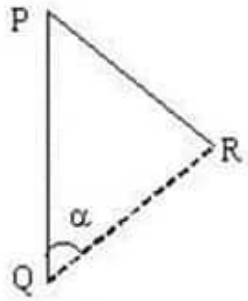


Fig. e

- ✓ Distance *PR* and *QR* can be measured and point *R* can be plotted by swinging two arcs to the same scale to which *PQ* has plotted. ***The principle is very much used in chain surveying***.
- ✓ A perpendicular *RS* can be dropped on the reference line *PQ* and length *PS* and *SR* are measured. The point *R* can then be plotted using square set. ***This principle is used for defining details.***
- ✓ The distance *QR* and the angle *PQR* can be measured and point *R* is plotted either by means of a protractor or trigonometrically. ***This principle is used in traversing.***
- ✓ In this method the distance *PR* and *QR* are not measured but angle *RPQ* and *RQP* are measured. Knowing the distance *PQ*, point *R* is plotted either by means of a protractor or by solution of triangle *PQR*. ***This principle is very much used in triangulation & for very extensive works.***

- ✓ Angle *RQP* and distance are measured and point *R* is plotted either by protracting an angle and swinging an arc from *P* or plotted trigonometrically. ***This principle, used in traversing.***

ERRORS IN SURVEYING:

In dealing with measurements it is important to distinguish between accuracy and precision. Precision is the degree of perfection used in the instruments, methods and the observation. Accuracy is the degree of perfection obtained.

The difference between a measurement and the true value of the quantity measured is the true error of the measurement and is never known since the true value of the quantity is never known. However, the important function of a surveyor is to secure measurements which are correct within a certain limit of error prescribed by the nature and purpose of a particular survey.

KINDS OF ERRORS IN SURVEYING:

Ordinary error met with in all classes of survey work may be classified as

A. **Mistakes:** Mistakes are errors which arise from inattention, inexperience, carelessness and poor judgment or confusion in the mind of the observer. If a mistake is undetected, it produces a serious effect upon the final result. Hence every value to be recorded in the field must be checked by some independent field observation.

B. **Systematic errors (Cumulative errors):** A systematic error or cumulative error is an error that, under the same conditions, will always be of the same size and sign. A systematic error always fallows some definite mathematical or physical law and a correction can be determined and applied. Such errors are constant in character and are regarded as positive or negative according as they make the result too great or too small. Their effect is cumulative. ***For example, if a tape is P cm short and if it is stretched N times, the total error in the measurement of the length will be P*N cm.***

C. **Accidental errors (Compensating errors):** Accidental errors or compensating errors are those which remains after mistakes and systematic errors have been eliminated and are caused by a combination of reasons beyond the ability of the observer to control. They tend some times in one direction and some times in the other. They are equally likely to make the apparent result too large or too small. ***For example, an error of 2cm in the tape may fluctuate on either side of the amount by reason of small variations in the pull to which it is subjected.***

UNITS OF MEASURMENTS

Unit of measurement is also known as the International System of Units, or SI. Units of measure in the metric system. The units of length or linear size are derived from the metre. They comprise of the kilometer (km) that is 1000 meters, the centimeter (cm), and the millimeter (mm) which is 1/1000th of a meter. There are four kinds of measurement used in plane surveying:

1. Horizontal distance
2. Vertical distance
3. Horizontal angle
4. Vertical angle

LINEAR MEASURMENTS

Linear measurement in surveying involves the measurement of horizontal and vertical distances of the points or places at a given area such a residential block, district, a city and a country. In surveying, linear measurement involves the use of instruments to measure the required horizontal and vertical distances such as scale, theodolites, taping pins, range poles, offset tapes, stylon tapes and the chain.

Also they use imperial units or US standard system such as inches, feet, yards and miles with 1foot being equal to 12inches, 1yard is equal to 3 feet and 1 mile is equal to 1760 yards. Therefore, surveyors are encouraged to use the above instruments and units of measurements since they produce reliable outcomes.

ANGULAR MEASURMENTS

Angular measurement is another factor in surveying. Angular measurement is the dimensionless though it may be specified as radians to avoid ambiguity. Angles are measured in degrees, subdivision of the degree are minutes and the angles measured are used to determine the bearings and directions of horizontal and vertical angels in control surveys in order to locate details when mapping and setting out all types of structures and features on an area being surveyed. A theodolite is a measuring instrument commonly measure the horizontal and vertical angles.

A. BASIC UNITS OF LENGTH

According to standards of weights and measures act (India) 1956 the unit of measurement of distance is metres and centimetres. Prior to the introduction of metric units in India, Feet was used. Table 1.1 gives the basic linear measures both in metric as well as in British system, while tables 1.2 & 1.3 gives the conversion factors.

TABLE 1.1 BASIC UNITS OF LENGTH

BRITISH UNITS		METRIC UNITS	
12 Inches	1 Feet	10 Millimetre	1 Centimetre
3 feet	1 Yard	10 Centimetre	1 Decimetre
5½ Yards	1 Rod, Pole or Perch	10 Decimetre	1 Metre
4 poles	1 Chain (66 feet)	10 Metre	1 Decametre
10 Chains	1 Furlong	10 Decametre	1 Hectometre
8 Furlongs	1 Mile	10 Hectometre	1 Kilometre
100 Links	1 Chain	1852 Meter	1 Nautical Mile
6 Feet	1 Fathom		
120 Fathom	1 Cable Length		
6080 Feet	1 Nautical Mile		

TABLE 1.2 CONVERSION FACTORS

METRES	YARDS	FEET	INCHES
1	1.0936	3.2808	39.3701
0.9144	1	3	36
0.3048	0.3333	1	12
0.0254	0.0278	0.0833	1

TABLE 1.3 CONVERSION FACTORS

KILOMETRES	NAUTICAL MILES	MILES
1	0.53996	0.6214
1.852	1	1.1508
1.6093	0.869	1

B. BASIC UNITS OF ANGULAR MEASURMENTS

An angle is the difference in directions of two intersecting lines. The radians are the unit of plane angle. The radian is an angle between two radii of a circle which cuts off on the circumference of an arc equal in length to the radius. There are three popular systems of angular measurements.

a. SEXAGESIMAL SYSTEM

1 Circumference	360^{o} (Degree of an Arc)
1 Degree	60' (Minutes of an Arc)
1 Minute	60" (Seconds of an Arc)

b. CENTESIMAL SYSTEM

1 Circumference	400^{g} (Grads)
1 Grad	100^{C} (Centigrades)
1 Centigrad	100^{CC} (Centi - Centigrades)

c. HOURS SYSTEM

1 Circumference	24^{h} (Hours)
1 Hour	60^{m} (Minutes)
1 Minute	60^{S} (Seconds)

The sexagesimal system is widely used in United states, Great Britain, India and others parts of the world. More complete tables are available in this system and most surveying instruments are graduated according to this system. However due to facility in computation and interpolation the centesimal system is gaining more favour in Europe. The hour's system is used in astronomy and navigation.

REFERENCES

1. Surveying Volume I by B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain.16^{th} Edition, Laxmi publications (P) Ltd, #113, Golden House, Daryagunj, New Delhi – 110002, India.

CHAIN SURVEYING

UNIT 02: CHAIN SURVEY

Chain surveying is the branch of surveying in which only linear measurements are made in the field. This is suitable for the survey of small areas with simple details and an area that is fairly flat. It derives its name from the fact that the principle equipment commonly used is the chain.

Chain survey is suitable when:

- When the ground is flat and with simple details.
- When the area to be surveyed is small.
- When large scale mapping is desired.

Chain survey is not suitable when:

- Area is very large.
- Too many undulations in the area.
- Construction of triangles become difficult.

OBJECTIVES AND PURPOSE OF CHAIN SURVEYING:

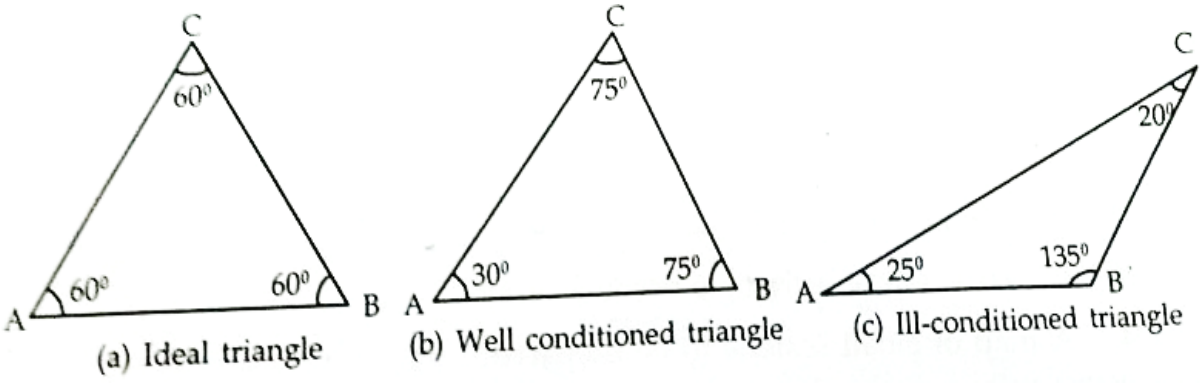
Chain surveying has the following purposes:

- ✓ To collect necessary data for exact description of the land.
- ✓ To calculate the area of the plot
- ✓ To prepare the plan of the site
- ✓ To demarcate the boundaries of the land
- ✓ For division of land into smaller units.

PRINCIPLE OF CHAIN SURVEYING:

The principle of chain surveying is triangulation. A triangle is the simple figure which can be plotted from the lengths of three sides even if the angles are not known. In chain surveying the area to be surveyed is divided into a framework consisting of triangles, these triangles should be well conditioned. A triangle is said to be well conditioned, when no angle greater than 120^0 or smaller than 30^0. To ensure minimum distortion due to errors in measurement and plotting, the best shaped triangle is equilateral triangle.

In case ill conditioned triangle are unavoidable (angle greater than 120^0 or smaller than 30^0) then great care is taken while chaining and plotting their sides. The Ideal triangle, well-conditioned triangle & ill conditioned triangle is shown in figure.



INSTRUMENTS USED IN CHAIN SURVEYING

The various instruments used for chain surveying are as follows.

- Chain.
- Tape.
- Arrows.
- Pegs.
- Ranging rods.
- Ranging poles.
- Offset rods.
- Plumb bob.
- Cross staff.

CHAIN

Chains are formed of straight links of galvanised mild steel wire bent into rings at the ends and joined each other by three small circular or oval wire rings. These rings offer flexibility to the chain. The ends of the chain are provided with brass handle at each end with swivel joint, so that the chain can be turned without twisting. The length of a link is the distance between the centres of two consecutive middle rings, while the length of the chain is measured from the outside of one handle to the outside of the other handle. Following are the various types of chains in common use.

- Metric Chain.
- Gunter's Chain.
- Engineer's Chain.
- Revenue Chain.

➢ METRIC CHAIN:

After the introduction of metric units in India the metric chains are widely used. Metric chains are generally available in lengths of 5, 10, 20 & 30 metres. IS 1492-1970 covers the requirements of metric surveying chains. Figure 2.1 & Figure 2.2 shows 5m and 10m chains respectively. Figure 2.3 & Figure 2.4 shows the 20m & 30m chains respectively. Figure 2.5 shows the details of the metric chain.

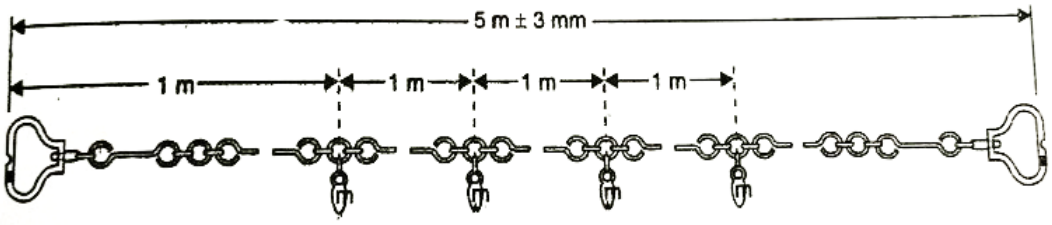


Figure 2.1

To enable the reading of fractions of a chain without much difficulty tallies are fixed at every meter length for chains of 5m and 10m lengths (see Figure 2.1 & Figure 2.2) and at every five metre length for chains of 20m & 30m lengths (see Figure 2.3 & Figure 2.4). in case of 20m & 30m chains small brass rings are provided at every metre length except where tallies are attached.

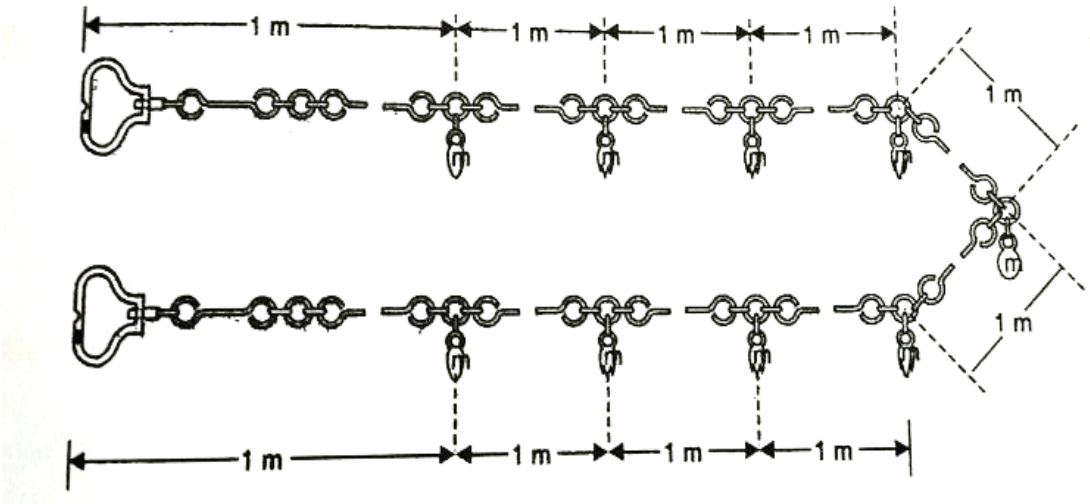


Figure 2.2

The shapes of tallies for chains of 5m and 10m lengths for different positions are shown in figure 2.5. To facilitate holding of arrows in position with the handle of the chain a groove is cut on the outside surface of the handle. The tallies used for marking distances in the metric chains are marked with letter M in the order to distinguish them from non-metric chain. The length of chain 5m, 10m, 20m & 30m as the case may be engraved on both handles to indicate the length and also to distinguish the chains from non-metric chains.

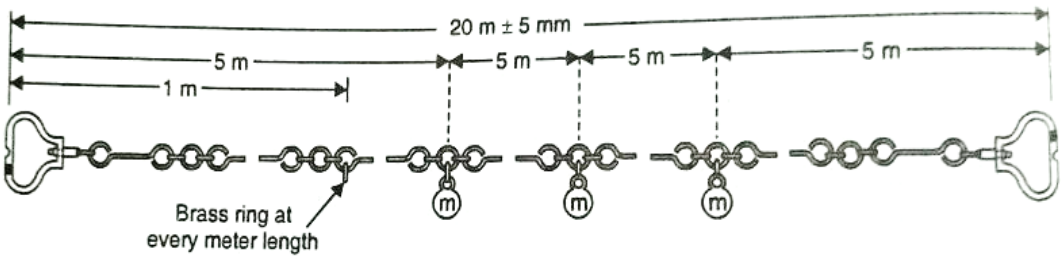


Figure 2.3

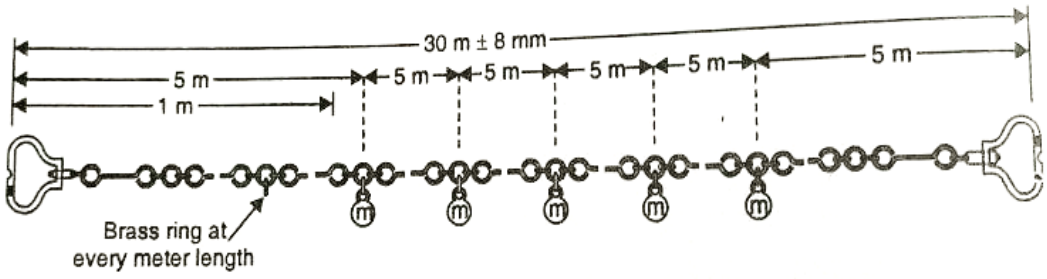


Figure 2.4

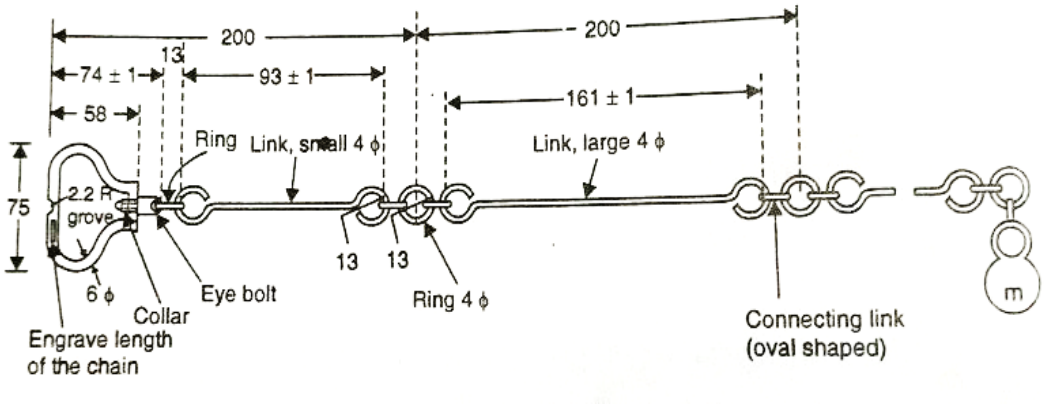


Figure 2.5

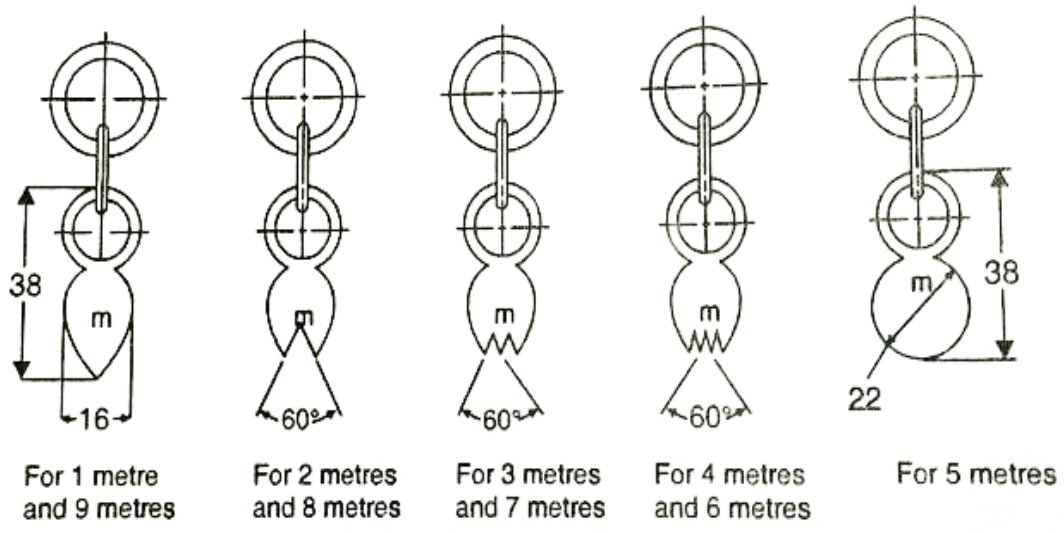


Figure 2.6

- **GUNTER'S CHAIN:** A Gunter's chain or surveyors chain is 66 feet long and consists of 100 links. Each link being 0.6 feet or 7.92 inches long. The length of 66 feet was originally adopted for convenience in land measurements since 10 square chains are equal to 1 acre. Also when linear measurements are required in furlongs and miles, it is more convenient since 10 Gunter's chains = 1 furlong and 80 Gunter's chain = 1 mile.

- **ENGINEERS CHAIN:** The engineer's chain is 100 ft. long and consists of 100 links, each link being 1 ft. long. At every 10 links, brass tags are fastened with notches on the tags indicating the number of 10 link segments between the tag and end of the chain. The distances measured are recorded in feet and decimals.

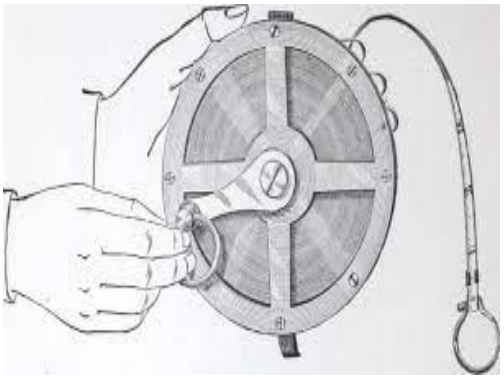
- **REVENUE CHAIN:** The revenue chain is 33 ft. long and consists of 16 links, each link being $2\frac{1}{16}$ ft. long. The chain is mainly used for measuring fields in cadastral survey.

TAPES

Tapes are used for more accurate measurements and are classed according to the materials of which they are made.

- **CLOTH OR LENIN TAPE:**
- **INVAR TAPE:**
- **METALLIC TAPE:** A metallic tape is made of varnished strip of waterproof Lenin interwoven with small brass, copper or bronze wires and does not stretch as easily as a cloth tape. Since metallic tapes are light and flexible and are not easily broken, they are particularly useful in cross sectioning and in some methods of topography where small errors in length of the tape are of no consequences. Metallic tapes are made in length of 2, 5, 10, 20, 30 & 50 metres. In the case of tapes of 10, 20, 30 & 50 m length a metal ring is attached to the outer ends and fastened to it by a metal strip of the same width as the tape. This metal strip protects the tape and at the same time inspectors stamp can be put on it. Tapes of 10, 20, 30 & 50 metre lengths are supplied in a metal or leather case fitted with a winding device.

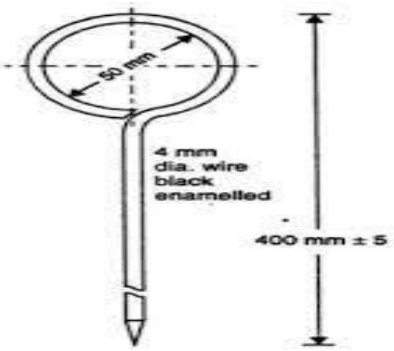
Metallic Tape



- **STEEL TAPE:** Steel tapes vary in quality and accuracy of graduation but even a poor steel tape is generally superior to a cloth or metallic tape for most of the linear measurements that are made in surveying. A steel tape consists of width 6 to 10 mm and is more accurately graduated. Steel tapes are available in lengths of 1, 2, 10, 20, 30 & 50 metres. The length of the tape includes metal ring. It is wound in well sewn leather case or a corrosion resisting metal case having a suitable winding device. Tapes of longer than 30 m length are wound on metal reel.

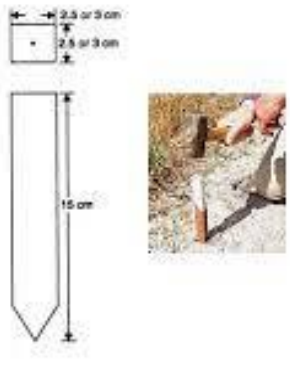
ARROWS

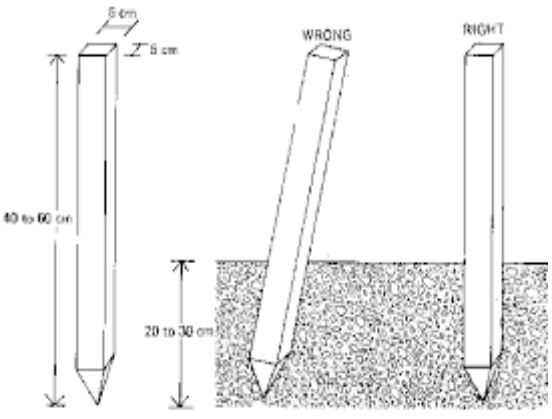
Arrows or marking pins are made of stout steel wire and generally 10 arrows are supplied with a chain. An arrow is inserted into the ground after every chain length measured on the ground. Arrows are made of good quality hardened and tempered steel wire 4mm in diameter and are black enamelled. The length of the arrow may vary from 25 cm to 50 cm, the most common length being 40 cm. one end of the arrow is made sharp and the other end is bent into a loop or circle for facility of carrying. The below figure shows the details of the 40 cm long arrow as recommended by the Indian standard.



PEGS

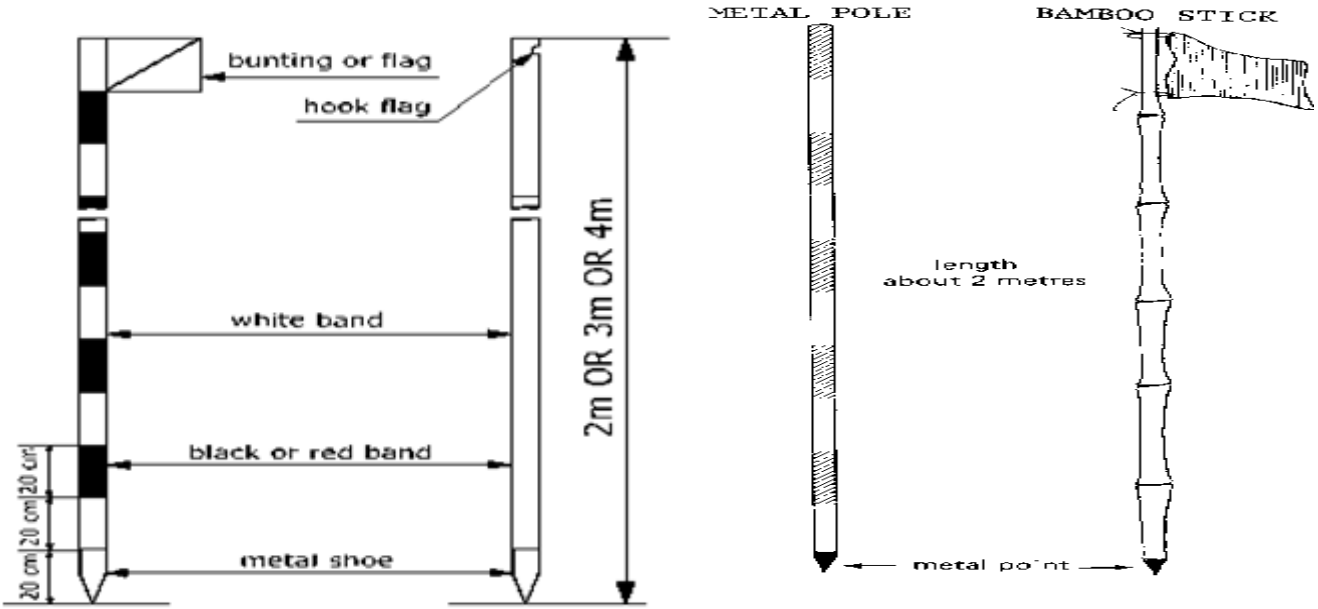
Wooden pegs are used to mark the positions of the stations or internal points of a survey line. They are made of stout timber generally 2.5 cm or 3 cm square and 15 cm long, tapered at the end. They are driven in the ground with the help of a wooden hammer and kept about 4cm projecting above the surface.





RANGING RODS

Ranging rods have a length of either 2 m or 3 m, the 2 metre length being more common. They are shod at the bottom with a heavy iron point and are painted in alternative bands of either black and white or red and white or black, each band being 20 cm deep so that on occasion the rod can be used for rough measurements of short lengths. Ranging rods are used to range some intermediate points in the survey line. They are circular or octagonal in cross section of 3 cm nominal diameter made of well-seasoned, straight grained timber. The rods are almost invisible at a distance of about 200 metres, hence when used on long lines each rod should have a red, white or yellow flag about 30 to 50 cm square tied on near its top.



RANGING POLES

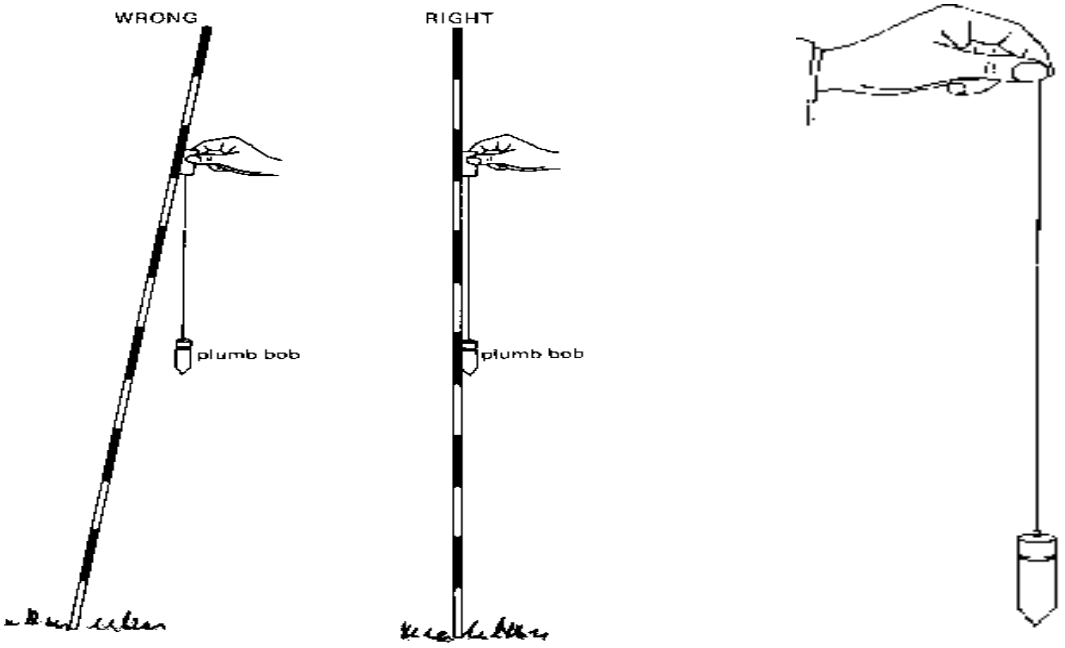
Ranging poles are similar to ranging rods except that they are longer of greater diameter and are used in case of very long lines. Generally, they are not painted but in all cases they are provided with a large flag. Their length may vary from 4 to 8 metre and diameter from 6 to 10 cm. the foot of each pole is sunk about ½ m into the ground. The pole being set quite vertical by aid of a plumb bob.

OFFSET RODS

An offset rod is similar to a ranging rod and has a length of 3 m. They are round wooden rods, shod with pointed iron shoe at one end and provided with a notch or a hook at the other. The hook facilitates pulling and pushing a chain through hedges and other obstructions. The rod is mainly used for measuring rough offsets nearby. It has also two narrow slots passing through the centre of the section and set at right angles to one another at the eye level for aligning the offset line.

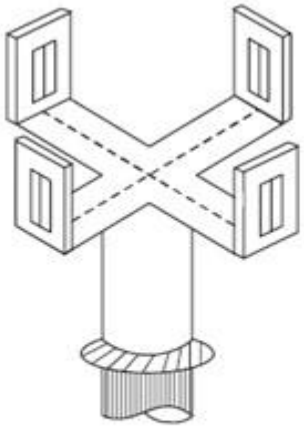
PLUMB BOB

While chaining along sloping ground a plumb bob is required transfer the points to the ground. It is also used to make ranging poles vertical and to transfer points from a line ranger to the ground. In addition, it is used centring aid in theodolites, compass, plane table and a variety of other surveying instruments.

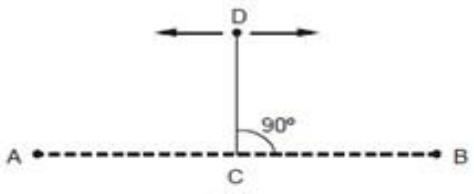


OPEN CROSS STAFF:

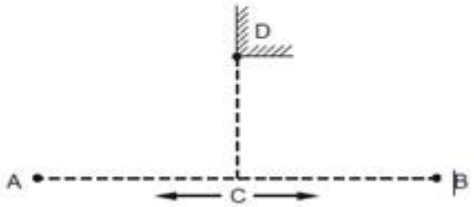
The below figure shows an open cross staff. It is provided with two pairs of vertical slits giving two lines of sight at right angles to each other. The cross staff is set up at a point on the line from which the right angle is to run and is then turned until one line of sight passes through ranging pole at the end of the survey line. The line of sight through the other vanes will be a line at right angles to the survey line and a ranging rod may be established in that direction.



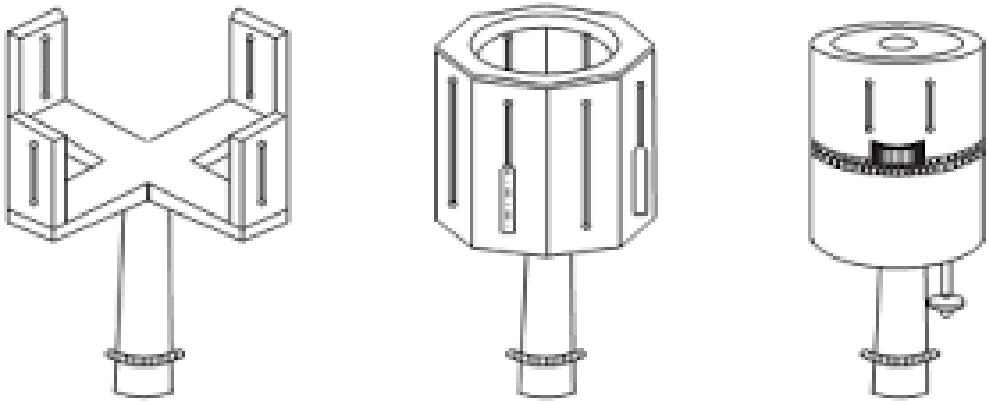
(a) Cross Staff



(b)



(c)

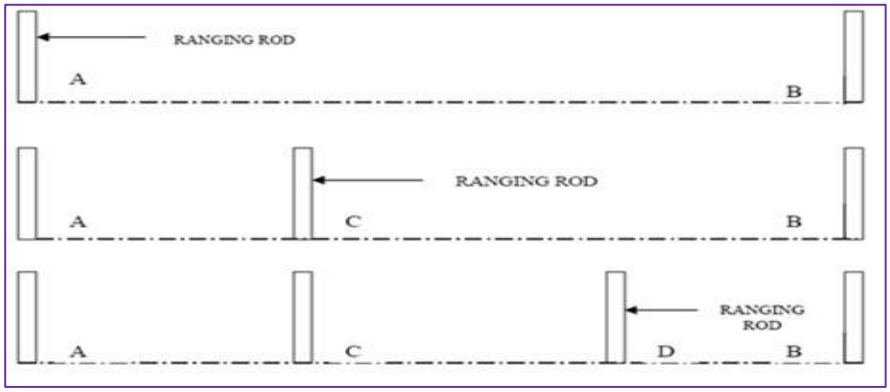


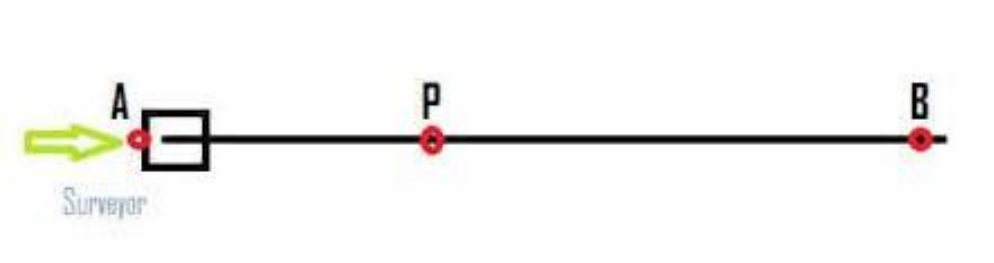
RANGING:

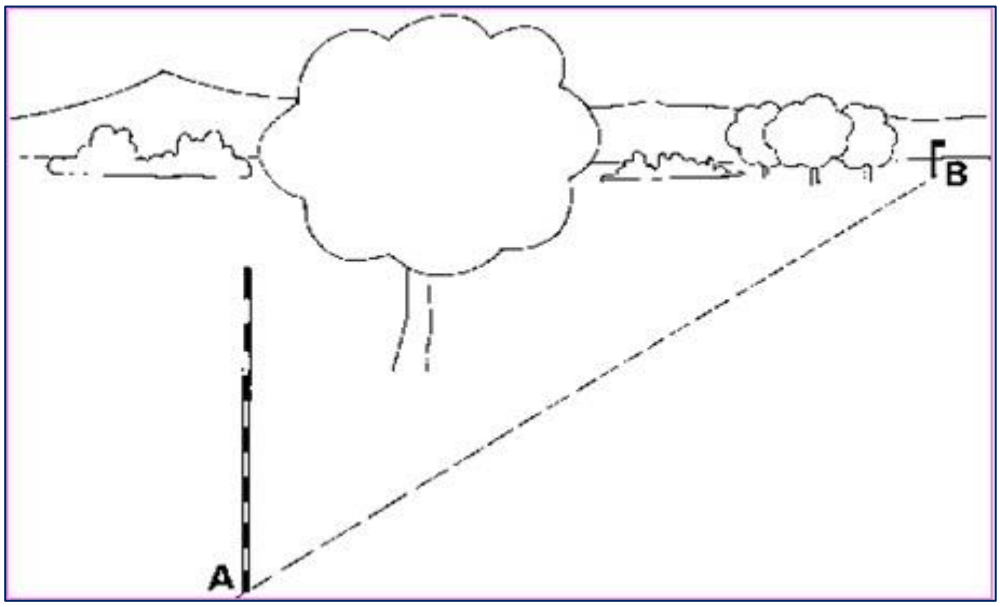
While measuring the length of a survey line or chain line, the chain or tape must be stretched straight along the line joining its two terminal stations. If the length of the line is less than the length of the chain, there will be no difficulty in doing so. If the length of the line exceeds the length of the chain, some intermediate points will have to be established in line with the two terminal points is known as ranging. There are two methods of ranging.

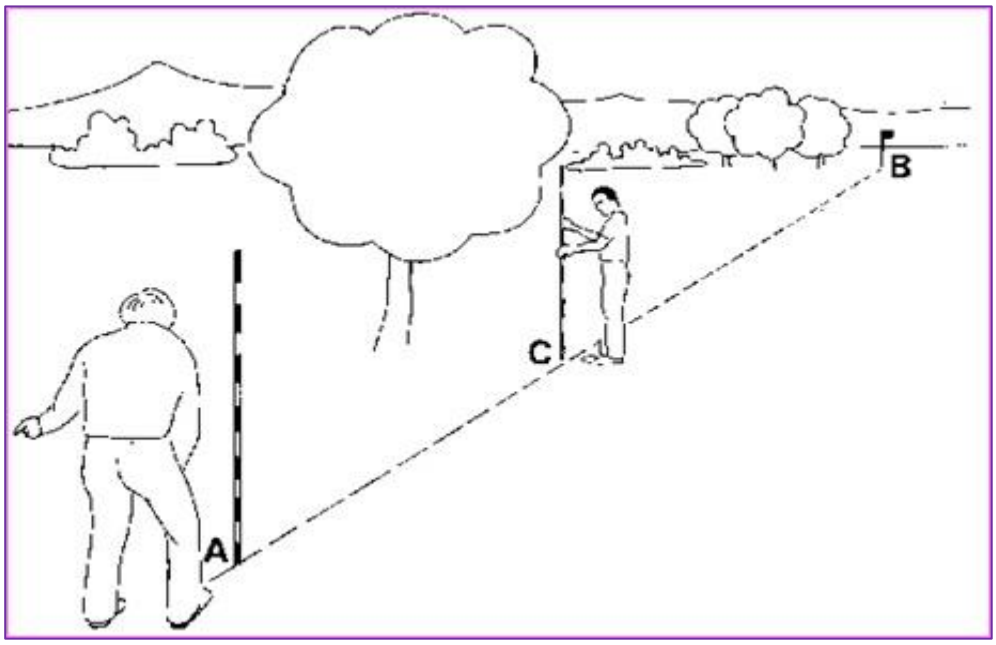
- Direct Ranging
- Indirect Ranging.

- **DIRECT RANGING:** Direct ranging is adopted when the two ends of the survey lines are intervisible. In such cases ranging can either be done by eye or through some optical instruments such as a line ranger.
  - ***Ranging by eye:*** Let A and B the two points at the ends of a survey line. One ranging rod is erected at the point B while the surveyor stands with another ranging rod at point A holding a rod about half meter length. The assistant than goes with another ranging rod and establishes the rod at a point approximately in the line with AB by eye judgement at a distance not greater than one chain length from A. the surveyor at A than signals the assistant to move transverse to the chain line, till he is in line with A & B. similarly other intermediate points can be established.





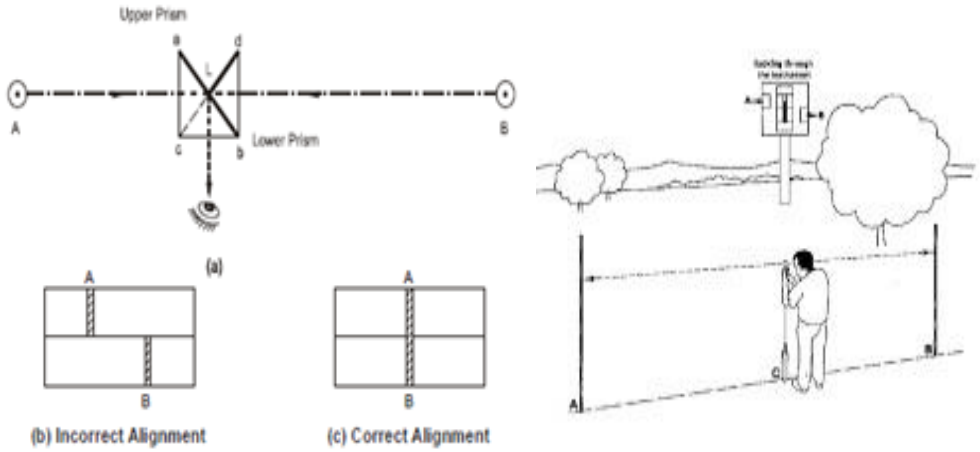




While carrying out direct ranging or ranging by eye, the surveyor has to follow certain rules and regulation for effective completion of a given survey work. One of the rules that a surveyor will use in surveying are some codes of signals for ranging to direct his assistant into survey line. These codes of signals are given below.

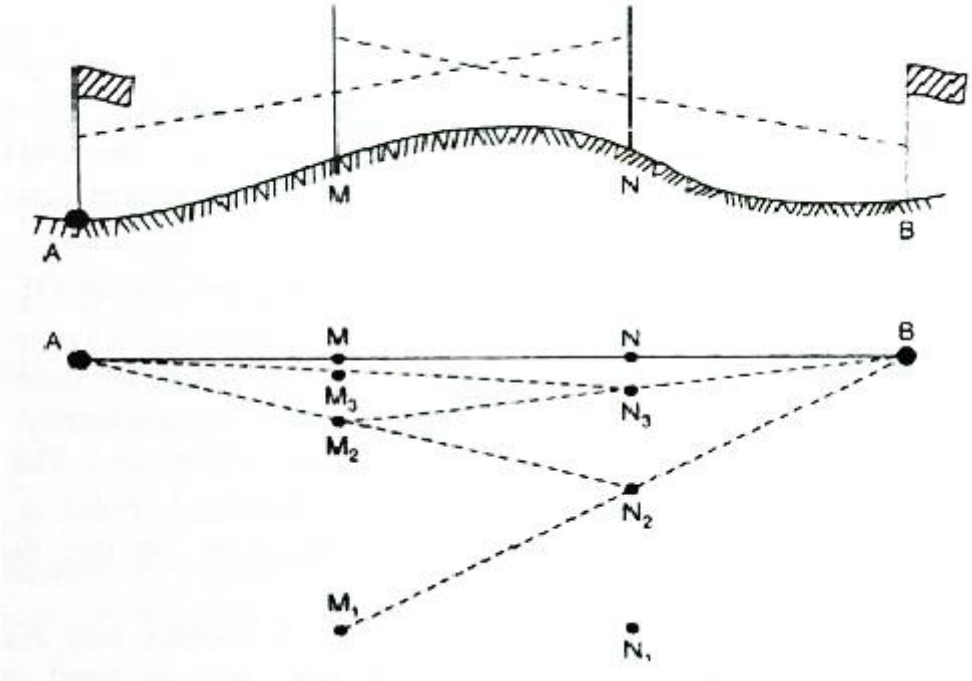
NO	SIGNAL BY THE SURVEYOR	ACTION BY ASSISTANT
01	Rapid sweep with right hand	Move considerably to the right
02	Slow sweep with right hand	Move slowly to the right
03	Right arm extended	Continue to move to the right
04	Right arm up and moved to the right	Plumb the rod to the right
05	Rapid sweep with left hand	Move considerably to the left
06	Slow sweep with left hand	Move slowly to the left
07	left arm extended	Continue to move to the left
08	Right arm up and moved to the left	Plumb the rod to the left
09	Both hands above head and then brought down	Correct
10	Both hands extended forward horizontally and the hands depressed briskly	Fix the rod

- ***Ranging by Line Ranger:*** A line ranger consists of either two plane mirrors or two right angled isosceles prisms place one above the other as shown in figure. The diagonals of the two prisms are silvered so as to reflect the incidental rays. A handle with hook is provided at the bottom to hold the instrument in hand to transfer the point on the ground with the help of plumb bob.



- **INDIRECT RANGING:** Indirect ranging or Reciprocal ranging is resorted to when both the ends of the survey line are not intervisible either due to high intervening ground or due to long distance between them. Let A and B are the ends of a chain line which has a rising ground intervening between them. In this case ranging is done indirectly by selecting two intermediate points M_1 and N_1 very near to chain line bye judgment in such a way that from M_1 both N_1 & B are visible and from N_1 both M_1 & A are visible. Two surveyors station themselves at M_1 & N_1 with ranging rods. The person @ M_1 then directs the person at N_1 to move to a new position N_2 in line with M_1B. The person @ N_2 then directs the person at

M_1 to move to a new position M_2 in line with N_2A. The two surveyors are now at M_2 & N_2 which are nearer to the chain line than the positions M_1 & N_1. The person @ M_2 then directs the person at N_2 to move to a new position N_3 in line with M_2B. The person @ N_3 then directs the person at M_2 to move to a new position M_3 in line with N_3A. The two surveyors are now at M_3 & N_3 which are nearer to the chain line than the positions M_2 & N_2. The process is repeated till the points M & N are located in such a way that the person at M finds the person at N in line with MB and the person @ N finds the person at M in line with NA. After having established M & N the other points can be fixed by direct ranging.



CHAINING:

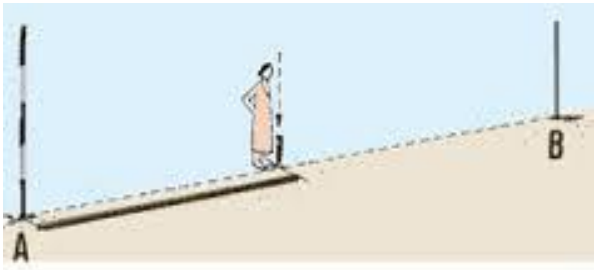
Two chainmen are required for measuring the length of a line which is greater than a chain length. The more experienced of the chainmen remains at the zero end or rear end of the chain and is called the follower. The other chainmen holding the forward handle is known as the leader. To start with the leader takes a bundle of the arrows in one hand and a ranging rod and the handle of the chain in the other hand.

CHAINING ON A FLAT GROUND:

The follower holds the zero end of the chain at the terminal point while the leader proceeds forward with the other end in one hand and a set of 10 arrows and a ranging rod in the other hand. When he is approximately one chain length away the follower directs him to fix his rod in line with the terminal poles.

When the point is ranged the leader makes a mark on the ground, holds the handle with both the hands and pulls the chain so that it becomes straight between the terminal point and the

fixed point. Little jerks may be given for this purpose but the pull applied must be just sufficient to make the chain straight in line.



The leader then puts an arrow at the end of the chain, swings the chain slightly out of the line and proceeds further with the handle in one hand and the rest of the arrows and ranging rod in the other hand. The follower also takes the end handle in one hand and a ranging rod in the other hand, follows the leader till the leader has approximately travelled one chain length. The follower puts the zero end of the chain straight in the line and fixes the second arrow in the ground and proceeds further. The follower takes the arrow and the ranging rod in one hand and handle in the other and follows the leader. At the end of ten chains the leader calls for the arrows. The follower takes out the tenth arrow from the ground, puts the ranging rod there and hands over ten arrows to the leader. The transfer of ten arrow is recorded by the surveyor. To measure the fractional length at the end of a line, the leader drags the chain beyond the end station, stretches it straight and tight and reads the links.

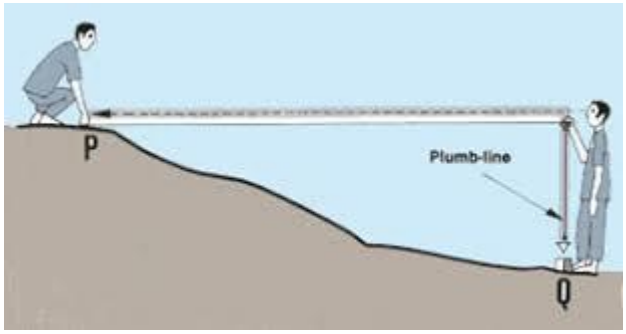
CHAINING ON UNEVEN OR SLOPING GROUND:

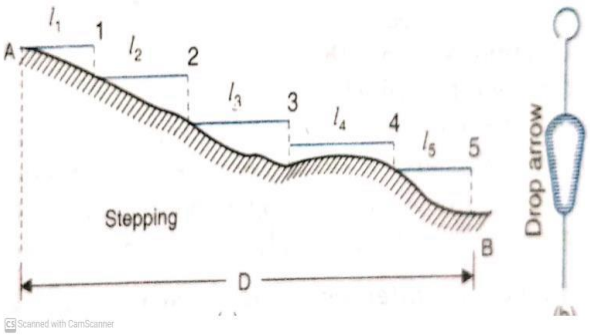
For all plotting works, horizontal distance between the points are required. It is therefore necessary either to directly measure the horizontal distance between the points or to measure the sloping distance and reduce it to horizontal. There are two methods for getting the horizontal distance between two points. Direct method & Indirect method.

DIRECT METHOD OR METHOD OF STEPPING

In the direct method or the method of stepping as is sometimes called the distance is measured in small horizontal steps. The below figure illustrates the procedure, where it is required to measure the horizontal distance between the two points A & B.

The follower holds the zero end of the tape at A while the leader selects any suitable length l_1 of the tape and moves forward. The follower directs the leader for ranging. The leader pulls the tape tight, makes it horizontal and the point 1 is then transferred to the ground by a plumb bob. Sometimes a special form of drop arrow is used to transfer the point to the surface. The procedure is repeated. The total length D of the line is equal to ($l_1 + l_2 + l_3 + \ldots\ldots$). In case of irregular slopes this is the only suitable method.





CHAIN TRIANGULATION:

The principle of chain survey or Chain Triangulation, as is sometimes called is to provide a skeleton or framework consisting of a number of connected triangles, as triangle is the only simple figure that can be plotted from the lengths of its sides measured in the field. To get good results in plotting, the framework should consist of triangles which are as nearly equilateral or well-conditioned triangles as possible.

SURVEY STATIONS:

A survey station is a prominent point on the chain line and can be either at the beginning of the chain line or at the end. Such stations are known as main station. However, subsidiary or tie station can also be selected anywhere on the chain line and subsidiary or tie lines may be run through them.

A survey station may be marked on the ground by driving pegs if the ground is soft. However, on roads and streets the survey station can be marked or located by making two or preferably three tie measurements with respect to some permanent reference objects near the station.

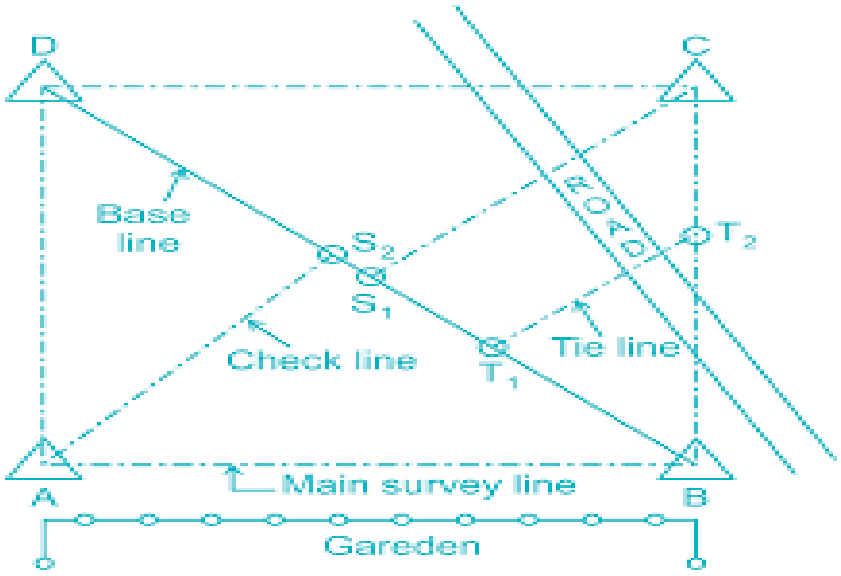
SURVEY LINES:

- ***Main survey line:*** The line joining the main survey stations are called main survey lines. The biggest of the main survey line is called base line and various stations are plotted with reference to this.

- ***Check line:*** Check line or proof lines are the lines which are run in the field to check the accuracy of the work. The length of the check line measured in the field must agree with its length on the plan.

- ***Tie line:*** A tie line is a line which joins subsidiary station or tie stations on the main survey line. The main object of running a tie line is to take the details of nearby objects but it also serves the purpose of a check line. The accuracy in the location of the objects depends upon the accuracy in laying the tie line.

- ***Offset:*** An offset is the lateral distance of an object or ground feature measured from a survey line. When the angle of offset is 90º, it is called a perpendicular offset, when the angle the angle of offset is other than 90º, it is called an oblique offset. If the length of the offset is less than 15m in length is called a short offset. If the length of the offset is more than 15m it is called a long offset. As far as possible offset should be short for accuracy of work.



SELECTION OF SURVEY STATIONS:

Survey stations should be so selected that a good system of lines is obtained fulfilling the following conditions

- Survey stations must be mutually visible.
- Survey lines must be as few as possible so that the frame work can be plotted conveniently.
- The frame work must have one or two base lines. If one base line is used, it must run along the length and the through the middle of the area. If two base lines are used, they must intersect in the form of letter X.
- Survey lines must run through level ground as far as possible.

- The main lines should form well-conditioned triangles.
- Each portion of skeleton must be provided with sufficient check lines.
- All the lines from with offsets are taken should be placed near the surface features so as to get short offset.
- As far as possible, main survey lines should not pass through the obstacles.
- To avoid trespassing, the main survey lines should fall within the boundaries of the property to be surveyed.

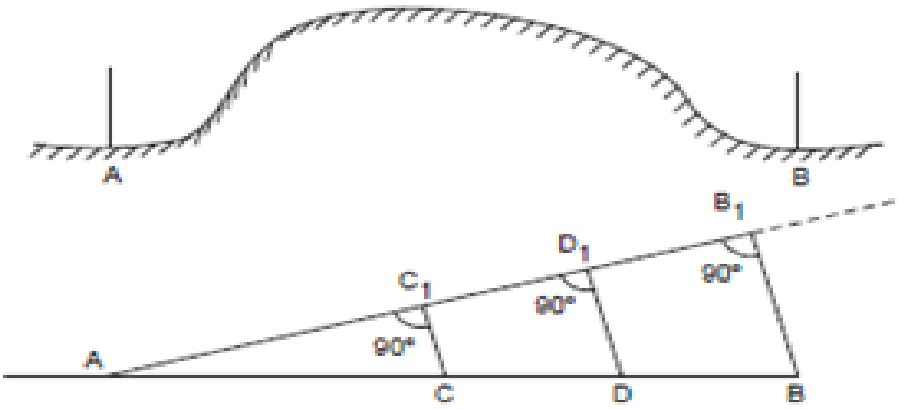
OBSTACLES IN CHAINING:

Obstacles in chaining prevent chainman from measuring directly between two points and give rise to a set of problems in which distances are found by indirect measurements. Obstacles to chaining are of three kinds.

- Obstacle to ranging.
- Obstacle to chaining.
- Obstacle to both chaining and ranging.
- ***OBSTACLE TO RANGING:***

This type of obstacle in which the ends are not intervisible is quite common. There are two cases of these obstacles.

- ✓ Both ends of the line may be visible from intermediate points on the line – To overcome this obstacle reciprocal ranging or indirect ranging may be used.
- ✓ Both ends of the line may not be visible from intermediate points – Let AB be the line in which A and B are not visible from intermediate point on it. Through A draw a random line AB_1 in any convenient direction but as nearly towards B as possible. The point B_1 should be so selected that B_1 is visible from B and BB_1 is perpendicular to the random line. Measure BB_1 select points C_1 and D_1 on the random line and erect perpendiculars C_1C and D_1D in such a way that $CC_1 = \frac{AC_1}{AB_1} * BB_1$ and $DD_1 = \frac{AD_1}{AB_1} * BB_1$ Join C and D and prolong.



➢ *OBSTACLE TO CHAINING:*

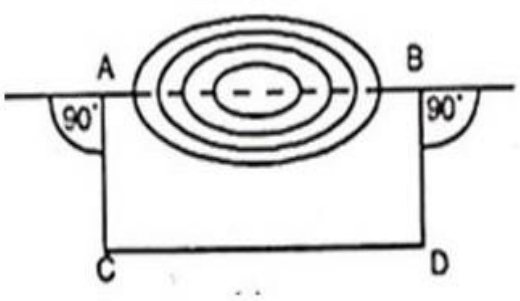
There may be two cases of this obstacle.

- ✓ When it is possible to chain round the obstacle, pond or hedge.
- ✓ When it is not possible to chain round the obstacle River.

✓ *When it is possible to chain round the obstacle, pond or hedge.*

CASE 01:

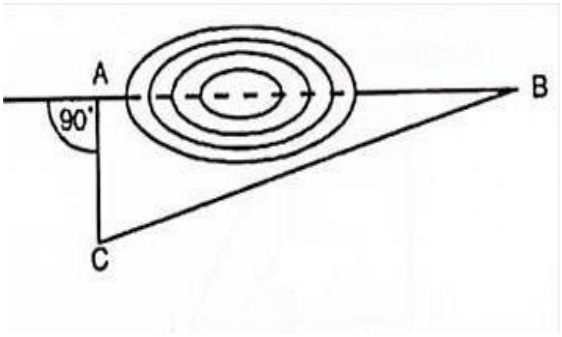
Select two points A and B on either side of the obstacle on the chain line PQ. Set out perpendiculars AC and BD. Measure the length CD, then CD = AB.



CASE 02:

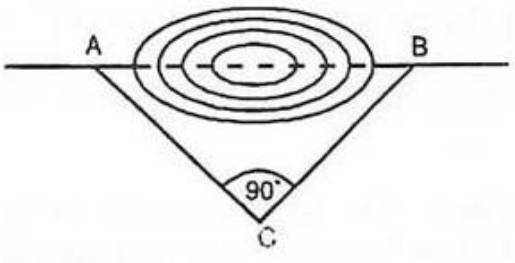
Set out perpendicular AC to the chain line such that the line CB lies outside the obstacle. Measure AC and BC. The length AB is calculated from the formula

$$AC = \sqrt{BC^2 - AC^2}$$



CASE 03:

Using cross staff find point C such that angle ACB is 900 and the lines AC and CB are outside the obstacle. Measure AC and BC. The length AB is calculated from the formula $AB = \sqrt{AC^2 + BC^2}$



CASE 04:

Select two points C and D one on either side of the point A conveniently and they are on the same straight line. Measure AC, AD, BC and BD. Let angle BCD be equal to θ.

From Δ BCD, $BD^2 = BC^2 + CD^2 - 2BC\ X\ CD\ Cos\ \theta$

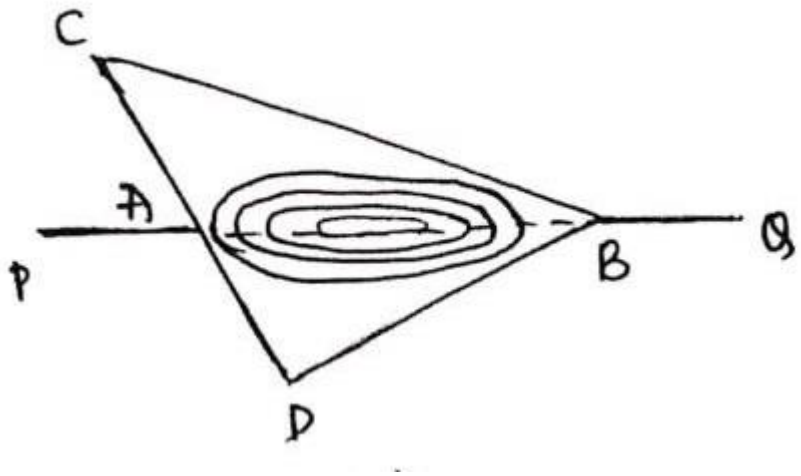
$$Cos\ \theta = \frac{BC^2 + CD^2 - BD^2}{2\ BC * CD} \quad \ldots\ldots\ldots\ldots 1$$

Similarly From Δ BCA

$$Cos\ \theta = \frac{BC^2 + AC^2 - AB^2}{2\ BC * AC} \quad \ldots\ldots\ldots\ldots 2$$

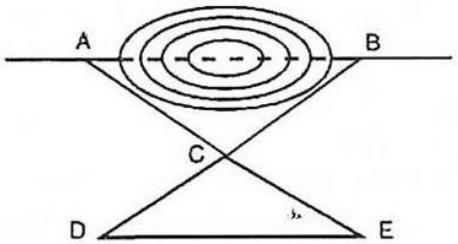
Equating Equation 1 & 2 and solving for AB we get.

$$AB = \sqrt{\frac{(BC^2 * AD) + (BD^2 * AC)}{CD} - (AC * AD)}$$



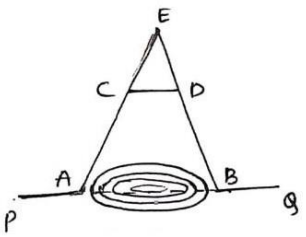
CASE 05:

Select any point E and range C in line with AE, such that AE = EC. Range D in line with BE and make BE = ED. Measure CD, then CD = AB.



CASE 06:

Select any suitable point E and measure AE and BE. Select two points C and D on AE and BE respectively such that CE= AE/n and DE = BE/n, where n is any convenient number. Measure the length of CD. Then, AB = n × CD



✓ *When it is not possible to chain round the obstacle, River.*

CASE 01: Select point B on one side and A and C on the other side of the obstacle on the chain line as shown in fig (a). Erect AD and CE as perpendiculars at A and C respectively in such a way that points E, D and B are along the same straight line. Measure AC, AD and CE. Draw a line DF parallel to AB. Then triangles ABD and FDE are similar.

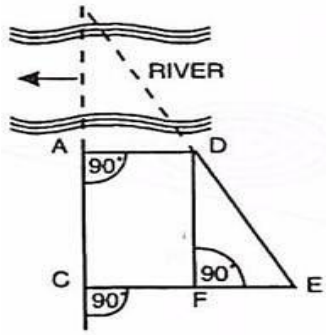
Then triangles ABD and FDE are similar.

Therefore $\frac{AB}{AD} = \frac{DF}{FE}$

But $FE = CE - CF = CE - AD$ & $DF = AC$

Therefore $\frac{AB}{AD} = \frac{AC}{CE-AD}$

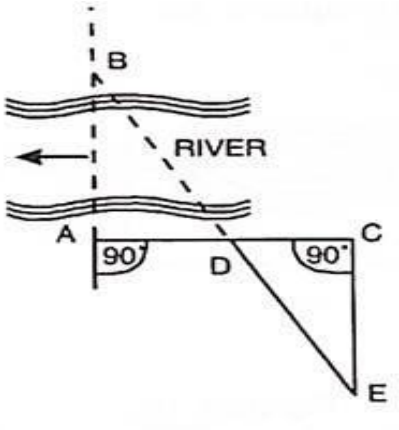
From which $AB = \frac{AC*AD}{CE-AD}$



CASE 02:

Select points A and B on either side of the obstacle on the chain line. At C erect perpendicular AC of convenient length and bisect it at D. At C erect perpendicular CE and fix the point E in such a way that points E, D and B are on the same straight line.

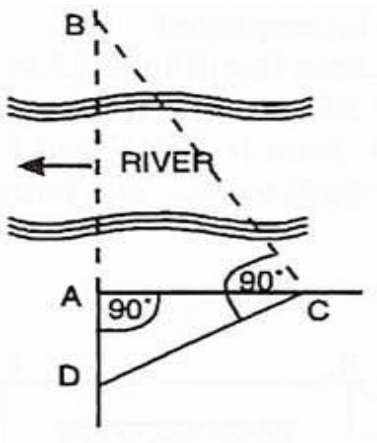
Then measure CE, which is equal to AB.



CASE 03:

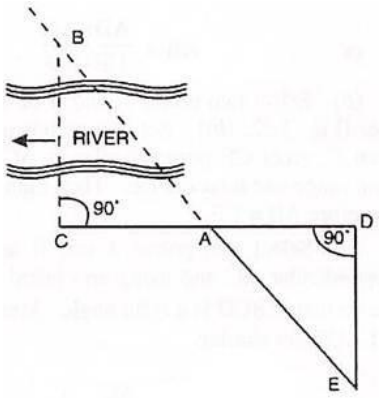
Select points A and B on either side of the obstacle. At A erect a perpendicular AC of any convenient length. With the help of a cross staff fix a point D on the chain line in such a way that angle BCD is 90º. Measure AC and AD, now the triangles ABC and DAC are similar. Hence $\frac{AB}{AC} = \frac{AC}{AD}$

Therefore $AB = \frac{AC^2}{AD}$



CASE 04:

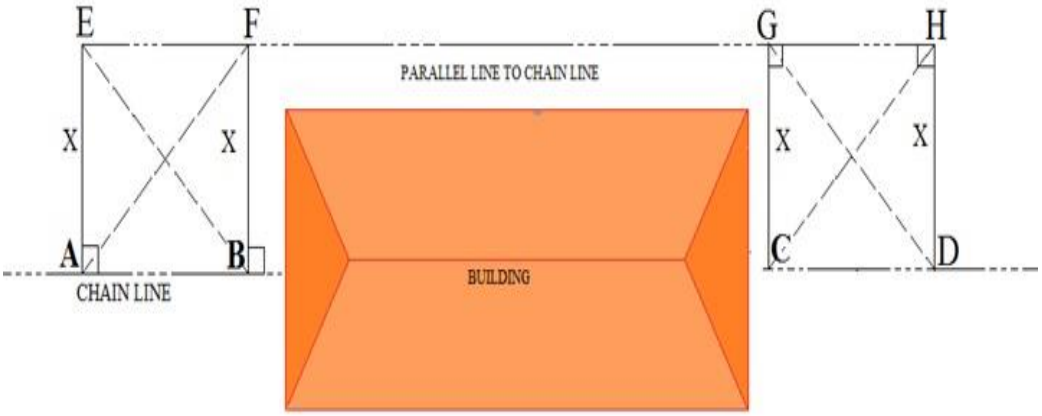
Fix point C conveniently on one side of the chain line. Set a cross staff at C and fix the point D on the other side of the chain line so that CA = AD and angle BCD is 90º, mark point A on the chain line where the line CD cuts the chain line. At D erect a perpendicular to the line DC, which cuts the chain line at E. Measure the length of AE. Then AB = AE.



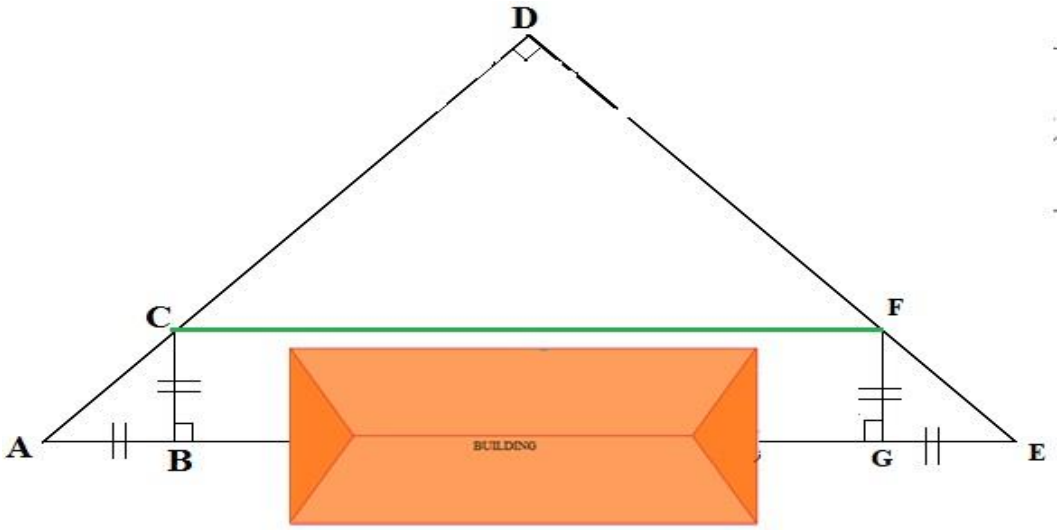
- ***OBSTACLE TO BOTH CHAINING AND RANGING:***

A Building is typical example of this type of obstacle. The problem lies in prolonging the line beyond the obstacle and determining the distances across it. The following are some of the methods.

- ✓ ***CASE 01:*** Choose two points A & B to one side and erect perpendiculars AC and BD of equal length. Join CD and Prolong it past Obstacle. Choose two points E & F on CD and erect perpendiculars EG and FH equal to that of AC. Join GH and prolong it. Measure DE. Evidently BG = DE.

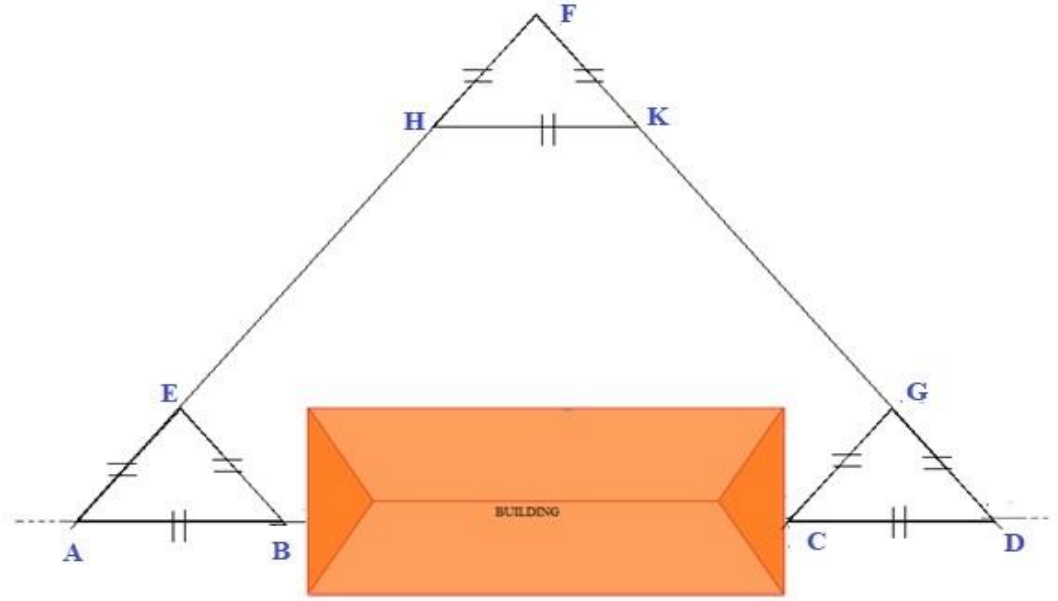


- ✓ ***CASE 02:*** Select a point A and erect a perpendicular AC of any Convenient length select another point B on the chain line such as AB=AC. Join B & C and prolong it to any convenient point D. At D set a right angle DE such that DE=DB. Choose another point F as centre and AB as radius, draw an arc. Draw another arc of the same radius to cut the previous arc in G. join GE which will be in range with the chain line. Measure CF. than AG=CF.



- ***CASE 03:*** Select two points A & B on the chain line and construct an equilateral triangle ABE by swinging arcs. Join AE and produce it to any point F. on AF choose any point H and construct an equilateral triangle FHK. Join F & K and produce it to D such that FD=FA. Choose a point G on FD and construct an equilateral triangle CDG. The direction CD is in range with the chain line. The length BC is given by

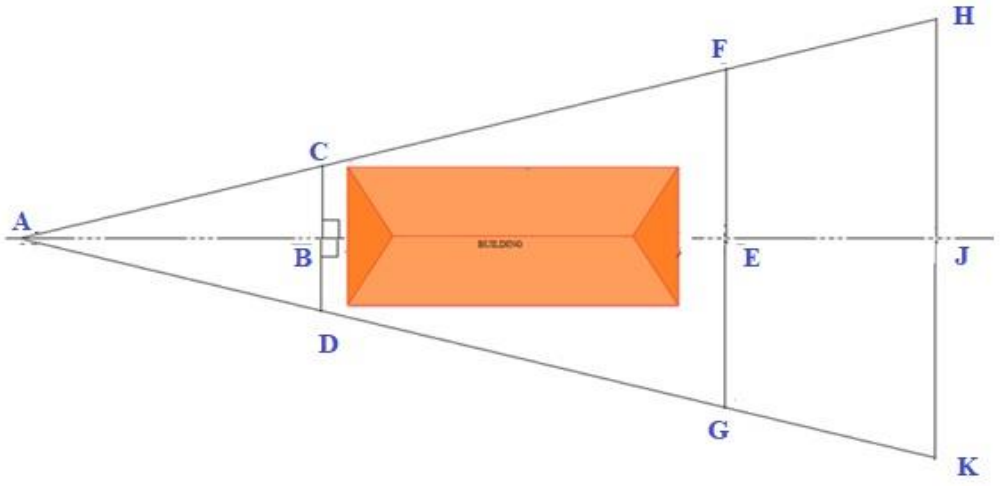
$$BC = AD - AB - CD = AF - AB - CD$$



- ***CASE 04:*** Select two points A & B on the chain line and set a line CBD. Join A & C and produce it to F such that AF=n*AC. Similarly join A & D and produce it to G such that AG=n*AD. Join F & G and mark point E on it in such a way that FE=n*BC. Similarly produce AF and AG to H and K respectively such that AH=n'*AC and AK=n'*AD. Join H & K and mark J on it in such a way that

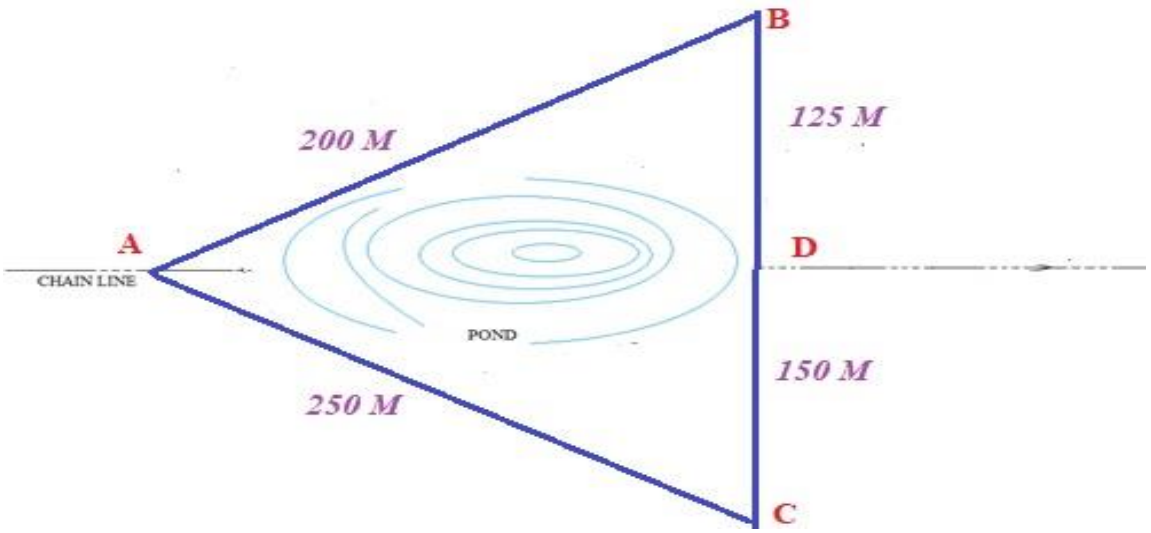
HJ=n'*CB. Join EJ which will be in range with chain line. The obstructed distance BE is given by $BE = AE - AB$ But $AE = n * AB, BE = n * AB - AB$

$BE = (n - 1) * AB$



SIMPLE PROBLEMS:

1. **In passing an obstacle in the form of a pond. Station A & D on the main line were taken on the opposite sides of the pond. On the left of AD, a line AB, 200 metre long was laid down and a second line AC, 250 Metre long was ranged right angles to AD. The points B, D & C being in same straight line. BC & DC were then chained and found to be 125M & 150M respectively. Find the length of AD?**



$$AD = \sqrt{\frac{(AB^2 * DC) + (AC^2 * DB)}{BC} - (BD * DC)}$$

$$AD = \sqrt{\frac{(200^2 * 150) + (250^2 * 125)}{275} - (125 * 150)}$$

$$AD = \sqrt{\frac{(40000 * 150) + (62500 * 125)}{275} - (6250)}$$

$$AD = \sqrt{\frac{6000000+7812500}{275} - (6250)}$$

$$AD = \sqrt{50227.27 - 6250}$$

$$AD = \sqrt{50227.27 - 6250}$$

$$AD = 209.71\ M$$

2. A survey line BAC crosses a river, A and C being on the near and distant banks respectively. Standing at D, a point 50 metres measured perpendicularly to AB from A, the bearing of C and B are 320° and 230° respectively. AB being 25 metres. Find the width of the river?

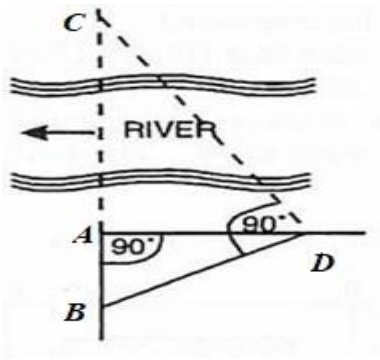
Triangles ACD and ADBC are similar.

Hence $\frac{AC}{AD} = \frac{AD}{AB}$

Therefore $AC = \frac{AD^2}{AB}$

$$AC = \frac{50^2}{25}$$

$$AC = 100.00\ M$$



ERRORS IN CHAINING:

It is necessary in studying this article to keep clearly in mind the difference between the cumulative and compensating errors and between positive and negative errors. A cumulative error is that which occurs in the same direction and tends to accumulate while a compensating error may occur in either direction and hence tends to compensate. Errors are regarded as positive or negative according as they make the result too great or too small. Errors and mistakes may arise from.

- ***Erroneous length of chain or tape:*** (Cumulative + or -). The error due to the wrong length of the chain is always cumulative and is the most serious source of error. If the length of the chain is more, the measured distance will be less and hence the error will be negative. Similarly, if the chain is too short, the measured distance will be more and error will be positive. However, it is possible to apply proper correction if the length is checked from time to time.
- ***Bad ranging:*** (Cumulative +). If the chain is stretched out of the line. the measured distance will always be more and hence the error will be positive. For each and every stretch of the chain, the error due to bad ranging will be cumulative and the effect will be too great a result. The error is not very serious in ordinary work if only the length is required. But if offsetting is to be done, the error is very serious.

- ***Careless holding and marking:*** (Compensating). The follower may sometimes hold the handle to one side of the arrow and sometimes to the other side. The leader i may thrust the arrow vertically into the ground or exactly at the end of chain. This causes a variable systematic error. The error of marking due to an inexperienced chainman is often of a cumulative nature, but with ordinary care such errors tend to compensate
- ***Bad straightening:*** (Cumulative +). If the chain is not straight but is lying in an irregular horizontal curve, the measured distance will always be too great. The error is, therefore, of cumulative character and positive.
- ***Non – horizontality:*** (Cumulative +). If the chain is not horizontal (specially in case of sloping or irregular ground), the measured distance will always be too great. The error is, therefore, of cumulative character and positive
- ***Sag in chain:*** (Cumulative +). When the distance is measured by stepping or when the chain is stretched above the ground due to undulations or irregular ground. the chain sags and takes the form of a catenary. The measured distance is, therefore. too great and the error is cumulative and positive
- ***Variation in pull:*** (Compensating ± or Cumulative + or -). If pull is applied in straightening the chain or tape is not equal to that of the standard pull at which it was calibrated, its length changes. If the pull applied is not measured but is irregular (sometimes more, sometimes less), the error tends to compensate. A chainman may, however. apply too great or too small a pull every time and the error becomes cumulative
- ***Variation in temperature:*** (Cumulative + or -). When a chain or tape is used at temperature different from that at which it was calibrated, its length changes. Due to the rise in the temperature. the length of the chain increase. The measured distance thus less and the error becomes negative. Due to the fall in temperature, the length decreases The measured distance is thus more and the error becomes negative. In either cases de error is cumulative.
- ***Personal mistakes:*** Personal mistakes always produce quite irregular effects. The following are the most common mistakes:
  - ***Displacement of arrows***. If an arrow is disturbed from its position either by knocking or by pulling the chain, it may be replaced wrongly. To avoid this, a cross must also be marked on the ground while inserting the arrows.
  - ***Miscounting chain length.*** This is a serious blunder but may be avoided if a systematic procedure is adopted to count the number or arrows.
  - ***Misreading.*** A confusion is likely between reading a 5 m tally for 15 m tally. since both are of similar shape. It can be avoided by seeing the central tag. Sometimes. A

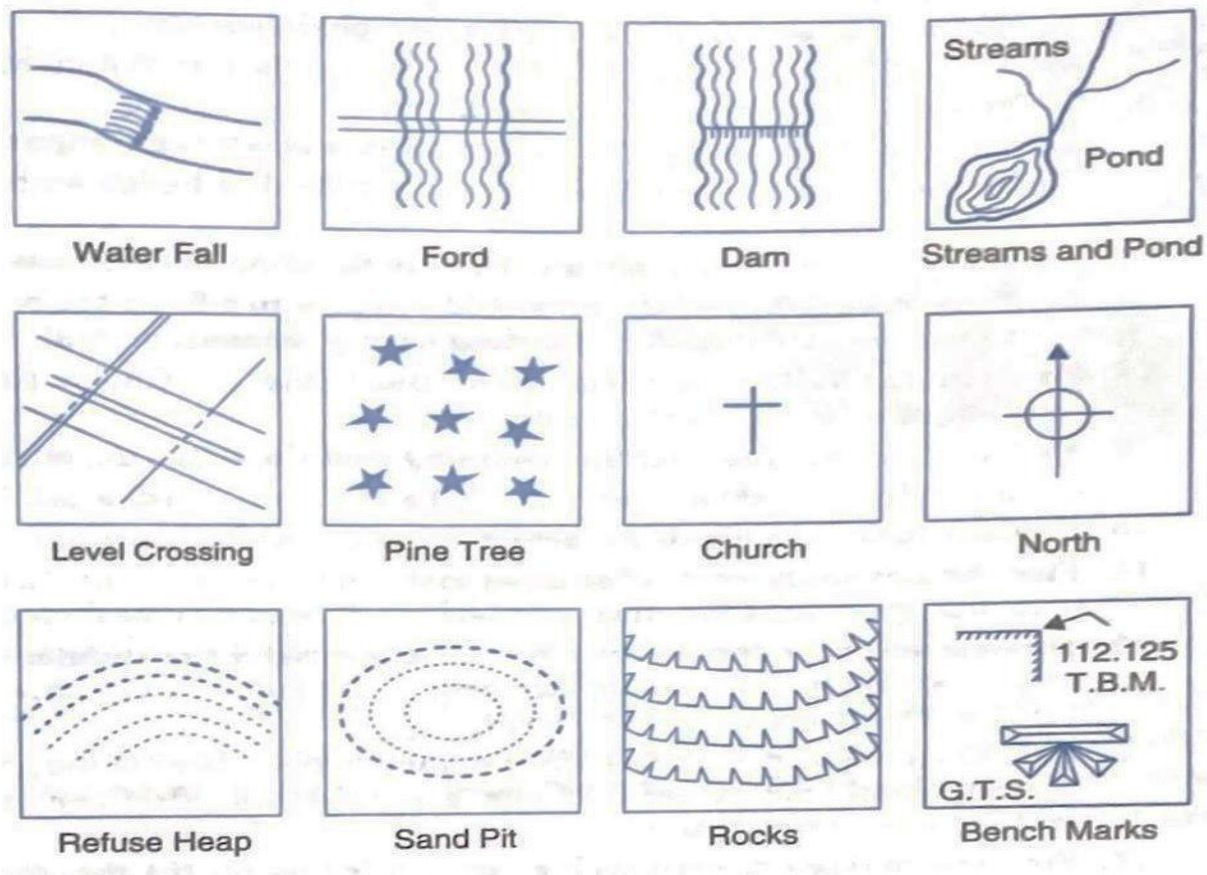
chainman may pay more attention on cm reading on the tape and read the metre reading A surveyor may sometimes read 6 in place of 9 or 28.26 in place of 28.62.

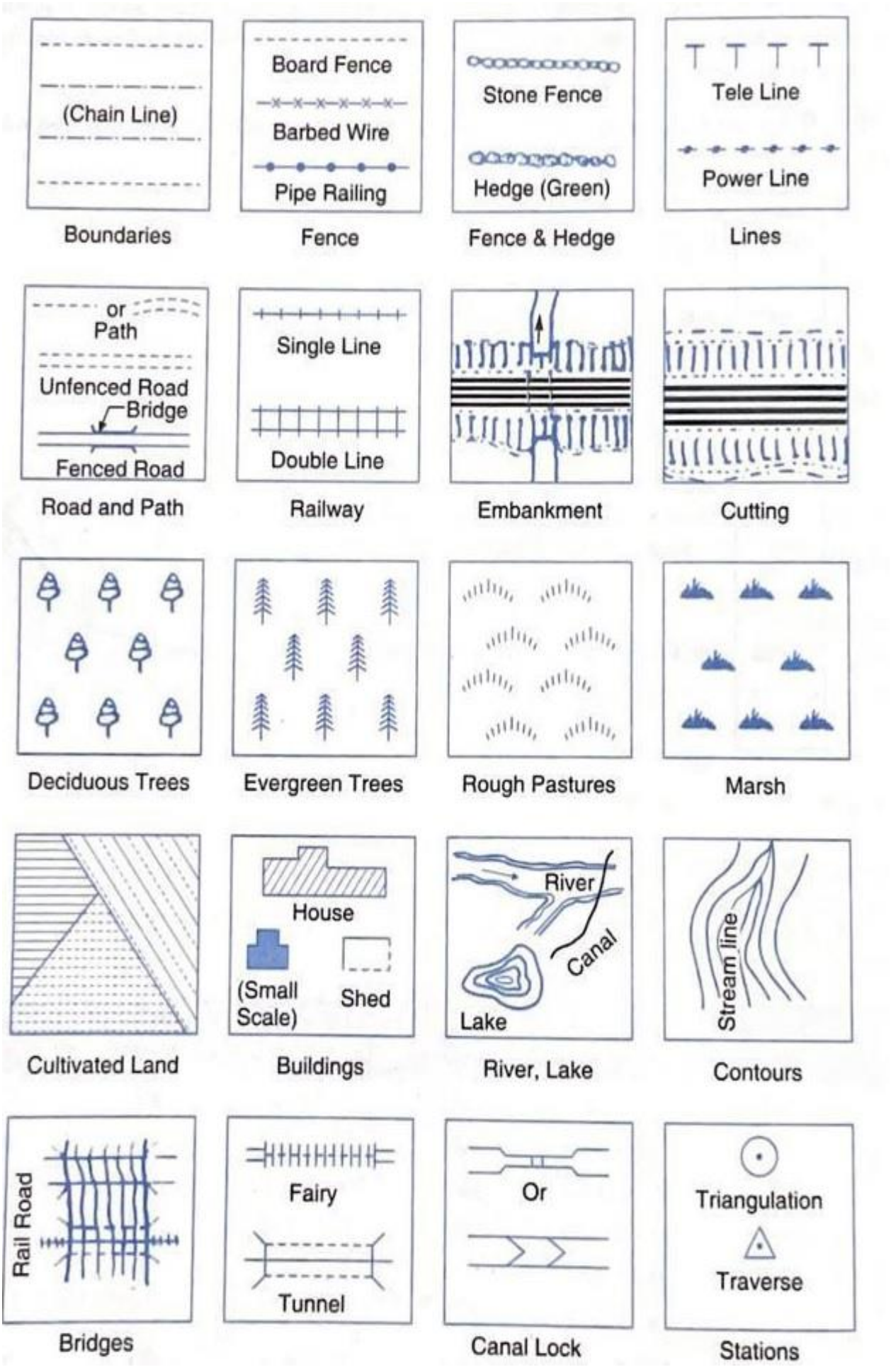
- ✓ ***Erroneous booking.*** The surveyor may enter 246 in place of 264 etc. To avoid such possibility, the chainman should first speak out the reading loudly and the surveyor should repeat the same while entering in the field book.

SUMMARY OF ERRORS IN CHAINING

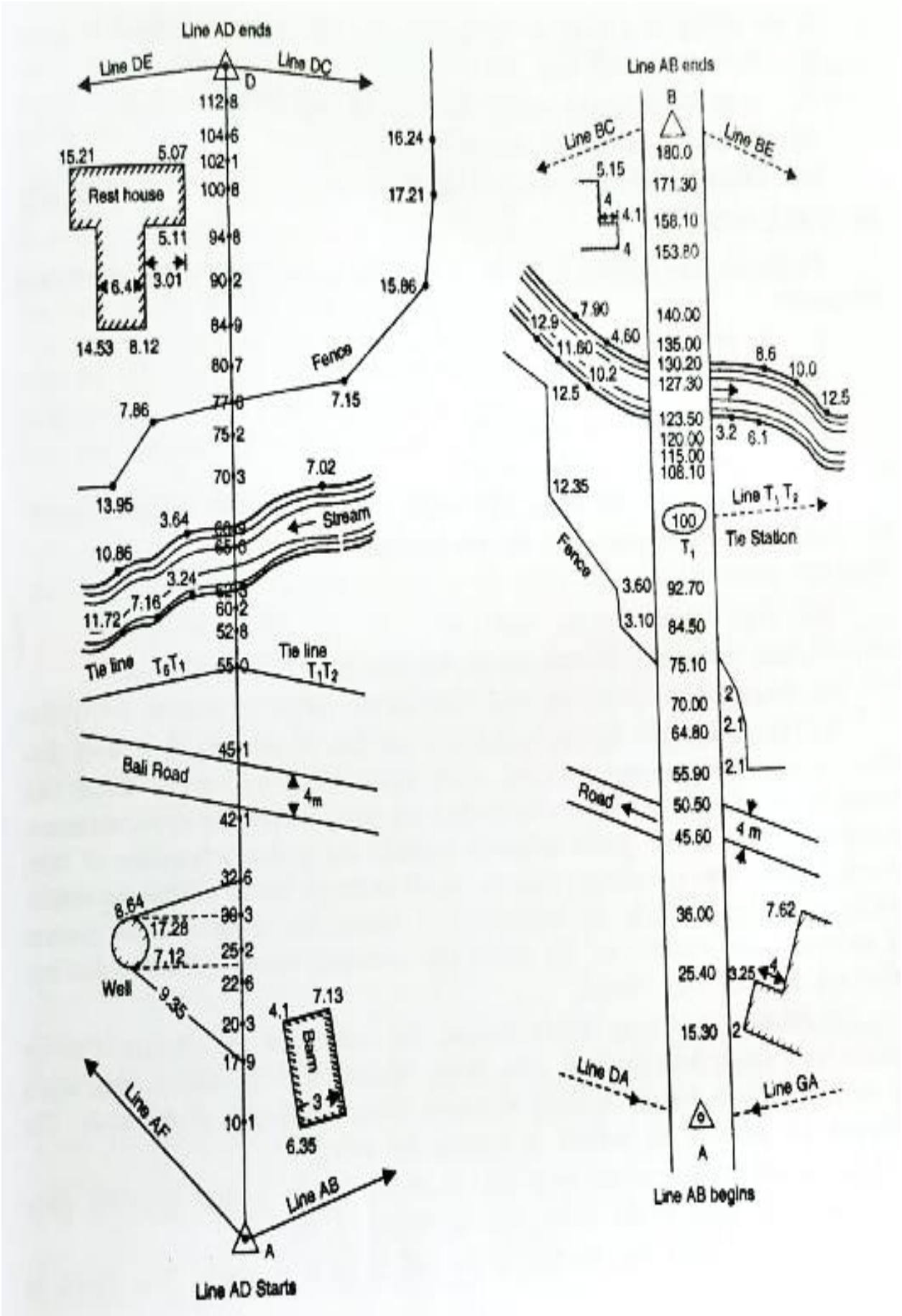
1.	Incorrect length of tape	Cumulative + or -
2.	Bad ranging	Cumulative+
3.	Tape not stretched horizontally	Cumulative +.
4.	Tape not stretched tight and straight, but both ends in line	Cumulative +.
5.	Error due to temperature	Cumulative + or -
6.	Variation in pull	Compensating ±
7.	Error due to sag	Cumulative +
8.	Error in marking tape lengths	Compensating ±.
9.	Disturbing arrows after they are set	Blunder.
10.	Errors in reading the tape	Mistake
11.	Incorrect counting of tape lengths	Blunder.

CONVENTIONAL SYMBOLS




(Chain Line)
Boundaries
Board Fence
Barbed Wire
Pipe Railing
Fence
Stone Fence
Hedge (Green)
Fence & Hedge
Tele Line
Power Line
Lines
or
Path
Unfenced Road
Bridge
Fenced Road
Road and Path
Single Line
Double Line
Railway
Embankment
Cutting
Deciduous Trees
Evergreen Trees
Rough Pastures
Marsh
Cultivated Land
House
(Small
Scale)
Shed
Buildings
River
Canal
Lake
River, Lake
Stream line
Contours
Rail Road
Bridges
Fairy
Tunnel
Or
Canal Lock
Triangulation
Traverse
Stations

FIELD BOOK:


Line AD ends
Line DE
Line DC
D
112.8
104.6
102.1
100.8
94.8
90.2
84.9
80.7
77.6
75.2
70.3
60.2
52.8
55.0
45.1
42.1
32.6
30.3
25.2
22.6
20.3
17.9
10.1
16.24
17.21
15.86
15.21
5.07
Rest house
5.11
3.01
6.45
14.53
8.12
Fence
7.15
7.86
13.95
7.02
3.64
Stream
10.86
3.24
7.16
11.72
Tie line T5T1
Tie line T1T2
Bali Road
4m
8.64
17.28
7.12
Well
9.35
7.13
4.1
Barn
3
6.35
Line AF
Line AB
A
Line AD Starts
Line AB ends
B
Line BC
Line BE
180.0
171.30
158.10
153.80
5.15
4
4.1
4
7.90
12.9
11.60
4.60
10.2
12.5
140.00
135.00
130.20
127.30
123.50
120.00
115.00
108.10
8.6
10.0
12.5
3.2
6.1
12.35
Line T1 T2
100
T1
Tie Station
Fence
3.60
3.10
92.70
84.50
75.10
70.00
64.80
55.90
50.50
45.60
2
2.1
2.1
Road
4 m
36.00
7.62
25.40
3.25
4
15.30
2
Line DA
Line GA
A
Line AB begins

The book in which the chain or tape measurements are entered is called the field book. It is an oblong book of size about 20 cm x 12 cm and opens lengthwise. The main requirements of the field book are that it should contain good quality stout opaque paper, it should be well - bound and of a size convenient for the pocket. The chain line may be represented either by a single line or by two lines spaced about 1/2 to 2 cm apart, ruled down the middle of each page.

The double line field book is most commonly used for ordinary work, the distance along the chain being entered between the two lines of the page. Single line field book is used for a comparatively large scale and most detailed dimension work. A chain line is started from the bottom of the page and works upwards.

All distances along the chain line are entered in the space between the two ruled lines while the offsets are entered either to the left or to the right of the chain line, as the case may be. Offsets are entered in the order they appear at the chain line. As the various details within offsetting distances are reached, they are sketched and entered as shown in Figure. Every chain line must be started from a fresh page. All the pages must be machine numbered

REFERENCES

1. Surveying Volume I by B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain.16th Edition, Laxmi publications (P) Ltd, #113, Golden House, Daryagunj, New Delhi – 110002, India.

COMPASS SURVEYING

UNIT 03: COMPASS SURVEY

TECHNICAL TERMS:

- ***ANGLE***: The direction of survey line with reference to the another survey line meeting with it is known as Angle.

- ***BEARING:*** Bearing of a line is its direction relative to a given meridian.
  - ✓ ***True Bearing:*** The bearing of a line is the horizontal angle which it makes with the true meridian through one of the extremities of the line. Since the direction of true meridian through a point remains fixed, the true being of a line is a constant quantity.
  - ✓ ***Magnetic Bearing:*** The magnetic bearing of a line is the horizontal angle which it makes with the magnetic meridian passing through one of the extremities of the line. A magnetic compass is used to measure it.
  - ✓ ***Arbitrary Bearing:*** Arbitrary bearing of a line is the horizontal angle which it makes with any arbitrary meridian passing through one of the extremities. A theodolite or sextant is used to measure it.

- ***MERIDIAN:*** Meridian is an imaginary reference line or it is fixed direction in which the bearings of the survey lines are measured.
  - ✓ ***True Meridian:*** True meridian through a point is the line in which a plane, passing that point and the north and south poles, intersects with surface of the earth. It passes through the true north and south. The direction of the true meridian through a point can be established by an astronomical observation.
  - ✓ ***Magnetic Meridian:*** Magnetic meridian through a point is the direction shown by a freely floating balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of a magnetic compass.
  - ✓ ***Arbitrary Meridian:*** Arbitrary meridian is any convenient direction towards a permanent and prominent mark or signal, such as a church spire or top of a chimney. Such meridians are used to determine the relative positions of lines in a small area.

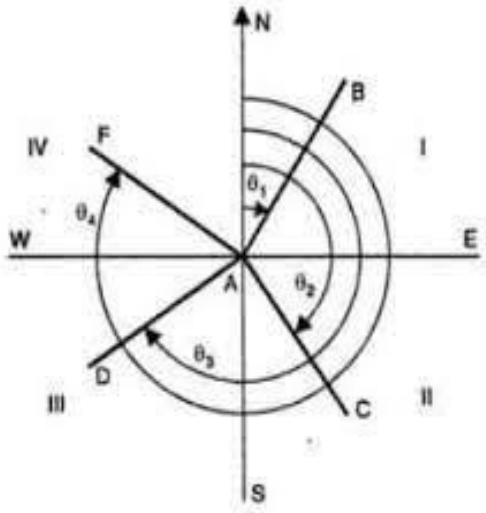
DESIGNATION OF BEARINGS:

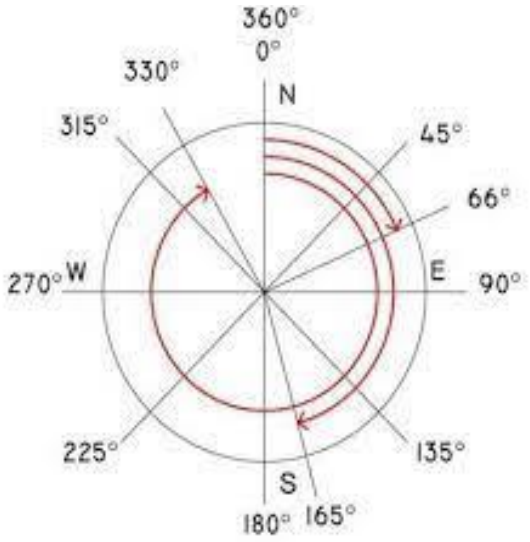
The common systems of notation of bearings are:

- The Whole Circle Bearing (WCB) system.
- The Quadrantal Bearing (QB) system.

THE WHOLE CIRCLE BEARING SYSTEM:

In this system, the bearings of a line are measured with magnetic north in clockwise direction. The value of the bearing varies from 0º to 360º. Prismatic compass is graduated on this system. In India and UK, the whole circle bearing system is measured clockwise with magnetic north. Referring to the below figure the WCB of AB is θ_1, AC is θ_2, AD is θ_3 and AF is θ_4.

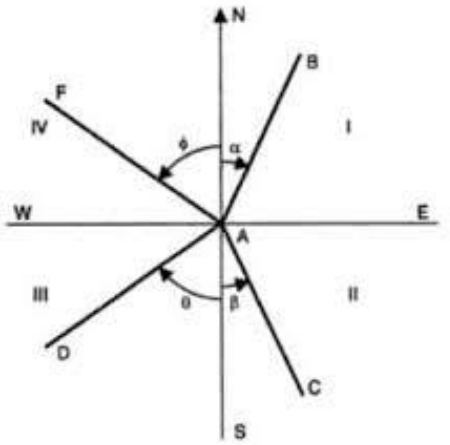


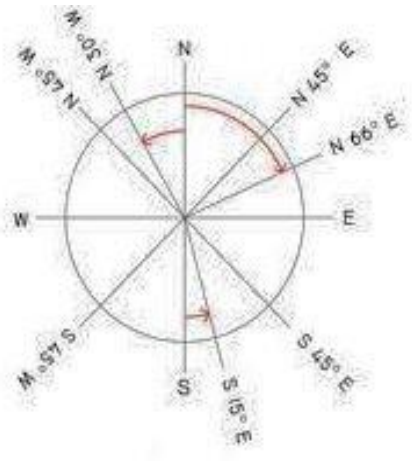


THE QUADRANTAL BEARING OR REDUCED BEARING SYSTEM:

In this system, the bearings of a line are measured eastward or westward from north or south, whichever is nearer. Both north and south are used as reference meridians and directions can be either clockwise or anticlockwise depending upon the positions of the line. In this system, the quadrant in which the line lies are mentioned. These bearings are observed by surveyor's compass.

Referring to the below figure, the QB of the line AB is α and is written as N α E, the bearing being measured with reference to north meridian (since it is nearer) towards east. The bearing of AC is β and is written as S β E, it is being measured with reference to South in anticlockwise direction towards east. Similarly, the bearings of the AD and AF are respectively S θ W and N Φ W.





In the Quadrantal system, the reference meridian prefixed and the direction of measurement (Eastward or Westward) is affixed to the numerical value of the bearing. The QB of a line varies from 0º to 90º. The bearings of this system are known as Reduced bearings.

CONVERSION OF BEARINGS FROM ONE SYSTEM TO OTHER:

CONVERSION OF WCB INTO RB:

The bearing of a line can be very easily converted from one system to the other with the aid of a diagram. Referring to the figure in WCB system, the conversion of WCB to QB can be expressed in the following table.

Line	WCB between	Rule for RB	Quadrant
AB	0º to 90º	RB = WCB	NE
AC	90º to 180º	RB =180º - WCB	SE
AD	180º to 270º	RB = WCB - 180º	SW
AF	270º to 360º	RB = 360º - WCB	NW

CONVERSION OF RB INTO WCB:

The bearing of a line can be very easily converted from one system to the other with the aid of a diagram. Referring to the figure in RB system, the conversion of RB to WCB can be expressed in the following table.

Line	RB	Rule for WCB	WCB between
AB	N α E	WCB = RB	0º to 90º
AC	S β E	WCB =180º - RB	90º to 180º
AD	S θ W	WCB = 180º + RB	180º to 270º
AF	N Φ W	WCB = 360º - RB	270º to 360º

EXAMPLES ON CONVERSION OF BEARINGS FROM ONE TO ANOTHER:

1. **Convert the following whole circle bearings to reduced bearings?**
   a. **22º 30', b. 170º 12', c. 211º 54'& d. 327º 24'**

   Solution:

   a. **RB = WCB = 22º 30' = N 22º 30' E.**
   b. **RB = 180º - WCB = 180º - 170º 12' = S 9º 48' E.**
   c. **RB = WCB - 180º = 211º 54' - 180º = S 31º 54' W.**
   d. **RB = 360º - WCB = 360º - 327º 24' = N 32º 36' W.**

2. **Convert the following Quadrantal bearings to whole circle bearings?**
   a. **N 12º 24' E, b. S 31º 36' E, c. S 68º 6' W & d. N 5º 42' W.**

   Solution:

   a. **WCB = RB = 12º 24'.**
   b. **WCB = 180º - RB = 180º - 31º 36' = 148º 24'.**

c. **WCB = RB + 180⁰ = 68⁰ 6’ + 180⁰ = 248⁰ 6’.**

d. **WCB = 360⁰ - RB = 360⁰ - 5⁰ 42’ = 354⁰ 18’.**

3. **The following are observed fore bearings of the lines.**

   a. **AB 12⁰ 24’, b. BC 119⁰ 48’, c. CD 266⁰ 30’, d. DE 354⁰ 18’, e. PQ N 18⁰ 0’ E, f. QR S 12⁰ 24’ E, g. RS S 59⁰ 18’ W, h. ST N 86⁰ 12’ W. Find the back bearings?**

   Solution:

   a. **BB of line AB = 180⁰ + 12⁰ 24’= 192⁰ 24’.**

   b. **BB of line BC = 180⁰ + 119⁰ 48’= 299⁰ 48’.**

   c. **BB of line CD = 266⁰ 30’ - 180⁰ = 86⁰ 30’.**

   d. **BB of line DE = 354⁰ 18’ - 180⁰ = 174⁰ 42’.**

   e. **BB of line PQ = S 18⁰ 0’ W.**

   f. **BB of line QR = N 12⁰ 24’ W.**

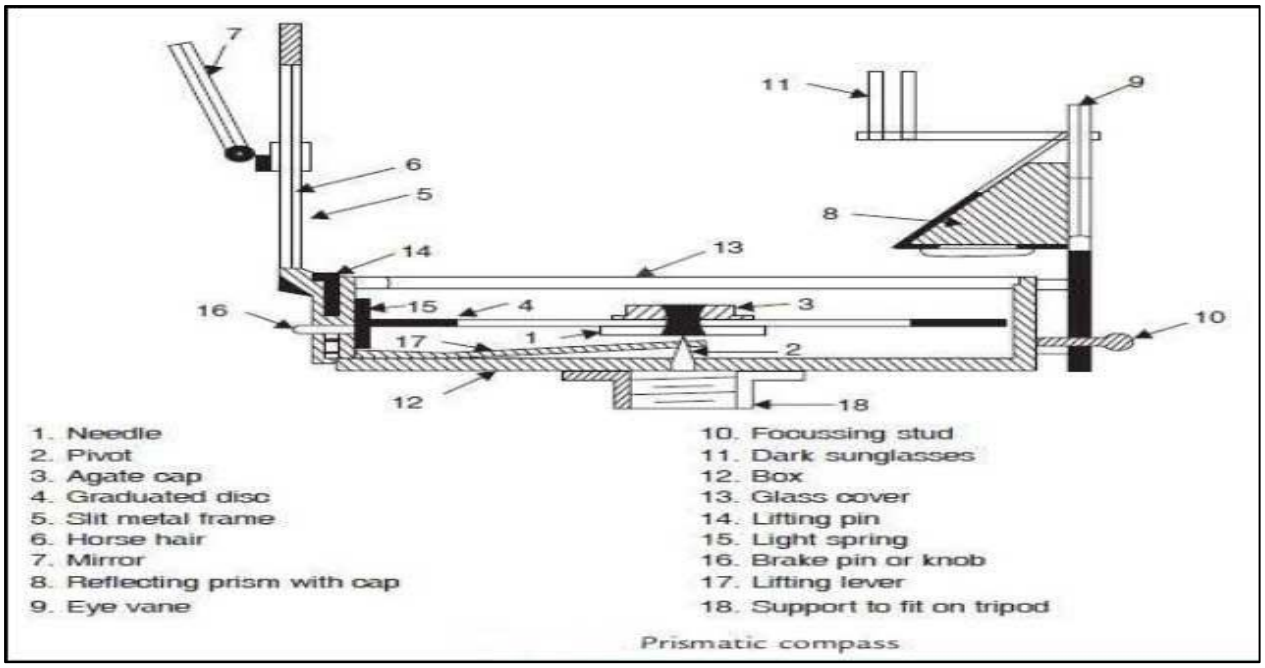
   g. **BB of line RS = N 59⁰ 18’ E.**

   h. **BB of line PQ = S 86⁰ 12’ E.**

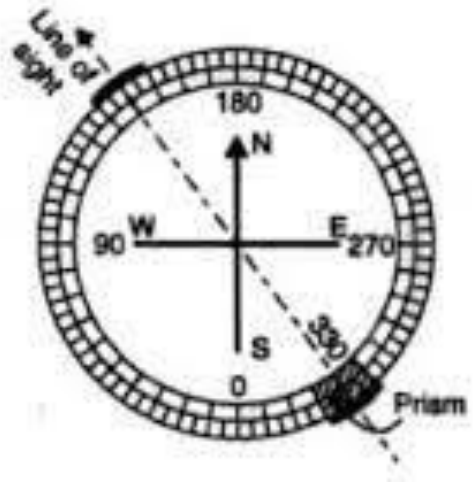
COMPONENT PARTS OF PRISMATIC COMPASS:

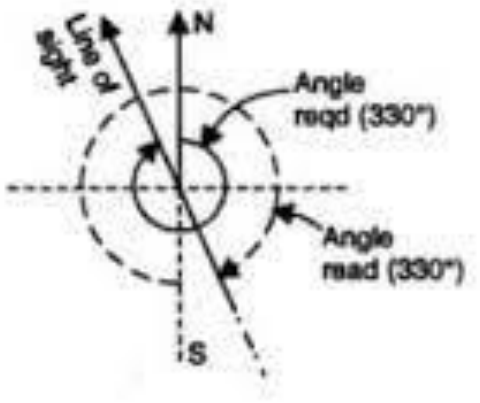
Prismatic compass is the most convenient and portable form of magnetic compass which can either be used as a hand instrument or can be fitted on a tripod. The main parts of the prismatic compass are shown in Figure. As illustrated in the diagram, the magnetic needle is attached to the circular ring or compass card made up of aluminium, a non - magnetic substance. When the needle is on the pivot, it will orient itself in the magnetic meridian and, therefore, the N and S ends of the ring will be in this direction. The line of sight is defined by the object vane consists of vane and the eye slit, both attached to the compass box. The object wane consists of a vertical hair attached to a suitable frame while the eye slit consists of a vertical slit cut into the upper assembly of the prism unit, both being hinged to the box.

When an object is sighted, the sight vanes will rotate with respect to the NS end of ring through an angle which the line makes with the magnetic meridian. A triangular prism is fitted below the eye slit, having suitable arrangement for focusing to suit different eye sights. The prism has both horizontal and vertical faces convex, so that a magnified image of the ring graduation is formed. When the line of sight is also in the magnetic meridian, the South end of the ring comes vertically below the horizontal face of the prism. The 0° or 360° reading is, therefore, engraved on the South end of the ring, so that bearing of the magnetic meridian is read as 0° with the help of the prism which is vertically above South end in this particular position. The readings increase in clockwise direction from 0⁰ at South end to 90° at West end, 180° at North end and 270° at East end This has been clearly illustrated in Figure.

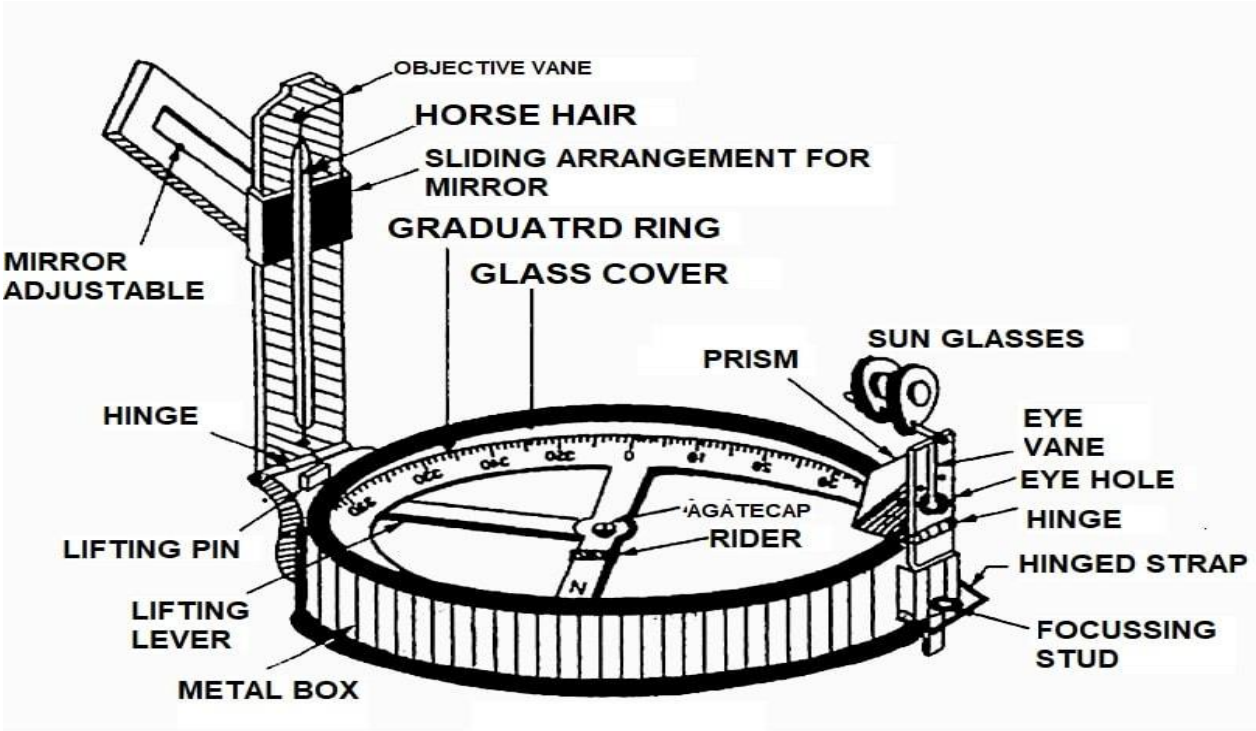


Prismatic compass





When not in use, the object vane frame can be folded on the glass lid which covers the top of the box. The object vane, thus presses against a bent lever which lifts the needle off the pivot and holds it against the glass lid. By pressing knob or brake - pin placed at the base of the object vane, a light spring fitted inside the box can be brought into the contact with the edge of the graduated ring to damp the oscillations of the needle when about to take the reading. The prism can be folded over the edge of the bot A metal cover fits over the circular box, when not in use. To sight the objects which are too high or too low to be sighted directly, a hinged mirror capable of sliding over the object vane is provided and the objects sighted by reflection. When bright objects are sighted, dark glasses may be interposed into the line of sight. The greatest advantage of prismatic compass is that both sighting the object as well as reading circle can be done simultaneously without changing the position of the eye. The circle is read at the reading at which the hair line appears to cut the graduated ring.



Prismatic Compass

METHOD OF USING PRISMATIC COMPASS:

The compass may be held in the hand, but for better results, it is usually mounted on a tripod which carries a vertical spindle in a ball and socket joint to which the box is screwed. By means of this arrangement the instrument can be quickly levelled and also rotated in a horizontal plane and clamped in any position.

ADJUSTMENT OF PRISMATIC COMPASS:

The following are the adjustments usually necessary in the prismatic compass.

- ***Station or Temporary Adjustments:*** Temporary adjustments are those adjustments which have to be made at every set up of the instrument. They comprise the following:
  - ✓ ***Centring:*** Centring is the process of keeping the instrument exactly over the station. Ordinary prismatic compass is not provided with fine centring device as is generally fitted to engineer's theodolite. The centring is invariably done by adjusting or manipulating the legs of the tripod. A plumb - bob may be used to judge the centring and if it is not available, it may be judged by dropping a pebble from the centre of the bottom of the instrument.
  - ✓ ***Levelling:*** If the instrument is a hand instrument, it must be held in hand in such a way that graduated disc is swinging freely and appears to be level as judged from the top edge of the case. Generally, a tripod is provided with ball and socket arrangement with the help of which the top of the box can be levelled.
  - ✓ ***Focusing the Prism:*** The prism attachment is slided up or down for focusing till the readings are seen to be sharp and clear.

- ***Permanent Adjustments:*** The permanent adjustments of prismatic compass are almost the same as that of the surveyor's compass except that there are no bubble tubes to be adjusted and the needle cannot be straightened. The sight vanes are generally not adjustable.

OBSERVING BEARINGS:

To observe the bearing of a line AB:

- ✓ Centre the compass over the station A and level it.
- ✓ Having turned up vertical prism and the sighting vane, raise or lower the prism until the graduations are clearly visible.
- ✓ Turn the compass box until the ranging rod at the station B is bisected by the hair When looked through the slit above the prism.
- ✓ When the needle comes to rest, look through the prism and note the reading at which The hair line produced appears to cut the image of the graduated ring which gives the Required bearing of the line AB.

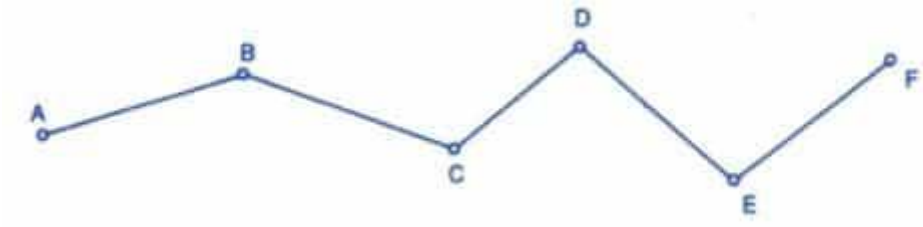
TRAVERSE:

A traverse is a series of connected lines whose lengths and directions are to be measured and the process of surveying to find such measurements is known as traversing. In general, chains are used to measure length and compass or theodolite are used to measure the direction of traverse lines.

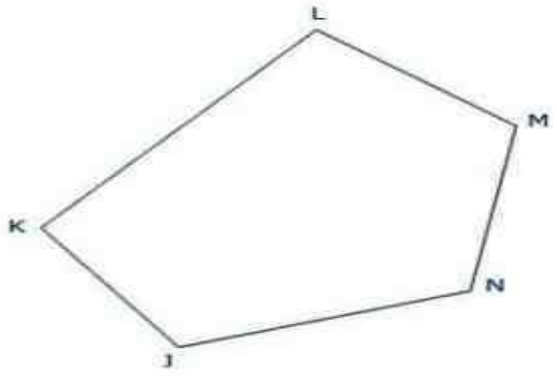
TYPES OF TRAVERSE:

A Traverse may be of two types. Namely,

- Open Traverse
- Closed Traverse
- ***OPEN TRAVERSE:*** A traverse is said to be open traverse when the traverse starts at one point and terminates at another point as shown in the figure. Open traverse is also called as unclosed traverse. It is suitable for surveying of roads, coastal lines, etc.



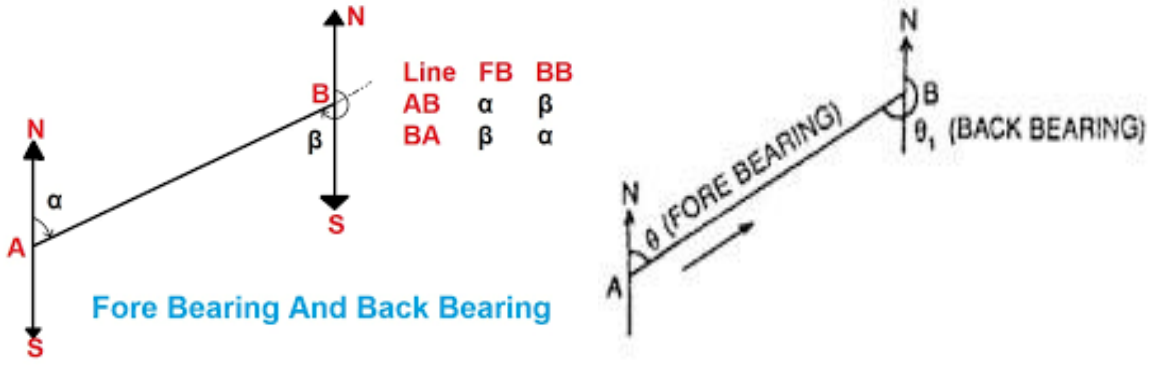
- ***CLOSED TRAVERSE:*** A traverse is said to be closed traverse when the traverse formed a closed circuit as shown in the figure. In this case, both starting and terminating points of the traverse coincide with each other. It is suitable for the survey of boundaries of ponds, sports grounds, forests, etc.



FORE BEARING & BACK BERING:

The bearing of the line, whether expressed in WCB or QB system differs according as the observations is made from one end of the line or from the other.

The bearing of the line is measured in the direction of the progress of survey is called the ***forward bearing or fore bearing***. While the bearing measured in the opposite direction is called as the ***backward bearing or back bearing.***



The difference between the fore bearing and back bearing of a line is 180º.

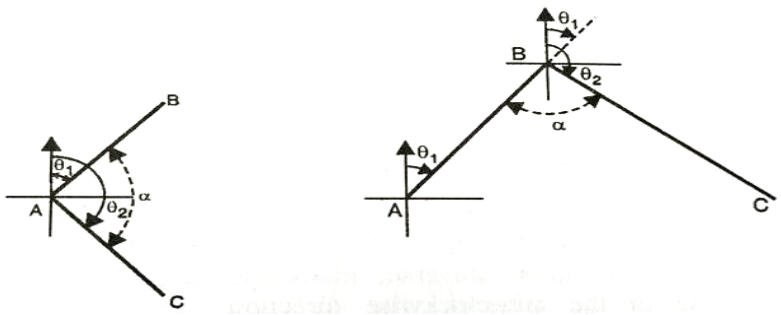
Back bearing = fore bearing ± 180º.

Note:

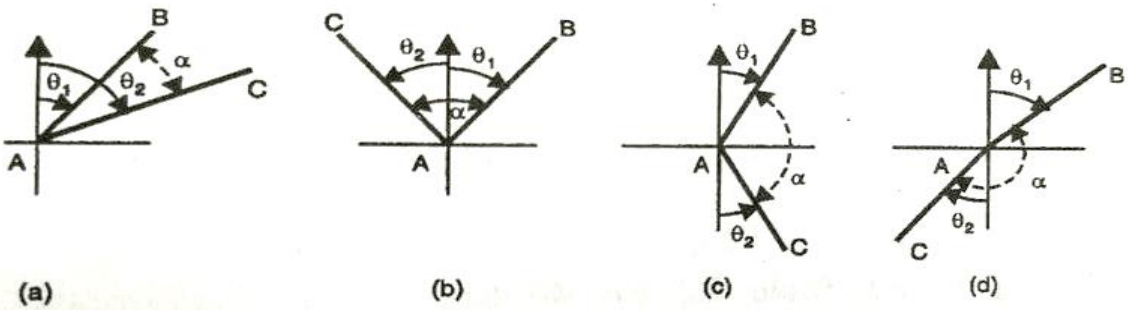
- If Fore bearing is less than 180º, then Back bearing (B.B) = Fore bearing+ 180º.
- If Fore bearing is more than 180º, then Back bearing (B.B) = Fore bearing- 180º.

CALCULATION OF ANGLES FROM BEARINGS:

Knowing the bearing of two lines, the angle between the two can very easily be calculated with the help of a diagram. Referring to the figure, the included angle α between the lines AC and AB = θ_2 - θ_1 = FB of line AC – FB of line AB, both bearings are measured from a common point A. Referring to the figure, the angle α = (180º+ θ_1) - θ_2 = BB of previous line – FB of next line. both bearings are measured from a common point A.



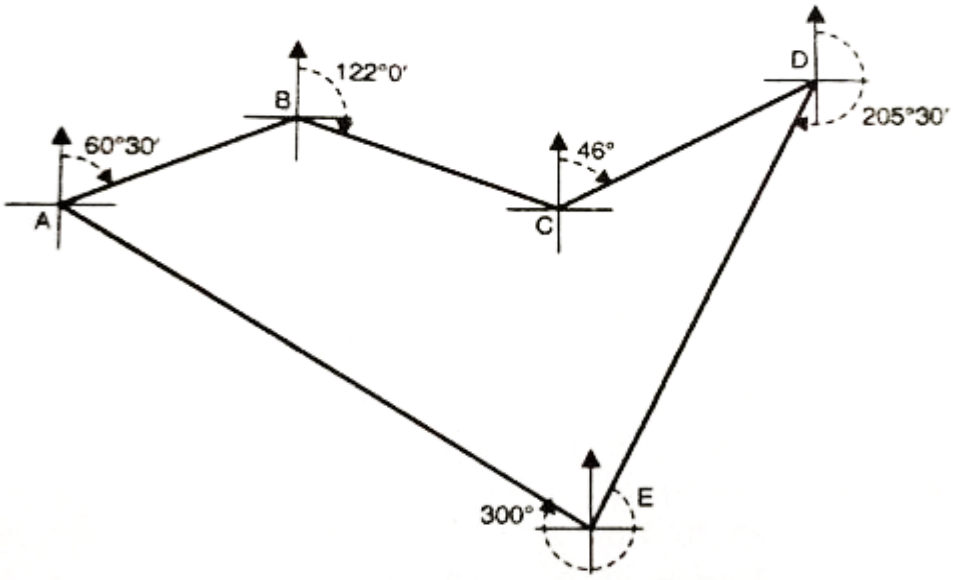
Let us consider the Quadrantal bearing. Referring to figure (a) in which both the bearings have been measured to the same side of the common meridian, the included angle $\alpha = \theta_2 - \theta_1$. Referring to figure (b) in which both the bearings have been measured to the opposite sides of the common meridian, the included angle $\alpha = \theta_1 + \theta_2$. Referring to figure (c) in which both the bearings have been measured to the same side of the different meridian, the included angle $\alpha = 180^0 - (\theta_2 + \theta_1)$. Referring to figure (d) in which both the bearings have been measured to the opposite sides of the different meridian, the included angle $\alpha = 180^0 - (\theta_1 - \theta_2)$.



EXAMPLES ON ANGLES AND BEARINGS:

1. **The following bearings were observed with a compass. Calculate the interior angles?**

Line	AB	BC	CD	DE	EA
Fore Bearing	60° 30’	122° 0’	46° 0’	205° 30’	300° 0’



$$\textbf{\textit{Included angle} = \textit{Bearing of Previous Line} - \textit{Bearing of Next Line}}$$

$\angle A = Bearing\ of\ AE - Bearing\ of\ AB = (300^0 0' - 180^0 0') - 60^0 30' = 59^0 30'$

$\angle B = Bearing\ of\ BA - Bearing\ of\ BC = (60^0 30' + 180^0 0') - 122^0 = 118^0 30'$

$\angle C = Bearing\ of\ CB - Bearing\ of\ CD = (122^0 + 180^0 0') - 46^0 = 256^0$

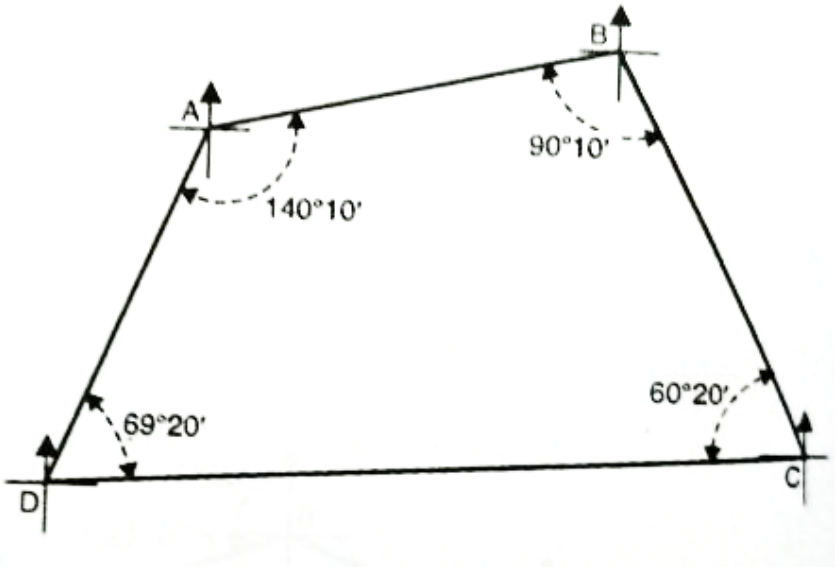
$\angle D = Bearing\ of\ DC - Bearing\ of\ DE = (46^0 + 180^0 0') - 205^0 30' = 20^0 30'$

$\angle E = Bearing\ of\ ED - Bearing\ of\ EA = (205^0 30' - 180^0 0') - 300^0 + 360^0 = 85^0 30'$

Sum = 59º 30' + 118º 30' + 256º + 20º 30' + 85º 30' = 540º 0'

$\boldsymbol{CHECK = (2n - 4) * 90^0}$ **= (2*5 -4) *90º = (10-4) *90º = 540º 0'**

2. **The following interior angles were measured with a compass in a closed traverse. The bearing of line AB was measured as 60º 0'. Calculate the bearings of other lines if ∠A = 140º 10', ∠B = 90º 10', ∠C = 60º 20' & ∠D = 69º 20'.**



Clockwise angles will be obtained if we proceed in the anti-clockwise direction round the traverse. Starting with A and proceeding toward D, C & B we have,

$Bearing\ of\ AD = Bearing\ of\ AB + \angle A = 60^0 0' + 140^0 10' = 200^0 10'$

$\therefore Bearing\ of\ DA = Bearing\ of\ AD \pm 180^0 = 200^0 10' - 180^0 0' = 20^0 10'$

$Bearing\ of\ DC = Bearing\ of\ DA + \angle D = 20^0 10' + 69^0 20' = 89^0 30'$

$\therefore Bearing\ of\ CD = Bearing\ of\ DC \pm 180^0 = 89^0 30' + 180^0 0' = 269^0 30'$

$Bearing\ of\ CB = Bearing\ of\ CD + \angle C = 269^0 30' + 60^0 20' = 329^0 50'$

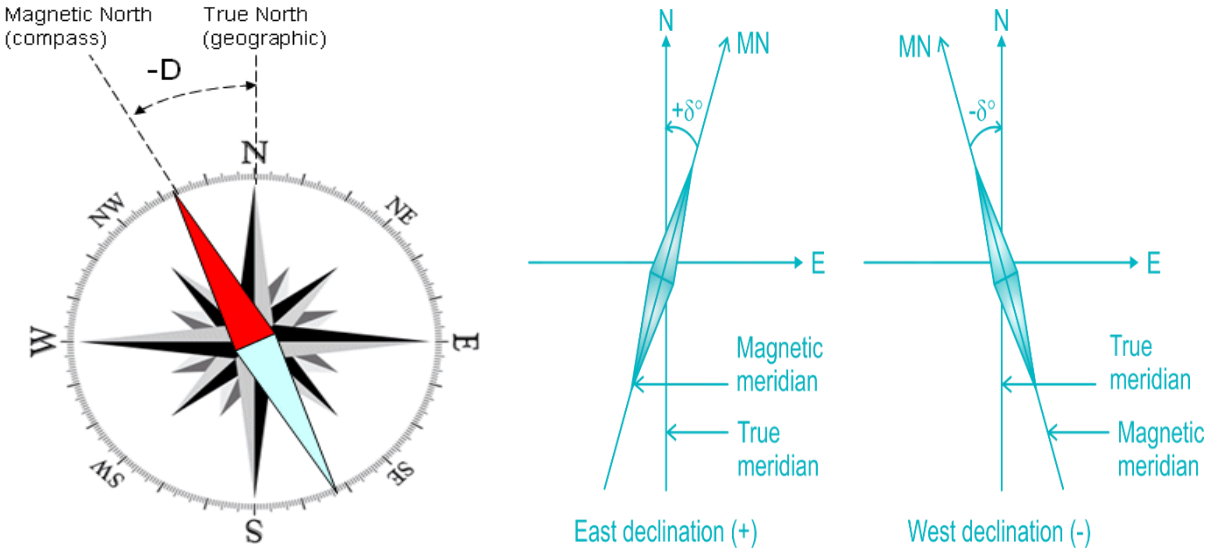
$\therefore Bearing\ of\ BC = Bearing\ of\ CB \pm 180^0 = 329^0 50' - 180^0 0' = 149^0 50'$

$Bearing\ of\ BA = Bearing\ of\ CB + \angle B = 149^0 50' + 90^0 10' = 240^0 0'$

$\therefore Bearing\ of\ AB = Bearing\ of\ BA \pm 180^0 = 240^0 0' - 180^0 0' = 60^0 0'\ (CHECK)$

MAGNETIC DECLINATION:

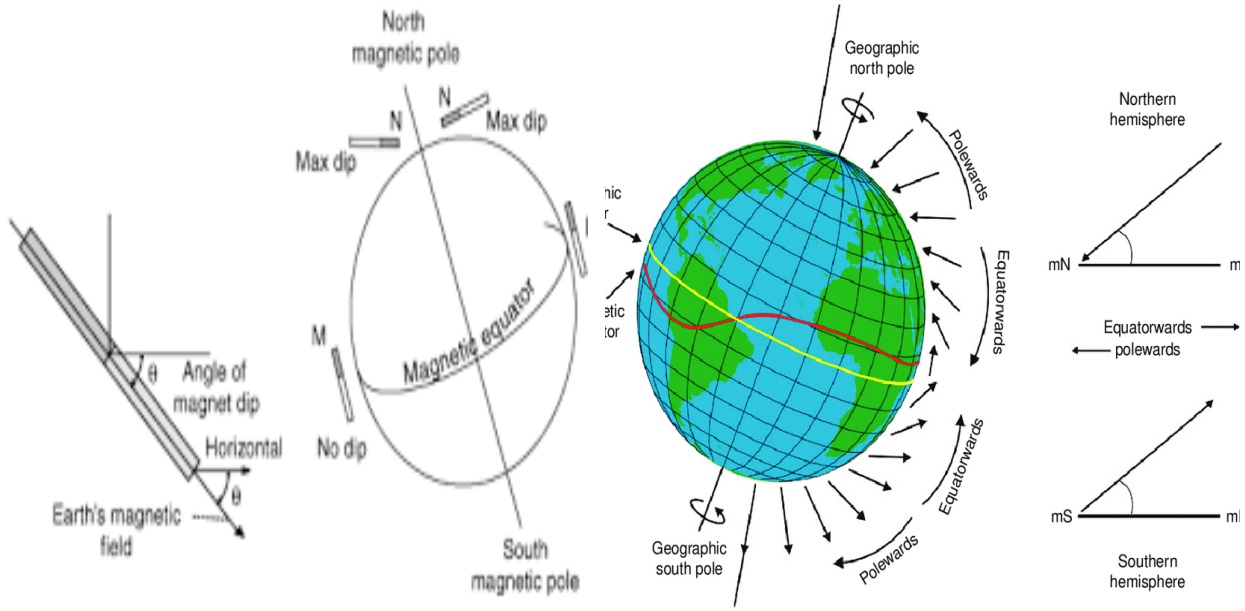
Magnetic declination at a place is the horizontal angle between the true meridian and the magnetic meridian shown by the needle at the time of observation. If the magnetic meridian is to the right side of the true meridian, declination is said to be ***Eastern or Positive.*** If the magnetic meridian is to the left side of the true meridian, declination is said to be ***Western or Negative.***



Mariners call declination by the name Variation. The declination at any particular location can be obtained by establishing a true meridian from astronomical observations and then reading the compass while sighting along the true meridian.

Isogonic lines is the line drawn through the points of same declination. The distribution of earth's magnetism is not regular and consequently, the isogonic lines do not form complete great circles, but radiating from the north and South magnetic regions they follow irregular paths. ***Agonic line*** is the line made up of points having a zero declination.

DIP:



The earth acts as a powerful magnet and like any magnet, forms a field of magnetic force which exerts a directive influence on a magnetised bar of steel or iron. If any slender symmetrical bar magnet is freely suspended at its centre of gravity so that it is free to turn in Azimuth, it will align itself in a position parallel to the lines of magnetic force of the earth at the point.

The lines of the force of earth's magnetic field run generally from south to north. Near the equator, they are parallel to the earth surface. The horizontal projections of the lines of force define the magnetic meridian. The angle which these lines of force make with the surface of the earth is called ***angle of Dip*** or ***Dip of the needle***.

SIMPLE PROBLEMS ON DECLINATION:

1. **The magnetic bearing of a line is 48º 24'. Calculate the true bearings if the magnetic declination is 5º 38' East?**

   Solution:

   Declination = +5º 38'.

   ∴ True Bearing = Magnetic bearing + Declination

   True Bearing = 48º 24' + 5º 38'

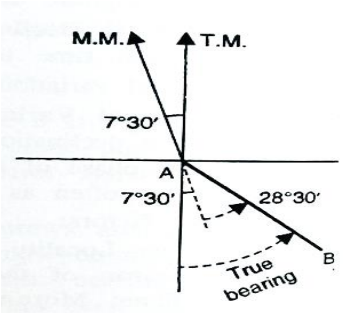
   True Bearing = 54º 02'

2. **The magnetic bearing of a line AB is S 28º 30' E. Calculate the true bearings if the magnetic declination is 7º 30' West?**

   Solution: The position of the true meridian, magnetic meridian and the line have been shown in picture. Since the declination is to be west, the magnetic meridian will be to the west of true meridian.

   True bearing = S 28º 30' E + 7º 30'

   True bearing = S 36º E



3. **In an old map, a line AB was drawn to a magnetic bearing of 5º 30'. The magnetic declination at the time being 1º East. To what magnetic bearing should the line be set now if the present magnetic declination is 8º 30' East?**

   Solution:

   The True bearing of the line = 5º 30' + 1º = 6º 30'

   Present Declination = + 8º 30' East

   Now, True bearing of the line = Magnetic Bearing + 8º 30'

   ∴ Magnetic Bearing = True Bearing - 8º 30'

   Magnetic Bearing = 6º 30' - 8º 30'

   Magnetic Bearing = - 2º (In the anticlockwise direction)

   Magnetic Bearing = 358º (360º-2º)

LOCAL ATTRACTION:

A magnetic meridian at a place is established by a magnetic needle which is uninfluenced by other attracting forces. However, sometimes the magnetic needle may be attracted and prevented from indicating the true magnetic meridian when it is in proximity to certain magnetic substances. ***Local attraction is a term used to denote any influence, such as the above, which prevents the needle from pointing to the magnetic North in a given locality***.

SOURCES OF LOCAL ATTRACTION:

The following objects are the main sources for local attraction of a magnetic needle.

1. Iron ore, Magnetite in ground
2. Cables carrying electric current
3. Steel structures, railroad rails
4. Underground iron pipes
5. Bunch of keys, axes, chains, steel tapes.

DETECTION OF LOCAL ATTRACTION:

The local attraction at a particular place can be detected by observing the Fore and Back bearings of each line and finding its difference. If the difference between fore bearing and back bearing is 180^0, it may be taken that both the stations are free from local attraction, provided there are no observational and instrumental errors. If the difference is other than 180^0 , the fore bearing should be measured again to find out whether the discrepancy is due to avoidable attraction from the articles on person, chain, tapes etc., If the difference still remains, the local attraction exists at one or both the stations.

METHOD OF CORRECTION OF OBSERVED BEARINGS:

CORRECTION @ STATION:

This is more a general method and is based on the fact that through the bearings measured at a station may be incorrect due to local attraction, the included angle calculated from the bearings will be correct since the amount of error is the same for all the bearings measured at the stations.

The included angles between the lines are calculated at all the stations. If the traverse is a closed one, the sum of the internal included angles must be (2n-4) *90º. If there is any discrepancy in this, observational and instrumental errors also exist. Such error is distributed equally to all the angles. Proceeding now with the line, the bearings of which differs by 180º. The bearings of the all other lines are calculated.

SIMPLE PROBLEMS ON LOCAL ATTRACTION:

1. **The following bearings were observed in running a closed traverse. At what stations do you suspect local attraction? Determine the correct magnetic bearings. if declination was 5º 10' East, what are the true bearings?**

Line	AB	BC	CD	DE	EA
Fore Bearing	75º 5'	115º 20'	165º 35'	224º 50'	304º 50'
Back Bearing	254º 20'	296º 35'	345º 35'	44º 5'	125º 5'

Solution: By inspection of the observed bearings it will be noticed that the stations C & D are free from local attractions since the BB & FB of CD differs exactly by 180º. All the bearings measured at C & D are correct.

Line	Observed bearings	Corrections	Corrected bearings	True bearings	Remarks
AB	75º 5'	+ 30' @ A	75º 35'	80º 45'	Station A, B & E are affected by local attraction
BA	254º 20'	+ 1º 15' @ B	255º 35'	260º 45'	
BC	115º 20'	+ 1º 15' @ B	116º 35'	121º 45'	
CB	296º 35'	0 @ C	296º 35'	301º 45'	
CD	165º 35'	0 @ C	165º 35'	170º 45'	
DC	345º 35'	0 @ D	345º 35'	350º 45'	
DE	224º 50'	0 @ D	224º 50'	230º 00'	
ED	44º 5'	+ 45' @ E	44º 50'	50º 00'	
EA	304º 50'	+ 45' @ E	305º 35'	310º 45'	
AE	125º 5'	+ 30' @ A	125º 35'	130º 45'	

PLOTTING A TRAVERSE SURVEY:

There are two principal methods of plotting a traverse survey:

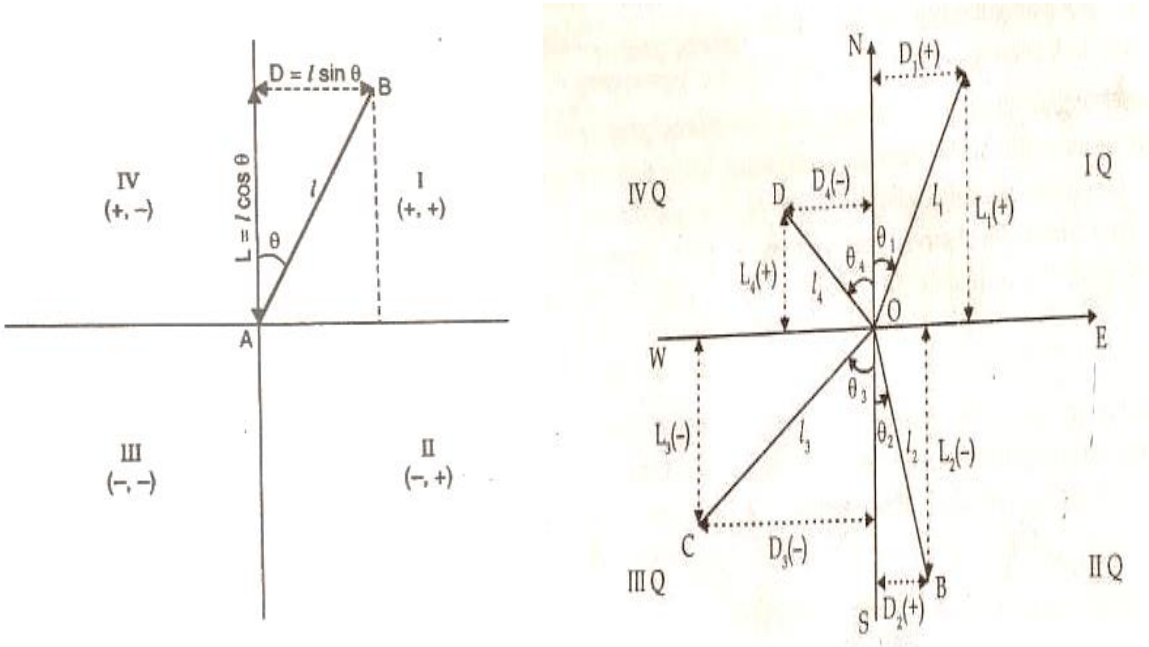
- Angle and distance method
- Coordinate's method
- **ANGLE AND DISTANCE METHOD:** In this method, distances between stations are laid off to scale and angles are plotted by one of the methods outlined below. This method is suitable for the small surveys, and is much inferior to the coordinate method in respect of accuracy of plotting. The more commonly used angle and distance method of plotting an angle (or bearing) are by protractor, by the tangent of the angle & by the chord of the angle.

- **COORDINATE METHOD:** In this method, survey stations are plotted by calculating their co-ordinates. This method is by far the most practical and accurate one for plotting traverses or any other extensive system of horizontal control. The biggest advantage in this method of plotting is that the closing error can be eliminated by balancing, prior to plotting.

CONSECUTIVE COORDINATES: LATTITUDE AND DEPARTURE

The latitude of survey line may be defined as its coordinate length measured parallel to an assumed meridian direction (true north or magnetic north or any other reference direction). The latitude of the line is positive when measured northward (Upward) and is termed as northing. The latitude of the line is negative when measured southward (Downward) and is termed as southing.

The Departure of survey line may be defined as its coordinate length measured right angles to an assumed meridian direction. The departure of the line is positive when measured eastward and is termed as easting. The departure of the line is negative when measured westward and is termed as westing.



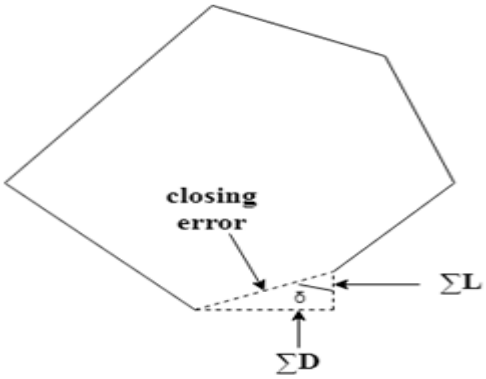
In above figure the latitude and departure of the line AB of the length ***l*** and reduced bearing **θ** are given by $\boldsymbol{Lattitude = L = l\,Cos\,\theta}$ and $\boldsymbol{Departure = D = l\,Sin\,\theta}$. To calculate the latitudes and departure of the traverse lines, it is first essential to reduce the bearing in the quadrant system.

The sign of latitudes and departures will depend upon the reduced bearing of a line. Following table gives signs of latitude and departures.

Whole Circle Bearing	Reduced Bearing	Sign of	
		Latitude	Departure
0^0 to 90^0	N θ E : I	+	+
90^0 to 180^0	S θ E : II	-	+
180^0 to 270^0	S θ W : III	-	-
270^0 to 360^0	N θ W : IV	+	-

CLOSING ERROR:

If a closed traverse is plotted according to the field measurements, the end point of the traverse will not coincide exactly with the starting point, owing to the errors in the field measurements of angles and distances. Such error is known as closing error. In a closed traverse, the algebraic sum of latitudes ($\sum$ L) should be zero and the algebraic sum of departure ($\sum$ D) should be zero.



Closing error = e = $\sqrt{(\sum L)^2 + (\sum D)^2}$

The direction of closing error is given by $\tan \delta = \frac{\sum D)}{\sum L)}$

The sign of $\sum D$ and $\sum L$ will thus define the quadrant in which the closing error lies.

ERRORS IN COMPASS SURVEY:

The error may be classified as

a) ***Instrumental Error:*** They are those which arise due to the faulty adjustments of the instruments. They may be due to the following reasons.

1. The needle not being perfectly straight.
2. Pivot being bent.
3. Sluggish needle.
4. Blunt pivot point.
5. Improper balancing weight.
6. Plane of sight not being vertical.
7. Line of sight not passing through the centres of the right.

b) ***Personal error:*** They may be due to the following reasons.

1. Inaccurate levelling of the compass box.
2. Inaccurate centring.
3. Inaccurate bisection of signals.
4. Carelessness in reading and recording.

c) ***Error due to Natural cause:*** They may be due to the following reasons.

1. Variation in declination.
2. Local attraction due to proximity of local attraction forces.
3. Magnetic changes in the atmosphere due to clouds and storms.
4. Irregular variations due to magnetic storms.

REFERENCES

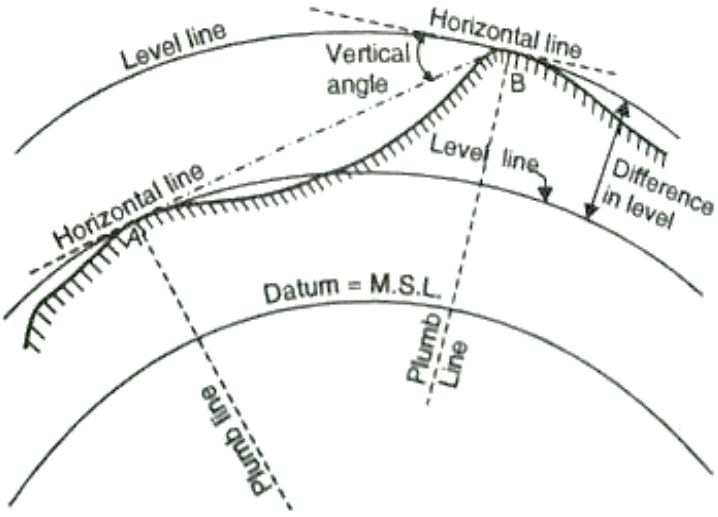
1. Surveying Volume I by B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain.16th Edition, Laxmi publications (P) Ltd, #113, Golden House, Daryagunj, New Delhi – 110002, India.

LEVELLING

UNIT 04: LEVELLING

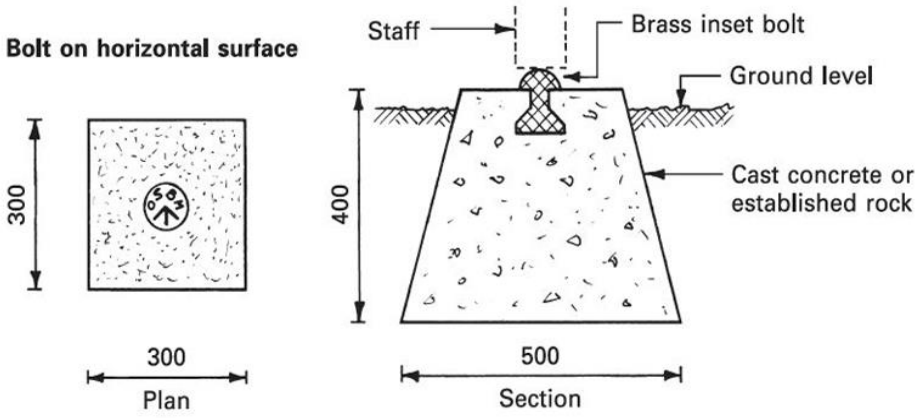
TERMINOLOGIES:

- ***LEVELLING***: Levelling is branch of surveying the objects of which is to find the elevation of given points with respect to a given or assumed datum and to establish points at a given elevation or at different elevations with respect to a given or assumed datum. The first operation is required to enable the works to be designed while the second operation is required in the setting out of all kinds of engineering works. Levelling deals with measurement of vertical measurements.
- ***LEVEL SURFACE:*** A level surface is defined as a curved surface which at each point is perpendicular to the direction of gravity at the point. The surface of a still water is truly level surface. Any surface parallel to the mean sea spheroidal surface of the earth is a level surface.
- ***LEVEL LINE:*** A level line is a line lying in a level surface. It is normal to the plumb line at all points.



- ***HORIZONTAL LINE:*** It is straight line tangential to the level line at a points. It is also perpendicular to the plumb line.
- ***VERTICAL LINE:*** It is a line normal to the level line at a point. It is commonly considered to be the line defined by plumb line.
- ***DATUM:*** Datum is any surface to which elevations are referred. The mean sea level affords a convenient datum world over and elevations are commonly given as so much above or below sea level. It is often more convenient, to assume some other datum, especially if only the relative elevations of points are required.
- ***VERTICAL ANGLE:*** Vertical angle is an angle between two intersecting lines in a vertical plane. Generally, one of these lines is horizontal.

- ***ELEVATION:*** The elevation of a point on or near the surface of the earth is its vertical distance above or below an arbitrarily assumed level surface or datum. The difference in elevation between two points is the vertical distance between the two level surfaces in which the two points lie.
- ***MEAN SEA LEVEL:*** Mean sea level is the average height of the sea for all stages of the tides. At any particular place it is derived by averaging the hourly tides heights over a long period of 19 years.
- ***BENCH MARK:*** Benchmark is a relatively permanent point of reference whose elevation with respect to some assumed datum is known. It is used either as a starting point for levelling or as a point upon which to close as a check.
  - ✓ ***G.T.S. Bench Mark***: The Great Trigonometrical Survey (G.T.S) bench marks are established by the survey of India throughout the country. The levels of this bench marks are established very accurately at a large interval with respect to the mean sea level at Bombay port.



  - ✓ ***Permanent Bench Mark:*** These are established by different Government departments like PWD, Railways, Irrigation etc., The RL of these points are determined with reference to the G.T.S. Bench Marks. Points on rocks, culvert, gate pillars, etc.

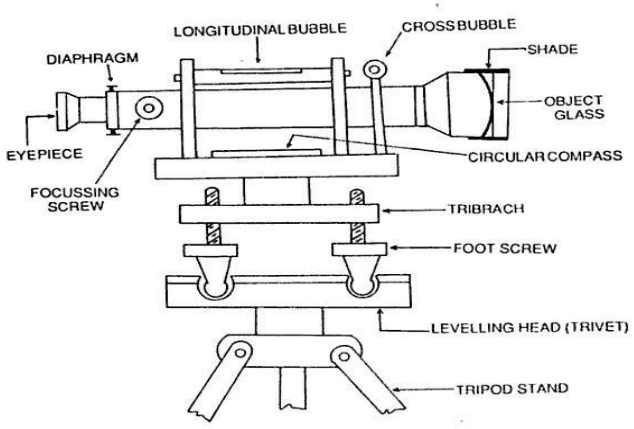
Permanent Benchmark

- ✓ ***Temporary bench Mark:*** These are established temporarily whenever required. These are generally chosen to the day's work and the start the next days. Points on roofs, walls, basements etc.
- ✓ ***Arbitrary Bench mark:*** When the RL of some fixed points are assumed, they are termed arbitrary benchmark.

INSTRUMENTS USED FOR LEVELLING:

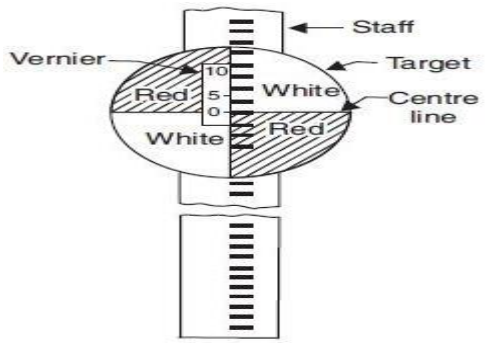
The instruments commonly used in direct levelling are:

- ***A Level:*** The purpose of a level is to provide a horizontal line of sight. Essentially, a level consists of the following four parts.
  - ✓ A telescope to provide line of sight.
  - ✓ A level tube to make the line of sight horizontal.
  - ✓ A levelling head (tribrach and trivet stage) to bring the bubble in its centre of run.
  - ✓ A tripod to support the instrument.



Typical side view of a level

- ***A Level staff:*** A levelling staff is a straight rectangular rod having graduations. The foot of the staff representing zero reading. During levelling staff is held vertical at the point and from level horizontal sight is taken. Levelling staff may be divided in to two groups: Self-reading & Target staff



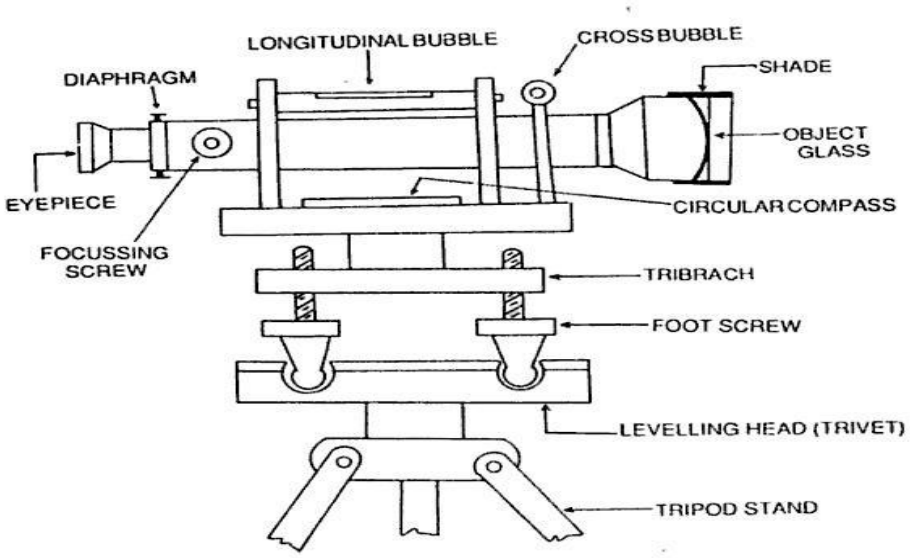
Target Staff

Self-reading staff

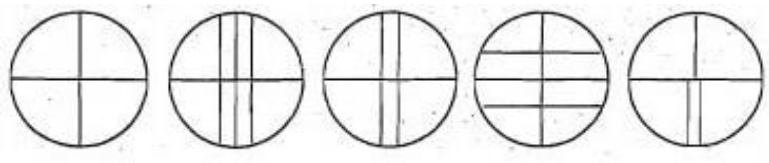
TYPES OF LEVELS:

Levels are the different instruments used for levelling in surveying. There are various types of levels such as dumpy level, Y level, tilting level, digital level and automatic level instruments for levelling in surveying. The process of measuring vertical distances in surveying is called levelling. To perform levelling, we need some level instruments to focus or to read the object. Nowadays, the technology also introduced in surveying and so many easy measuring instruments are designed. Here we discuss few important levels used in levelling. Dumpy level, Auto level & Digital level.

- **DUMPY LEVEL:** Dumpy level is the most commonly used instrument in levelling. In this level the telescope is restricted against movement in its horizontal plane and telescope is fixed to its support. A bubble tube is provided on the top of the telescope. But however, the levelling head can be rotated in horizontal plane with the telescope. The telescope is internal focusing telescope is a metal tube contains four main parts as given below.

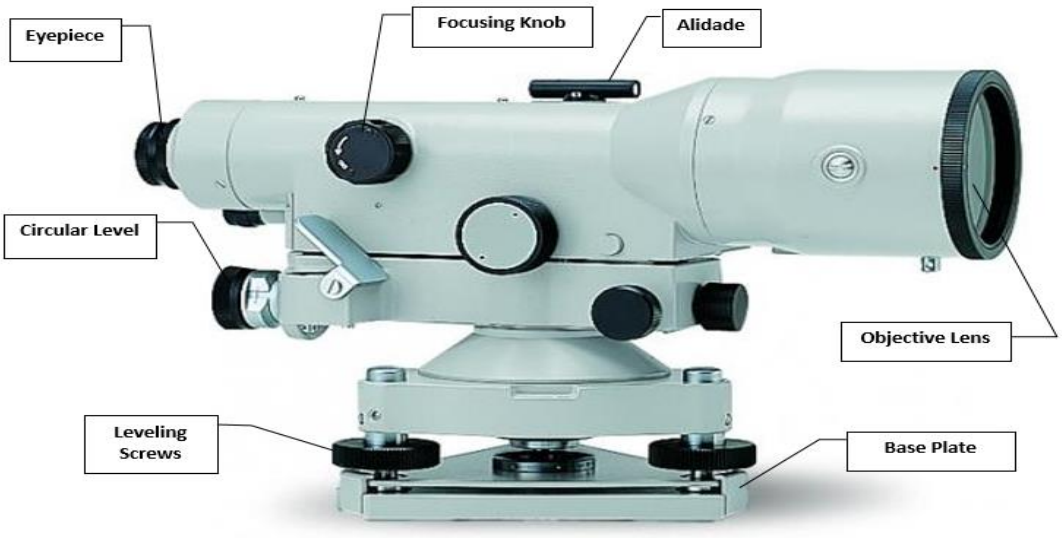


- ✓ ***Objective Lens:*** Objective lens should be made as the combination of crown glass and flint glass. Because of this some defects like spherical aberration and chromatic aberration can be eliminated. A thin layer coating which has smaller refractive index than glass is provided on the objective lens to reduce the loss due to reflection.
- ✓ ***Negative Lens:*** Negative lens located co axial to the objective lens. So, the optical axis for both lenses is same.
- ✓ ***Diaphragm:*** Diaphragm is fitted inside the main tube which contains cross hairs (vertical and horizontal) and these are adjusted by capstan headed screws. The cross hairs are made of dark metal as filament wires which are inserted in diaphragm ring in exact position. For stadia levelling purposes, extra two horizontal cross hairs are provided above and below the horizontal wire.



✓ ***Eyepiece:*** Eyepiece lens enable the ability to sight the object together with cross hairs. The image seen through eye piece is magnified and inverted. Some eyepieces erect the image into normal view and those are called as erecting eyepieces.

➢ **AUTO LEVEL:** Automatic level is like the dumpy level. In this case the telescope is fixed to its supports. Circular spirit can be attached to the side of the telescope for approximate levelling. For more accurate levelling, compensator is attached inside the telescope.



Compensator can help the instrument to level automatically. Compensator is also called as stabilizer which consists two fixed prisms and it creates an optical path between eye piece and objective. Due to the action of gravity, the compensator results the optical system to swing into exact position of line of sight automatically. But before the process of levelling, compensator should be checked. To check the compensator, just move the foot screws slightly if the levelling staff reading remains constant then compensator is perfect. If it is not constant, then tap the telescope gently to free the compensator. Automatic level is also called as self-adjusting level.

➢ **DIGITAL LEVEL:** Digital levelling systems for surveying rely on an electronic laser to scan a level staff with bar code markings. This type of level reduces the chance of human error when interpreting graduation marks, and a digital display ensures accurate readings. When job sites need fast and accurate height determinations, precision digital levelling equipment serves as valuable time-saving technology. An upside to digital levels is the

potential for data integration. A surveyor can store readings in the internal memory and refer to them later, or transfer data to computers using external memory ports.



COMPONENT PARTS OF DUMPY LEVEL: As already we have discussed about dumpy level while discussing types of level. In this we shall see different component parts of dumpy level.

- ***Telescope:*** The telescope is used to measure distant objects in the line of sight. The telescope is generally connected with vertical spindle, facilitating telescope to be movable in various directions. Telescope comprises of various parts; all the parts are described below.
  - ✓ ***Eye Piece:*** It comprises of a magnifying glass and is primarily used by the observer.
  - ✓ ***Objective Piece*:** it is placed at the farther end of eyepiece. It comprises a convex lens and a concave lens.
  - ✓ ***Diaphragm:*** Provided in the outline of the eyepiece with the cross of dark metal. They are provided to bisect object.
  - ✓ ***Focusing Screw:*** They are meant to align the focus and image clarity of the object.
  - ✓ ***Ray Shade:*** Prevents sunlight from entering the objective lens.

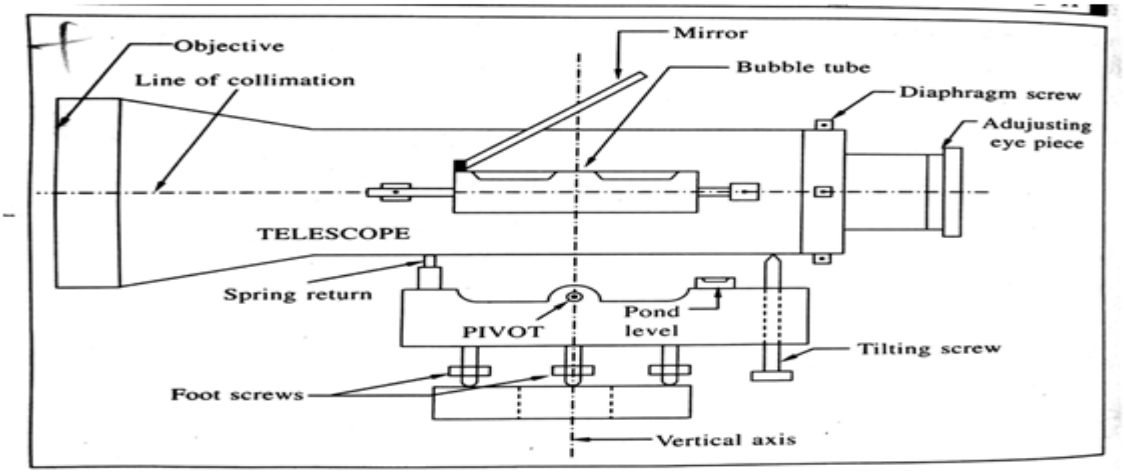
- ***Bubble tube:*** They are provided to align the level of instrument. Provided by bubble tubes on horizontal and vertical direction. The instrument is ready to survey when both the bubbles are in the centre.
- ***Tribrach:*** It is parallel to the levelling head and primarily utilized to adjust the horizontal level of the instrument. The trivet is connected through foot screws.
- ***Levelling Head:*** Also known as a trivet, it comprises of two triangular plates aligned parallel to each other. Comprises of groves to hold foot screws.
- ***Foot screws:*** The foot screws are used to calibrate the instrument through the bubble tube. Adjusting foot screws one can calibrate tribrach plate. To ensure the bubble is at the centre, foot screws are operated.

- ***Tripod:*** Tripod is the supporting medium of the complete dumpy level. Comprising of three legs made of hollow steel sections or light or hardwood. Steel shoes provided at the foot ensures that the tripod is immobile with slight jerks.
- ***Circular compass:*** It is used to determine the magnetic bearing of the line of the path of the survey. The compass comprises of pointer on marking of directions. The compass is aligned for the magnetic bearing in the north direction.

FUNDAMENTAL AXES OF LEVEL:

Following are the four fundamental axes of a level

- ***Vertical axis*:** It is the centre line of the axis of rotation of level.
- ***Axis of bubble tube:*** It is an imaginary line tangential to the longitudinal curve of the tube at its middle point. It is horizontal when the bubble is at centre
- ***The line of collimation OR Line of sight:*** It is the line joining the intersection of cross hairs and optical centre of the object glass.
- ***The axis of telescope:*** It is the line joining the optical centre of object glass and the centre of eye piece.



TEMPORARY ADJUSTMENT OF LEVEL:

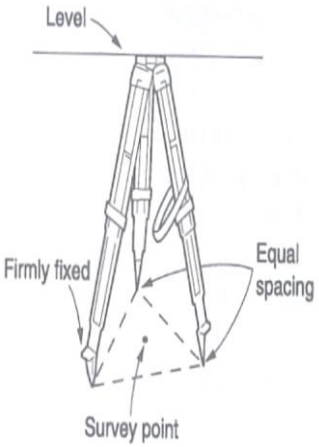
Each surveying instruments needs two types of adjustments, Temporary & Permanent adjustments. Temporary adjustments or station adjustments are those which are made at every instrument setting and preparatory to taking observations with the instruments. Permanent adjustments need be made only when the fundamental relations between some parts or lines are disturbed.

The temporary adjustments for a level consist of the following.

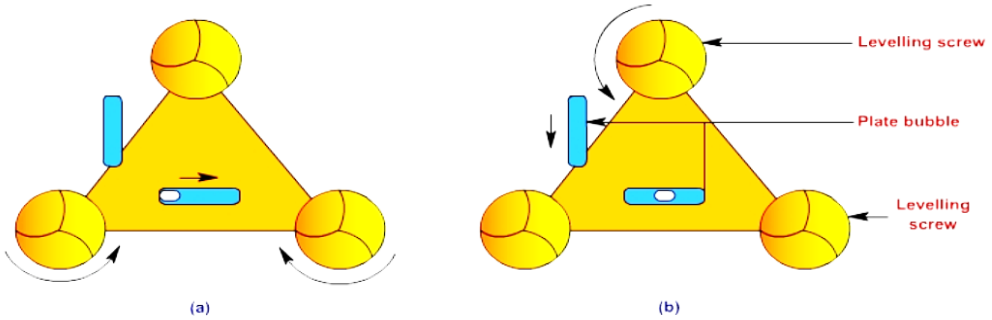
- Setting up the level.
- Levelling up.
- Elimination of parallax.

- ***Setting up the level:***

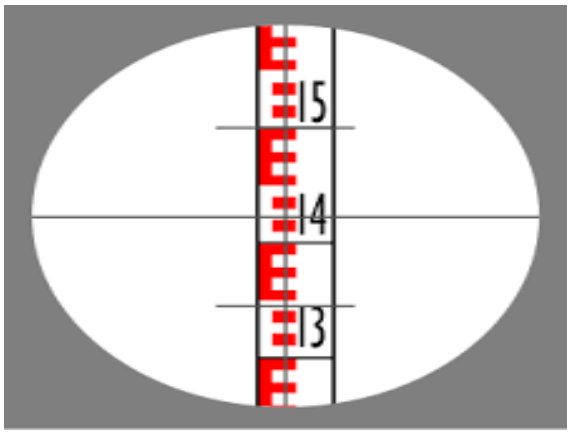
The operation of setting up includes fixing the instrument on stand and levelling the instrument approximately by leg adjustment. To fix the level to the tripod, the clamp is released, instrument is held in the right hand and is fixed on the tripod by turning round the lower part with the left hand. The tripod legs are so adjusted that the instrument is at the convenient height and the tribrach is approximately horizontal. Some instruments are also provided with a small circular bubble on the tribrach.

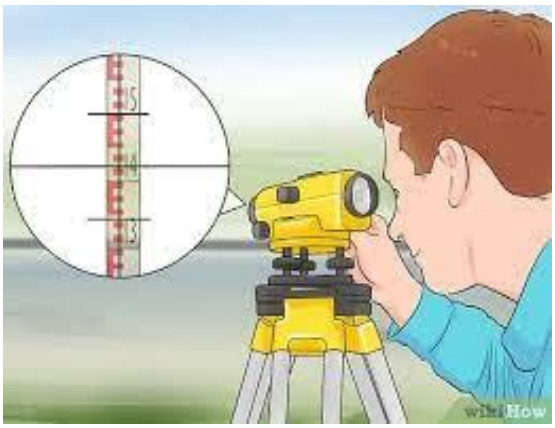


- ***Levelling up:*** After having levelled the instrument approximately, accurate levelling is done with the help of foot screws and with reference to the plate levels. The purpose of levelling is to make the vertical axis truly vertical. The matter of levelling the instrument by the plate levels depends upon whether there are three levelling screws or four levelling screws.
  - ***Three Screw head:***
    - Loose the clamp. Turn the instruments until the longitudinal axis of the plate level is roughly parallel to a line joining any two (Such as A & B) of the levelling screws.
    - Hold these two levelling screws between the thumb and first finger of each hand and turn them uniformly so that the thumbs move either towards each other or away from each other until the bubble in central. It should be noted that the bubble will move in the direction of movement of the left thumb.
    - Turn the upper plate through 90º until the axis on the level passes over the position of the third levelling screw C.
    - Turn this levelling screw until the bubble is central.
    - Return the upper part through 90º to its original position and repeat step 2 till the bubble is central.
    - Turn back again through 90º and repeat step 4.
    - Repeat steps 2 and 4 till the bubble is central in both the positions.
    - Now rotate the instrument through 180º. The bubble should remain in the centre of its run, provided it is in correct adjustment. The vertical axis will then be truly vertical.



- ***Elimination of Parallax:*** Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. Unless parallax is eliminated, accurate sighting is impossible. Parallax can be eliminated in two steps. By focusing the eye piece for distinct vision of the cross hairs and by focusing the objective to bring the image of the object in the plane of cross hairs.



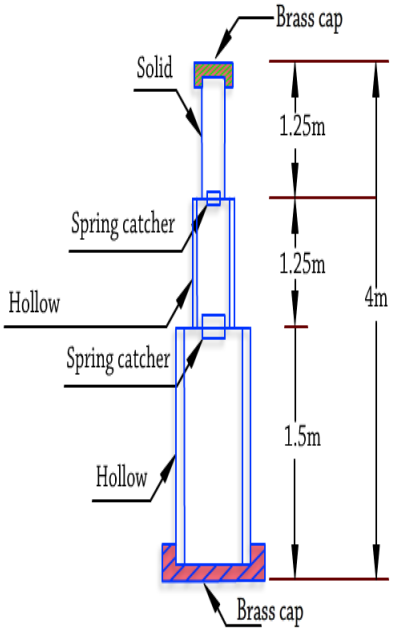


  - ✓ ***Focusing the eye piece:*** to focus the eye piece for distinct vision of the cross hairs. Point the telescope towards the sky or hold a sheet of white paper in front of the objective and move eye piece in or out till cross hairs are seen sharp and distinct. In some telescopes, graduations are provided at the eye piece so that one can always remember the particular graduations positions suit his eyes. This may save much of time.
  - ✓ ***Focusing the objective:*** The telescope is now directed towards the staff and the focusing is turned till the image appears clear and sharp. The image so formed is in the plane of cross hairs.

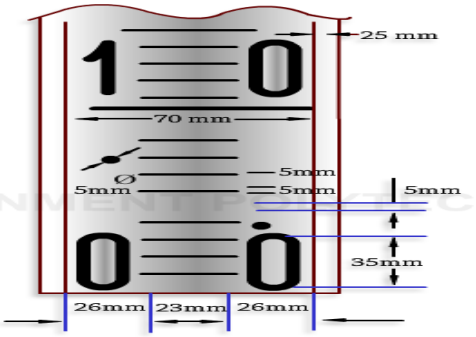
LEVELLING STAFF: A levelling staff is a straight rectangular rod having graduations, the foot of the staff representing zero reading. The purpose of a level in to establish a horizontal line of sight. The purpose of the levelling staff is to determine the amount by which the station is above or below the line of sight. Types of Levelling staves may be divided into two classes, Self-reading staff or Telescopic staff & Target staff. A self-reading staff is the one which can be read directly by the instrument man through the telescope. A target staff, on the other hand, contains a moving target against which reading is taken by staff man.

- **SELF-READING STAFF:** Self reading staff, which can be read by the instrument operator which sighting through the telescope and noting the operant intersection of cross wires on the rod. This is the most common type. The following are the different types of self-reading staff:
  - ✓ ***Solid staff or single piece staff:*** The single piece or solid staff is a single long flat rod of well-seasoned wood about 75mm wide and 25mm thick, with a metal shoe at the bottom, and graduated on the face. The smallest division is of 5mm in metric system. The length of the staff is generally 3m.
  - ✓ ***Folding staff:*** A folding staff is hinged at the middle so that top half can be folded over to lie against the lower half. When fully extended, the upper part is held firmly in position by a metal pin passing through holes in plates at the side of the hinge. When staff is not in use it can be folded about the hinge so that it becomes convenient to carry it from one place to the other.
  - ✓ ***Telescopic staff:***

Telescopic staff is arranged in three lengths placed one in to the other. It can be extended to its full length by pulling. The top portion is solid and of length 1.25m, the central box portion is hallow and 1.5m long. The total length of the staff is 4m. The top portions are held in the vertical positions by a brass spring catcher. The staff is graduated in such a way that smallest division is 5mm (0.005m). The values in meter are marked in red on the left and those in decimetres are marked in block on the right.



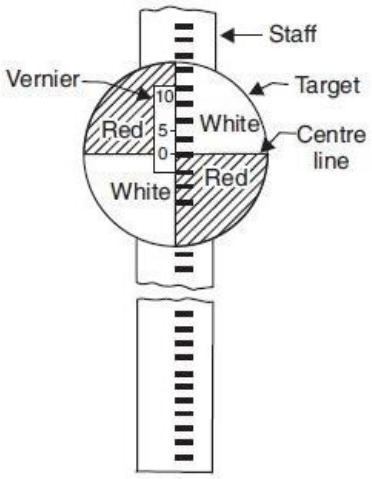
Graduations on the staff:



- The graduations of the staff are machine divided to 1/200 of a meter.
- A meter is divided into 10 equal parts so that each part will be equal to 0.1m
- This 0.1m is further divided into 20 equal parts by block and white strips, so that $1/20^{th}$ of 0.1m works out to 0.005m or 5mm.
- The meter numerals are in red and the sub numerals are block in colour.
- The top of the numerals is exactly in line with its corresponding division.
- In some staffs the graduations are marked inverted so that they appear erect when viewed through telescope.

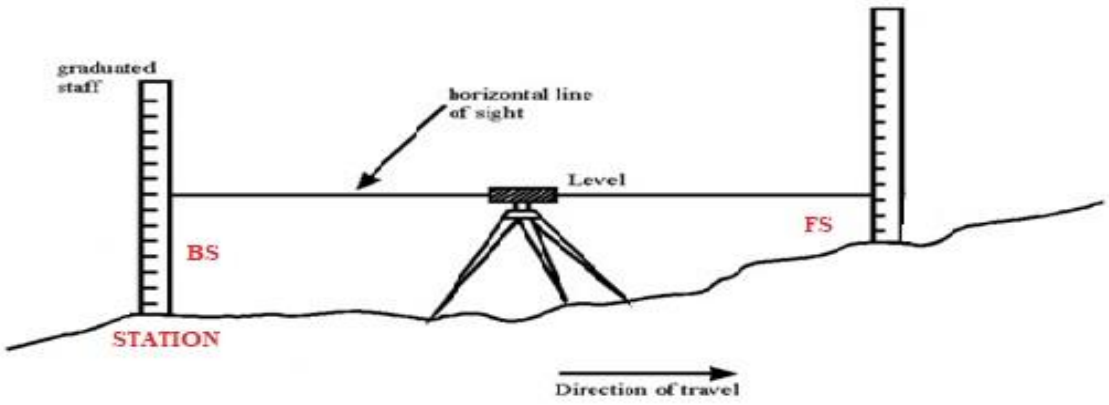
➢ **TARGET STAFF:**

Target staff is another type of levelling staff. Figure shows a target staff having a sliding target equipped with Vernier. The rod consists of two sliding lengths, the lower one of approx. 7ft and the upper one of 6 ft. The rod is graduated in feet, tenths and hundreds and the Vernier of the target enable the readings to be taken up to a thousand part of a foot. For taking reading the level man directs the staff man to raise or lower the target till it is bisected by the line of sight. The staff holder then clamps the target and takes the reading.



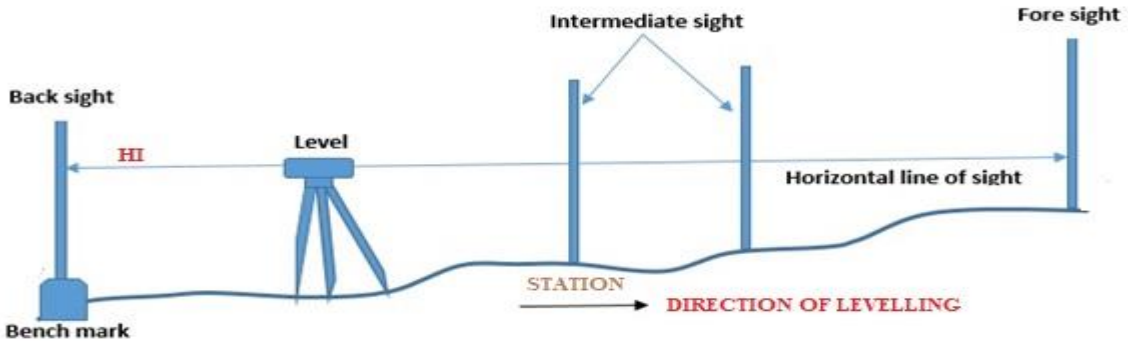
TERMS AND ABBREVIATIONS:

➢ **STATION:** In levelling, a station is that point where the level rod is held and not where level is set up. It is the point whose elevation is to be ascertained or the point that is to be established at a given elevation.

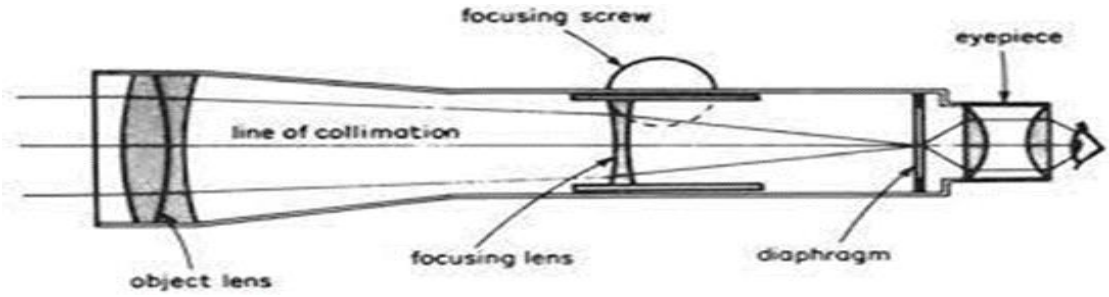


➢ **HEIGHT OF INSTRUMENT (H.I):** For any set up of the level, the height of instrument is the elevation of plane of sight (line of sight) with respect to the assumed datum. It does not mean the height of the telescope above the ground where the level stands.

- **BACK SIGHT (B.S):** Back sight is the sight taken on a rod held at a point of known elevation, to ascertain the amount by which the line of sight is above that point and thus to obtain the height of the instrument. Back sighting is equivalent to measuring up from the point of known elevation to the line of sight. It is also known as a plus as the back sight reading is always added to the level of the datum to get the sight height of the instrument. The object of back sighting is, therefore, to ascertain the height of the plane of sight.
- **FORE SIGHT (F.S):** Fore sight is a sight taken on a rod held at a point of unknown elevation, to ascertain the amount by which the point is below the line of sight and thus to obtain the elevation of the station. Fore sighting is equivalent to measuring down from the line of sight. It is also known as a minus sight as the fore sight reading is always subtracted (except in special cases of tunnel survey) from the height of the instrument to get the elevation of the point. The object of fore sighting is, therefore, to ascertain the elevation of the point.
- **TURNING POINT (T.P):** Turning point or change point is a point on which both minus sight and plus sight are taken on a line of direct levels. The minus sight (fore sight) is taken on the point in one set of instrument to ascertain the elevation of the point while the plus sight (back sight) is taken on the same point in other set of the instrument to establish the new height of the instrument.
- **INTERMEDIATE STATION (I.S):** Intermediate station is a point, intermediate between two turning points, on which only one sight (minus sight) is taken to determine the elevation of the station.

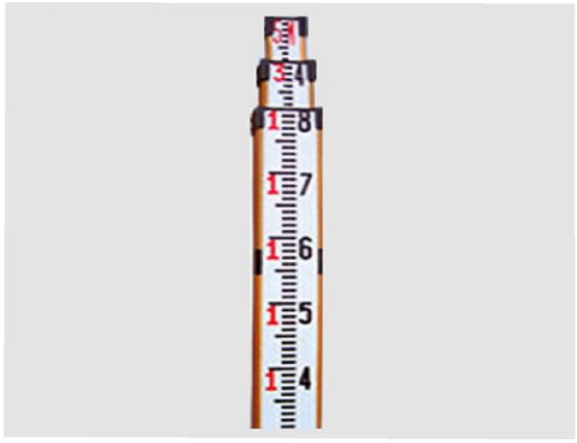


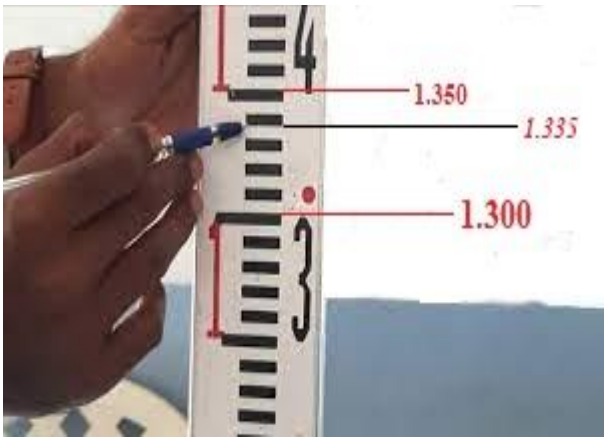
- **LINE OF SIGHT OR LINE OF COLLIMATION:** It is an imaginary line passing through the intersection of the cross hairs at the diaphragm and the optical centre of the object glass and its continuation.



OBSERVING STAFF READING AND RECORDING IN LEVEL BOOK

This staff reading is directly read by the instrument man through telescope. In a metric system staff, one-meter length is divided into 200 subdivisions, each of uniform thickness of 5 mm. All divisions are marked with black in a white background. Meters and decimetres are written in red colour. Let us consider a self-reading staff of length 4m shown below.





In the above shown figure the reading which is on left side marked on red is in meter and the reading on right side is in decimetre. Each block and white division in the above figure is 5mm thick. In the above figure let us consider **1.3m** length. The white gap between two block division is 5mm if we add 5mm to 1.3m then we will get 1.305m. Like this we have taken or observe staff reading**.** A level filed book or a level book is used for booking and reducing the levels of various points in a systematic way. There are two methods for reducing the levels namely The height of the instrument method & The rise and fall method.

HAND SIGNALS DURING OBSERVATIONS:

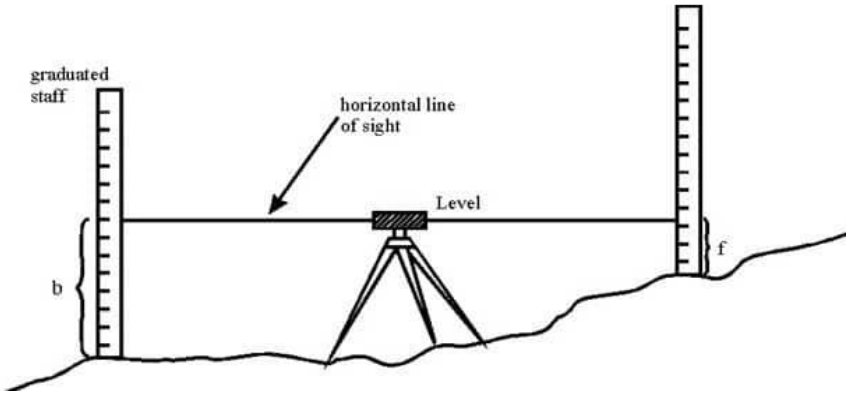
When levelling is done at construction site located in busy, noisy areas, it becomes difficult for the instrument man to give instructions to the man holding the staff at the other end, through vocal sound. In this case the following hand signals are found to be useful.

SIGNAL	MESSAGE	PICTURE
Movement of left arm over 90º	**Move to my left**	
Movement of right arm over 90º	**Move to my right**	
Movement of left arm over 30º	**Move top of staff to my left**	
Movement of right arm over 30º	**Move top of staff to my right**	
Extension of arm horizontally and moving hand upwards	**Raise height peg or staff**	
Extension of arm horizontally and moving hand downwards	**Lower height peg or staff**	
Extension of both arms and slightly thrusting downwards	**Establish the position**	
Extension of both arms and placement of hand on top of head.	**Return to me**	

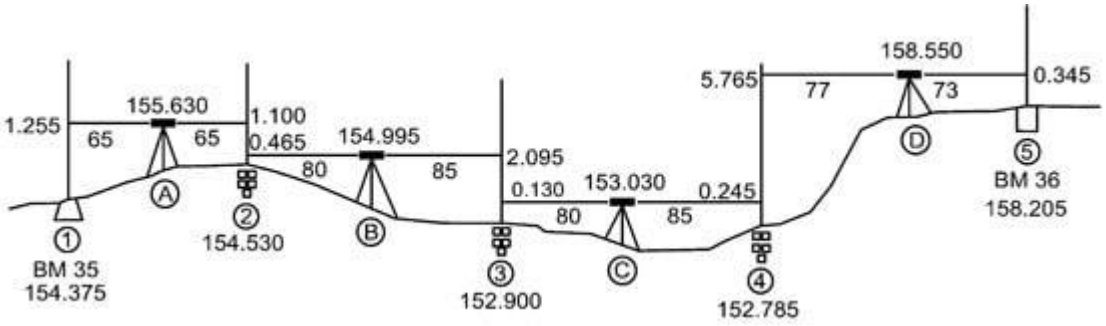
Back Sight	Intermediate	Fore Sight	Plant of Gollimation	Reduced Level	Distance	Total Distance	STATION	Fore bearing	Back bearing	Remarks

TYPES OF LEVELLING:

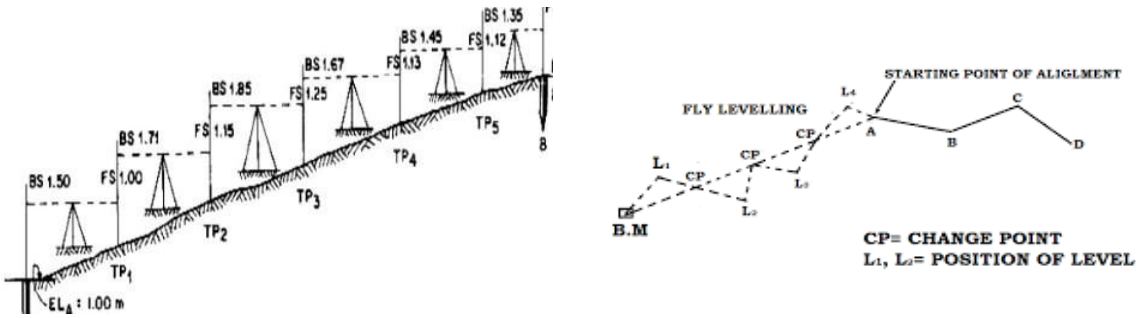
- ***Simple Levelling:*** It is a simple and basic form of levelling in which the levelling instrument is placed between the points which elevation is to be find. Levelling rods are placed at that points and sighted them through levelling instrument. It is performed only when the points are nearer to each other without any obstacles.



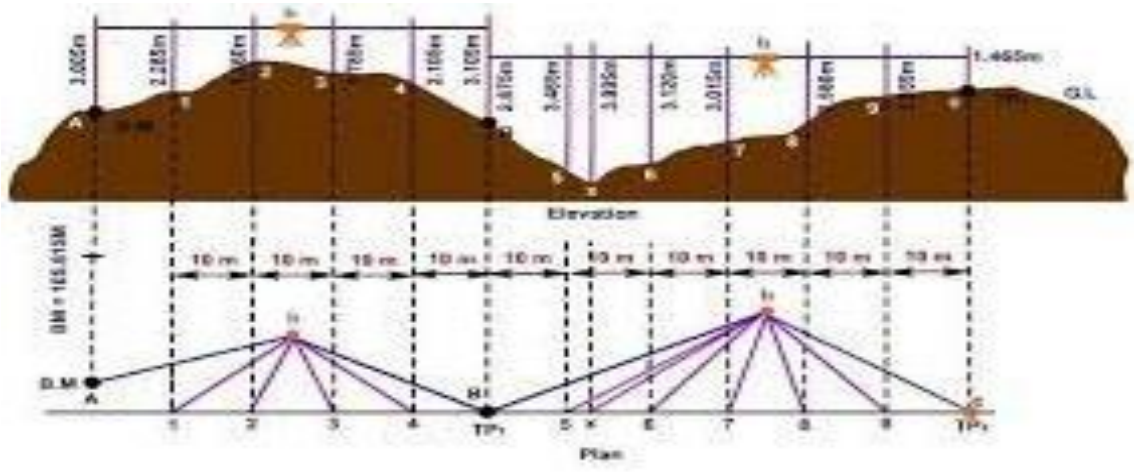
- ***Differential Levelling:*** Differential levelling is performed when the distance between two points is more. In this process, number of inter stations are located and instrument is shifted to each station and observed the elevation of inter station points. Finally difference between original two points is determined.

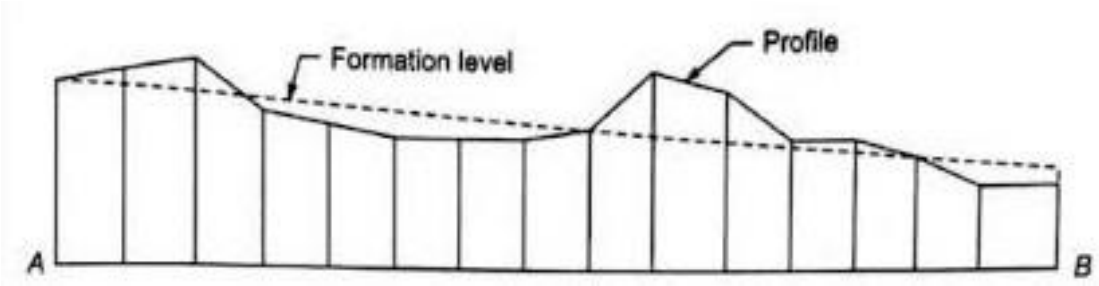


- ***Fly levelling:*** Fly levelling is conducted when the benchmark is very far from the work station. In such case, a temporary bench mark is located at the work station which is located based on the original benchmark. Even it is not highly precise it is used for determining approximate level. Here only BS and FS readings are taken to determine reduced level of different stations.

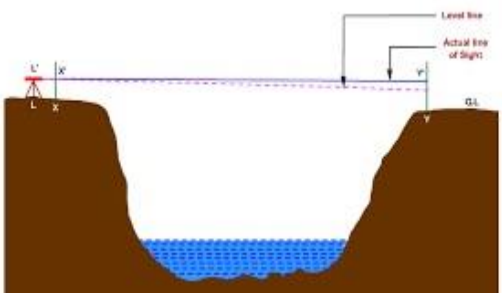


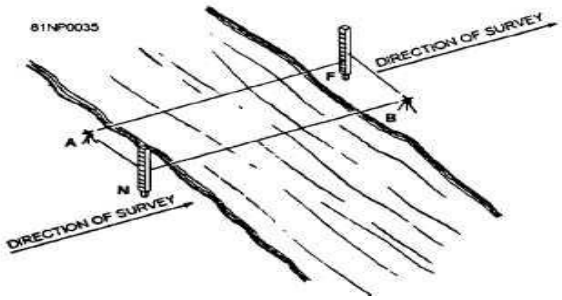
- ***Profile levelling:*** Profile levelling is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn.





- ***Reciprocal levelling:*** When it is not possible to locate the levelling instrument in between the inter visible points, reciprocal levelling is performed. This case appears in case of ponds or rivers etc. in case of reciprocal levelling, instrument is set nearer to 1st station and sighted towards 2nd station.





REDUCING THE LEVELS:

There are two methods of booking and reducing the elevation of points from the observed staff readings:

- Collimation or Height of Instrument method
- Rise & Fall method.
- ***COLLIMATION OR HEIGHT OF INSTRUMENT METHOD:*** In this method, the height of the instrument (H I) is calculated for each setting of the instrument by adding back sight (Plus Sight) to the elevation of Bench Mark (First point). The elevation of reduced level of the turning point is then calculated by subtracting from H I the fore sight (Minus Sight). For the next setting up of the instrument, the HI is obtained by adding the BS taken on Turning Point (TP 1) to its RL. The process continues till the RL of the last

point (Fore Sight) is obtained by subtracting the staff reading from height of the last points is calculated by subtracting the intermediate sight (Minus sight) from the height of the instrument for that setting. The following is the specimen page of a level field book illustrating the method of booking staff readings and calculating reduced levels by height of instrument method.

STATION	BACK SIGHT	INTERMIDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	REMARKS
A	0.865			561.365	560.500	BM
B	1.025		2.105	560.285	559.260	
C		1.580			558.705	PLAT FORM
D	2.230		1.865	560.650	558.420	
E	2.355		2.835	560.170	557.815	
F			1.760		558.410	

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

6.475 – 8.565 = 558.410 – 560.500

-2.090 = -2.090

- **RISE & FALL METHOD:** In rise and fall method, the height of instrument is not at all calculated but the difference of level between consecutive points is found by comparing the staff readings on the two points for the same setting of the instrument. The difference between their staff readings indicates a rise or fall according as the staff reading at the point is smaller or greater than that at the preceding point. The figure for rise and fall worked out thus for all the points give the vertical distance of each point above or below the preceding one, and if the level of any one point is known the level of the next will be obtained by adding its rise or subtracting its fall. The following is the specimen page of a level field book illustrating the method of booking staff readings and calculating reduced levels by rise & fall method.

STATION	BACK SIGHT	I S	FORE SIGHT	RISE	FALL	REDUCED LEVEL	REMARKS
A	0.865					560.500	BM
B	1.025		2.105		1.240	559.260	
C		1.580			0.555	558.705	PLAT FORM
D	2.230		1.865		0.285	558.420	
E	2.355		2.835		0.605	557.815	
F			1.760	0.595		558.410	

Arithmetic Check = ΣBS – ΣFS = Σ Rise – Σ Fall = Last RL – First RL

6.475 – 8.565 = 0.595 – 2.685 = 558.410 – 560.500

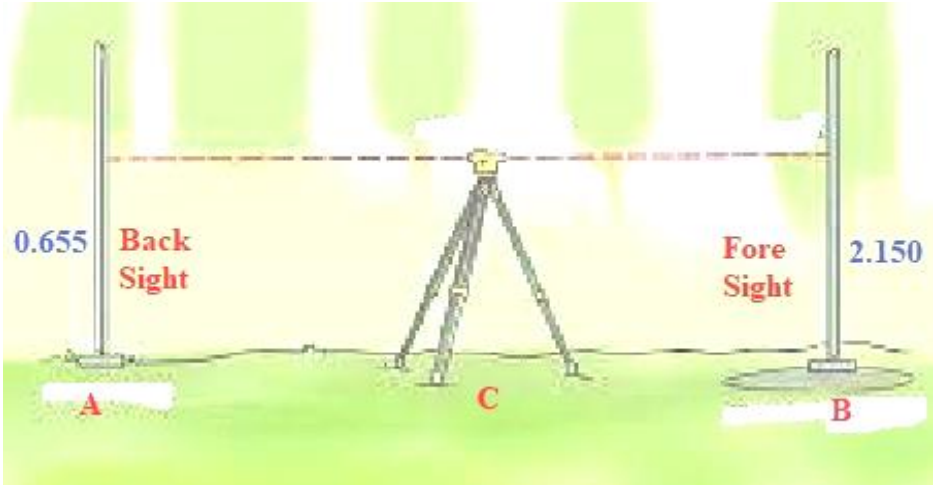
-2.090 = -2.090= -2.090

DIFFERENCE BETWEEN HI METHOD AND RISE AND FALL METHOD

SN	Height of Instrument method	Rise and fall method
1	It is rapid and it involves few calculations	It is laborious involves several calculations
2	There is no check on the RL of the intermediate sight	There is a check on the RL of the intermediate points
3	Errors in the intermediate RLs cannot be detected	Errors in the intermediate RLs can be detected as all the points are correlated
4	There are two checks on the accuracy of RLs calculations	There are three checks on the accuracy of RLs calculations
5	This system is suitable for longitudinal levelling where there are number of intermediate sights.	This system is suitable for fly levelling where there are no intermediate sights.

EXAMPLES OF REDUCING THE LEVELS:

1. **The simple levelling carried out to determine the RL of B. Instrument was set up at C and staff readings are taken at A & B are 0.655 & 2.150 respectively. RL of A is 100.000M. Find the RL of B & difference in level between A & B?**



Solution:

$$Height\ of\ the\ Instrument = RL\ of\ A + Staff\ reading\ on\ A$$

Height of the Instrument $= 100.000 + 0.655 = 100.655$M

$$Reduced\ Level\ of\ B = Height\ of\ the\ Instrument - Staff\ reading\ on\ B$$

Reduced Level of B $= 100.655 - 2.150 = 98.505$ M

$$Difference\ in\ level = RL\ of\ A - RL\ of\ B$$

Difference in level $= 100.00 - 98.505 = 1.495$ M (B is Lower than A)

2. **The following staff readings were observed successively with a level, the instrument was shifted after fifth and eleventh reading: 0.585, 1.010, 1.735, 3.295, 3.775, 0.350,**

1.300, 1.795, 2.075, 3.375, 3.895, 1.785, 1.635 & 1.600. Enter the above readings in a page of level book and calculate the R.L of points by Height of Instrument method. If the first reading was taken with a staff held on a bench mark of 136.440m?

Solution: Since the instrument was shifted after fifth and eleventh readings, these readings will be entered in the FS column and therefore, the sixth and twelfth readings will be entered on the BS column. Also the first reading will be entered in the BS column and last reading in the FS column. All other readings will be entered in I.S columns. The entry of given staff readings in level book are shown below.

STN	BS	IS	FS	HI	RL	REMARKS
A	0.585			137.025	136.440	BM
B		1.010			136.015	
C		1.735			135.290	
D		3.295			133.730	
E	0.350		3.775	133.600	133.250	CP_1
F		1.300			132.300	
G		1.795			131.805	
H		2.075			131.525	
I		3.375			130.225	
J	1.785		3.895	131.490	129.705	CP_2
K		1.635			129.855	
L			1.600		129.890	

Arithmetic Check:

Σ B.S = 2.72, Σ F.S = 9.270 LRL = 129.890, FRL = 136.440

Σ B.S ─ Σ F.S = Last RL ─ First RL

2.72─ 9.270 = 129.890─136.440

─ 6.550 = ─ 6.550

3. **The following staff readings were observed successively with a level, the instrument was shifted after fifth and eleventh reading: 0.585, 1.010, 1.735, 3.295, 3.775, 0.350, 1.300, 1.795, 2.075, 3.375, 3.895, 1.785, 1.635 & 1.600. Enter the above readings in a page of level book and calculate the R.L of points by Rise & Fall method. If the first reading was taken with a staff held on a bench mark of 136.440m?**

Solution: Since the instrument was shifted after fifth and eleventh readings, these readings will be entered in the FS column and therefore, the sixth and twelfth readings will be

entered on the BS column. Also the first reading will be entered in the BS column and last reading in the FS column. All other readings will be entered in I.S columns. The entry of given staff readings in level book are shown below.

STN	BS	IS	FS	RISE	FALL	RL	REMARKS
A	0.585					136.440	BM
B		1.010			0.425	136.015	
C		1.735			0.725	135.290	
D		3.295			1.560	133.730	
E	0.350		3.775		0.480	133.250	CP_1
F		1.300			0.950	132.300	
G		1.795			0.495	131.805	
H		2.075			0.280	131.525	
I		3.375			1.300	130.225	
J	1.785		3.895		0.520	129.705	CP_2
K		1.635		0.150		129.855	
L			1.600	0.035		129.890	

Arithmetic Check:

Σ BS = 2.720, Σ FS = 9.270, Σ RISE = 0.185, Σ FALL = 6.735

Σ B.S ─ Σ F.S = Σ Rise - Σ Fall = Last RL ─ First RL

2.72- 9.270 = 0.185 - 6.735 = 129.890 - 136.440

- 6.550 = -6.550= -6.550

4. **The following consecutive staff readings were observed with a level and 5m levelling staff on continuously sloping ground at a common interval of 20m. 0.385, 1.030, 1.925, 2.825, 3.730, 4.685, 0.625, 2.005, 3.110 & 4.485. The reduced level of the first point was 208.125m. Rule out a page of a level field book and enter the above readings. Calculate the reduced levels of the points by Rise & Fall method and also the gradient of the line joining the first and last point?**

Solution: Since the readings were taken on a continuously sloping ground, the maximum staff reading can be 5 meters only and therefore, sixth reading will be a fore sight taken on a turning point and the seventh reading will be a back sight. Also the first reading will be back sight and the last reading will be fore sight. The levels can be readily calculated as shown in the tabular form below.

STN	BS	IS	FS	RISE	FALL	RL	REMARKS

1	0.385					208.125	BM
2		1.030			0.645	207.480	
3		1.925			0.895	206.585	
4		2.825			0.900	205.685	
5		3.730			0.905	204.780	
6	0.625		4.685		0.955	203.825	CP_1
7		2.005			1.380	202.445	
8		3.110			1.105	201.340	
9			4.485		1.375	199.965	

Arithmetic Check:

Σ BS = 1.010, Σ FS = 9.170, Σ RISE = 0.000, Σ FALL = 8.160

Σ B.S ─ Σ F.S = Σ Rise - Σ Fall = Last RL ─ First RL

1.010- 9.170 = 0.000 – 8.160 = 199.965 – 208.125

- 8.160 = - 8.160 = - 8.160

$$Gradient\ of\ the\ Line\ = \frac{Difference\ in\ elevation}{horizontal\ distance} = \frac{8.160}{(20 * 8)} = 1\ in\ 19.61\ (Falling)$$

5. The following consecutive staff readings were observed with a level and 5m levelling staff on continuously sloping ground at a common interval of 20m. 0.385, 1.030, 1.925, 2.825, 3.730, 4.685, 0.625, 2.005, 3.110 & 4.485. The reduced level of the first point was 208.125m. Rule out a page of a level field book and enter the above readings. Calculate the reduced levels of the points by height of instrument method and also the gradient of the line joining the first and last point?

Solution: Since the readings were taken on a continuously sloping ground, the maximum staff reading can be 5 meters only and therefore, sixth reading will be a fore sight taken on a turning point and the seventh reading will be a back sight. Also the first reading will be back sight and the last reading will be fore sight. The levels can be readily calculated as shown in the tabular form below.

Σ BS = 1.010, Σ FS = 9.170,

Σ B.S ─ Σ F.S = Last RL ─ First RL

1.010- 9.170 = 199.965 – 208.125

- 8.160 = - 8.160

$$Gradient\ of\ the\ Line\ = \frac{Difference\ in\ elevation}{horizontal\ distance} = \frac{8.160}{(20 * 8)} = 1\ in\ 19.61\ (Falling)$$

STN	BS	IS	FS	HI	RL	REMARKS

1	0.385			208.510	208.125	BM
2		1.030			207.480	
3		1.925			206.585	
4		2.825			205.685	
5		3.730			204.780	
6	0.625		4.685	204.450	203.825	CP_1
7		2.005			202.445	
8		3.110			201.340	
9			4.485		199.965	

COMPUTATION OF MISSING READINGS:

1. **The following figures were extracted from a level field book, some of the entries illegible to exposure to rain. Insert the missing figures and check your results. Rebook all the figures by rise and fall method?**

STATION	BS	IS	FS	RISE	FALL	RL
1	2.285					232.460
2	1.650		X	0.020		
3		2.105				
4	1.625		1.960	X		
5	2.050		1.925			
6		X		X		232.255
7	1.690		X	0.340		
8	2.865		2.100			
9			X	X		233.425

Solution:

- ✓ FS @ Station 2 = BS @ 1 – Rise @ 2 = 2.285 - 0.020 = 2.265
- ✓ RL @ Station 2 = RL @ 1 + Rise @ 2 = 232.460 + 0.020 = 232.480
- ✓ RL @ Station 3 = RL @ 2 – Fall@ 3 = 232.480 - 0.455 = 232.025
- ✓ Fall @ Station 3 = IS @ 3 – BS @ 2 = 2.105 – 1.650 = 0.455
- ✓ Rise @ Station 4 = IS @ 3 – FS @ 4 = 2.105 – 1.960 = 0.145
- ✓ RL @ Station 4 = RL@ 3 + Rise@ 2 = 232.025 + 0.145 = 232.170
- ✓ Fall @ Station 5 = FS @ 5 – BS @ 4 = 1.925 – 1.625 = 0.300
- ✓ RL @ Station 5 = RL @ 4 – Fall @ 5 = 232.170 – 0.300 = 231.870
- ✓ Rise @ Station 6 = RL @ 6 – RL @ 5 = 232.255 – 231.870 = 0.385
- ✓ IS @ Station 6 = BS @ 5 – Rise @ 6 = 2.050 – 0.385 = 1.665

- ✓ FS @ Station 7 = IS @ 6 – Rise @ 7 = 1.665 – 0.340 = 1.325
- ✓ RL @ Station 7 = RL @ 6 – Rise @ 7 = 232.255 + 0.340 = 232.595
- ✓ Fall @ Station 8 = FS @ 8 – BS @ 7 = 2.100 – 1.690 = 0.410
- ✓ RL @ Station 8 = RL @ 7 - Fall @ 8 = 232.595 - 0.410 = 232.185
- ✓ Rise @ Station 9 = RL @ 9 – RL @ 8 = 233.425 – 232.185 = 1.240
- ✓ FS @ Station 9 = BS @ 8 – Rise @ 9 = 2.865 – 1.240 = 1.625

STN	BS	IS	FS	RISE	FALL	RL	REMARKS
1	2.285			-	-	232.460	
2	1.650		**2.265**	0.020	-	**232.480**	CP_1
3		2.105		-	0.455	**232.025**	
4	1.625		1.960	**0.145**	-	**232.170**	CP_2
5	2.050		1.925		0.300	**231.870**	CP_3
6		**1.665**		**0.385**	-	232.255	
7	1.690		**1.325**	0.340	-	**232.595**	CP_4
8	2.865		2.100		0.410	**232.185**	CP_5
9			**1.625**	**1.240**	-	233.425	

Arithmetic Check:

Σ BS = 12.165, Σ FS = 11.200, Σ RISE = 2.130, Σ FALL = 1.165

Σ B.S ─ Σ F.S = Σ Rise - Σ Fall = Last RL ─ First RL

12.165 – 11.200 = 2.130 – 1.165 = 233.425 – 232.460

- 0.965 = - 0.965 = - 0.965

2. The following is an incomplete page of a level book with X indicates missing entry. Calculate all missing entries and complete the page of level book. Also give the arithmetic checks?

STATION	BS	IS	FS	RISE	FALL	RL
A	2.560					100.000
B		3.540			X	X
C		3.200		X		X
D		2.340		X		X
E	1.950		X	1.080		X
F		2.440			X	X
G			3.465		X	X

Solution:

- ✓ Fall @ Station B = IS @ B – BS @ A = 3.540 – 2.560 = 0.980
- ✓ RL @ Station B = RL @ A – Fall @ B = 100.000 – 0.980 = 99.020

- ✓ Rise @ Station C = IS @ B – IS @ C = 3.540 – 3.200 = 0.340
- ✓ RL @ Station C = RL @ B + Rise @ C = 99.020 + 0.340 = 99.360
- ✓ Rise @ D = IS @ C – IS @ D = 3.200 – 2.340 = 0.860
- ✓ RL @ Station D = RL @ C + Rise @ D = 99.360 + 0.860 = 100.220
- ✓ FS @ Station E = IS @ D – Rise @ E = 2.340 – 1.080 = 1.260
- ✓ RL @ Station E = RL @ D + Rise @ E = 100.220 + 1.080 = 101.300
- ✓ Fall @ Station F = IS @ F – BS @ E = 2.440 – 1.950 = 0.490
- ✓ RL @ Station F = RL @ E – Fall @ F = 101.300 – 0.490 = 100.810
- ✓ Fall @ Station G = FS @ G – IS @ F = 3.465 – 2.440 = 1.025
- ✓ RL @ Station G = RL @ F – Fall @ G = 100.810 – 1.205 = 99.785

STATION	BS	IS	FS	RISE	FALL	RL	REMARKS
A	2.560					100.000	BM
B		3.540			**0.980**	**99.020**	
C		3.200		**0.340**		**99.360**	
D		2.340		**0.860**		**100.220**	
E	1.950		**1.260**	1.080		**101.300**	CP_1
F		2.440			**0.490**	**100.810**	
G			3.465		**1.025**	**99.785**	

Arithmetic Check:

Σ BS = 4.510, Σ FS = 4.725, Σ RISE = 2.260, Σ FALL = 2.495

Σ B.S ─ Σ F.S = Σ Rise - Σ Fall = Last RL ─ First RL

4.510 – 4.725 = 2.280 – 2.495 = 99.785 – 100.000

- 0.215 = - 0.215 = - 0.215

ERRORS IN LEVELLING:

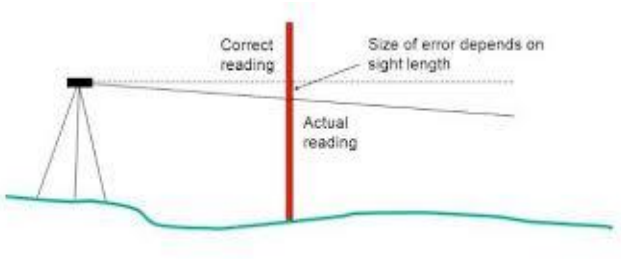
All levelling instruments are subjected to three principal sources of errors:

- ➢ Instrumental Errors.
- ➢ Natural Errors.
- ➢ Personal Errors.

➢ INSTRUMENTAL ERRORS:

- ✓ ***Error due to Imperfect adjustment:*** The essential adjustment of a level is that the line of sight shall be parallel of the bubble tube. If the instrument is not in this

adjustment, the time of sight will either be inclined upwards or downwards when the bubble is centred and the rod readings will be incorrect. The error in the rod reading will be proportional to the distance and can be eliminated by balancing the back sight and foresight distances. The error is likely to de cumulative, particularly in going up or down a steep hill, where all back sights are longer or shorter than all foresights unless care is taken to run a zigzag line.



- ✓ ***Error due to sluggish bubble:*** if the bubble is sluggish, it will come to rest in wrong position, even though it may creep back to correct position while the sight is being taken, such a bubble is a constant source of annoyance and delay. However, the error may be partially avoided by observing the bubble after the target has been sighted. The error is compensating.
- ✓ ***Error in the movement of the objective slide:*** In the case of external focusing instruments, if the objective slide is slightly worn out it may my move in truly horizontal direction. In the short sights, the objective side is moved out nearly its entire length and the error is more. Due to this reason extremely short sights are to be avoided. The error is compensating and can be eliminated by balancing back sight and foresight, since in that case, focus is not changed and hence the side is not moved.
- ✓ ***Rod not of standard length:*** Incorrect lengths of divisions on a rod cause errors similar to those resulting from incorrect marking on a tape. The error is systematic and is directly proportional to the difference in elevation. If the rod is too long, the correction is added to a measured difference in elevation; if the rod is too short, the correction is subtracted. Uniform wearing of the shoe at the bottom of the rod makes HI values incorrect, but the effect is cancelled when included in both back and foresight readings. For accurate levelling the rod graduations should be tested and compared with any standard tape.
- ✓ ***Error due to defective joint:*** The joint of the extendable rods may be worn out from setting the rod down on the run and from other sources. The failure to test the rod at frequent interval may result in a large cumulative error.

- ➢ **NATURAL ERRORS:**

- ✓ ***Earths Curvature:*** The effect of curvature is to increase the rod readings. When the distances are small the error is negligible, but for greater distances when the back and foresights are not balanced, a systematic error of considerable magnitude is produced.
- ✓ ***Refraction:*** Due to refraction, the ray of light bends downwards in the form of curve with its concavity towards the earth surface, thus decreasing the staff readings. Since the atmospheric refraction often changes rapidly and greatly in short distance, it is impossible to eliminate entirely the effect of refraction even though the back sight and foresight distances are balanced. It is particularly uncertain when the line of sight passes close to the ground. Errors due to refraction tend to be compensating over a long period of time but may be cumulative on a full day's run.
- ✓ ***Variation in Temperature:*** The effect of variation in temperature on the adjustment of the instrument is not of much consequence in levelling of ordinary precision, but it may produce an appreciable error in precise work. The adjustment of the instrument is temporarily disturbed by unequal heating and the consequent warping and distortion. The heating of the level vial will cause the liquid to expand and bubble to shorten. If one end of the vial is warmed more than the other, the bubble will move towards the heated end and appreciable errors will be produced. In precise levelling, it is quite possible that errors from change of length of levelling rod from variations in temperature may exceed the errors arising from the levelling itself. Heat waves near the ground surface or adjacent to heated objects make the rod appear to wave and prevent accurate sighting. The heating effect is practically eliminated by shielding the instrument from the rays of the sun. The error is usually accidental, but under certain conditions it may become systematic.
- ✓ ***Settlement of tripod on turning point:*** If the tripod settles in the interval that elapses between taking a back sight and the following foresight, the observed foresight will be too small and the elevation of the turning point will be too great. Similarly, if a turning point settles in the interval that elapses between taking a foresight and the following back sight in the next set up, the observed back sight will be too great and H.I. calculated will be too great. Thus, whether the tripod settles or the turning point settles, the error is always systematic and the resulting elevation will always be too high.
- ✓ ***Wind Vibrations:*** High wind shakes the instrument and thus disturbs the bubble and the rod. Precise levelling work should never be done in high wind.

➢ **PERSONAL ERRORS:**

- ✓ ***Mistakes in manipulation:*** These include mistakes in setting up the level, imperfect focusing of eye - piece and of objective, errors in centring the bubble and failure to watch it after each sight, and errors due to resting the hands on tripods or telescope. In the long sights, the error due bubble not being centred at the time of sighting are more important. Habit should be developed of checking the bubble before and after each sight. Parallax caused by improper focusing result in incorrect rod readings; it produces an accidental error and can be eliminated by carefully focusing.
- ✓ ***Rod handling:*** If the rod is not in plumb, the reading taken will be too great. The error varies directly with the magnitude of the rod reading and directly as the square of the inclination. In running a line of levels uphill, back sight readings are likely to be increased more than foresight from this source and the evaluation of a bench mark on top will be too great. Similarly, the elevation of a bench mark at the bottom, while levelling downhill, will be too small. Thus, a positive systematic error results. Over level ground, the resultant error the back sights are about equal to the foresights. The error can be is accidental since minimised by carefully plumbing the rod either by eye estimation or by using a rod level, a special attachment devised for plumbing the rod or by waving the level rod slowly towards or away from the level thereby taking the minimum rod reading. Vertical cross - hair may be used to plumb the rod in the direction transverse to the line of sight.
- ✓ ***Errors in sighting:*** The error is caused when it is difficult to tell when the crosshair coincides with the centre of the target in a target rod and to determine the exact reading which the cross - hair appears to cover in the case of self - reading rod. This is an accidental error the magnitude of which depends upon the coarseness of the cross - hair, the type of rod, the form of target, atmospheric conditions, length of sight and the observer.
- ✓ ***Mistakes in reading the rod:*** The common mistakes in reading the rod are:
  - Reading upwards, instead of downwards.
  - Reading downwards, instead of upwards when the staff is inverted.
  - Reading wrong metre mark when the staff is near the level and only one metre mark is visible through the telescope.
  - To omit a zero or even two zeros from a reading. For example, 1.28 instead of 1.028 or 1.06 instead of 1.006.
  - Reading against a stadia hair.
  - Concentrating more attention on decimal part of the reading and noting whole metre reading wrongly.

✓ ***Mistakes in recording and computing:*** The common mistakes are:

- Entering the readings with digits interchanged i.e., 1.242 instead of 1.422.
- Entering back sight & fore sight in wrong column.
- Mistaking the numerical value of readings called out by the level man.
- Omitting entry.
- Entering wrong remark against a reading.
- Adding a fore sight instead of subtracting it and subtracting a back sight reading instead of adding it.
- Ordinary arithmetical mistakes.

REFERENCES

1. Surveying Volume I by B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain.16th Edition, Laxmi publications (P) Ltd, #113, Golden House, Daryagunj, New Delhi – 110002, India.

PRACTICAL EXCERCISES

Name of the Practical - 01: Units of measurement and conversion of units

AIM: To study the various units of measurements and its conversion

THEORY:

Unit of measurement is also known as the International System of Units, or SI. Units of measure in the metric system. The units of length or linear size are derived from the metre. They comprise of the kilometer (km) that is 1000 meters, the centimeter (cm), and the millimeter (mm) which is 1/1000th of a meter.

There are four kinds of measurement used in plane surveying:

1. Horizontal distance
2. Vertical distance
3. Horizontal angle
4. Vertical angle

LINEAR MEASURMENTS

Linear measurement in surveying involves the measurement of horizontal and vertical distances of the points or places at a given area such a residential block, district, a city and a country. In surveying, linear measurement involves the use of instruments to measure the required horizontal and vertical distances such as scale, theodolites, taping pins, range poles, offset tapes, stylon tapes and the chain.

Also they use imperial units or US standard system such as inches, feet, yards and miles with 1foot being equal to 12inches, 1yard is equal to 3 feet and 1 mile is equal to 1760 yards. Therefore, surveyors are encouraged to use the above instruments and units of measurements since they produce reliable outcomes.

ANGULAR MEASURMENTS

Angular measurement is another factor in surveying. Angular measurement is the dimensionless though it may be specified as radians to avoid ambiguity. Angles are measured in degrees, subdivision of the degree are minutes and the angles measured are used to determine the bearings and directions of horizontal and vertical angels in control surveys in order to locate details when mapping and setting out all types of structures and features on an area being surveyed. A theodolite is a measuring instrument commonly measure the horizontal and vertical angles.

C. BASIC UNITS OF LENGTH

According to standards of weights and measures act (India) 1956 the unit of measurement of distance is metres and centimetres. Prior to the introduction of metric units in India, Feet was used. Table 1.1 gives the basic linear measures both in metric as well as in British system, while tables 1.2 & 1.3 gives the conversion factors.

TABLE 1.1 BASIC UNITS OF LENGTH

BRITISH UNITS		METRIC UNITS	
12 Inches	1 Feet	10 Millimetre	1 Centimetre
3 feet	1 Yard	10 Centimetre	1 Decimetre
5½ Yards	1 Rod, Pole or Perch	10 Decimetre	1 Metre
4 poles	1 Chain (66 feet)	10 Metre	1 Decametre
10 Chains	1 Furlong	10 Decametre	1 Hectometre
8 Furlongs	1 Mile	10 Hectometre	1 Kilometre
100 Links	1 Chain	1852 Meter	1 Nautical Mile
6 Feet	1 Fathom		
120 Fathom	1 Cable Length		
6080 Feet	1 Nautical Mile		

TABLE 1.2 CONVERSION FACTORS

METRES	YARDS	FEET	INCHES
1	1.0936	3.2808	39.3701
0.9144	1	3	36
0.3048	0.3333	1	12
0.0254	0.0278	0.0833	1

TABLE 1.3 CONVERSION FACTORS

KILOMETRES	NAUTICAL MILES	MILES
1	0.53996	0.6214
1.852	1	1.1508
1.6093	0.869	1

D. BASIC UNITS OF AREA

The units of measurements of area are Sq. Metres, Sq. Decimetres, Hectares & Sq. Kilometres. Table 1.4 gives the units of area both in metric as well as in British system, while tables 1.5 & 1.6 gives the conversion factors.

TABLE 1.4 BASIC UNITS OF AREA

BRITISH UNITS		METRIC UNITS	
144 Sq. Inches	1 Sq. Feet	100 Sq. Millimetre	1 Sq. Centimetre
9 Sq. feet	1 Sq. Yard	100 Sq. Centimetre	1 Sq. Decimetre
30½ Sq. Yards	1 Sq. Rod, Pole or Perch	100 Sq. Decimetre	1 Sq. Metre
40 Sq. Rods	1 Rood	100 Sq. Metre	1 Sq. Decametre
4 Roods	1 Acre		1 Are
640 Acres	1 Sq. Mile	100 Ares	1 Hectare
484 Sq. Yards	1 Sq. Chain		1 Sq. Hectometre
10 Sq. Chains	1 Acre	100 Hectares	1 Sq. Kilometre

TABLE 1.5 CONVERSION FACTORS

SQ. METRES	SQ. YARDS	SQ. FEET	SQ. INCHES
1	1.196	10.7639	1550
0.8361	1	9	1296
0.0929	0.1111	1	144
0.00065	0.00077	0.0069	1

TABLE 1.6 CONVERSION FACTORS

ARES	ACRES	SQ. YARDS
1	0.0247	119.6
40.469	1	4840
0.0084	0.00021	1

E. BASIC UNITS OF VOLUME

The units of measurements of volumes are cubic decimetres & cubic meters. Table 1.7 gives the units of measurement of volumes both in metric as well as British units. Table 1.8 and 1.9 give the conversion factors.

TABLE 1.7 BASIC UNITS OF VOLUME

BRITISH UNITS		METRIC UNITS	
1728 Cu. Inches	1 Cu. Feet	1000 Cu. Millimetre	1 Cu. Centimetre
27 Cu. feet	1 Cu. Yard	1000 Cu. Centimetre	1 Cu. Decimetre
		1000 Cu. Decimetre	1 Cu. Metre

TABLE 1.8 CONVERSION FACTORS

Cu. Metres	Cu. Yards	Gallons
1	1.308	219.969
0.7645	1	168.178
0.00455	0.000595	1

TABLE 1.9 CONVERSION FACTORS

Cu. Metres	Acre Feet	Gallons	kilolitres
1	0.000811	219.969	0.99997
1233.48	1	271327	1233.45
0.00455	0.00000369	1	0.00455
1.000028	0.000811	219.976	1

F. BASIC UNITS OF ANGULAR MEASURMENTS

An angle is the difference in directions of two intersecting lines. The radians are the unit of plane angle. The radian is an angle between two radii of a circle which cuts off on the circumference of an arc equal in length to the radius. There are three popular systems of angular measurements.

a. SEXAGESIMAL SYSTEM

1 Circumference	360º (Degree of an Arc)
1 Degree	60’ (Minutes of an Arc)
1 Minute	60” (Seconds of an Arc)

b. CENTESIMAL SYSTEM

1 Circumference	400^{g} (Grads)
1 Grad	100^{C} (Centigrades)
1 Centigrad	100^{CC} (Centi - Centigrades)

c. HOURS SYSTEM

1 Circumference	24^{h} (Hours)
1 Hour	60^{m} (Minutes)
1 Minute	60^{S} (Seconds)

The sexagesimal system is widely used in United states, Great Britain, India and others parts of the world. More complete tables are available in this system and most surveying instruments are graduated according to this system. However due to facility in computation and interpolation the centesimal system is gaining more favour in Europe. The hour's system is used in astronomy and navigation.

RESULT: The units of length, area and volumes and their conversion factors have been discussed in detail.

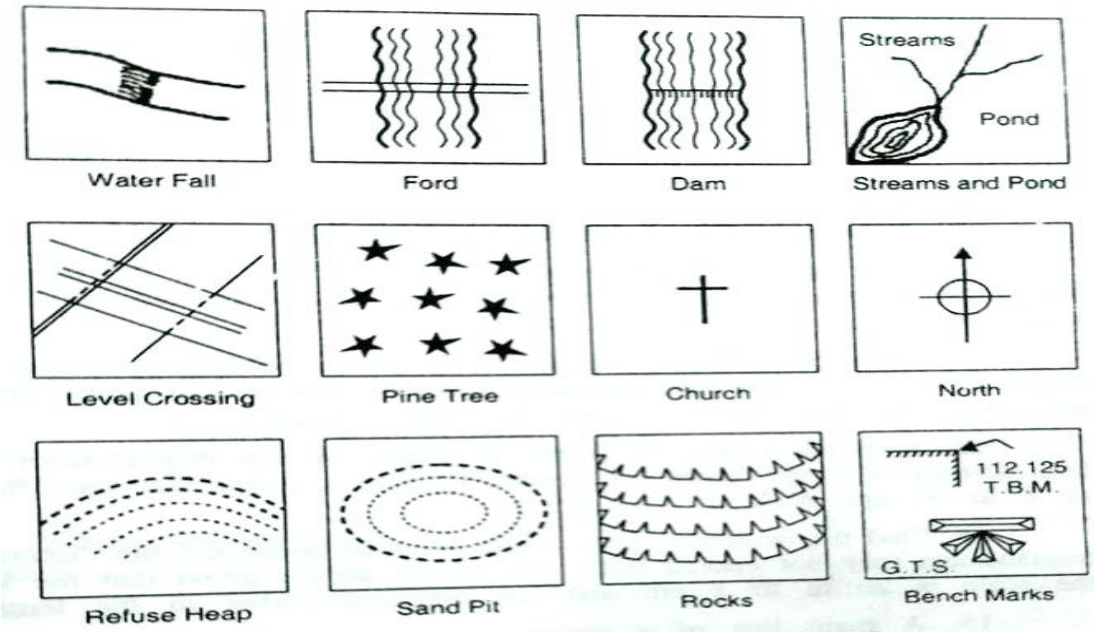
Name of the Practical - 02: Effective communication and signs used in survey Practice

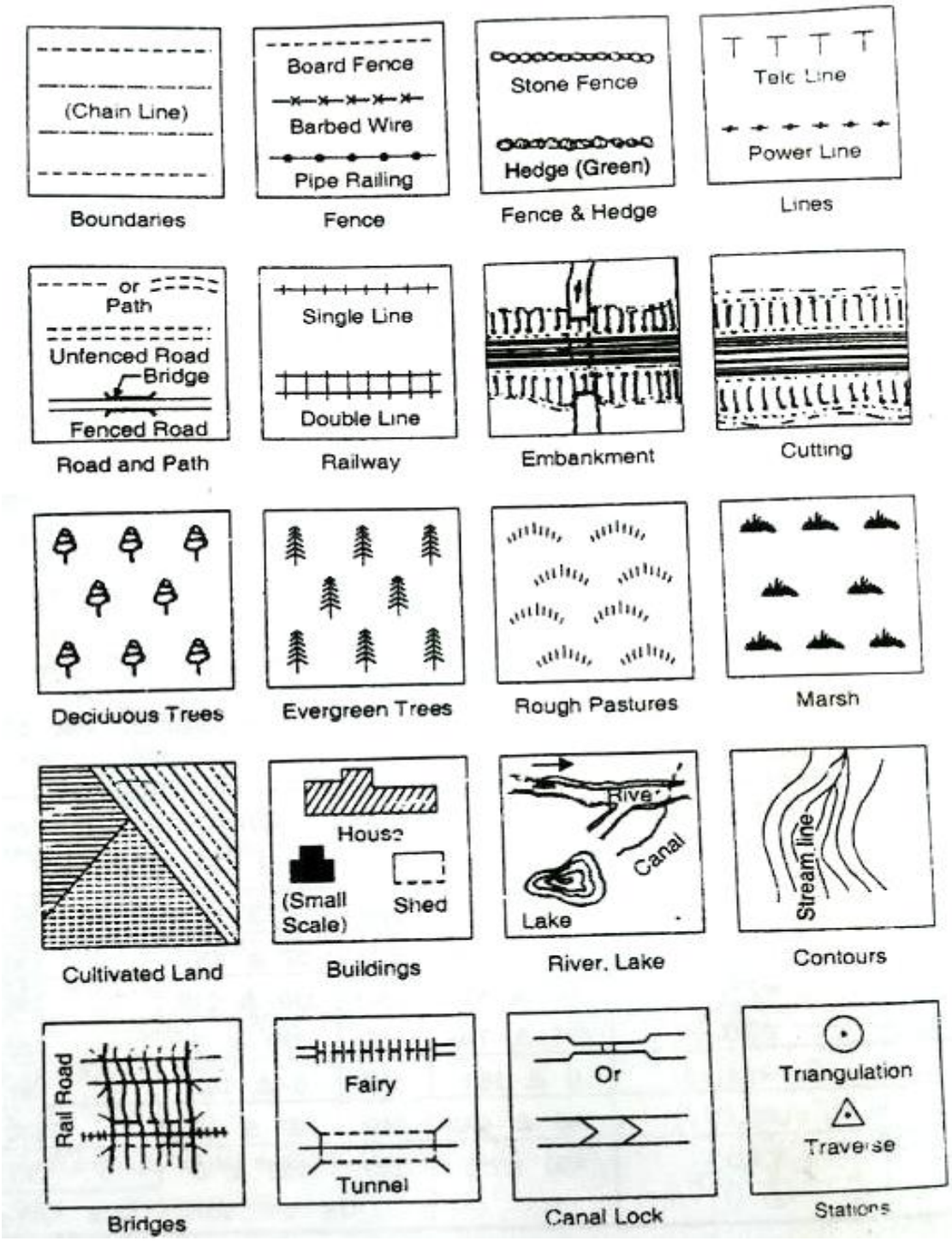
AIM: To study various code of signals and signs that are used while surveying in directing the assistant into survey line.

PROCEDURE:

While carrying out direct ranging or ranging by eye, the surveyor has to follow certain rules and regulation for effective completion of a given survey work. One of the rules that a surveyor will use in surveying are some codes of signals for ranging to direct his assistant into survey line. These codes of signals are given below.

NO	SIGNAL BY THE SURVEYOR	ACTION BY ASSISTANT
01	Rapid sweep with right hand	Move considerably to the right
02	Slow sweep with right hand	Move slowly to the right
03	Right arm extended	Continue to move to the right
04	Right arm up and moved to the right	Plumb the rod to the right
05	Rapid sweep with left hand	Move considerably to the left
06	Slow sweep with left hand	Move slowly to the left
07	left arm extended	Continue to move to the left
08	Right arm up and moved to the left	Plumb the rod to the left
09	Both hands above head and then brought down	Correct
10	Both hands extended forward horizontally and the hands depressed briskly	Fix the rod





CONVENTIONAL SYMBOLS

RESULT: The various codes of signal and conventional signs have been discussed in detail.

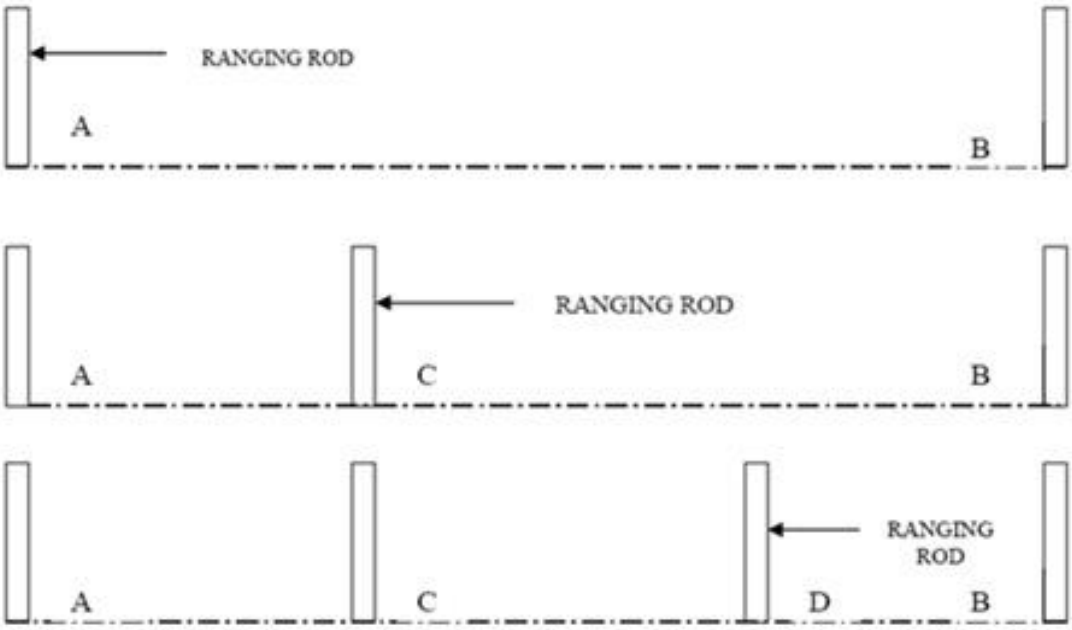
Name of the Practical - 03: Measuring distance between two survey stations using chain, tape and ranging rods when two stations are mutually intervisible.

AIM: To measure distance between two mutually inter visible survey stations using chain, tape and ranging rods.

EQUIPMENT'S REQUIRED:

- Chain
- Arrows
- Tapes
- Ranging rod
- Plumb bob
- Pegs

THEORY: By the various methods of determining distance the most accurate and common method is the method of measuring distance with a chain or tape is called Chaining. For work of ordinary precision, a chain is used. But where great accuracy is Required a steel tape is invariably used. The term chaining was originally applied to measure Distance with a chain. The term chaining is used to denote measuring distance with chain or tape, In the process of chaining, the survey party consists of a leader (the surveyor at the forward end of the chain) a follower (the surveyor at the rare end of the chain and an assistant to establish intermediate points).



PROCEDURE:

Two men are required for chaining operation; the chain man at the forward end of chain is called the **leader** while the other man at the rear end is known as the **follower**. Duties of leader & follower are listed below.

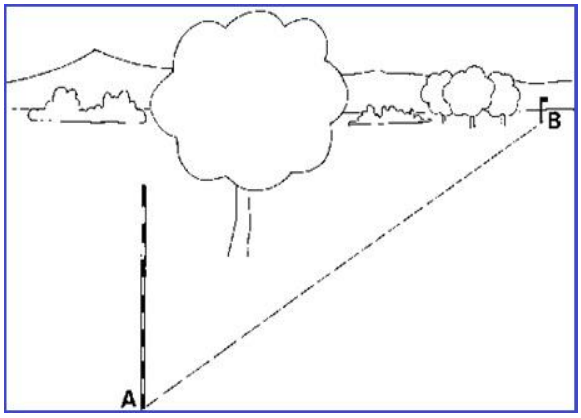
Leader:

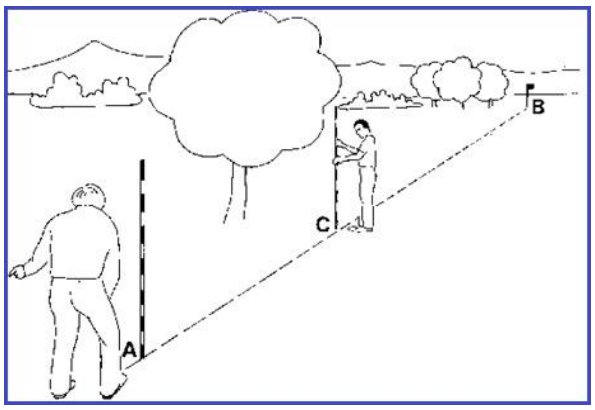
- ✓ To put the chain forward.
- ✓ To fix arrows at the end of chain.
- ✓ To follow the instruction of the followers.

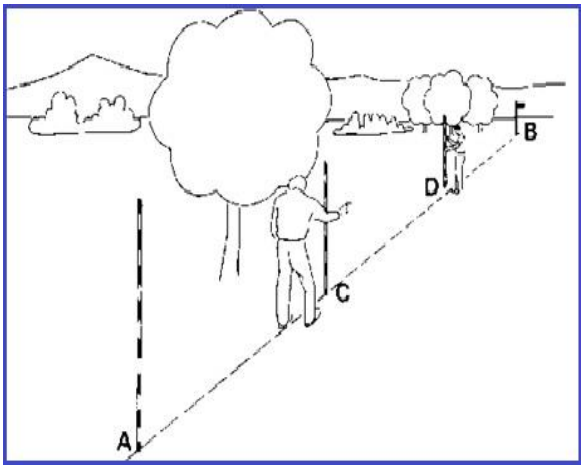
Follower:

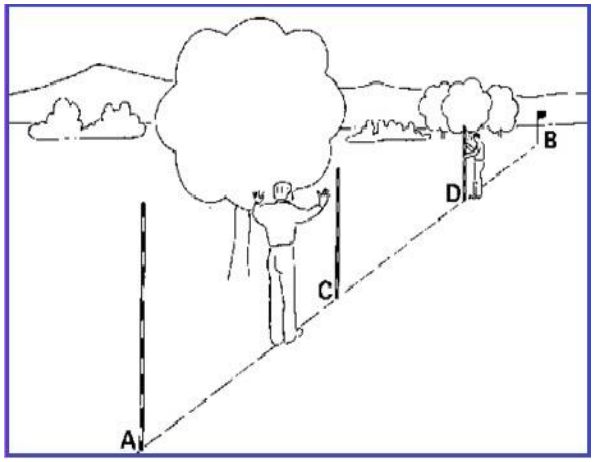
- ✓ To direct the leader to the line with the ranging rod.
- ✓ To carry the rear end of the chain.
- ✓ To pick up the arrows inserted by the leader.

1. The follower holds the zero handle of the chain against the peg &directs the leader to be in line of the ranging rod.
2. The leader usually with to arrows drags the chain alone the line.
3. Using code of signals, the follower directs the leader as required to the exactly in the line.
4. The leader then fixes the arrows at the end of chain the process is repeated.
5. Place ranging rods or poles vertically behind each point
6. Stand about 2m behind the ranging rod at the beginning of the line.
7. Direct the person to move the rod to right or left until the three ranging rods appear exactly in the straight line.
8. Sight only the lower portion of rod in order to avoid error in non-vertically.
9. After ascertaining that three rods are in a straight line, ask the person to fix up the rod.







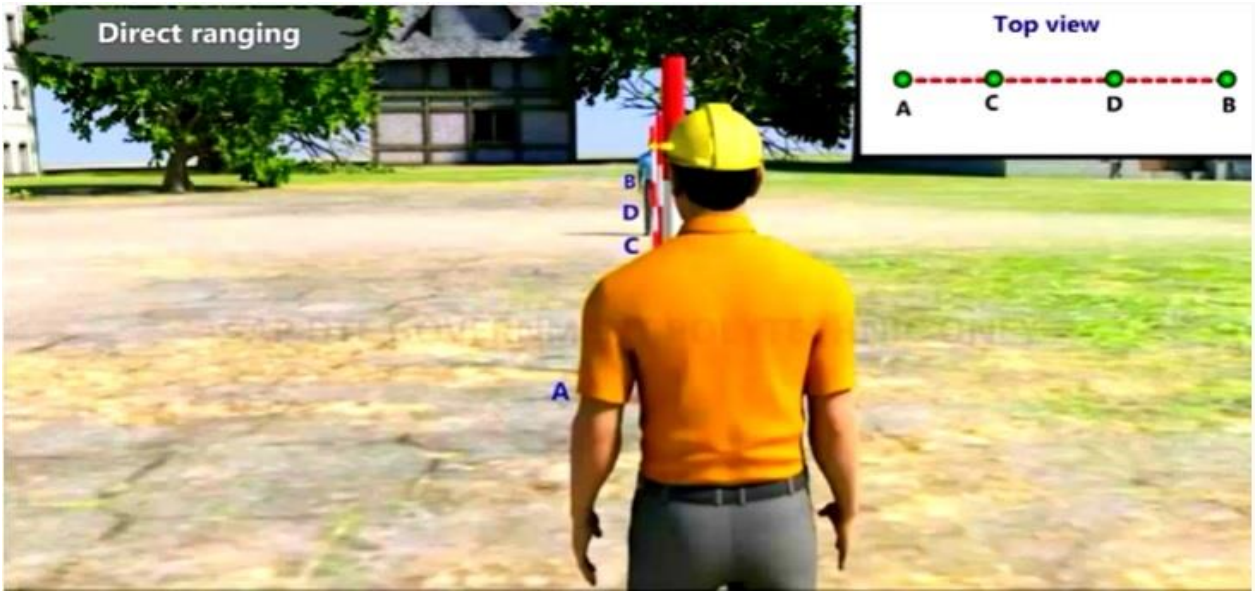



Direct ranging
Top view
A
B
A
B


Direct ranging
Top view
A
C
B
B
C
A
SUBSCRIBE NOW


Direct ranging
Top view
A
C
B
B
C
A


Direct ranging
Top view
A
C
D
B
B
D
C


Direct ranging
Top view
A
C
D
B
B
D
C
A


Direct ranging
Top view
A
C
D
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A
C
D
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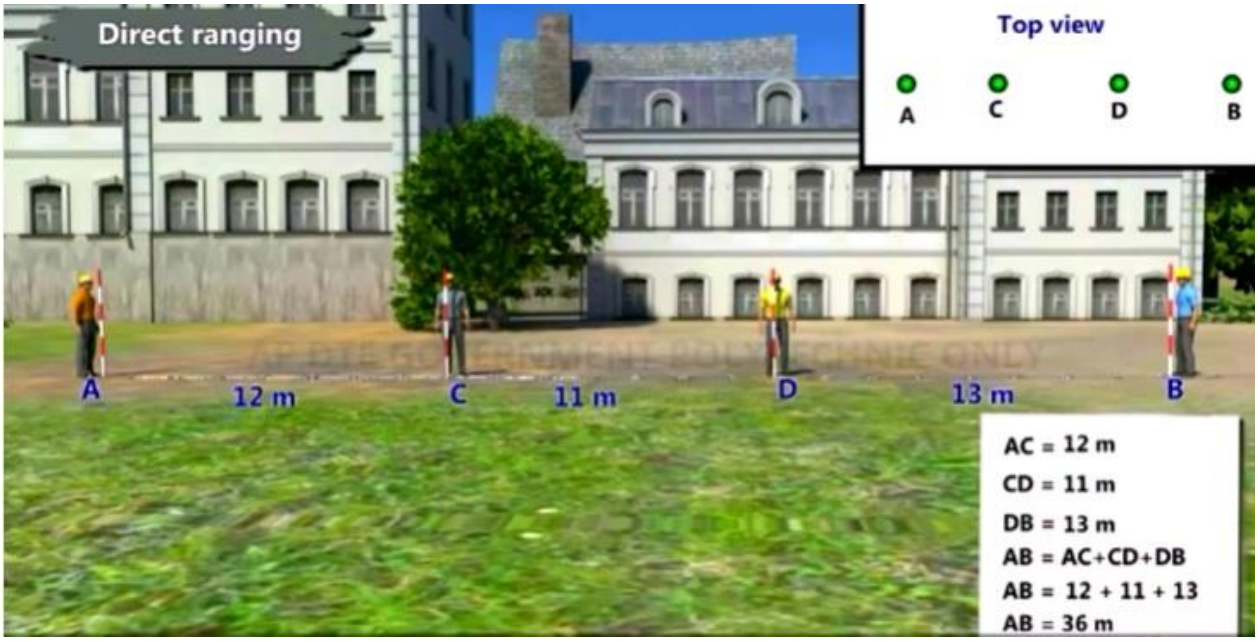


RESULT: By Chaining and ranging the total distance is found to be AB = _____ M

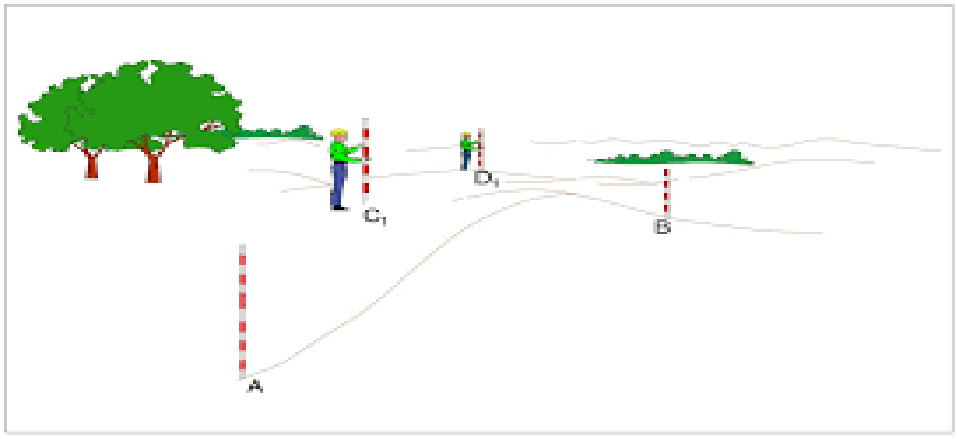
Name of the Practical - 04: Undertake reciprocal ranging and measure the distance between two stations using EDM or RODOMETER.

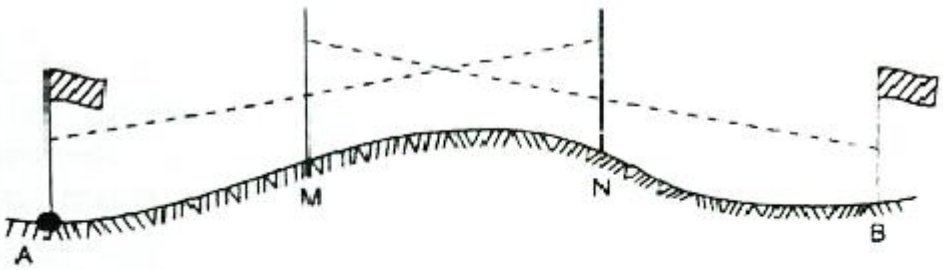
AIM: To undertake reciprocal ranging or indirect ranging and measuring the distance between two points using EDM or Rodometer

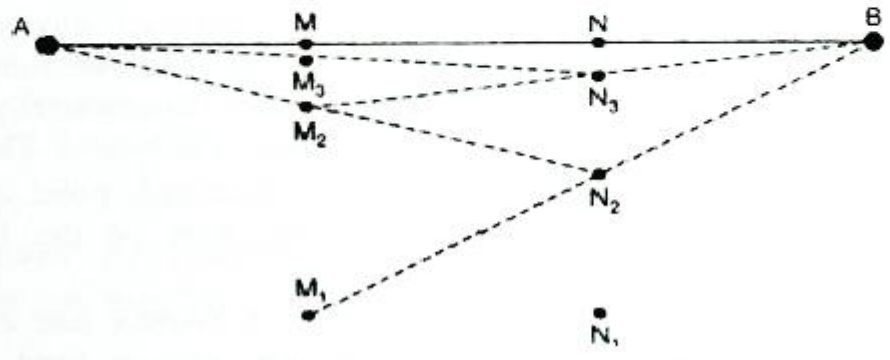
EQUIPMENT'S REQUIRED:

- Chain
- Arrows
- Tapes
- Ranging rod
- Plumb bob
- Pegs

THEORY: Indirect ranging or Reciprocal ranging is resorted to when both the ends of the survey line are not intervisible either due to high intervening ground or due to long distance between them.



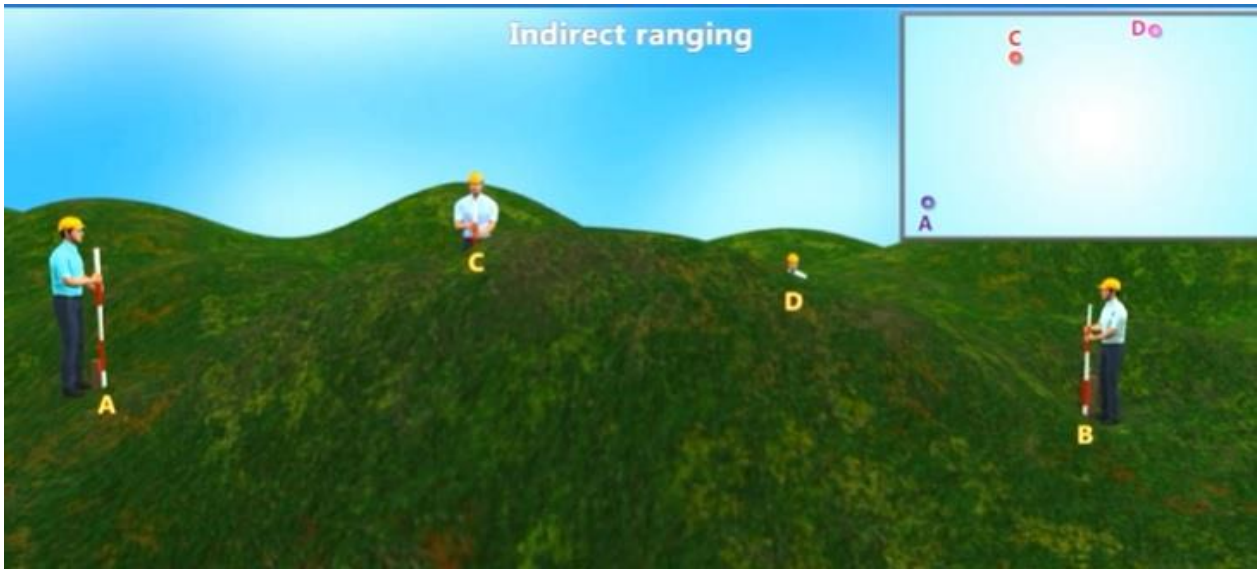


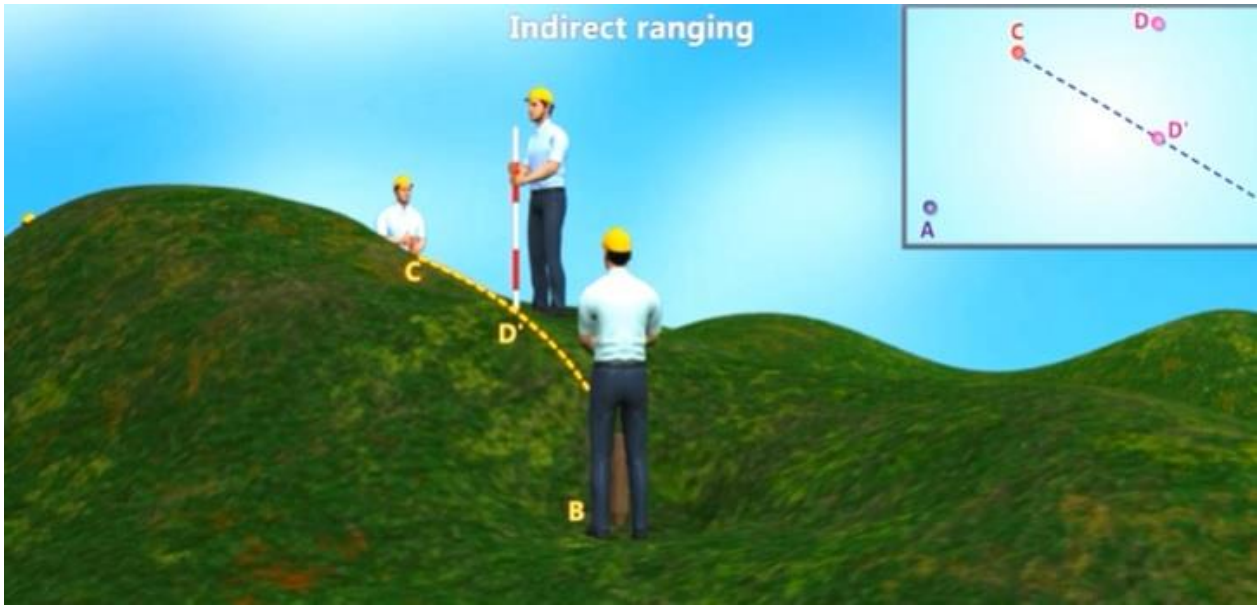


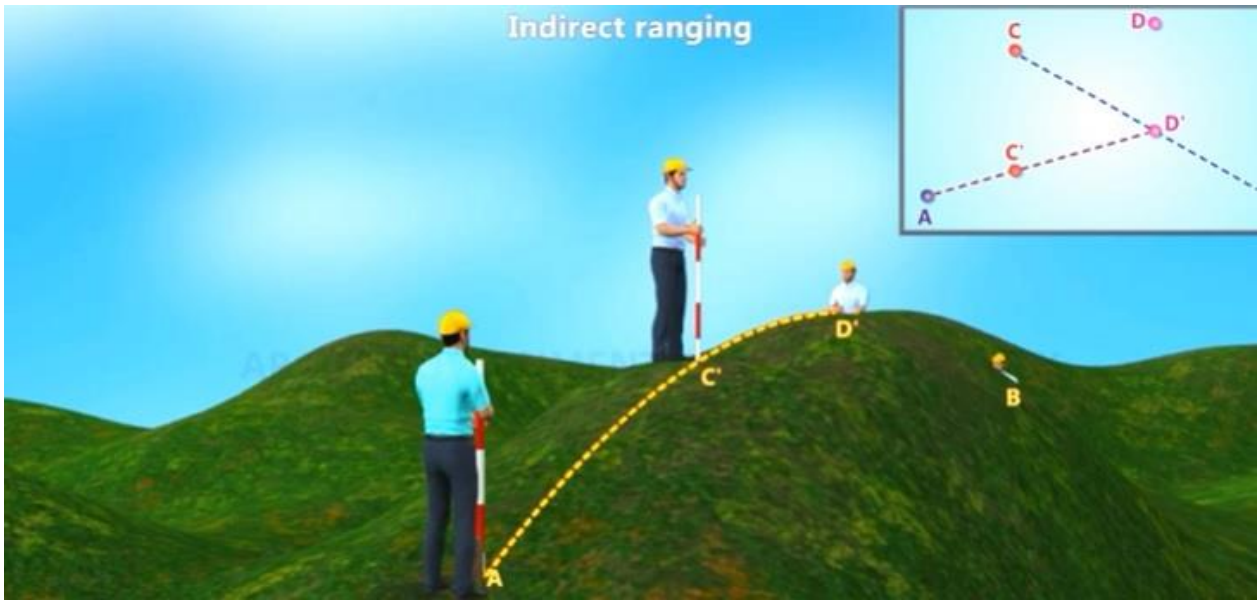
PROCEDURE:

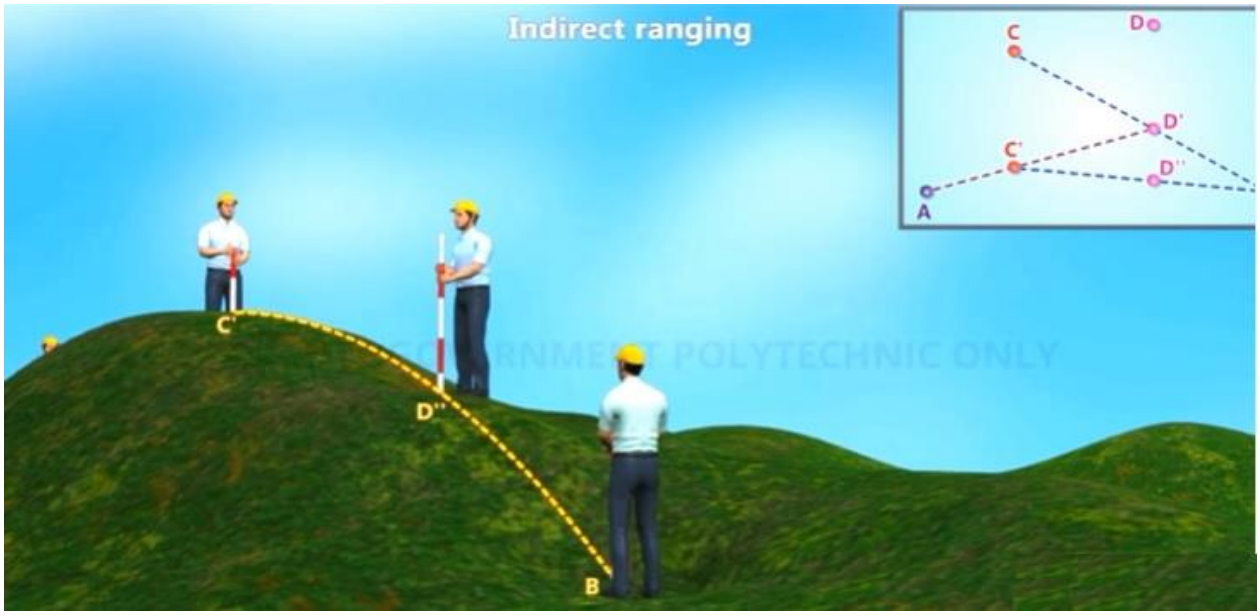
Let A and B are the ends of a chain line which has a rising ground intervening between them. In this case ranging is done indirectly by selecting two intermediate points M_1 and N_1 very near to chain line bye judgment in such a way that from M_1 both N_1 & B are visible and from N_1 both M_1 & A are visible.

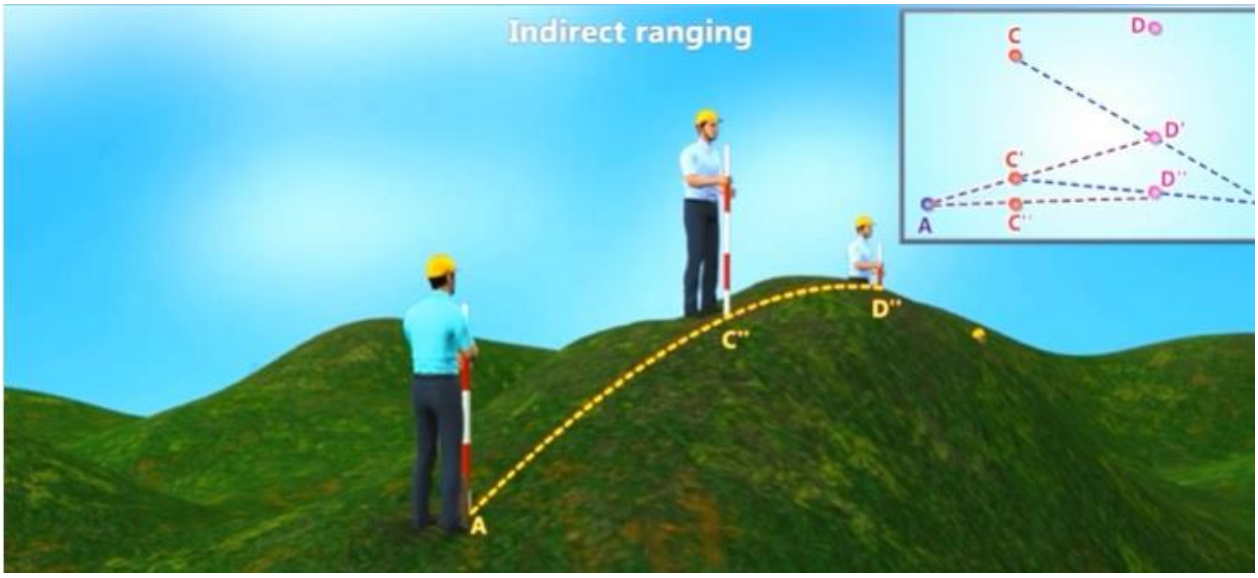
- Two surveyors station themselves at M_1 & N_1 with ranging rods.
- The person @ M_1 then directs the person at N_1 to move to a new position N_2 in line with M_1B.
- The person @ N_2 then directs the person at M_1 to move to a new position M_2 in line with N_2A.
- The two surveyors are now at M_2 & N_2 which are nearer to the chain line than the positions M_1 & N_1.
- The person @ M_2 then directs the person at N_2 to move to a new position N_3 in line with M_2B.
- The person @ N_3 then directs the person at M_2 to move to a new position M_3 in line with N_3A.
- The two surveyors are now at M_3 & N_3 which are nearer to the chain line than the positions M_2 & N_2.
- The process is repeated till the points M & N are located in such a way that the person at M finds the person at N in line with MB and the person @ N finds the person at M in line with NA.
- After having established M & N the other points can be fixed by direct ranging.


Indirect ranging
C
D
A
B


Indirect ranging
C
D
D'
A
B


Indirect ranging
C
D
D'
C'
A
B


Indirect ranging
C
D
D'
C'
D''
A
C''
D'''
B


Indirect ranging
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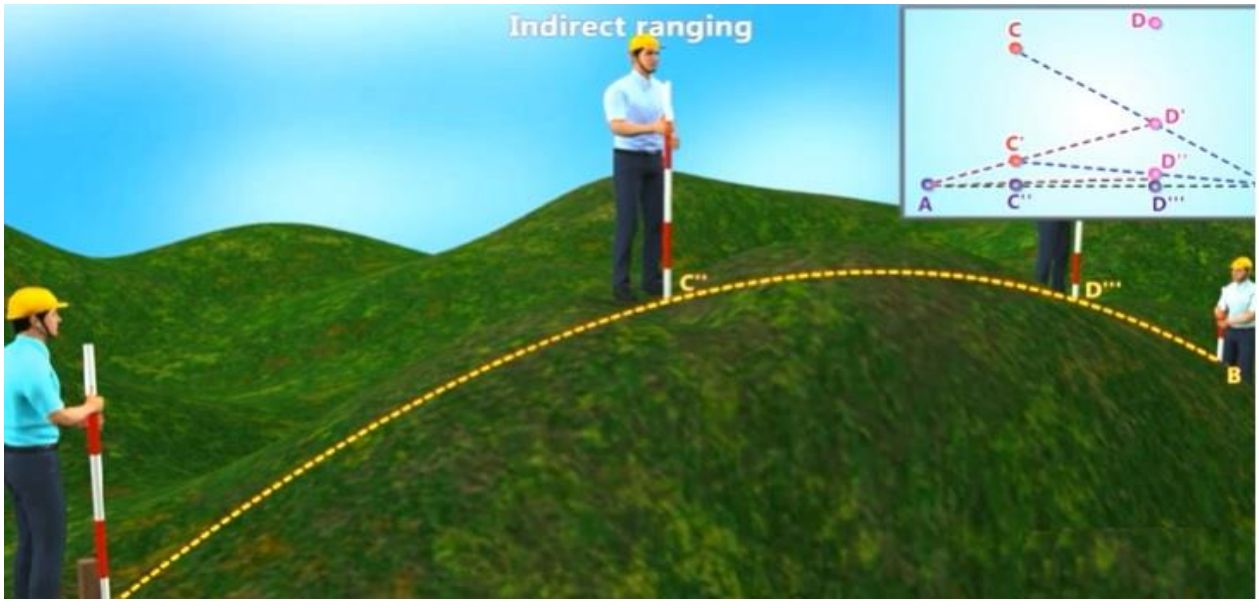
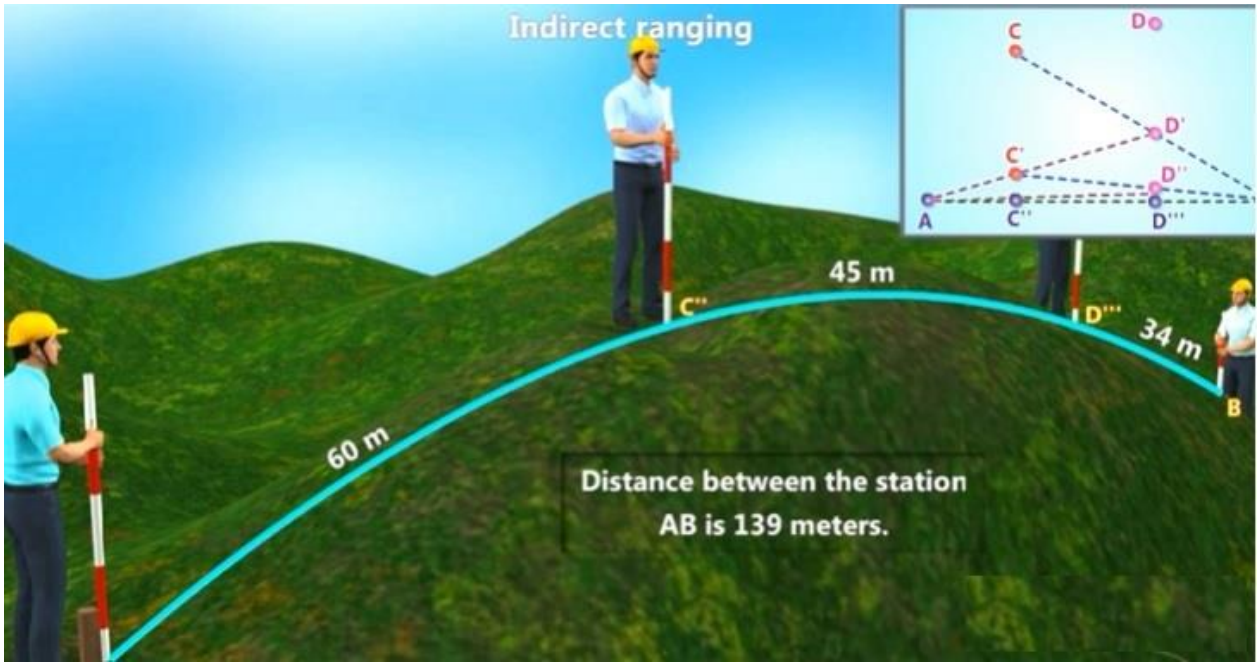
D'
C'
D''
A
C''
D'''
B


Indirect ranging
C
D
D'
C'
D''
A
C''
D'''
B



RESULT: The total distance between two points which are not visible to each other by reciprocal ranging is found to be AB = _____ M

Name of the Practical - 05: Setout perpendiculars to main survey line by different methods.

AIM: To set perpendicular distance to the main survey line by using chain or tape by different methods.

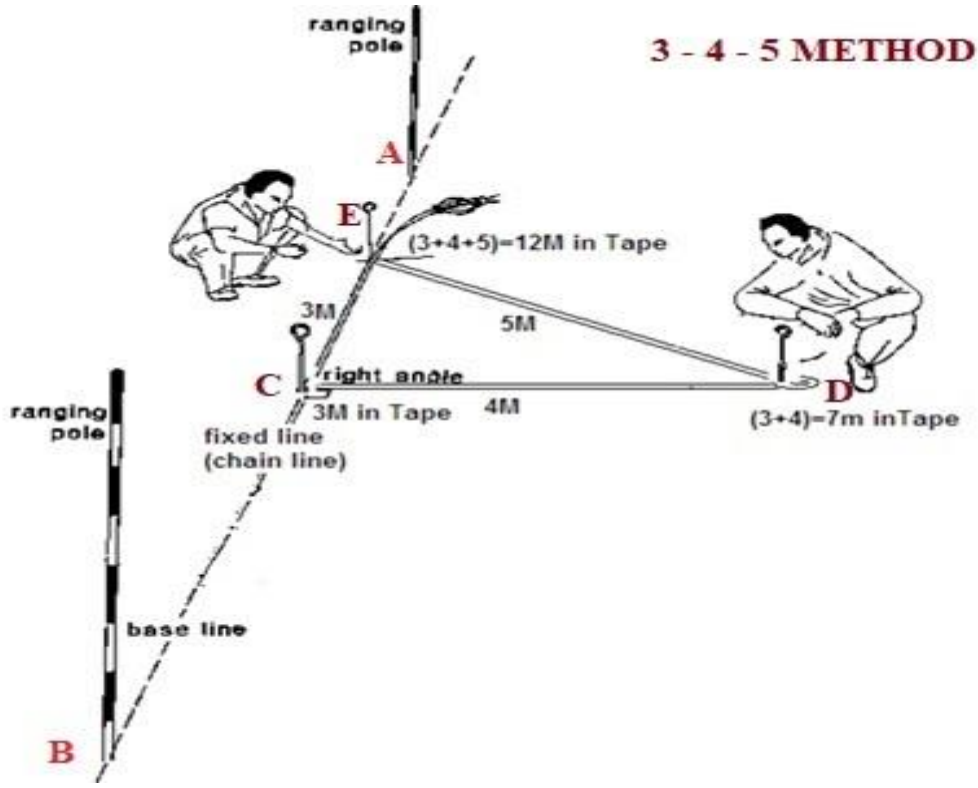
EQUIPMENT'S REQUIRED:

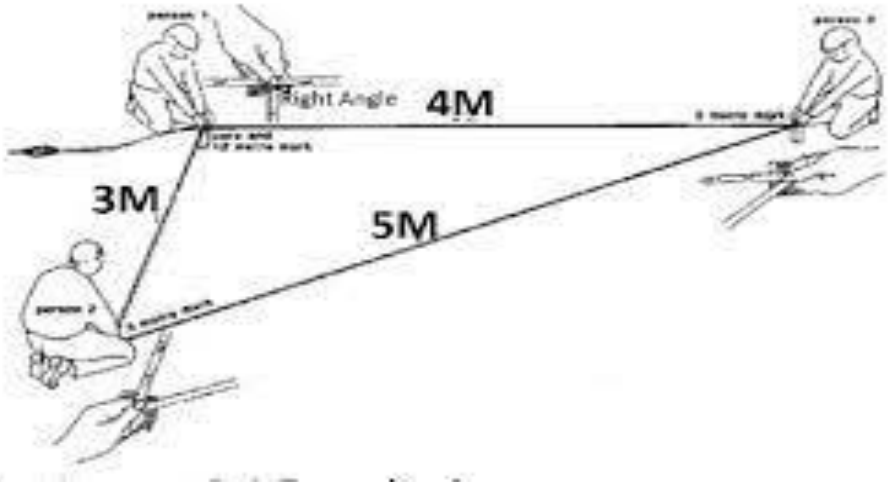
- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Cross staff.
- Pegs.

THEORY: The method of establishing perpendiculars with chain or tape is based on familiar geometrical constructions. Following are some of the method most commonly used. The illustrations given are for a 10m tape. However, 20m tape may also be used.

CONDITION 01: TO ERECT A PERPENDICULAR TO A CHAIN LINE FROM A POINT ON IT.

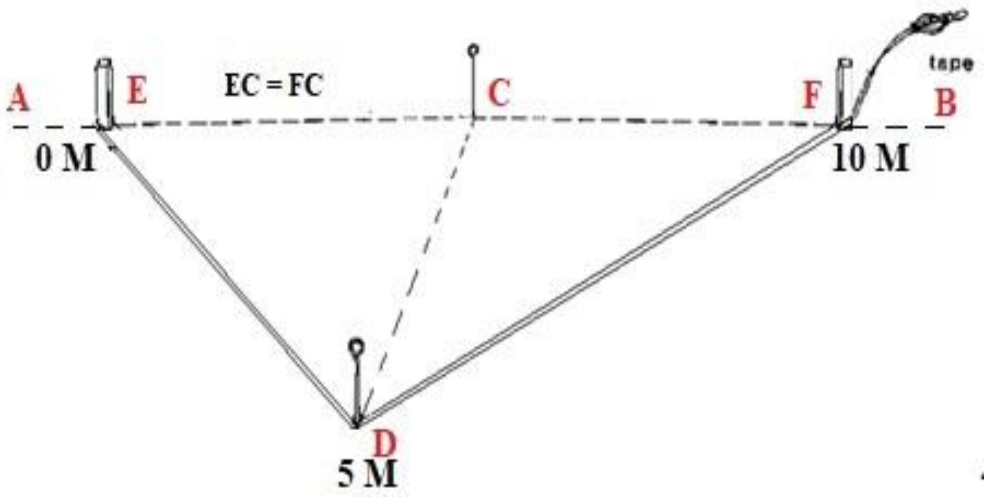
1. **THE 3-4-5 METHOD.**





- Erect a chain line AB on the ground.
- Let it be required to erect a perpendicular to the chain line at a point C on a chain line.
- Establish a point E at a distance of 3 metre from C.
- Put the zero end of the tape (10m long) at E and the 10m end at C.
- The 5m and 6m marks are brought together to form a loop of 1m.
- The tape is now stretched tight by fastening the ends E and C.
- The point D is thus established. Angle DCE will be 90 °. One person can set a right angle by this method.

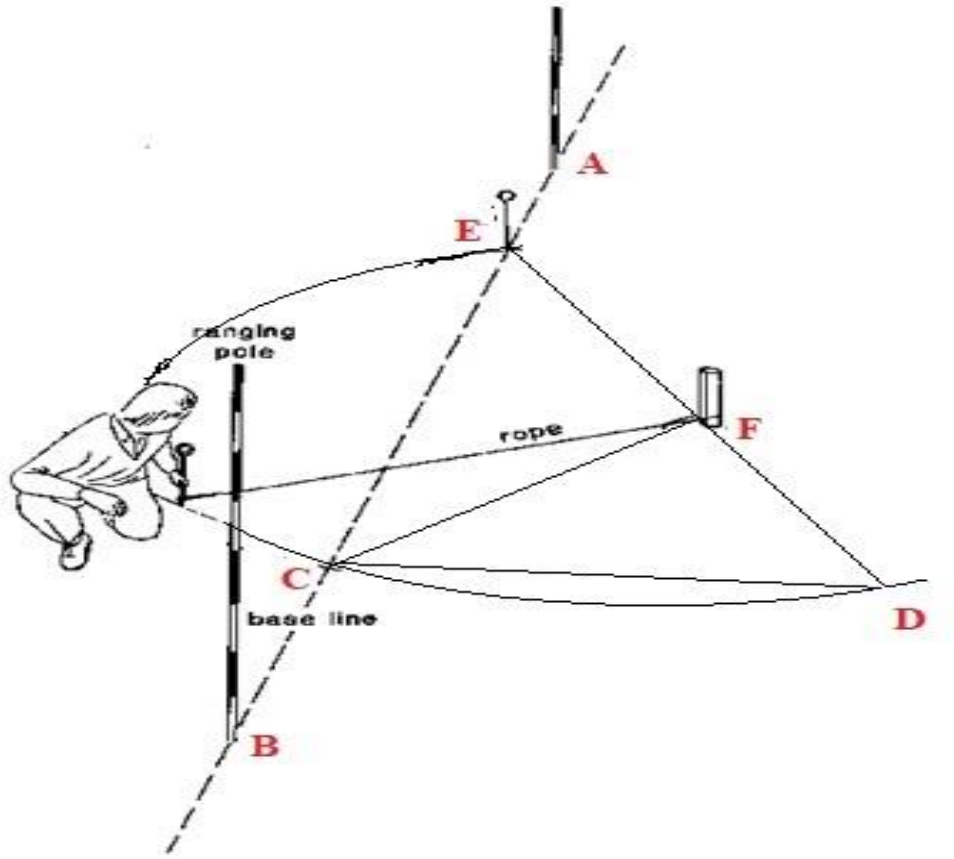
2. SECOND METHOD.



- Select a chain line AB.
- Select a point C on chain line AB.
- Select E and F equidistant from C, i.e. EC=CF.
- Hold the zero end of the tape at E, and 10 m end at F.
- Pick up 5m mark, stretch the tape tight and establish D. Join DC.

3. THIRD METHOD.

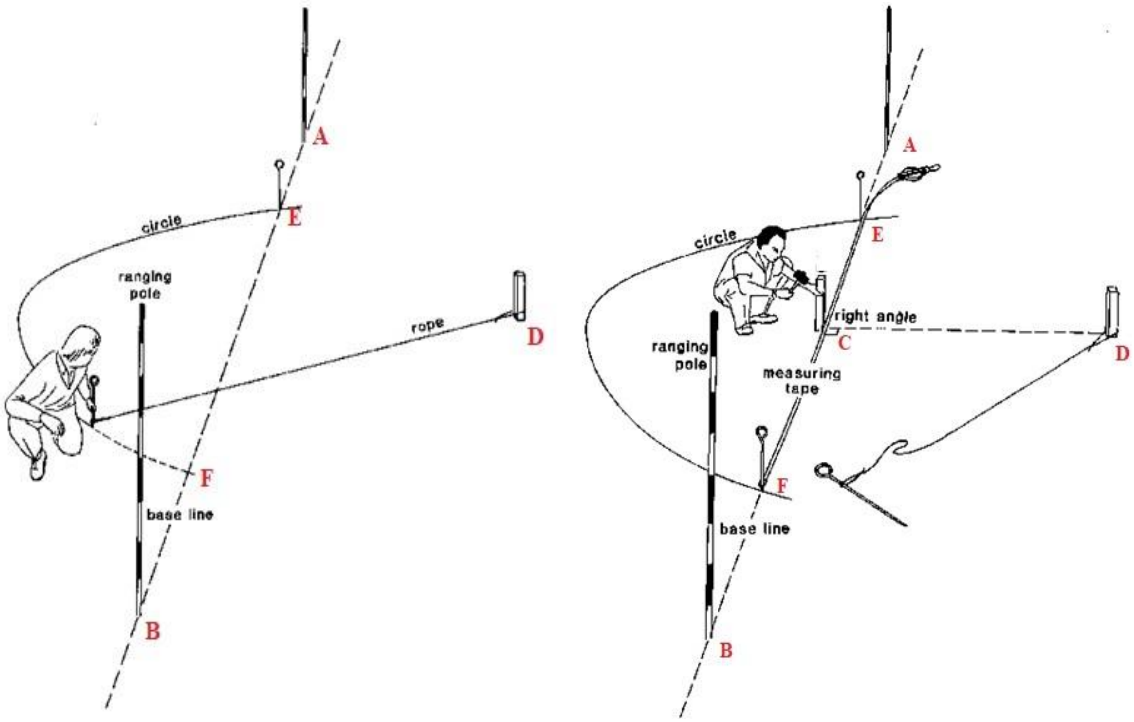
- Select a chain line AB on the ground.
- Select a point C on chain line AB.
- Select one more point F outside the chain line AB preferably at 5 m distance from C.
- Hold the 5m mark at F and zero mark at C and with F as center draw an arc to cut the line at E.
- Join EF and produce it to D, such that EF=FD. Thus the point D is done.
- Thus the point D will lie at the 10m mark of tape laid along EF with its zero end at E. Join DC.



CONDITION 02: TO DROP A PERPENDICULAR TO A CHAIN LINE FROM A POINT OUTSIDE IT.

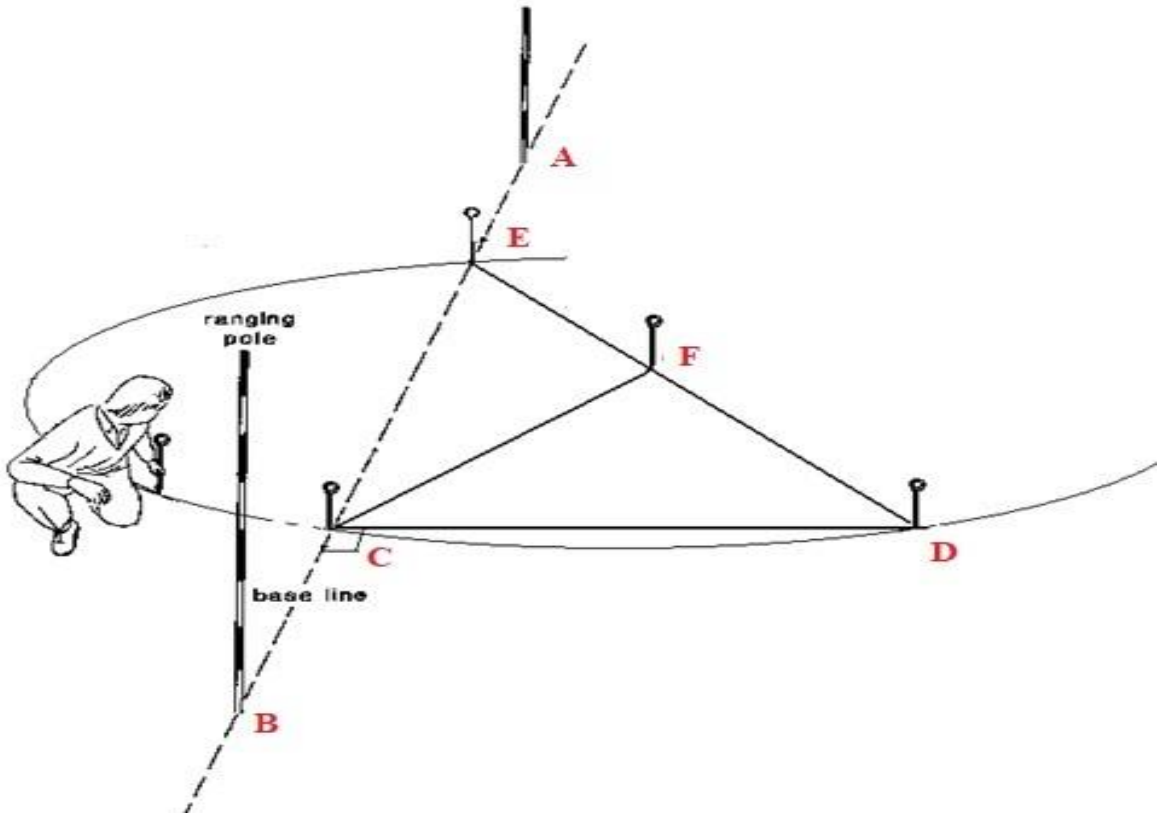
1. FIRST METHOD.

- Select a chain line AB on the ground.
- Let D be the point which is to be dropped perpendicularly to the chain line.
- Select any point E on the chain line.
- With D as center and DE as radius, draw an arc to cut the chain line in F.
- Bisect EF at C. Join C and D.CD will be perpendicular to AB.



- Select a chain line AB on the ground.
- Let D be the point which is to be dropped perpendicularly to the chain line.
- Select any point E on the chain line.
- With D as center and DE as radius, draw an arc to cut the chain line in F.
- Bisect EF at C. Join C and D.CD will be perpendicular to AB.

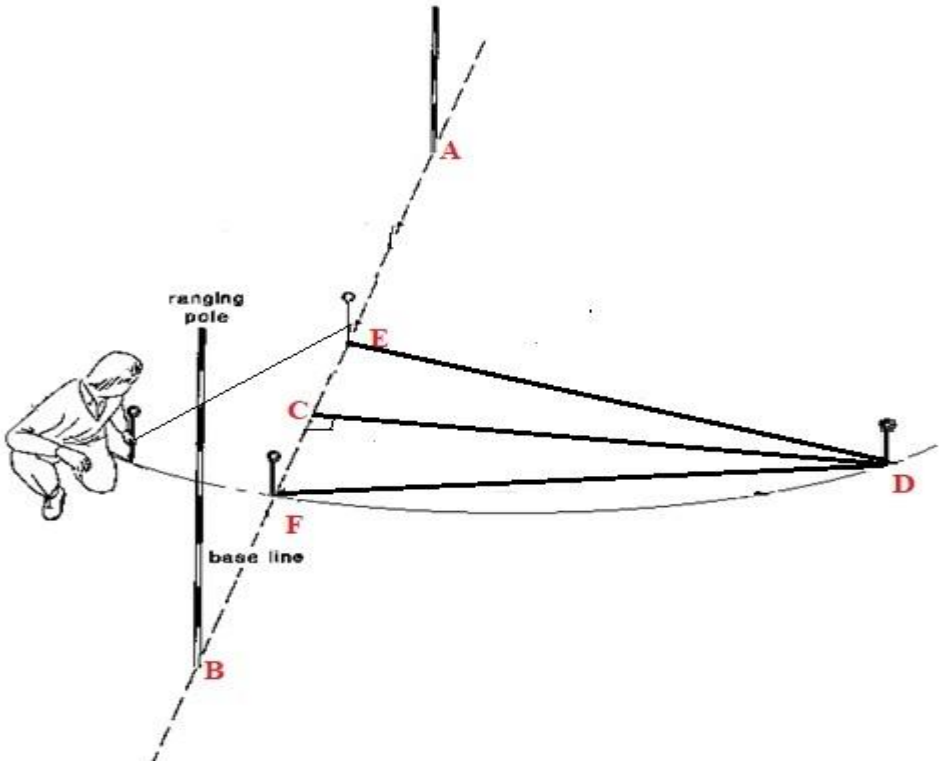
2. SECOND METHOD.



- Select any point E on the chain line AB.
- Join ED and bisect it at F.
- With F as center and EF or FD as radius, draw arc to cut the chain line in C. CD will be perpendicular to the chain line.

3. THIRD METHOD.

- Select any point E on the chain line AB.
- With E as center and ED as radius, draw arc to cut the chain line in F.
- Measure FD and FE.
- Obtain the point C on the line by making $FC = \frac{FD^2}{2FE}$.
- Join C and D.
- CD will be perpendicular to the chain line.



RESULT: The required perpendicular to a chain line from a point on it & from a point outside it has been done.

Name of the Practical - 06: Determine area of regular polygons (Trapezium, Pentagon, Hexagon) using chain and cross staff survey.

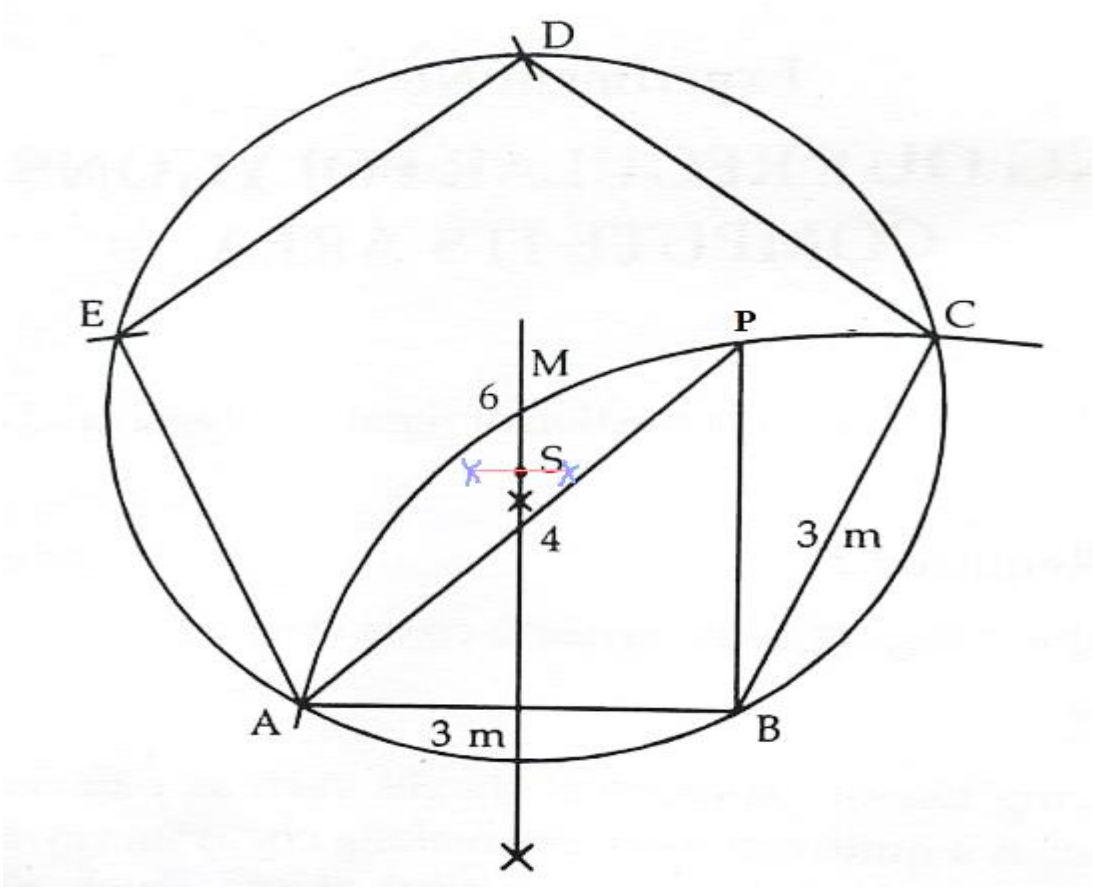
AIM: To determine the area of a given field with define boundary by conducting chain and cross staff survey.

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Cross staff.
- Pegs.

PROCEDURE

DETREMINATION OF AREA OF PENTAGON BY CHAIN SURVEYING



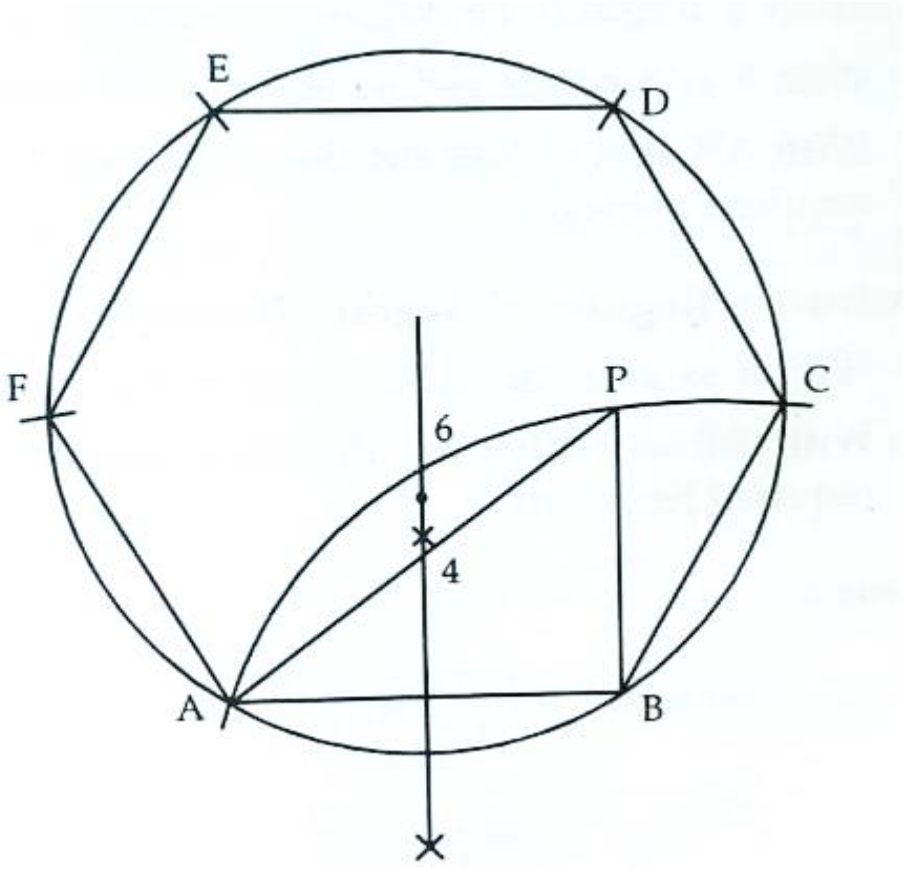
$$Area\ of\ Triangle = \sqrt{S(S-a)(S-b)(S-c)}$$

$$S = \frac{(a+b+c)}{2}$$

Where a, b & c are the sides of the triangle.

- Stretch a chain on the ground, range it to straight line with the help of ranging rods.
- Mark 3M on the chain line and fix the point A & B.
- At B set out a perpendicular BP to AB with cross staff or any other method such that AP = BP.
- With B as centre and radius equal to AB draw an arc till it touches point P. Join AP and BP.
- Set out another perpendicular line at the midpoint of line AB.
- Intersection point of arc AP with the perpendicular line is point 6, and Intersection point of line AP with the perpendicular line is point 4 and the midpoint of 6 and 4 is marked as 5.
- With 5 as centre and 5B or 5A as radius draw a circle.
- With radius equal to side of the pentagon cut an arc on circle with the centre B mark point C and carry on with other sides D & E.
- ABCDE is the required PENTAGON

DETREMINATION OF AREA OF PENTAGON BY CHAIN SURVEYING



$$Area\ of\ Triangle = \sqrt{S(S-a)(S-b)(S-c)}$$

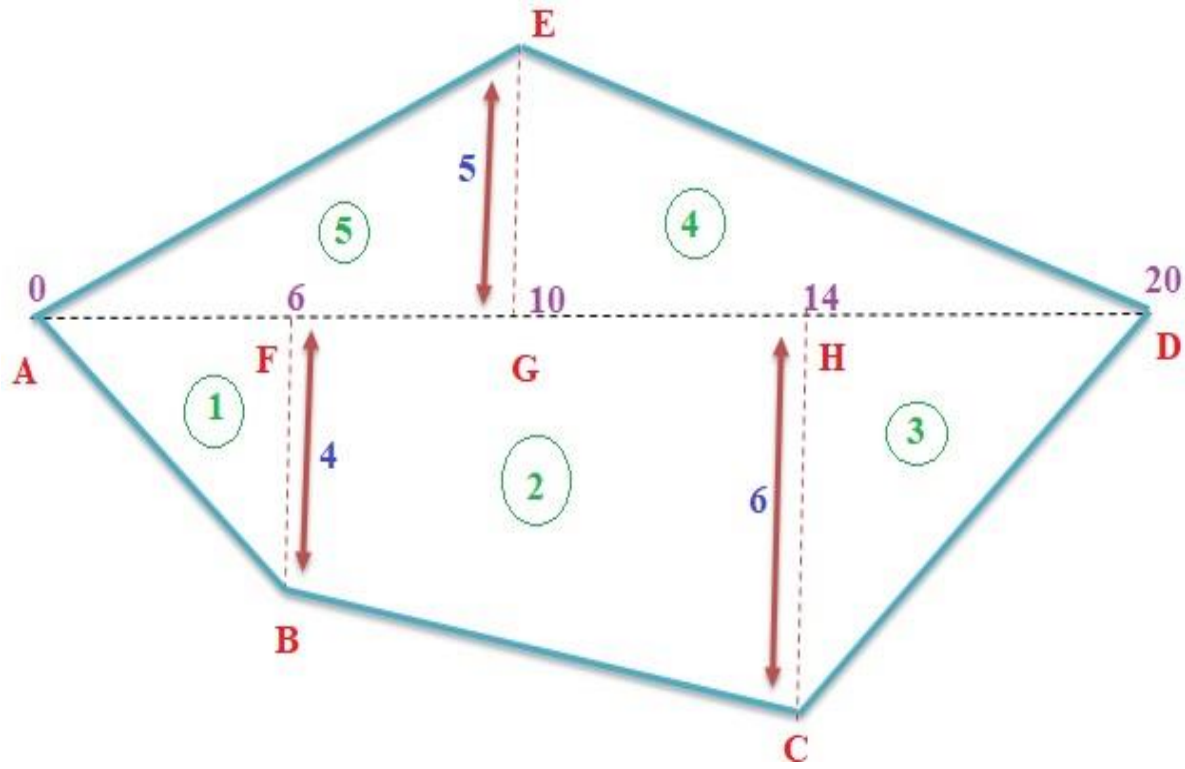
$$S = \frac{(a+b+c)}{2}$$

Where a, b & c are the sides of the triangle.

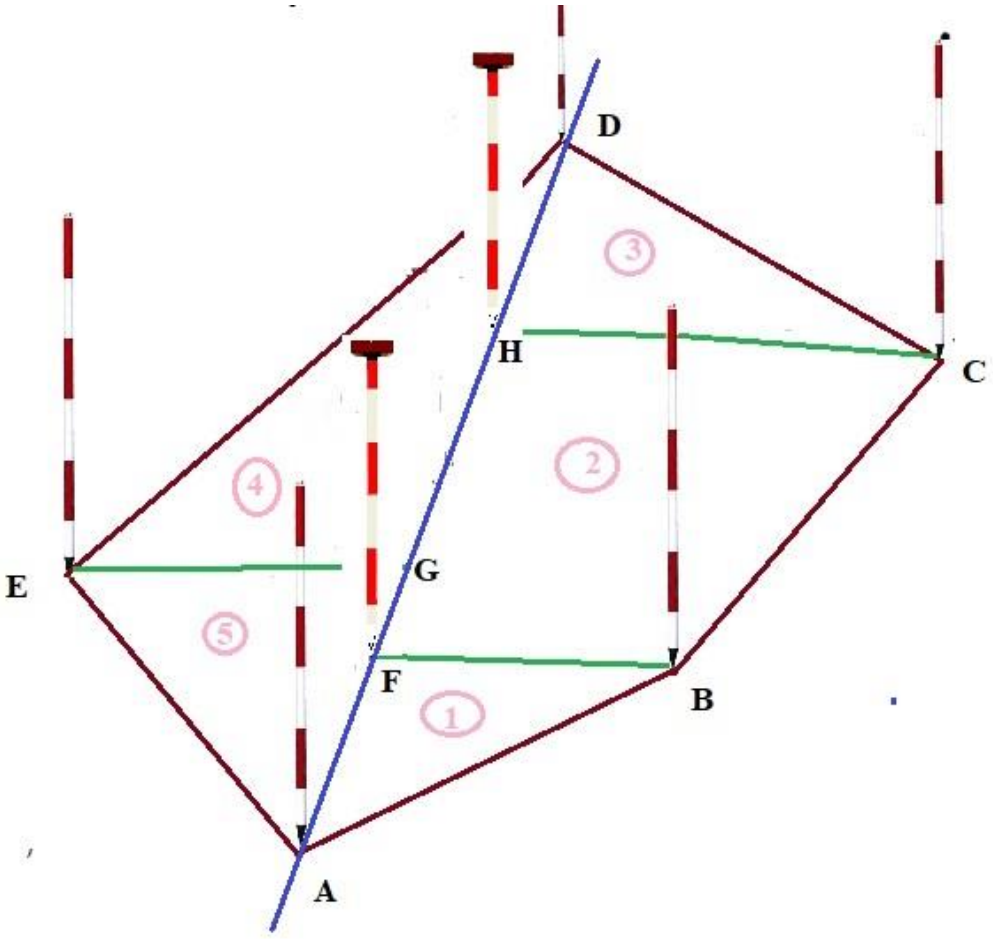
- Stretch a chain on the ground, range it to straight line with the help of ranging rods.
- Mark 3M on the chain line and fix the point A & B.
- At B set out a perpendicular BP to AB with cross staff or any other method such that AP = BP.
- With B as centre and radius equal to AB draw an arc till it touches point P. Join AP and BP.
- Set out another perpendicular line at the midpoint of line AB.
- Intersection point of arc AP with the perpendicular line is point 6, and Intersection point of line AP with the perpendicular line is point 4 and the midpoint of 6 and 4 is marked as 5.
- With 6 as centre and 6B or 6A as radius draw a circle.
- With radius equal to side of the hexagon cut an arc on circle with the centre B mark point C and carry on with other sides D, E & F.
- ABCDEF is the required HEXAGON.

DETREMINATION OF AREA BY CROSS STAFF SURVEYING

THEORY: Cross staff surveying is that type of surveying which means that fixing of boundaries, fields on plots and calculate the area. In this type of survey cross staff is used for setting out perpendicular from the chain line to boundaries. The land is divided into number of triangles, rectangles & trapezium. Area is determined by using formula for Triangle, Rectangle & Trapezium and then total area is computed.



- Run the chain line through the centre of the area. Run a base line (main survey line) AD approximately through the middle/centre of the field ABCDE to be surveyed.
- Along the base line set perpendicular offsets by using cross staff to the points F, G and H.
- Note the chainages at which the offsets are erected and measure the length of offsets by using a tape.
- Now the area is divided into a number of triangles, rectangles and trapeziums.
- Calculate the area of triangles, rectangles and trapeziums.
- Add all the area to get total area of the field by cross staff surveying.



SL	FIGURE	CHAINAGES	BASE	OFFSETS	MEAN OFFSET	AREA
1	AFB	0 & 6	6.00	0 & 4	2.00	12.00
2	FHCB	6 & 14	8.00	4 & 6	5.00	40.00
3	HDC	14 & 20	6.00	4 & 0	2.00	12.00
4	DGE	10 & 20	10.00	5 & 0	2.50	25.00
5	AGE	0 & 10	10.00	0 & 5	2.50	25.00
TOTAL AREA						**114.00 M^2**

RESULT: The required area of a given field with define boundary by conducting chain and cross staff survey has been calculated and tabulated below.

- ✓ **Area of Pentagon = M^2**
- ✓ **Area of Hexagon = M^2**
- ✓ **Area of Cross staff survey = M^2**

Name of the Practical - 07: Undertake ranging when the chain line passes through different obstacles.

AIM: To survey an area by chain survey across obstacles and to calculate the obstructed lengths by using different methods.

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Cross staff.
- Pegs.

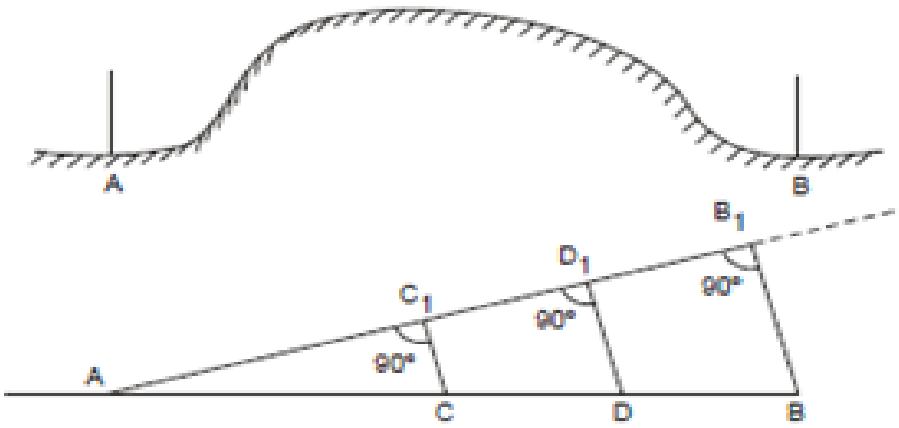
OBSTACLES IN CHAINING:

Obstacles in chaining prevent chainman from measuring directly between two points and give rise to a set of problems in which distances are found by indirect measurements. Obstacles to chaining are of three kinds.

- Obstacle to ranging.
- Obstacle to chaining.
- Obstacle to both chaining and ranging.
- ***OBSTACLE TO RANGING:***

  This type of obstacle in which the ends are not intervisible is quite common. There are two cases of these obstacles.

  - ✓ Both ends of the line may be visible from intermediate points on the line – To overcome this obstacle reciprocal ranging or indirect ranging may be used.
  - ✓ Both ends of the line may not be visible from intermediate points – Let AB be the line in which A and B are not visible from intermediate point on it. Through A draw a random line AB_1 in any convenient direction but as nearly towards B as possible. The point B_1 should be so selected that B_1 is visible from B and BB_1 is perpendicular to the random line. Measure BB_1 select points C_1 and D_1 on the random line and erect perpendiculars C_1C and D_1D in such a way that $CC_1 = \frac{AC_1}{AB_1} * BB_1$ and $DD_1 = \frac{AD_1}{AB_1} * BB_1$ Join C and D and prolong.



➢ *OBSTACLE TO CHAINING:*

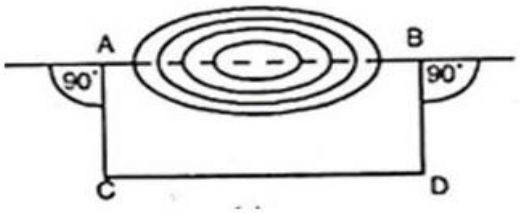
There may be two cases of this obstacle.

- ✓ When it is possible to chain round the obstacle, pond or hedge.
- ✓ When it is not possible to chain round the obstacle River.

✓ *When it is possible to chain round the obstacle, pond or hedge.*

CASE 01:

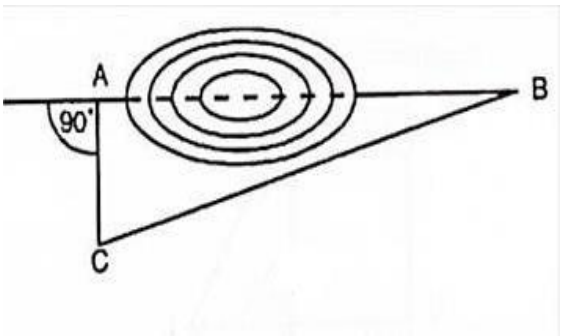
Select two points A and B on either side of the obstacle on the chain line PQ. Set out perpendiculars AC and BD. Measure the length CD, then CD = AB.



CASE 02:

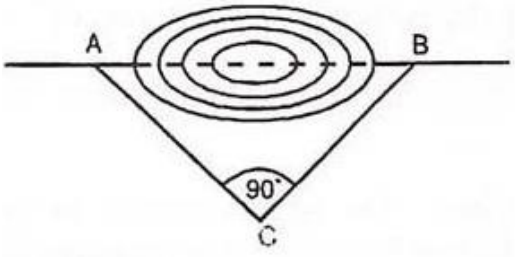
Set out perpendicular AC to the chain line such that the line CB lies outside the obstacle. Measure AC and BC. The length AB is calculated from the formula

$$AC = \sqrt{BC^2 - AC^2}$$



CASE 03:

Using cross staff find point C such that angle ACB is 900 and the lines AC and CB are outside the obstacle. Measure AC and BC. The length AB is calculated from the formula $AB = \sqrt{AC^2 + BC^2}$



CASE 04:

Select two points C and D one on either side of the point A conveniently and they are on the same straight line. Measure AC, AD, BC and BD. Let angle BCD be equal to θ.

From Δ BCD, $BD^2 = BC^2 + CD^2 - 2BC\ X\ CD\ Cos\ \theta$

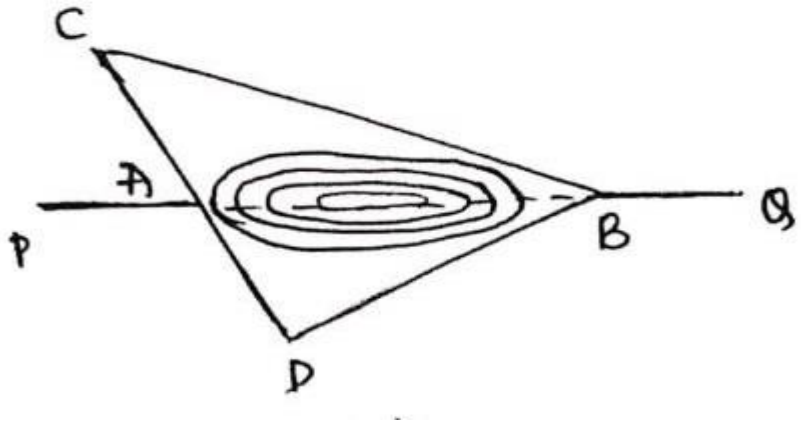
$$Cos\ \theta = \frac{BC^2 + CD^2 - BD^2}{2\ BC * CD} \quad \ldots\ldots\ldots\ldots 1$$

Similarly From Δ BCA

$$Cos\ \theta = \frac{BC^2 + AC^2 - AB^2}{2\ BC * AC} \quad \ldots\ldots\ldots\ldots 2$$

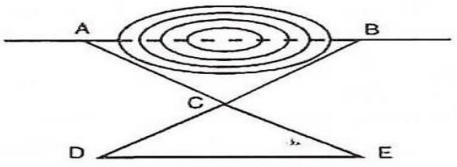
Equating Equation 1 & 2 and solving for AB we get.

$$AB = \sqrt{\frac{(BC^2 * AD) + (BD^2 * AC)}{CD} - (AC * AD)}$$



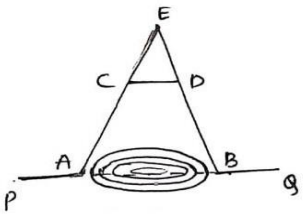
CASE 05:

Select any point E and range C in line with AE, such that AE = EC. Range D in line with BE and make BE = ED. Measure CD, then CD = AB.



CASE 06:

Select any suitable point E and measure AE and BE. Select two points C and D on AE and BE respectively such that CE= AE/n and DE = BE/n, where n is any convenient number. Measure the length of CD. Then, AB = n × CD



✓ ***When it is not possible to chain round the obstacle, River.***

CASE 01: Select point B on one side and A and C on the other side of the obstacle on the chain line as shown in fig (a). Erect AD and CE as perpendiculars at A and C respectively in such a way that points E, D and B are along the same straight line. Measure AC, AD and CE. Draw a line DF parallel to AB. Then triangles ABD and FDE are similar.

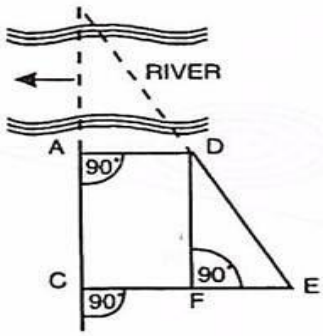
Then triangles ABD and FDE are similar.

Therefore $\frac{AB}{AD} = \frac{DF}{FE}$

But $FE = CE - CF = CE - AD$ & $DF = AC$

Therefore $\frac{AB}{AD} = \frac{AC}{CE-AD}$

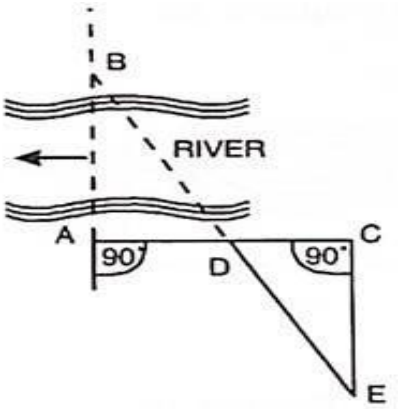
From which $AB = \frac{AC*AD}{CE-AD}$



CASE 02:

Select points A and B on either side of the obstacle on the chain line. At C erect perpendicular AC of convenient length and bisect it at D. At C erect perpendicular CE and fix the point E in such a way that points E, D and B are on the same straight line.

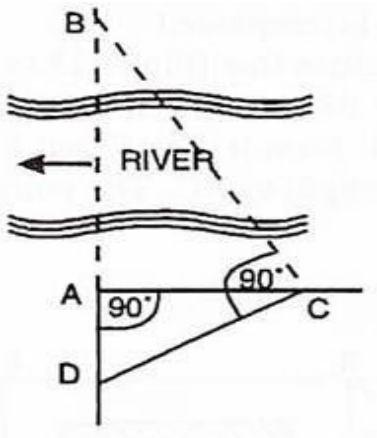
Then measure CE, which is equal to AB.



CASE 03:

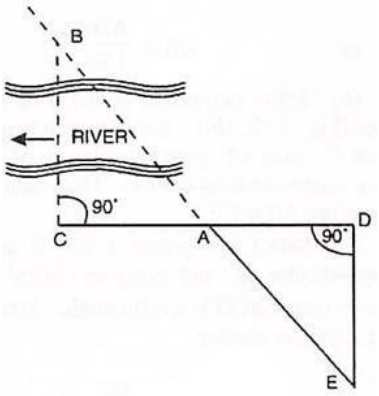
Select points A and B on either side of the obstacle. At A erect a perpendicular AC of any convenient length. With the help of a cross staff fix a point D on the chain line in such a way that angle BCD is 90º. Measure AC and AD, now the triangles ABC and DAC are similar. Hence $\frac{AB}{AC} = \frac{AC}{AD}$

Therefore $AB = \frac{AC^2}{AD}$



CASE 04:

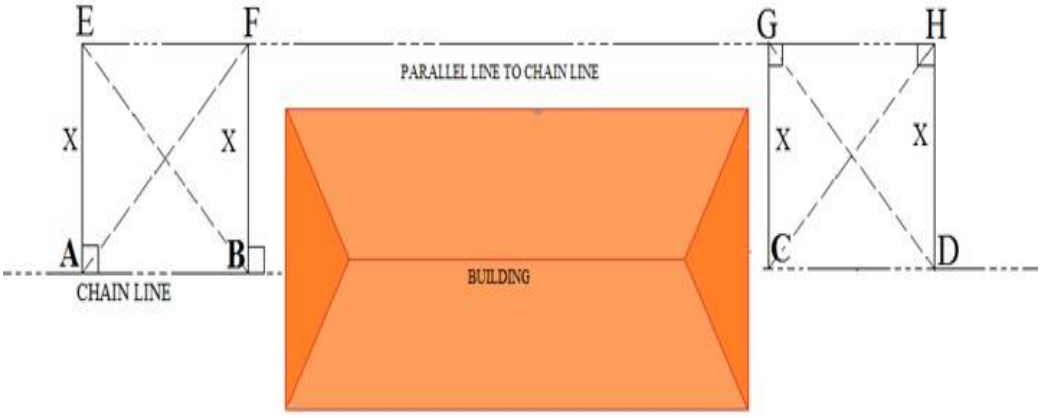
Fix point C conveniently on one side of the chain line. Set a cross staff at C and fix the point D on the other side of the chain line so that CA = AD and angle BCD is 90º, mark point A on the chain line where the line CD cuts the chain line. At D erect a perpendicular to the line DC, which cuts the chain line at E. Measure the length of AE. Then AB = AE.



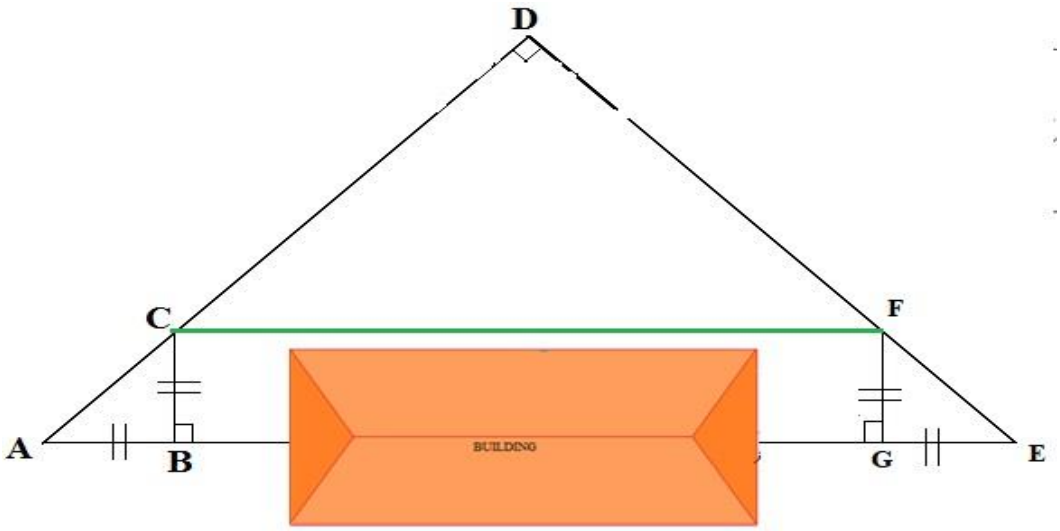
- ***OBSTACLE TO BOTH CHAINING AND RANGING:***

A Building is typical example of this type of obstacle. The problem lies in prolonging the line beyond the obstacle and determining the distances across it. The following are some of the methods.

- ✓ ***CASE 01:*** Choose two points A & B to one side and erect perpendiculars AC and BD of equal length. Join CD and Prolong it past Obstacle. Choose two points E & F on CD and erect perpendiculars EG and FH equal to that of AC. Join GH and prolong it. Measure DE. Evidently BG = DE.

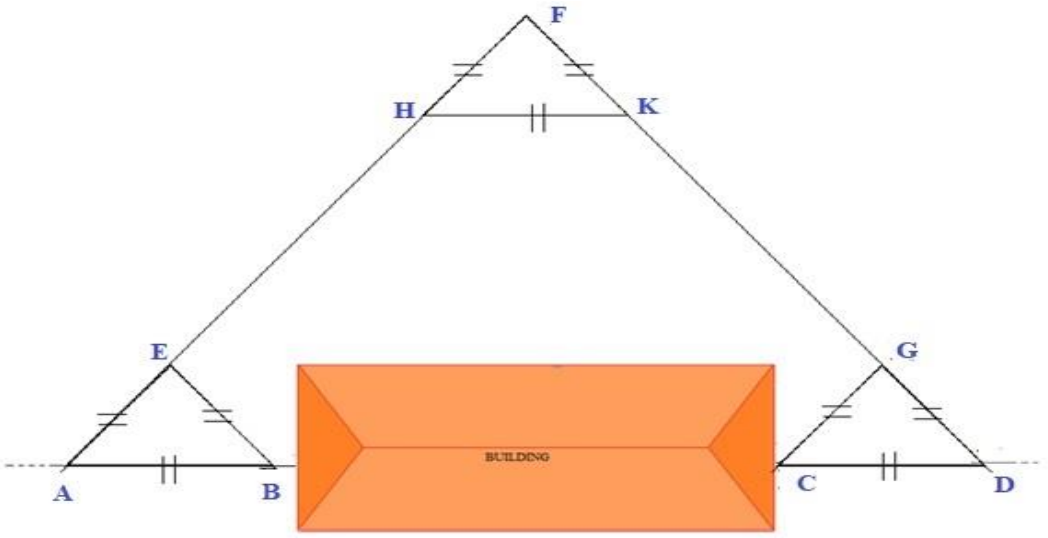


- ✓ ***CASE 02:*** Select a point A and erect a perpendicular AC of any Convenient length select another point B on the chain line such as AB=AC. Join B & C and prolong it to any convenient point D. At D set a right angle DE such that DE=DB. Choose another point F as centre and AB as radius, draw an arc. Draw another arc of the same radius to cut the previous arc in G. join GE which will be in range with the chain line. Measure CF. than AG=CF.



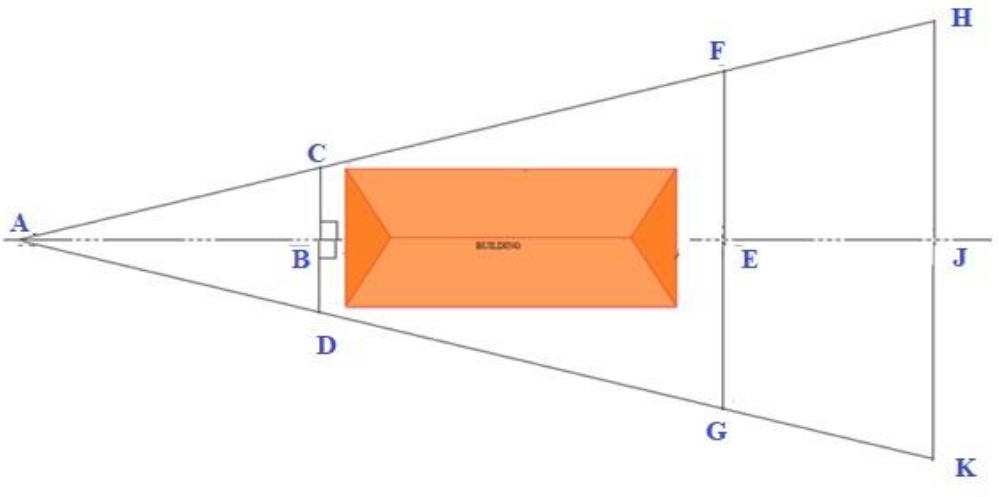
✓ ***CASE 03:*** Select two points A & B on the chain line and construct an equilateral triangle ABE by swinging arcs. Join AE and produce it to any point F. on AF choose any point H and construct an equilateral triangle FHK. Join F & K and produce it to D such that FD=FA. Choose a point G on FD and construct an equilateral triangle CDG. The direction CD is in range with the chain line. The length BC is given by

$$BC = AD - AB - CD = AF - AB - CD$$



✓ ***CASE 04:*** Select two points A & B on the chain line and set a line CBD. Join A & C and produce it to F such that AF=n*AC. Similarly join A & D and produce it to G such that AG=n*AD. Join F & G and mark point E on it in such a way that FE=n*BC. Similarly produce AF and AG to H and K respectively such that AH=n'*AC and AK=n'*AD. Join H & K and mark J on it in such a way that HJ=n'*CB. Join EJ which will be in range with chain line. The obstructed distance BE is given by $BE = AE - AB$ But $AE = n * AB, BE = n * AB - AB$

$BE = (n - 1) * AB$



RESULT:

- **Obstacles to ranging.**
  - ✓ Obstructed length PE 1 = ———— m
- **Obstacles to Chaining.**
- **When it is possible to chain round the obstacle Pond**
  - ✓ Obstructed length from method 1 = ———— m
  - ✓ Obstructed length from method 2 = ———— m
  - ✓ Obstructed length from method 3 = ———— m
  - ✓ Obstructed length from method 4 = ———— m
- **When it is not possible to chain round the obstacle River**
  - ✓ Obstructed length from method 1 = ———— m
  - ✓ Obstructed length from method 2 = ———— m
  - ✓ Obstructed length from method 3 = ———— m
  - ✓ Obstructed length from method 4 = ———— m

- **Both chaining and vision are obstructed.**
  - ✓ Obstructed length from method 1 = ———— m
  - ✓ Obstructed length from method 2= ———— m
  - ✓ Obstructed length from method 3 = ———— m
  - ✓ Obstructed length from method 4 = ———— m

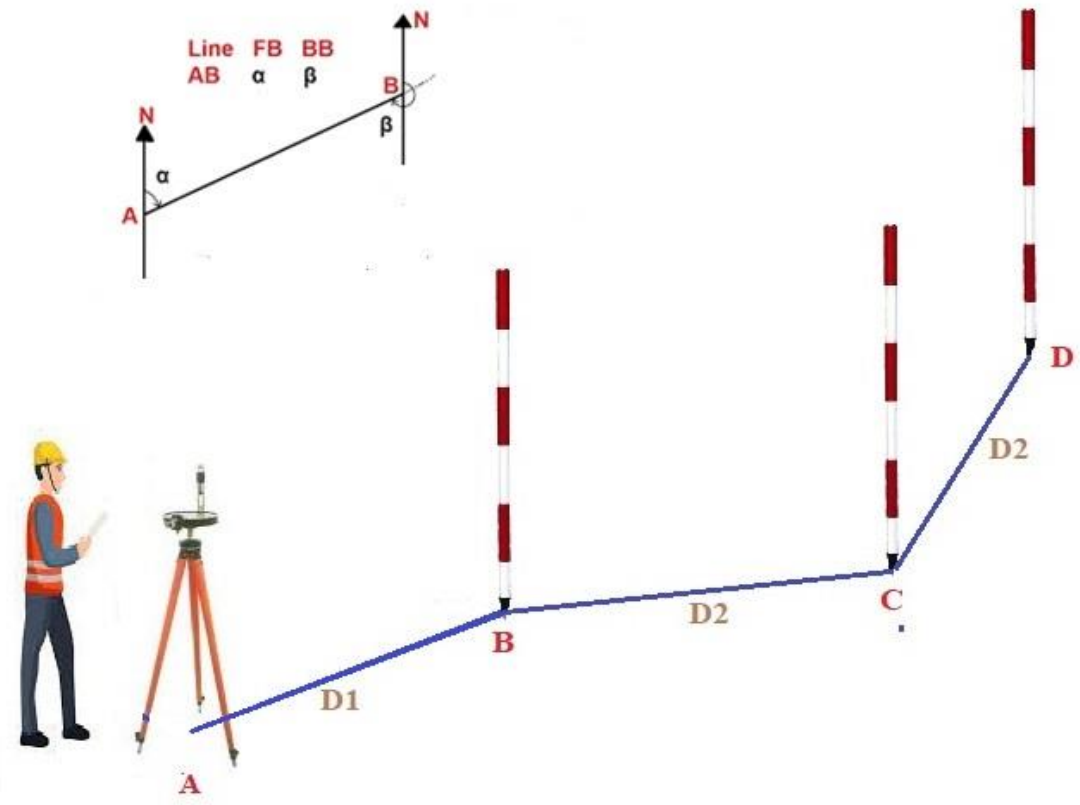
Name of the Practical - 08: Measure Fore Bearing (FB) and Back Bearing (BB) of survey lines of open traverse using Prismatic Compass.

AIM: To measure fore bearing and back bearing of a survey line of open traverse using prismatic compass.

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

OBSERVATION

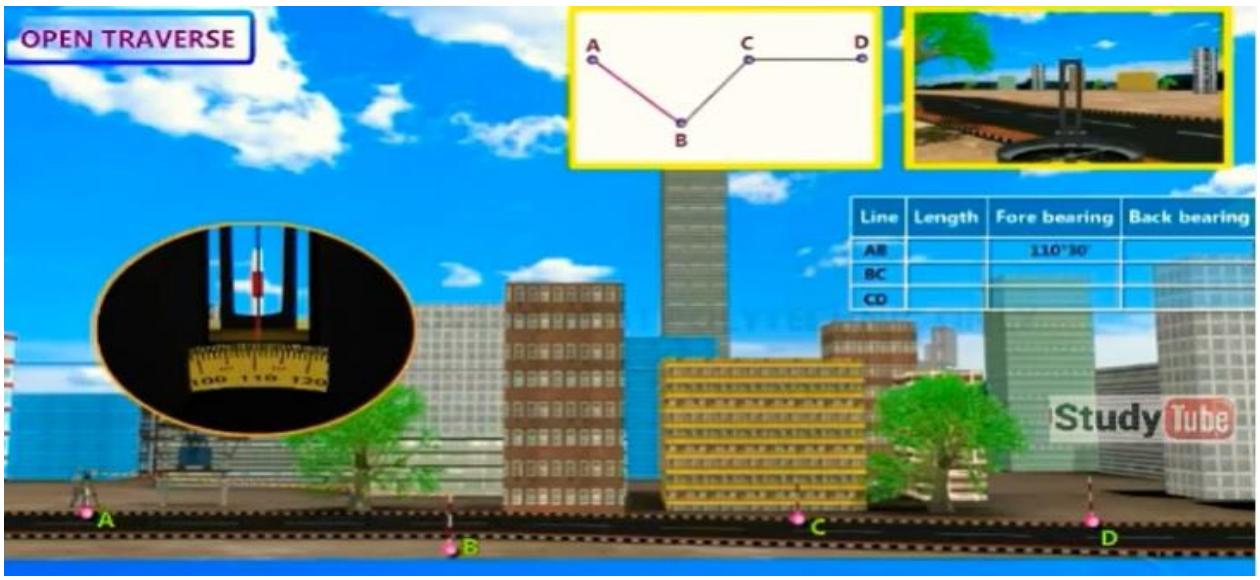


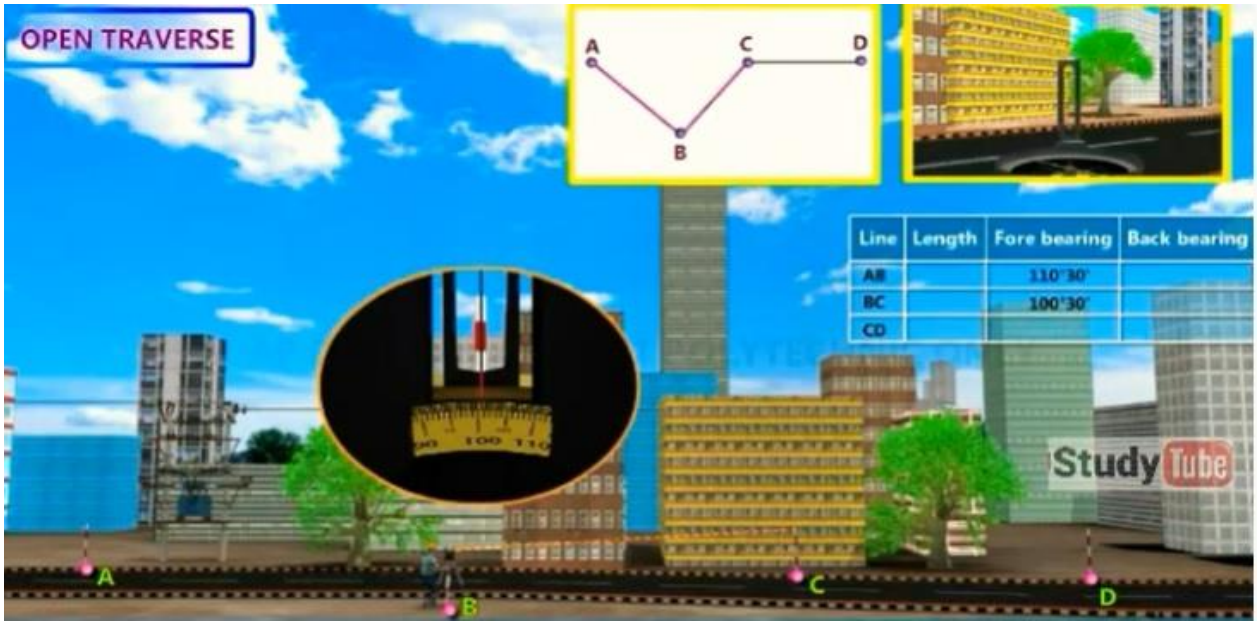
SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				

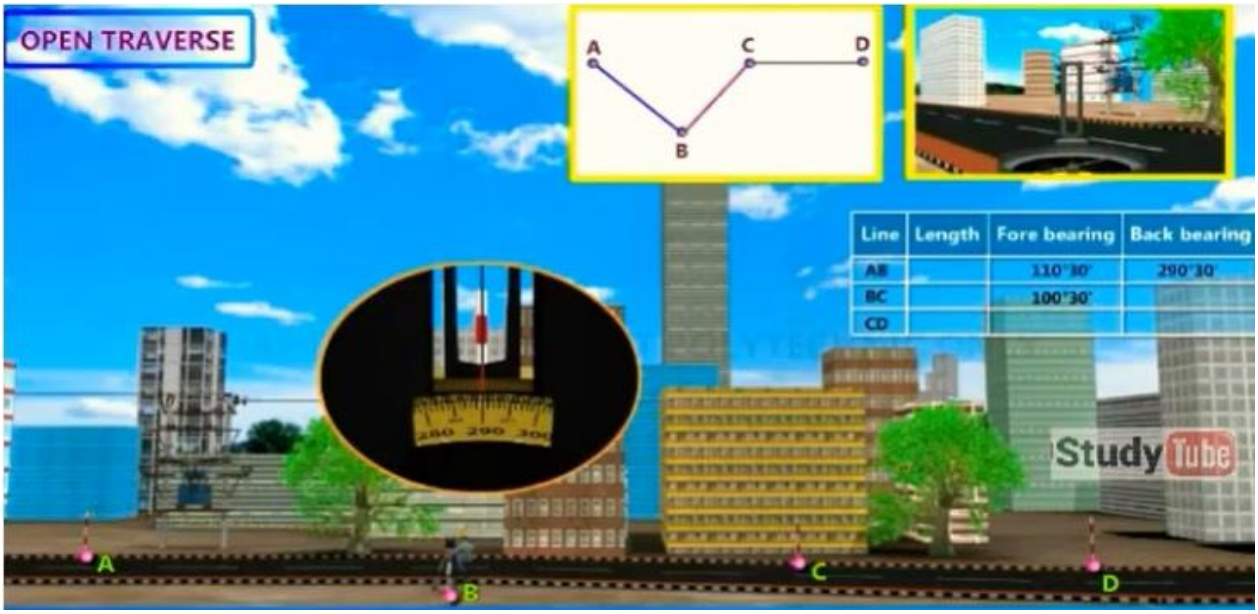
PROCEDURE:

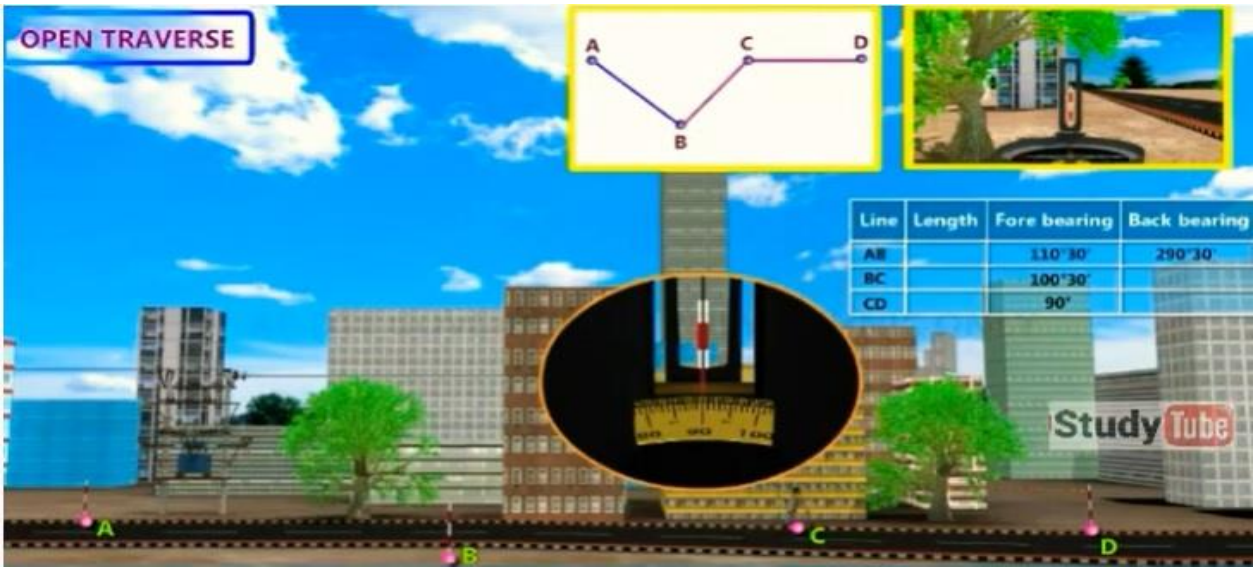
1. Set the instrument at the starting station A and perform all the necessary adjustments.
2. Sight the next station B & take Fore Bearing of line AB and measure the distance AB.
3. Shift the instrument to subsequent station B & perform all the temporary adjustments. Then take Back Bearing of line BA and Fore Bearing of line BC and measure the distance of line BC
4. Repeat the process at every station and note down Back Bearing of previous line and Fore Bearing of forward line.
5. It is to be noted that first station has only Fore Bearing and last station have only Back Bearing.
6. Enter the readings in a tabular form.

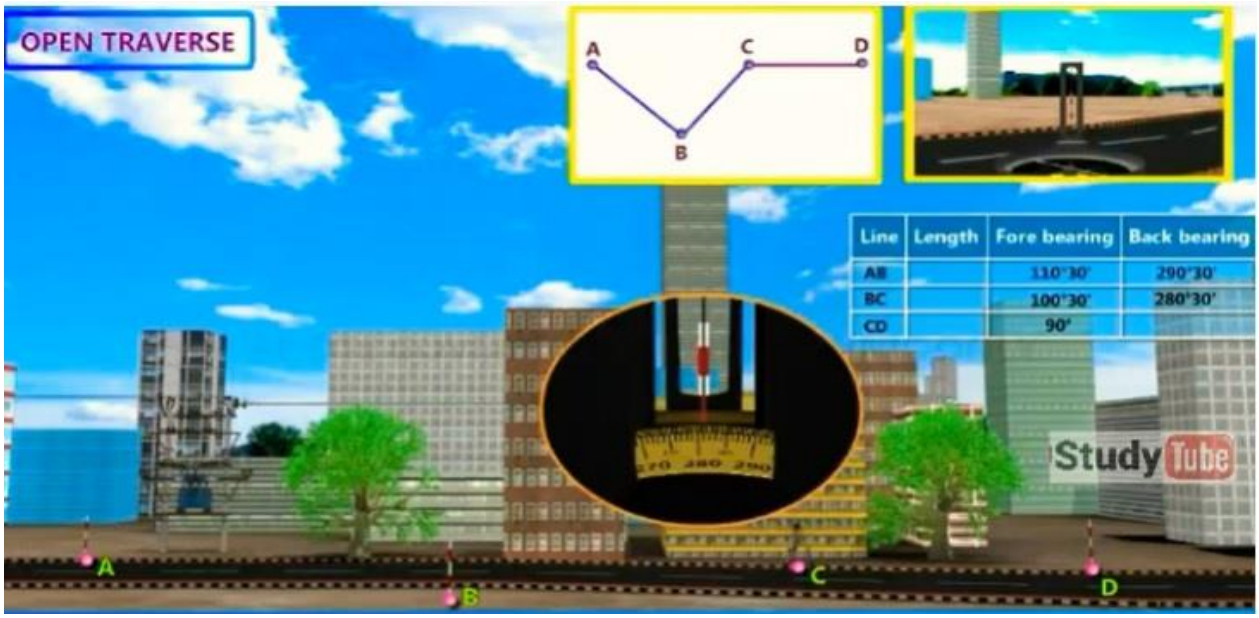
EXAMPLE:

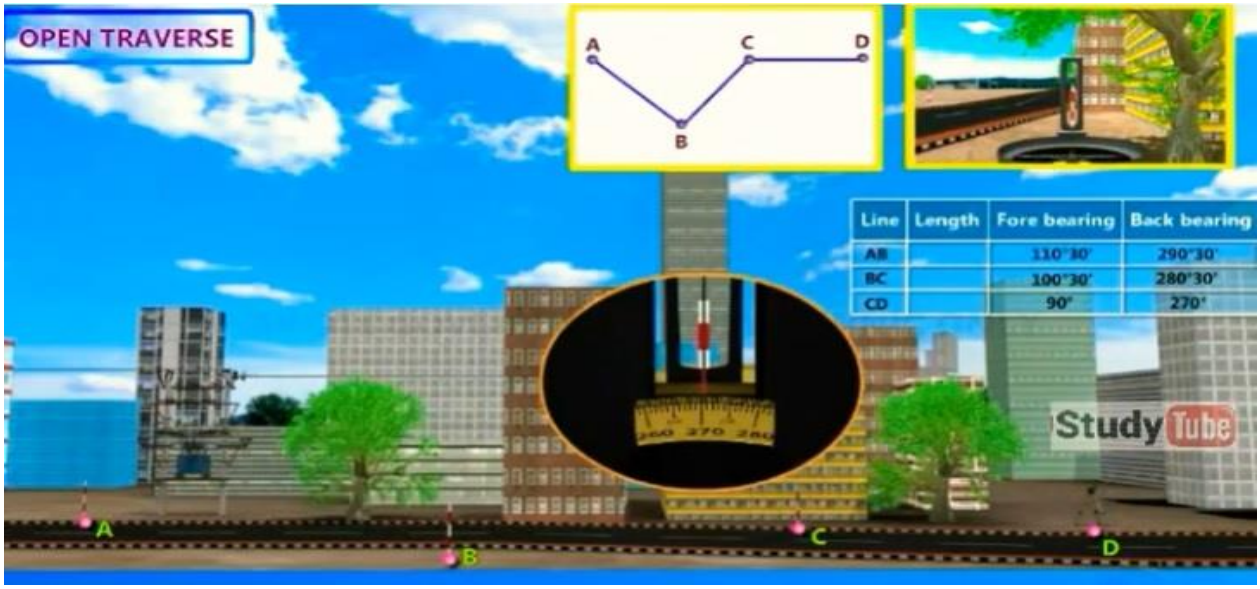


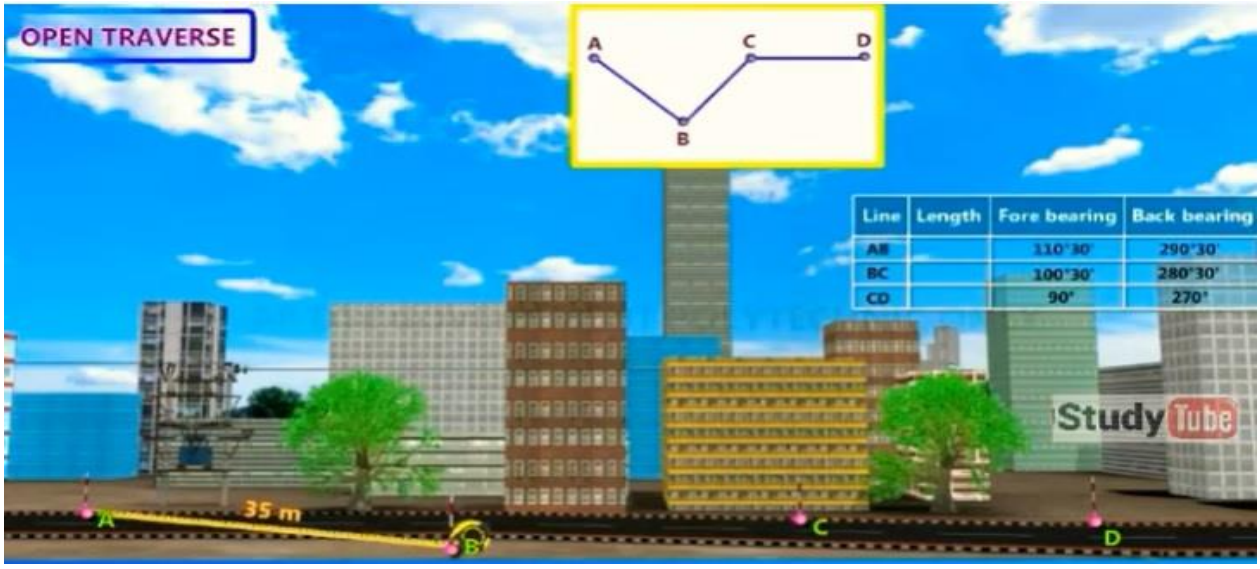

OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' |
BC | | 100°30' |
CD | | |
Study Tube

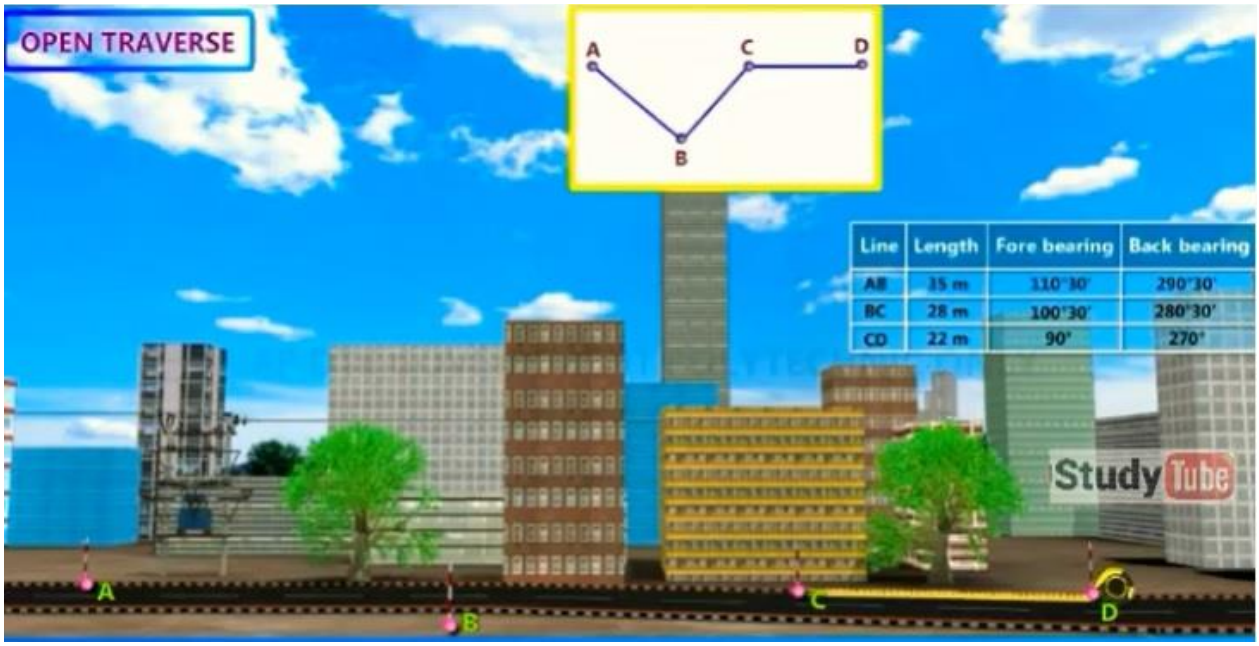

OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' | 290°30'
BC | | 100°30' |
CD | | |
Study Tube


OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' | 290°30'
BC | | 100°30' |
CD | | 90° |
Study Tube


OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' | 290°30'
BC | | 100°30' | 280°30'
CD | | 90° |
StudyTube


OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' | 290°30'
BC | | 100°30' | 280°30'
CD | | 90° | 270°
StudyTube


OPEN TRAVERSE
A
B
C
D
Line | Length | Fore bearing | Back bearing
AB | | 110°30' | 290°30'
BC | | 100°30' | 280°30'
CD | | 90° | 270°
35 m
StudyTube



RESULT: Fore bearing and Back bearing of given open traverse has been observed and tabulated using prismatic compass

Name of the Practical - 09: Measure Fore Bearing and back bearing of a closed traverse of 5 sides (Regular Pentagon) and correct the bearings and included angles for the local attraction.

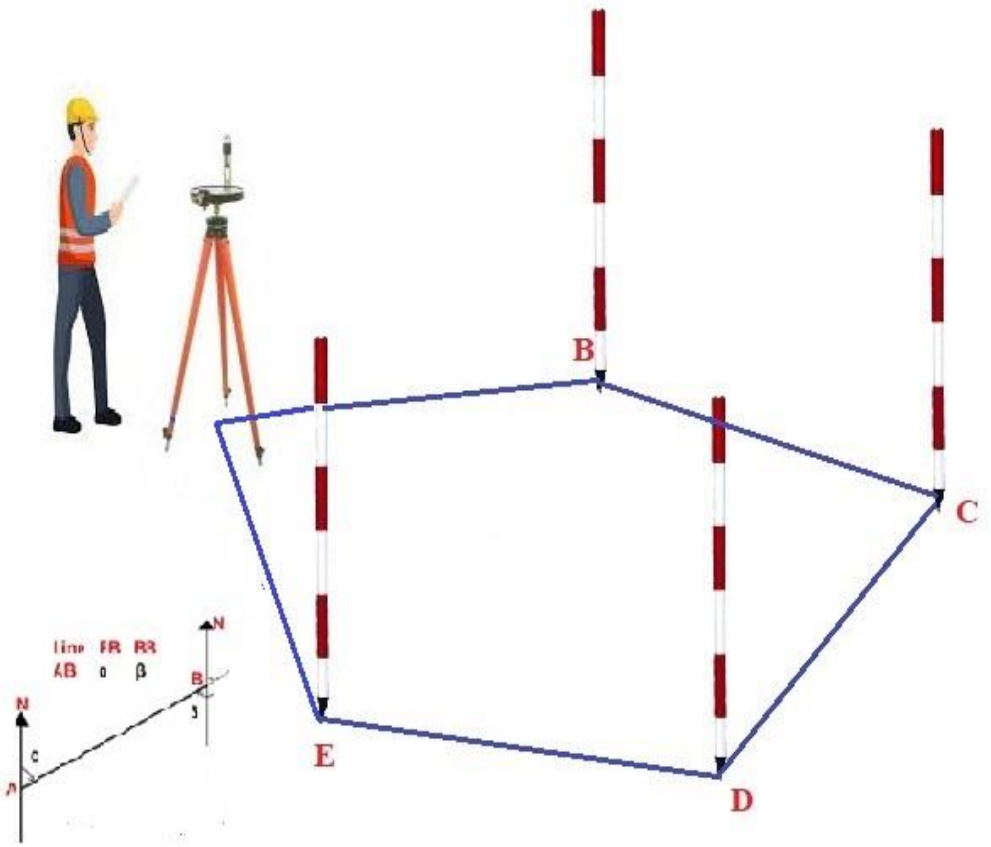
AIM: To perform the Compass survey in Closed Traverse (Regular Pentagon) formed by series of connected straight lines (traversing).

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

THEORY: A traverse is said to be closed traverse when the traverse formed a closed circuit as shown in the figure. In this case, both starting and terminating points of the traverse coincide with each other. It is suitable for the survey of boundaries of ponds, sports grounds, forests, etc.

OBSERVATION



SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				
4	DE				
5	EA				

PROCEDURE:

1. Set the instrument at the starting station A and perform all the necessary adjustments.
2. Sight the object at B and note down the Back Bearing of line BA.
3. Locate the details by observing bearings or lengths or both from the traverse stations wherever necessary.
4. Shift the instrument to subsequent station B & perform all the temporary adjustments. After fixing the instrument, sight the next station C and observe the reading which gives the fore bearing of BC and measure the distance BC. And now, sight the previous station A and observe the reading which gives the back bearing of BA.
5. Repeat the process at every station.
6. It is to be noted that first station has only Fore Bearing and last station have only Back Bearing.

SL NO	LINE	LENGTH	OBSERVED BEARING	CORRECTION	CORRECTED BEARING	REMARKS
1	AB					
2	BA					
3	BC					
4	CB					
5	CD					
6	DC					
7	DE					
8	ED					
9	EA					
10	AE					

Check on closed traverse:

- The difference between fore bearing and back bearing of each line should be 180º, if no local attraction exists at either station.

Check on angular measurements:

- $The\ sum\ of\ the\ measured\ interior/internal\ angles\ =\ (2n-4)\ x\ 90^0$
- $The\ sum\ of\ the\ measured\ exterior/external\ angles\ =\ (2n+4)\ x\ 90^o$

Where N= Number of sides of the traverse.

RESULT: Measured the Fore Bearing and back bearing of a closed traverse of 5 sides (Regular Pentagon) and correct the bearings and included angles for the local attraction are tabulated.

Name of the Practical - 10: Measure Fore Bearing and back bearing of a closed traverse of 6 sides (Regular Hexagon) and correct the bearings and included angles for the local attraction.

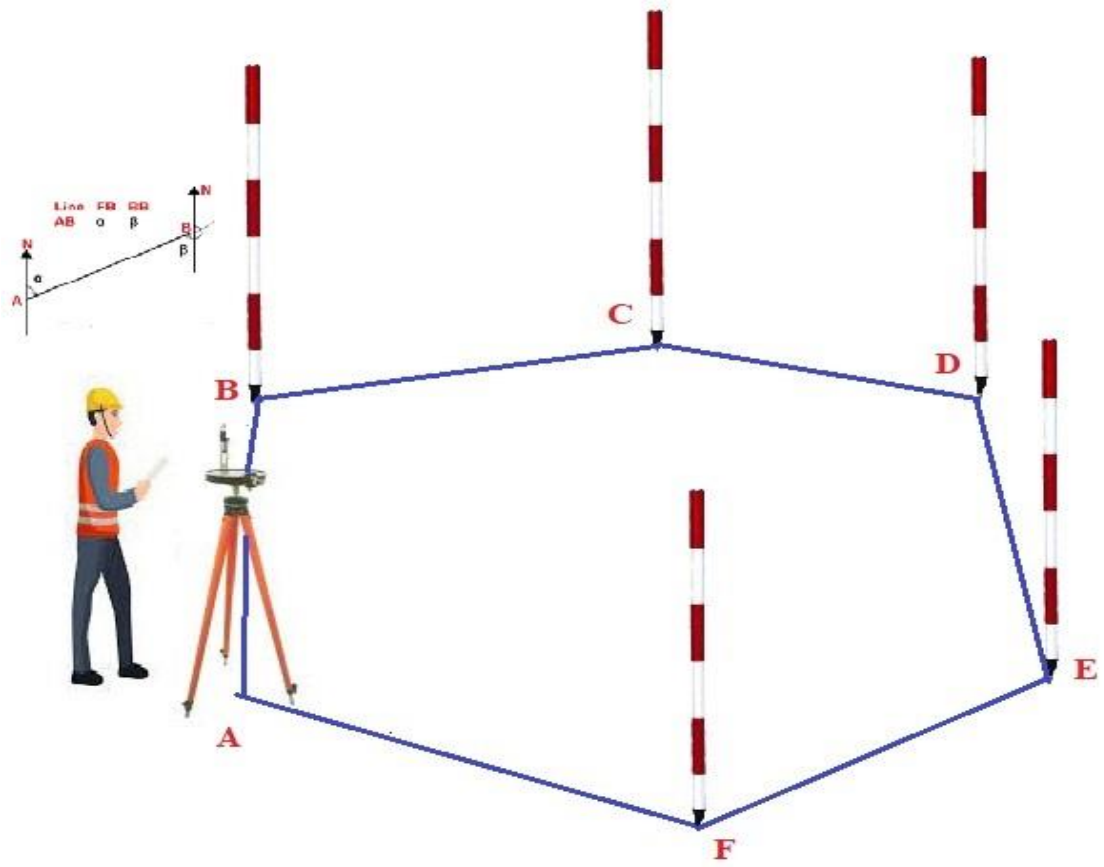
AIM: To perform the Compass survey in Closed Traverse (Regular Hexagon) formed by series of connected straight lines (traversing).

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

THEORY: A traverse is said to be closed traverse when the traverse formed a closed circuit as shown in the figure. In this case, both starting and terminating points of the traverse coincide with each other. It is suitable for the survey of boundaries of ponds, sports grounds, forests, etc.

OBSERVATION



SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				
4	DE				
5	EF				
6	FA				

PROCEDURE:

1. Set the instrument at the starting station A and perform all the necessary adjustments.
2. Sight the object at B and note down the Back Bearing of line BA.
3. Locate the details by observing bearings or lengths or both from the traverse stations wherever necessary.
4. Shift the instrument to subsequent station B & perform all the temporary adjustments. After fixing the instrument, sight the next station C and observe the reading which gives the fore bearing of BC and measure the distance BC. And now, sight the previous station A and observe the reading which gives the back bearing of BA.
5. Repeat the process at every station.
6. It is to be noted that first station has only Fore Bearing and last station have only Back Bearing.

SL NO	LINE	LENGTH	OBSERVED BEARING	CORRECTION	CORRECTED BEARING	REMARKS
1	AB					
2	BA					
3	BC					
4	CB					
5	CD					
6	DC					
7	DE					
8	ED					
9	EF					
10	FE					
11	FA					
12	AF					

Check on closed traverse:

- The difference between fore bearing and back bearing of each line should be 180º, if no local attraction exists at either station.

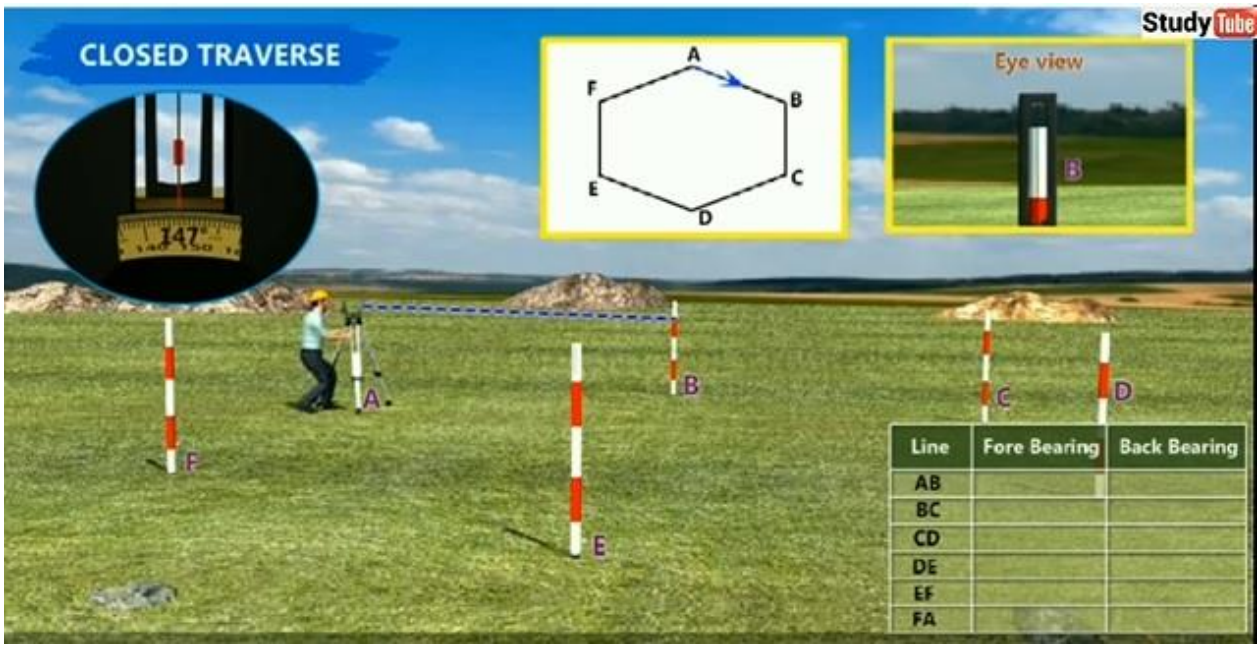
Check on angular measurements:

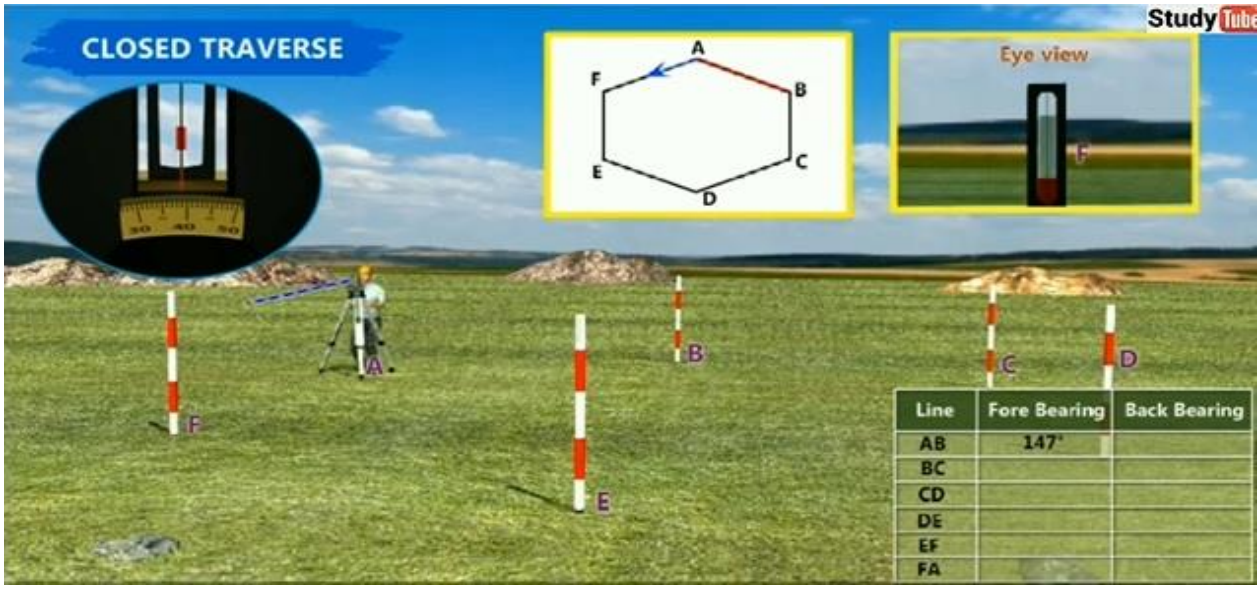
- $The\ sum\ of\ the\ measured\ interior/internal\ angles\ =\ (2n-4)\ x\ 90^0$
- $The\ sum\ of\ the\ measured\ exterior/external\ angles\ =\ (2n+4)\ x\ 90^o$

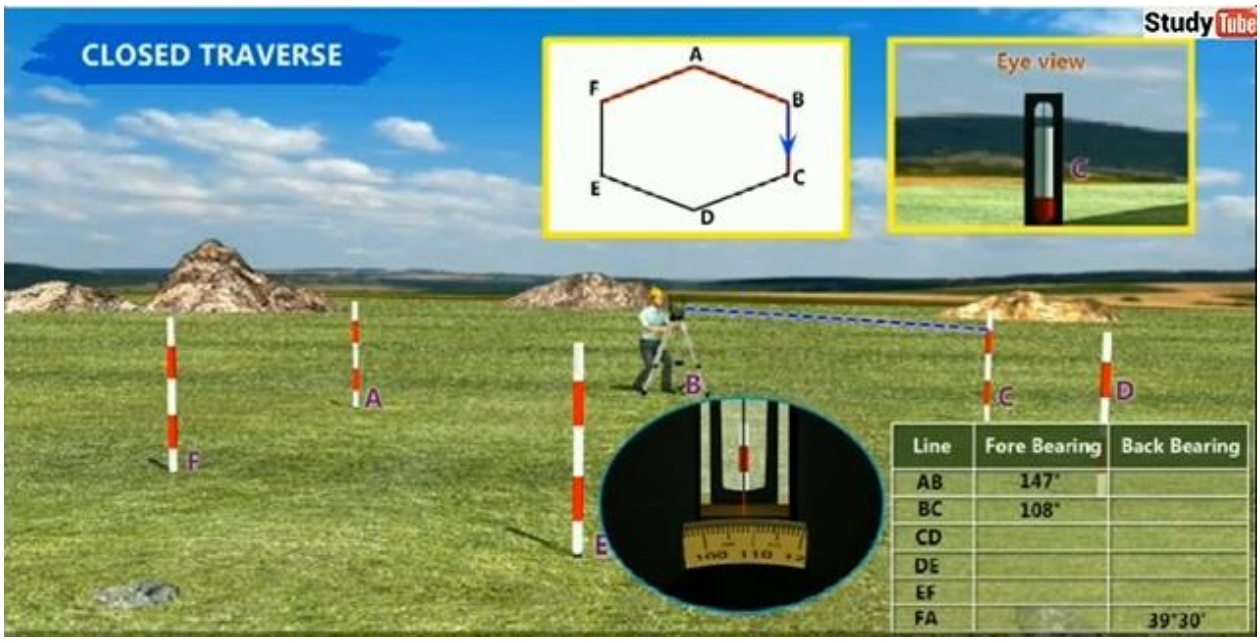
Where N= Number of sides of the traverse.

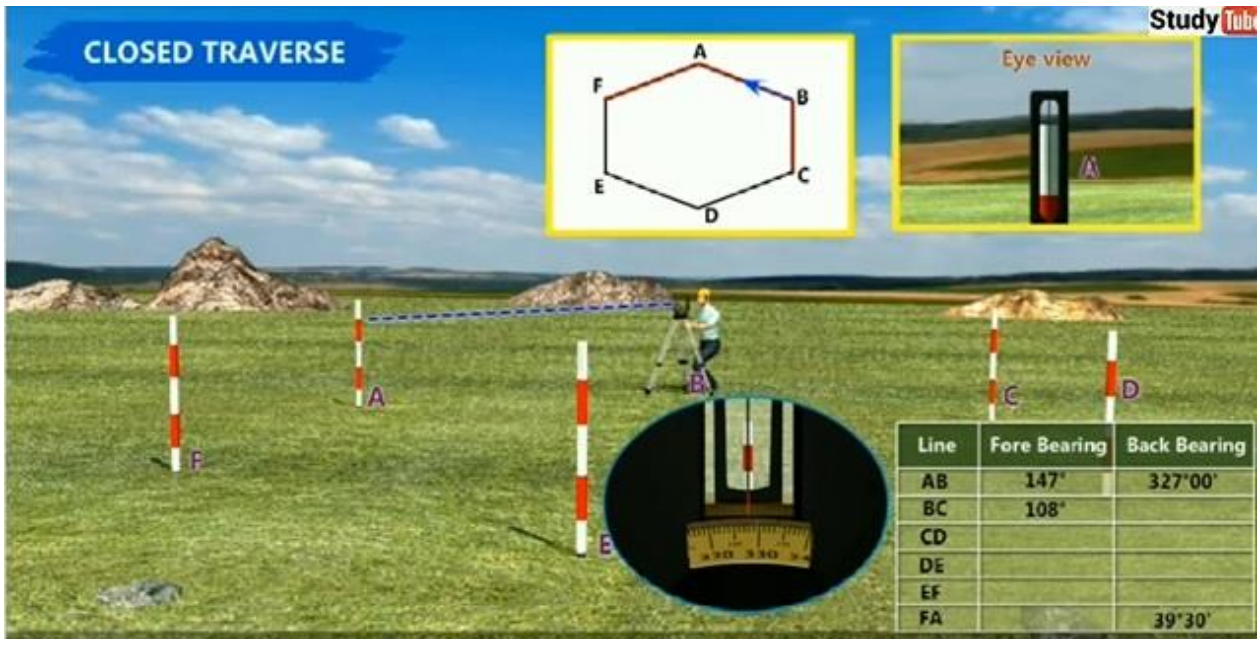
RESULT: Measured the Fore Bearing and back bearing of a closed traverse of 6 sides (Regular Hexagon) and correct the bearings and included angles for the local attraction are tabulated.

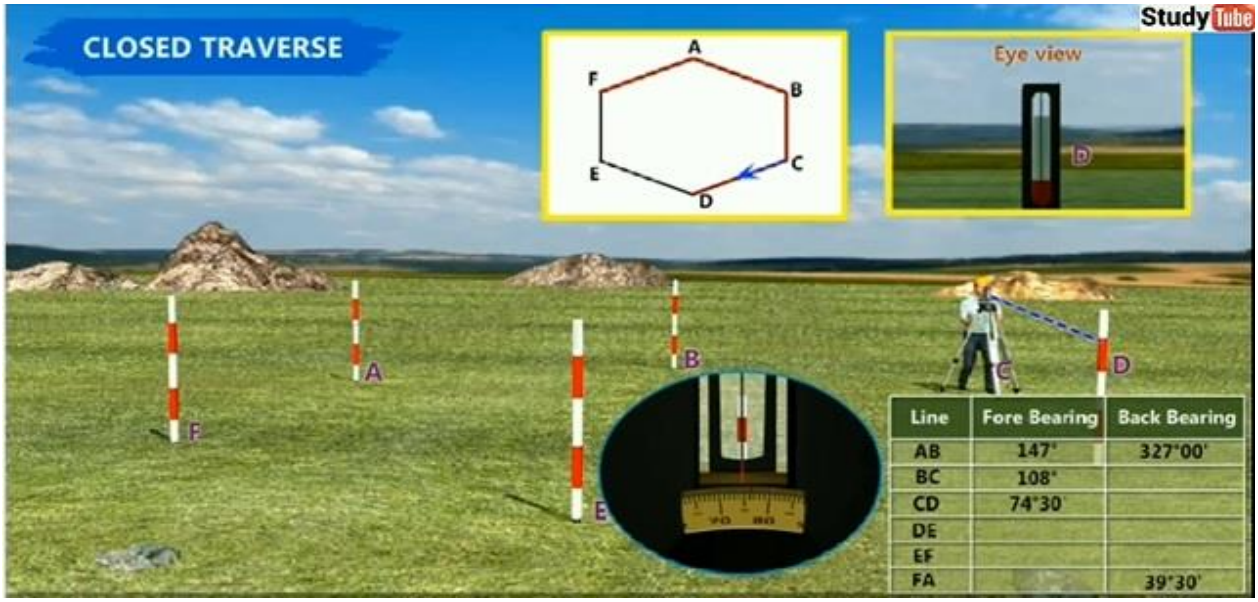
EXAMPLE:

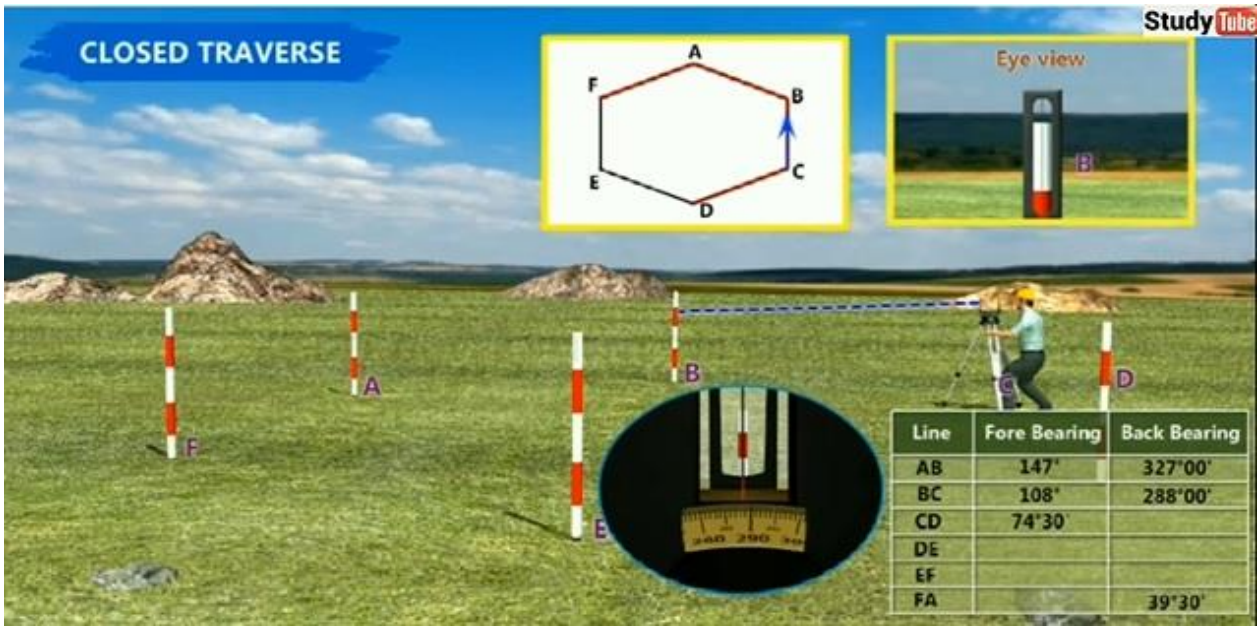


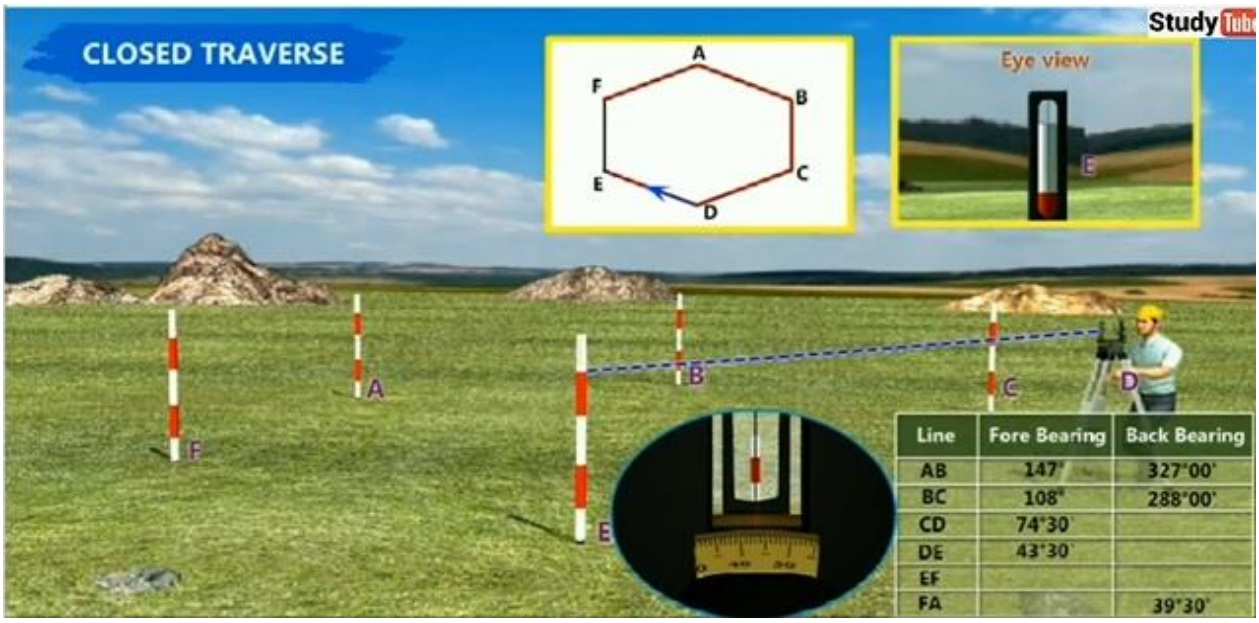

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147°
BC
CD
DE
EF
FA

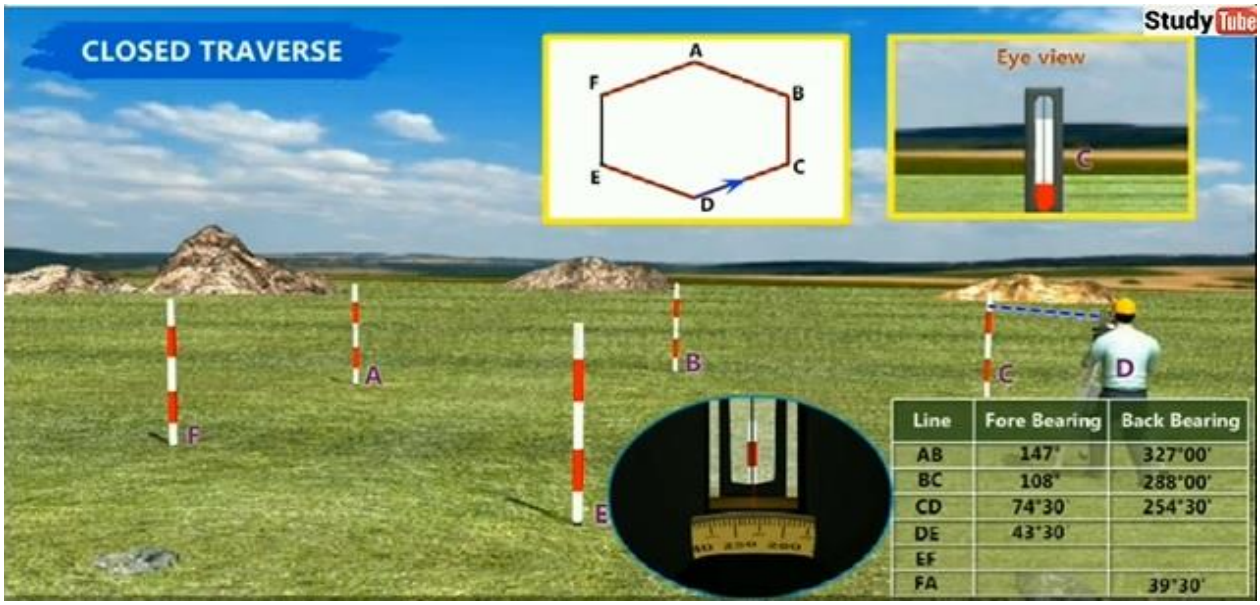

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147°
BC | 108°
CD
DE
EF
FA | 39°30'

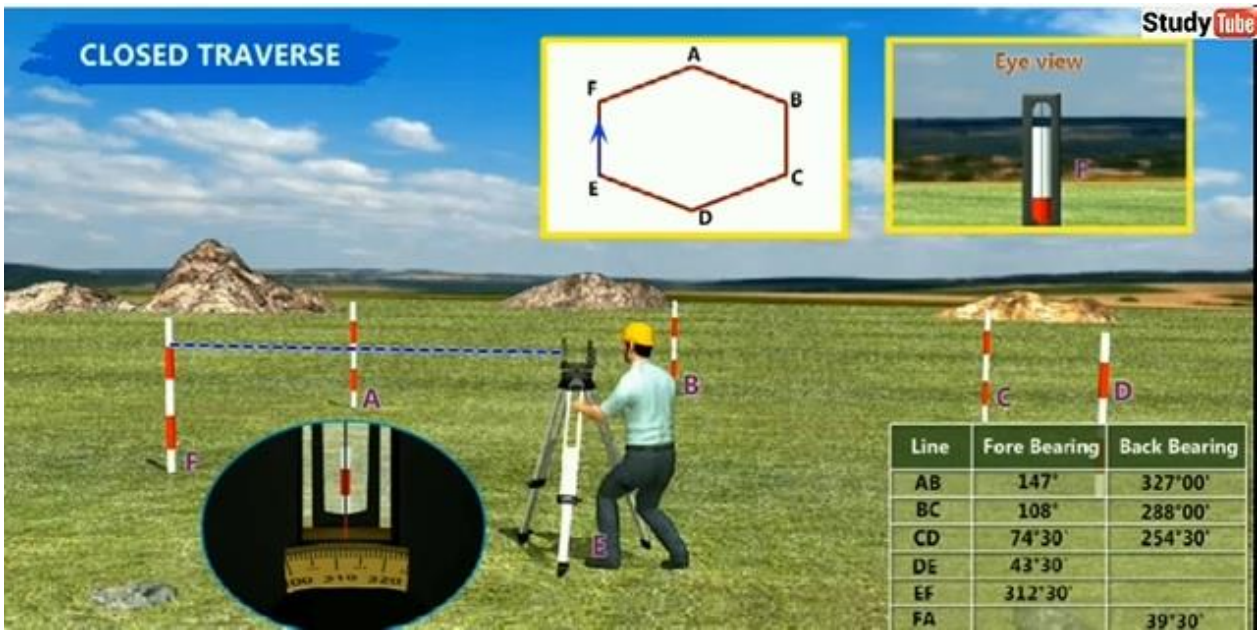

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108°
CD
DE
EF
FA | 39°30'

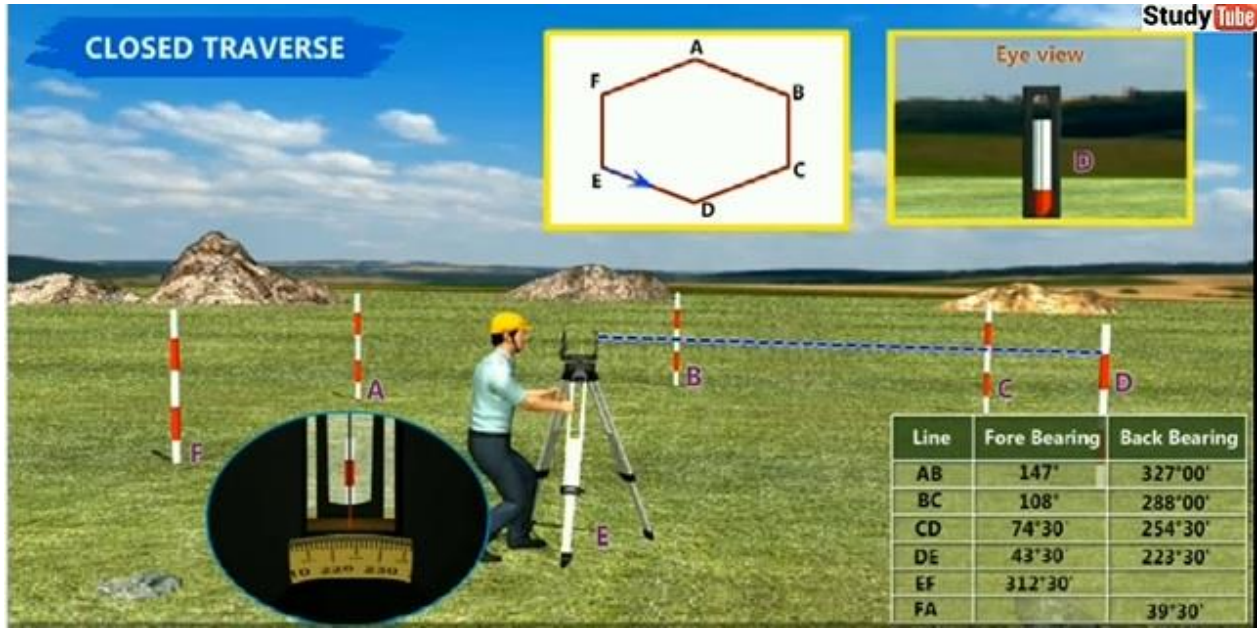

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° |
CD | 74°30' |
DE |
EF |
FA | 39°30'

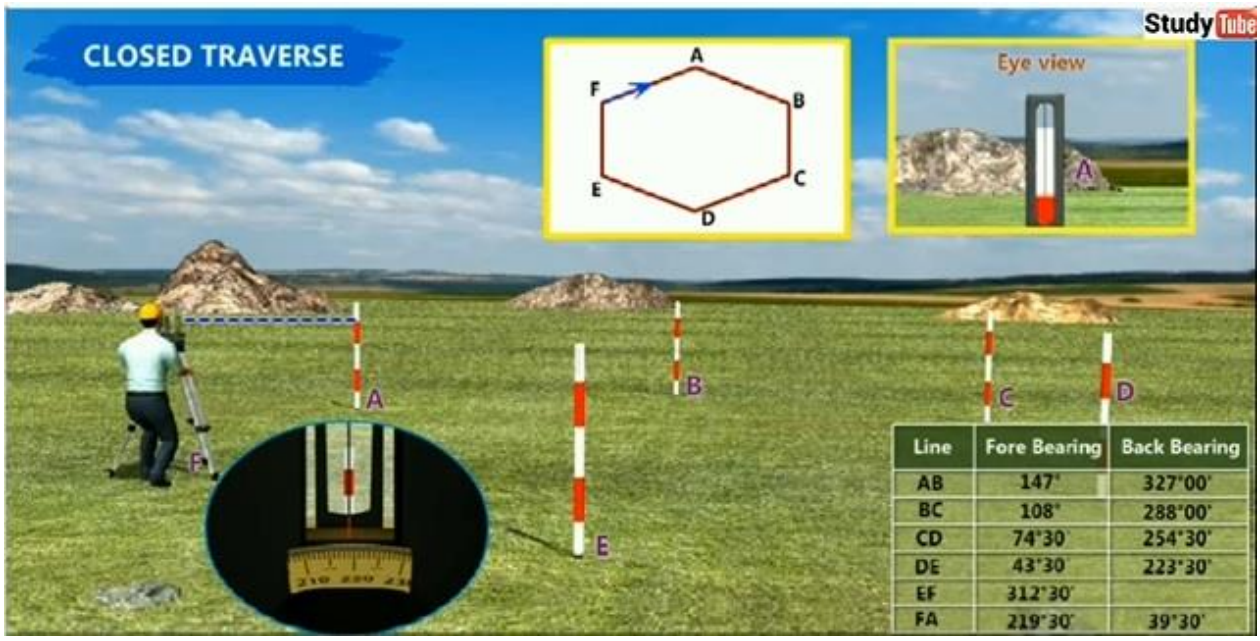

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' |
DE |
EF |
FA | 39°30'

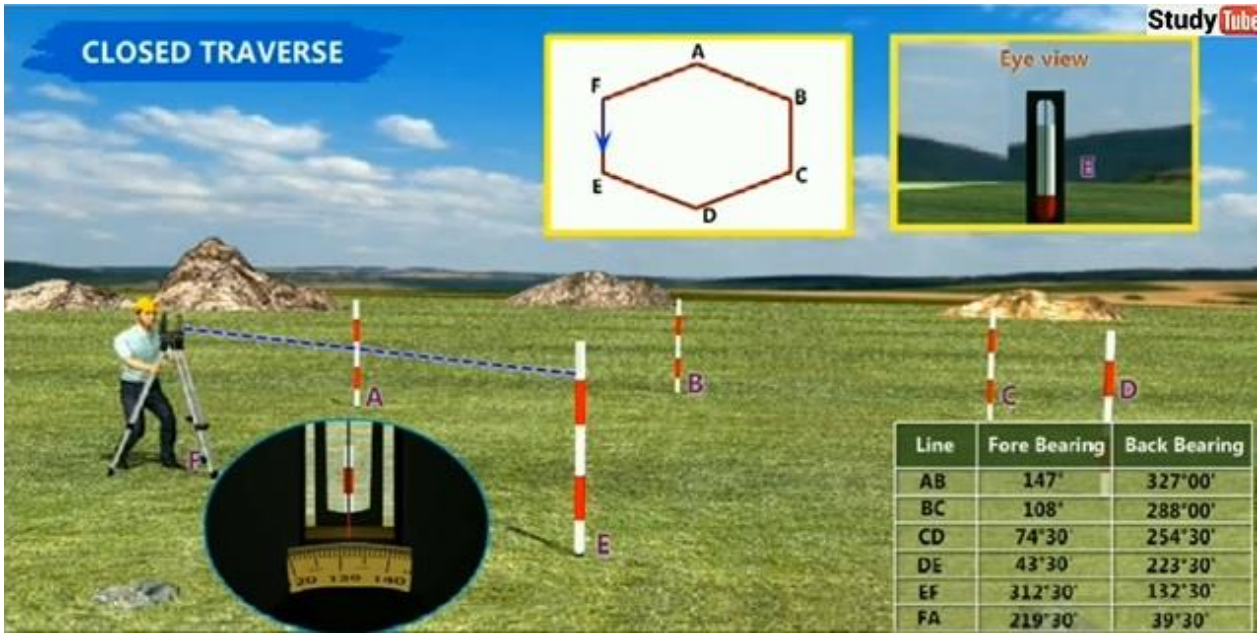

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' |
DE | 43°30' |
EF |
FA | 39°30'

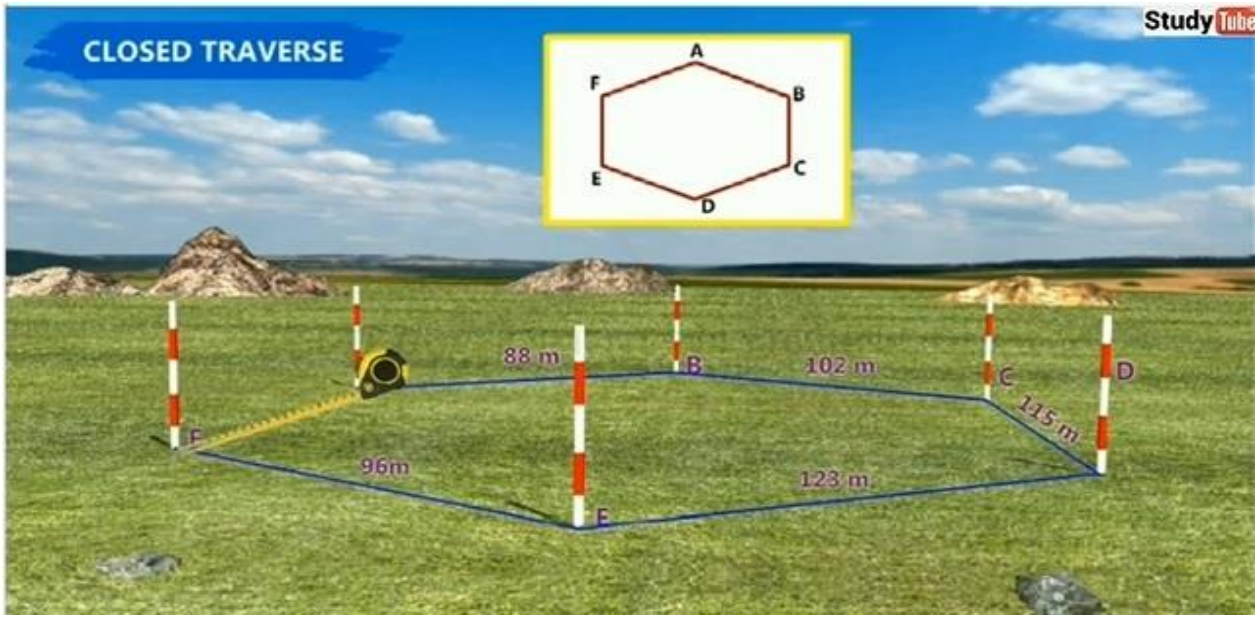

CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' | 254°30'
DE | 43°30'
EF
FA | 39°30'


CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' | 254°30'
DE | 43°30'
EF | 312°30'
FA | 39°30'


CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' | 254°30'
DE | 43°30' | 223°30'
EF | 312°30'
FA | 39°30'


CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' | 254°30'
DE | 43°30' | 223°30'
EF | 312°30' |
FA | 219°30' | 39°30'


CLOSED TRAVERSE
Study Tube
Eye view
A
B
C
D
E
F
Line | Fore Bearing | Back Bearing
AB | 147° | 327°00'
BC | 108° | 288°00'
CD | 74°30' | 254°30'
DE | 43°30' | 223°30'
EF | 312°30' | 132°30'
FA | 219°30' | 39°30'


CLOSED TRAVERSE
Study Tube
A
B
C
D
E
F
88 m
102 m
115 m
96m
123 m

Name of the Practical - 11: Measure Fore Bearing and back bearing of a closed traverse of 3 sides (Irregular Triangle) and correct the bearings and included angles for the local attraction

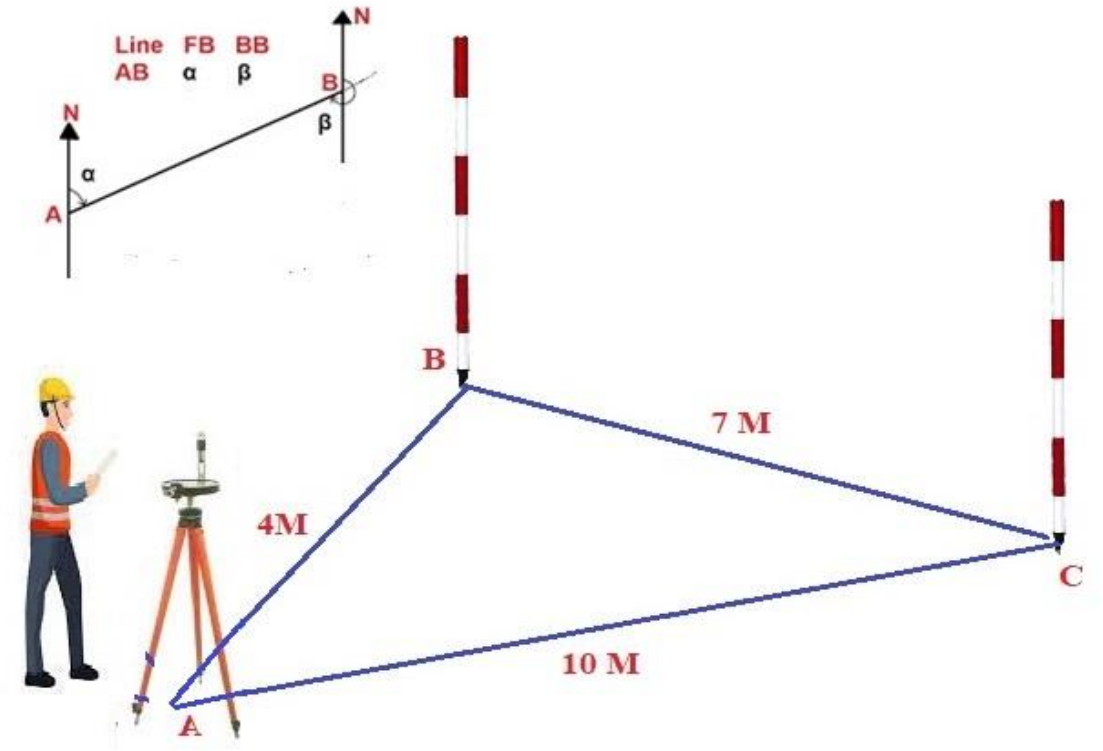
AIM: To measure fore bearing and back bearing of a closed traverse of 3 sides (Irregular triangle) formed by series of connected straight lines (traversing) using prismatic compass and corrections for local attraction if any.

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

THEORY: A traverse is said to be closed traverse when the traverse formed a closed circuit as shown in the figure. In this case, both starting and terminating points of the traverse coincide with each other. It is suitable for the survey of boundaries of ponds, sports grounds, forests, etc.

OBSERVATION



SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CA				

PROCEDURE:

1. Set the instrument at the starting station A and perform all the necessary adjustments.
2. Sight the object at B and note down the Back Bearing of line BA.
3. Locate the details by observing bearings or lengths or both from the traverse stations wherever necessary.
4. Shift the instrument to subsequent station B & perform all the temporary adjustments. After fixing the instrument, sight the next station C and observe the reading which gives the fore bearing of BC and measure the distance BC. And now, sight the previous station A and observe the reading which gives the back bearing of BA.
5. Repeat the process at every station.
6. It is to be noted that first station has only Fore Bearing and last station have only Back Bearing.

SL NO	LINE	LENGTH	OBSERVED BEARING	CORRECTION	CORRECTED BEARING	REMARKS
1	AB					
2	BA					
3	BC					
4	CB					
5	CA					
6	AC					

Check on closed traverse:

- The difference between fore bearing and back bearing of each line should be 180º, if no local attraction exists at either station.

Check on angular measurements:

- $The\ sum\ of\ the\ measured\ interior/internal\ angles\ =\ (2n-4)\ x\ 90^0$
- $The\ sum\ of\ the\ measured\ exterior/external\ angles\ =\ (2n+4)\ x\ 90^o$

Where N= Number of sides of the traverse.

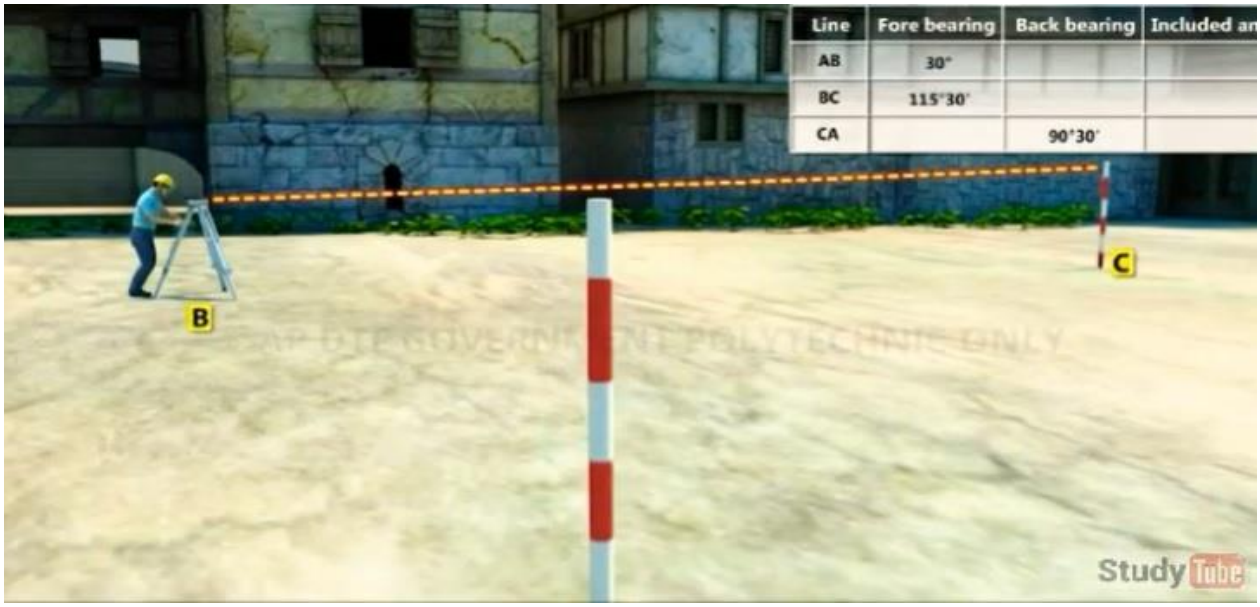
RESULT: Measured the Fore Bearing and back bearing of a closed traverse of 3 sides (Irregular Triangle) and correct the bearings and included angles for the local attraction are tabulated.

EXAMPLE:


B
C
Study Tube

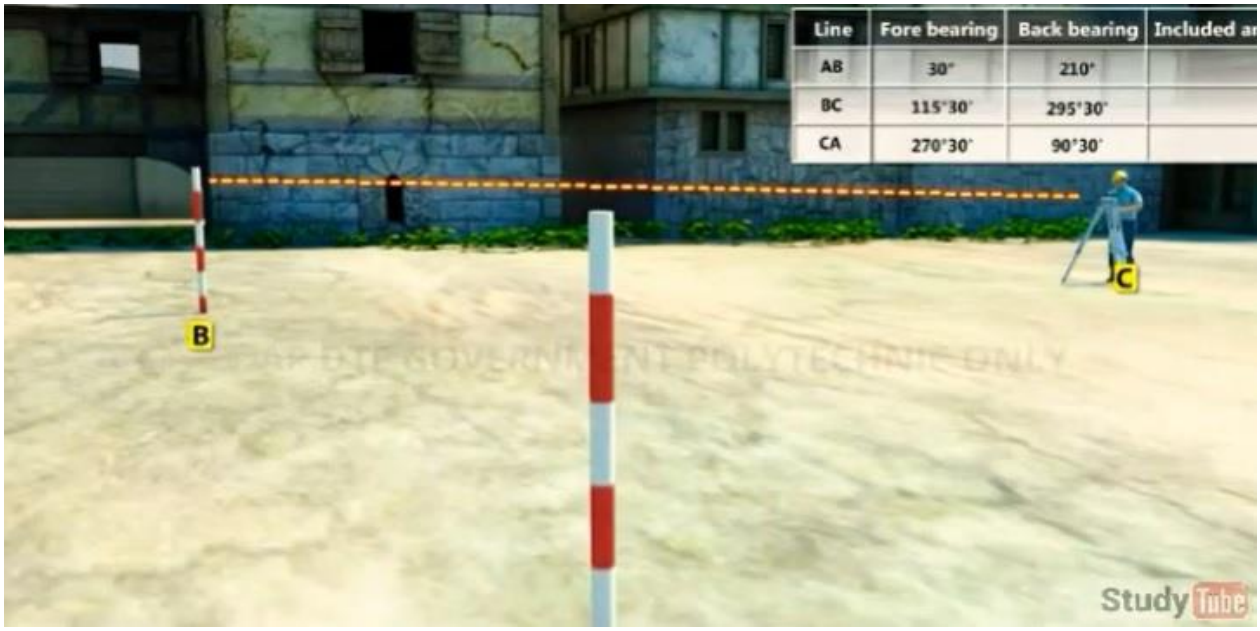

Line
Fore bearing
Back bearing
Included an
AB
30°
BC
CA
B
C
Study Tube

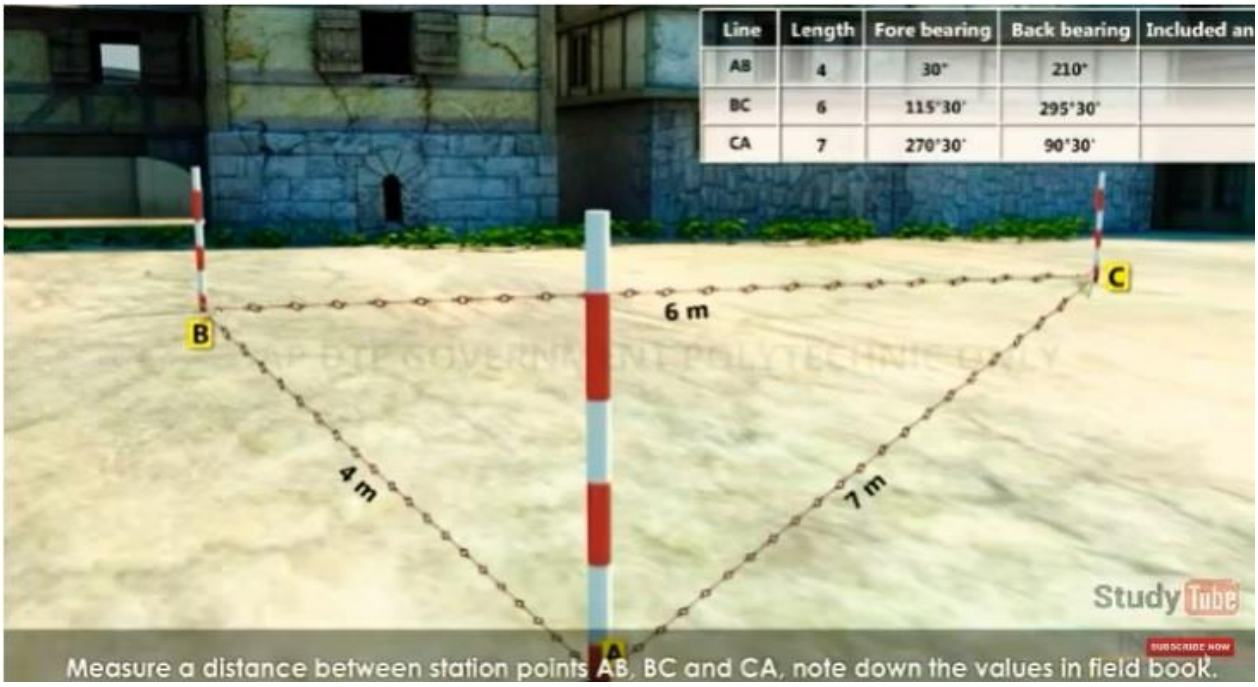

Line
Fore bearing
Back bearing
Included an
AB
30°
BC
CA
90°30'
B
C
Study Tube


Line
Fore bearing
Back bearing
Included an
AB
30°
BC
115°30'
CA
90°30'
B
C
Study Tube


Line
Fore bearing
Back bearing
Included an
AB
30°
210°
BC
115°30'
CA
90°30'
B
C
Study Tube


Line
Fore bearing
Back bearing
Included an
AB
30°
210°
BC
115°30'
CA
270°30'
90°30'
B
C
Study Tube





Calculation of included angles

Line	Length	Fore bearing	Back bearing	Included angle
AB	4	30°	210°	∠A = 60°30'
BC	6	115°30'	295°30'	∠B = 94°30'
CA	7	270°30'	90°30'	∠C = 25°

Sum of included angles = ∠A + ∠B + ∠C

= 60°30' + 94°30' + 25°

= 180°

Check for included angle = (2n - 4) 90°

= (2x3) - (4) 90° = (6 - 4) 90° = (2) 90°

= 180°

Hence observed bearing are correct.

Name of the Practical - 12: Measure Fore Bearing and back bearing of a closed traverse of 4 sides (Irregular Quadrilaterals) and correct the bearings and included angles for the local attraction.

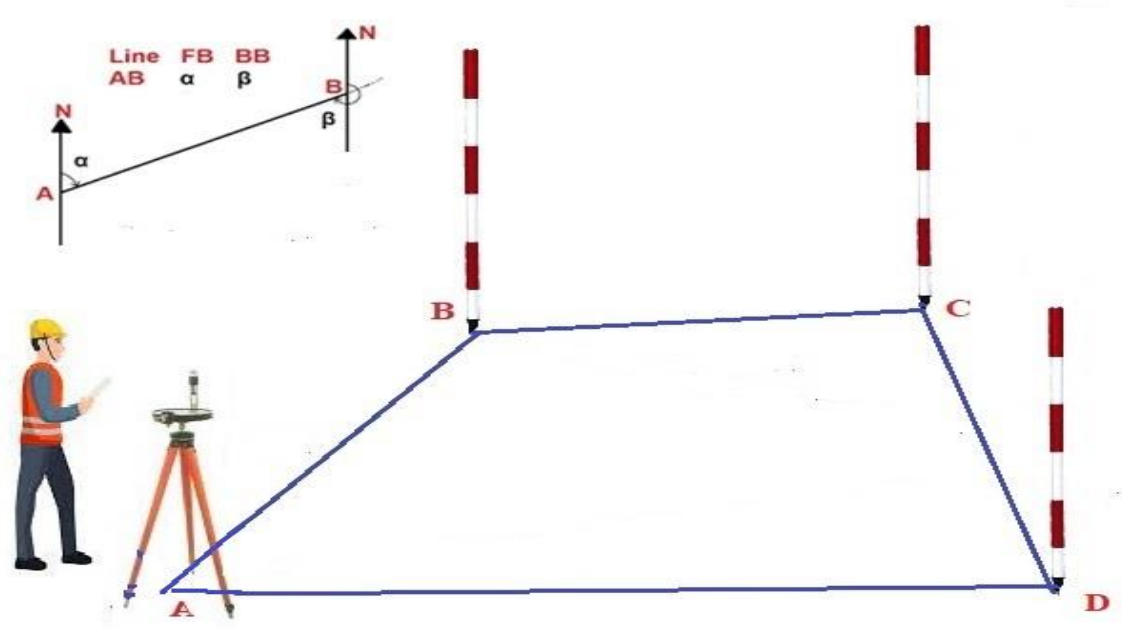
AIM: To perform the Compass survey in Closed Traverse (irregular quadrilateral) formed by series of connected straight lines (traversing) and corrections for local attraction if any.

EQUIPMENT'S REQUIRED:

- Chain.
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

THEORY: A traverse is said to be closed traverse when the traverse formed a closed circuit as shown in the figure. In this case, both starting and terminating points of the traverse coincide with each other. It is suitable for the survey of boundaries of ponds, sports grounds, forests, etc.

OBSERVATION



SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				
4	DA				

PROCEDURE:

1. Set the instrument at the starting station A and perform all the necessary adjustments.
2. Sight the object at B and note down the Back Bearing of line BA.
3. Locate the details by observing bearings or lengths or both from the traverse stations wherever necessary.
4. Shift the instrument to subsequent station B & perform all the temporary adjustments. After fixing the instrument, sight the next station C and observe the reading which gives the fore bearing of BC and measure the distance BC. And now, sight the previous station A and observe the reading which gives the back bearing of BA.
5. Repeat the process at every station.
6. It is to be noted that first station has only Fore Bearing and last station have only Back Bearing.

SL NO	LINE	LENGTH	OBSERVED BEARING	CORRECTION	CORRECTED BEARING	REMARKS
1	AB					
2	BA					
3	BC					
4	CB					
5	CD					
6	DC					
7	DA					
8	AD					

Check on closed traverse:

- The difference between fore bearing and back bearing of each line should be 180º, if no local attraction exists at either station.

Check on angular measurements:

- $The\ sum\ of\ the\ measured\ interior/internal\ angles\ =\ (2n-4)\ x\ 90^0$
- $The\ sum\ of\ the\ measured\ exterior/external\ angles\ =\ (2n+4)\ x\ 90^o$

Where N= Number of sides of the traverse.

RESULT: Measured the Fore Bearing and back bearing of a closed traverse of 4 sides (Irregular Quadrilateral) and correct the bearings and included angles for the local attraction are tabulated.

Name of the Practical - 13: Measure distance between two survey stations using compass when two stations are inaccessible.

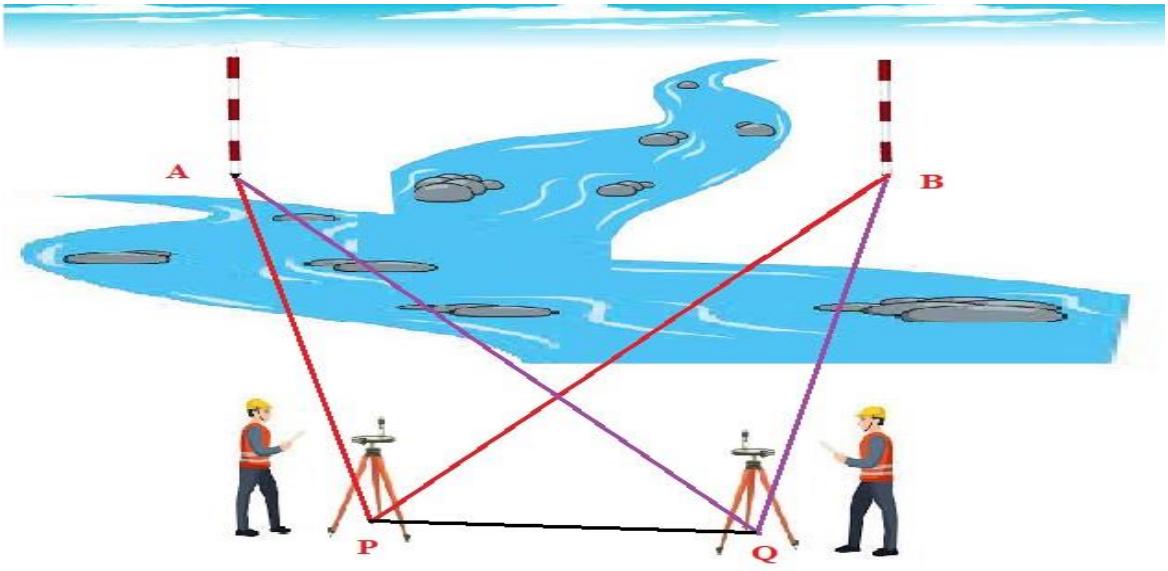
AIM: To measure distance between two survey stations using prismatic compass when two stations are inaccessible.

EQUIPMENT'S REQUIRED:

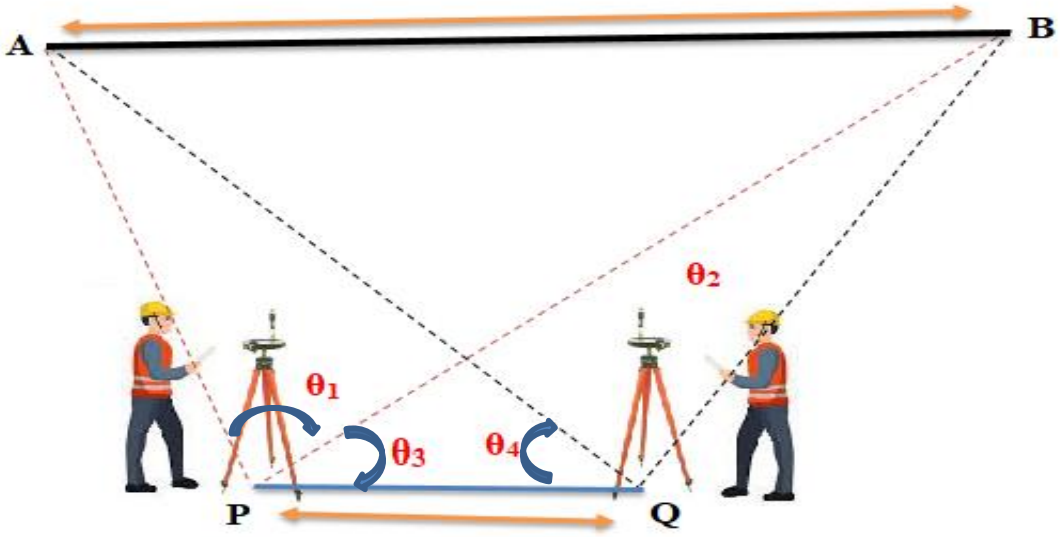
- Arrows.
- Tapes.
- Ranging rod.
- Prismatic Compass.

THEORY: When two points are too far away, unreachable and the chaining between them is difficult, the distance between these two points is called Inaccessible Distance. But the two points are visible to each other.

OBSERVATION



- ✓ Bearing of line PA =
- ✓ Bearing of line PB =
- ✓ Bearing of line PQ =
- ✓ Bearing of line QA =
- ✓ Bearing of line QB =
- ✓ Bearing of line QP =
- ✓ Horizontal Distance between PQ =



PROCEDURE:

1. Set up the compass at the station P and perform all necessary temporary arrangements.
2. Sight the object at A and B whose distance to be found and note down the Fore Bearing of line PA, PB and also PQ and measure the distance of line PQ and note it down.
3. Shift the instrument to station Q performs all necessary temporary adjustments.
4. Sight the object at A and B whose distance to be found and note down the Fore Bearing of line QA, QB and also Back Bearing of line QP.
5. Check whether the difference of Fore Bearing and Back Bearings is 180° or not for the line PQ.

$$In\ \Delta\ PBQ\ Applying\ Sine\ Rule = \frac{BQ}{Sin\ \theta 3} = \frac{BP}{Sin(\theta 2 + \theta 4)} = \frac{PQ}{Sin(180 - \theta 2 + \theta 4)}$$

$$In\ \Delta\ PAQ\ Applying\ Sine\ Rule = \frac{AP}{Sin\ \theta 4} = \frac{AQ}{Sin(\theta 1 + \theta 3)} = \frac{PQ}{Sin(180 - \theta 1 + \theta 3)}$$

Find AP, AQ, BP & BQ

$$\boldsymbol{For\ \Delta PAB\ Applying\ Cosine\ Rule = AB^2 = AP^2 + BP^2 - 2 * AP * BP * Cos\ \theta 1}$$

$$\boldsymbol{For\ \Delta PAB\ Applying\ Cosine\ Rule = AB^2 = AQ^2 + BQ^2 - 2 * AQ * BQ * Cos\ \theta 2}$$

RESULT: The distance between the two inaccessible points A and B is = M

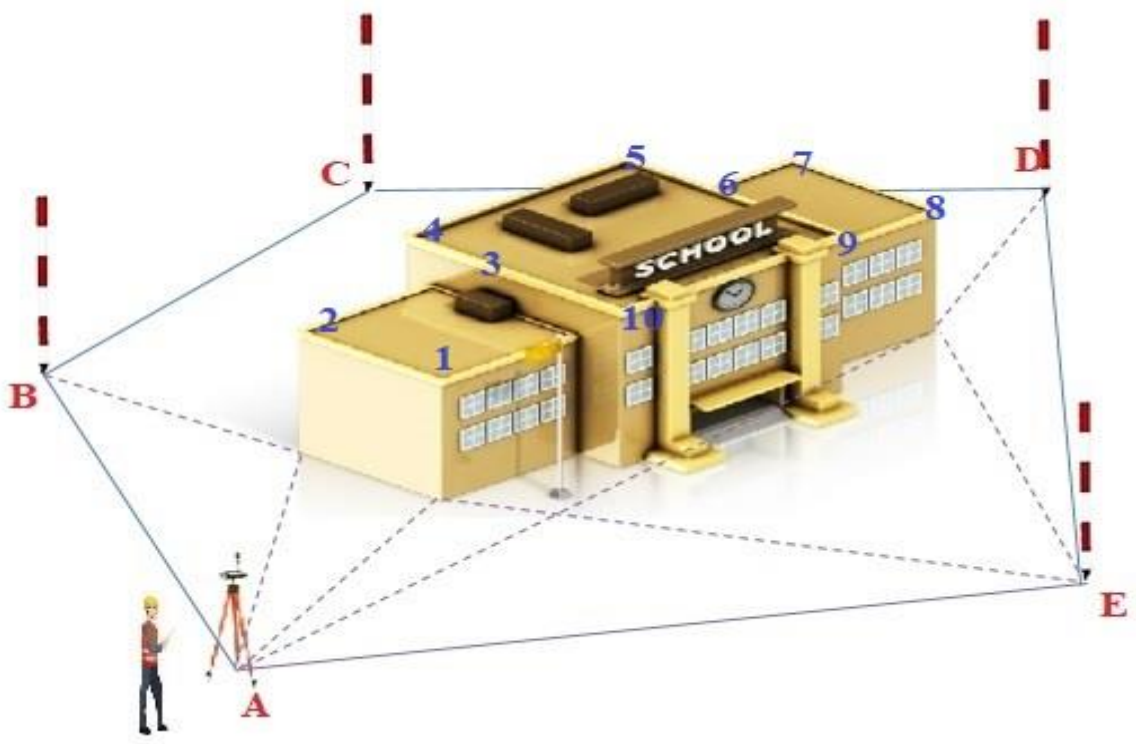
Name of the Practical - 14: Undertake Survey Project with chain and compass for closed traverse for minimum 5 sides around a building. (Compulsory)

AIM: To undertake survey work with chain and compass around a building (Closed traverse) and measuring bearing and distance around a building.

EQUIPMENT'S REQUIRED:

- Arrows.
- Chain.
- Tapes.
- Ranging rod.
- Prismatic Compass.

OBSERVATION



SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				
4	DE				
5	EA				

SL	FROM	TO	LENGTH	FORE BEARING	REMARKS
1	A	CORENER 1			
2	A	CORENER 2			
3	A	CORENER 10			
4	B	CORENER 2			
5	B	CORENER 3			
6	B	CORENER 4			
7	C	CORENER 2			
8	C	CORENER 4			
9	C	CORENER 5			
10	D	CORENER 5			
11	D	CORENER 7			
12	D	CORENER 8			
13	E	CORENER 8			
14	E	CORENER 9			
15	E	CORENER 10			
16	E	CORENER 1			

PROCEDURE:

1. Choose the building around which the required survey project is to be conducted.
2. Select minimum of 5 station points as A, B, C, D & E.
3. Fix the ranging rods at station B, C, D & E.
4. Set up the instrument at station A and do all necessary temporary adjustments.
5. Measure the Fore Bearing of Line AB and measure the horizontal distance between station A & B. and also measure the Back Bearing of Line AE and measure the horizontal distance AE.
6. From station A measure the bearings to the building corners and measure the horizontal distance between instrument station A and building corners.
7. Set up the instrument at station B and do all necessary temporary adjustments.
8. Measure the Fore Bearing of Line BC and measure the horizontal distance between station B & C. and also measure the Back Bearing of Line AB.
9. From station B measure the bearings to the building corners and measure the horizontal distance between instrument station A and building corners.
10. Repeat the above procedure to complete the traverse and tabulate the results.

RESULT: The Fore bearing and Back bearing and distances around a building (closed traverse) was carried out.

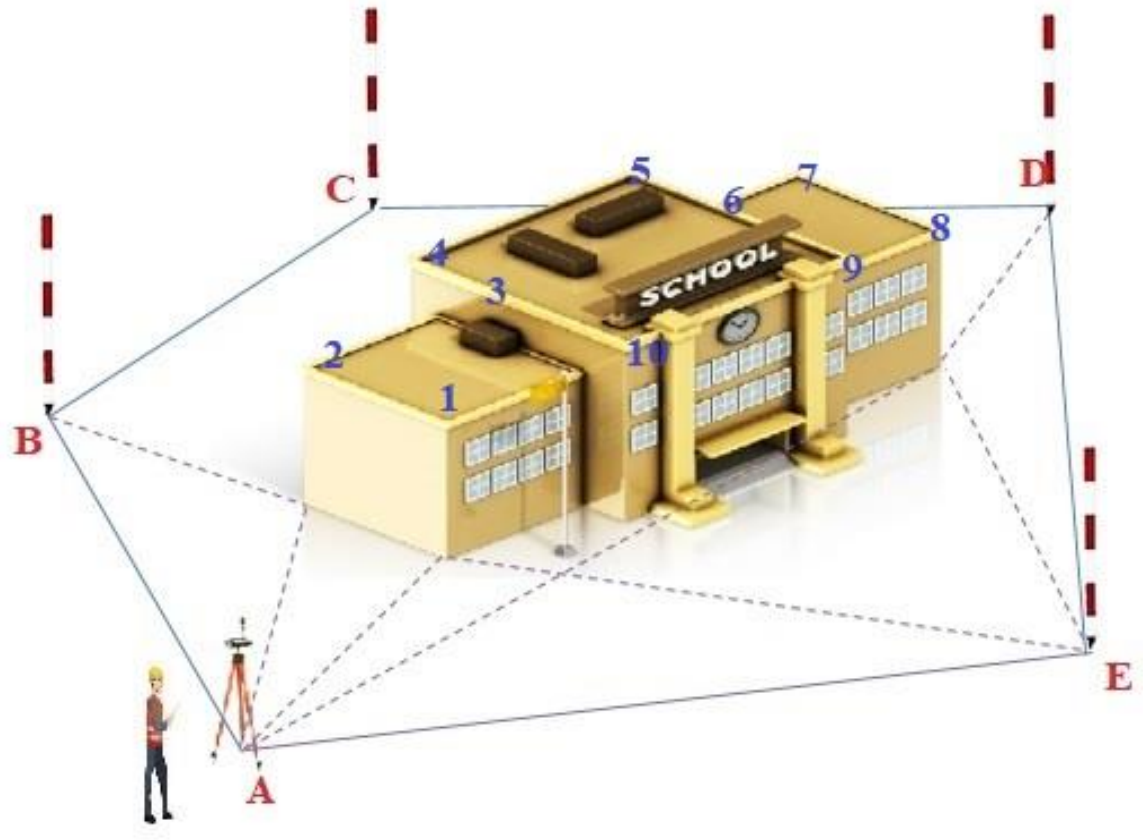
Name of the Practical - 15: Plot the traverse on a drawing sheet for data collected in the Survey Project mentioned at practical No.14.

AIM: To Plot the traverse on a drawing sheet for data collected in the Survey Project mentioned at practical No.14.

TOOLS REQUIRED:

- Drawing Board.
- Drawing sheet.
- Mini drafter / T Square.
- Scale.
- Pencil.
- Eraser.
- Protractor.
- Divider.
- Clips / Pins.
- Set Square.

OBSERVATION



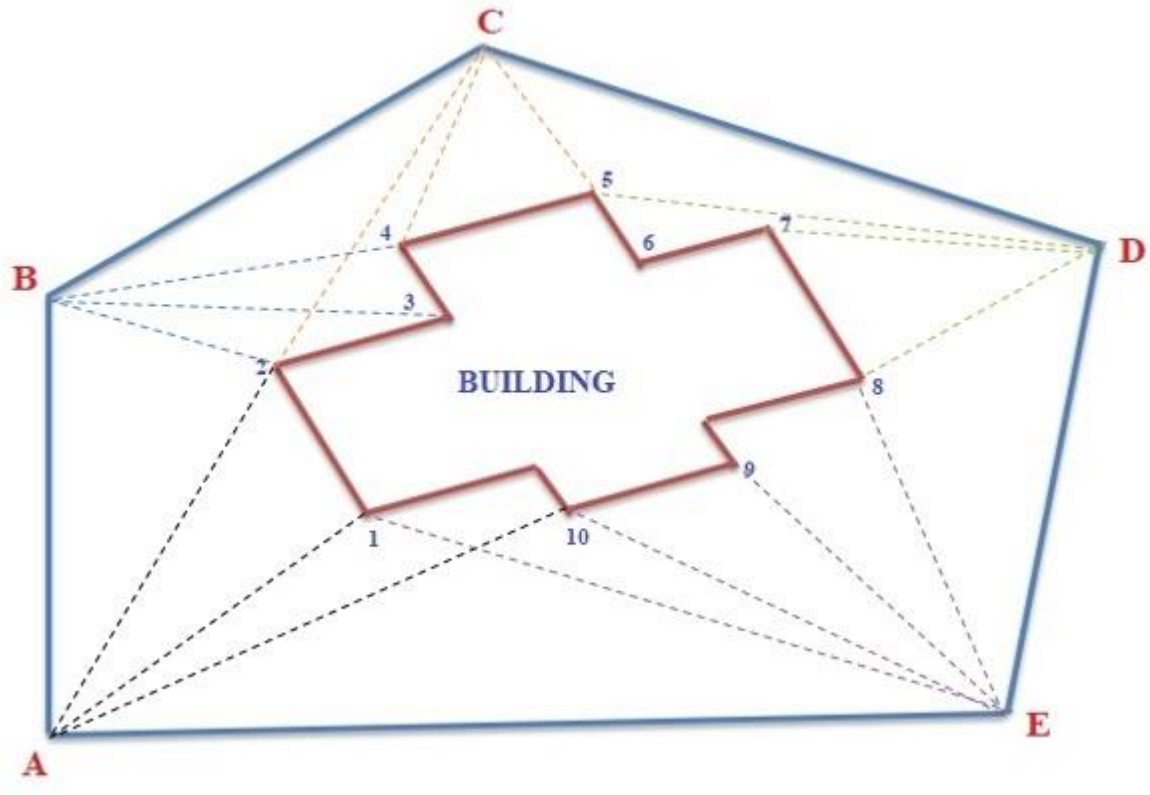
SL NO	LINE	LENGTH	FORE BEARING	BACK BEARING	REMARKS
1	AB				
2	BC				
3	CD				
4	DE				
5	EA				

SL	FROM	TO	LENGTH	FORE BEARING	REMARKS
1	A	CORENER 1			
2	A	CORENER 2			
3	A	CORENER 10			
4	B	CORENER 2			
5	B	CORENER 3			
6	B	CORENER 4			
7	C	CORENER 2			
8	C	CORENER 4			
9	C	CORENER 5			
10	D	CORENER 5			
11	D	CORENER 7			
12	D	CORENER 8			
13	E	CORENER 8			
14	E	CORENER 9			
15	E	CORENER 10			
16	E	CORENER 1			

PROCEDURE:

1. Fix the drawing sheet and mini drafter to the drawing board with the help of drawing clips or drawing pins.
2. Draw the borders according to the standards and also draw title block at the bottom right corner of the drawing sheet.
3. By observing the observed bearings and horizontal distances, choose suitable scale to draw the plan of the closed traverse.
4. Draw Main station points A, B, C, D & E with the help of Protractor, Scale & Pencil. join them with the help of mini drafter or T Square and required drawing tools.

5. Locate the building corners on drawing sheet by observed bearings and distances with the help of drawing tools.
6. By joining the building corners find out the area of the building.



RESULT: Plotting the traverse on a drawing sheet for data collected in the Survey Project mentioned at practical No.14 has been done and area is found out to be =_____ M^2

Name of the Practical - 16: Perform setting and temporary adjustments of Dumpy level/Auto level.

AIM: To perform temporary adjustment of Dumpy level/ Auto level

EQUIPMENTS REQUIRED:

- Dumpy Level.
- Stand.
- Plumb Bob.
- Arrow

PROCEDURE:

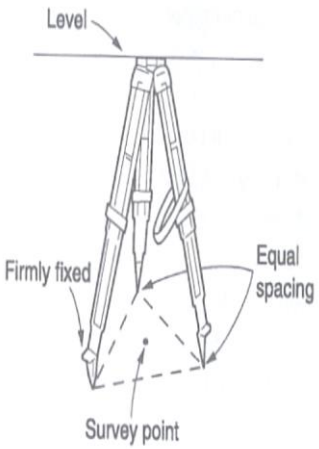
TEMPORARY ADJUSTMENT OF LEVEL:

Each surveying instruments needs two types of adjustments, Temporary & Permanent adjustments. Temporary adjustments or station adjustments are those which are made at every instrument setting and preparatory to taking observations with the instruments. Permanent adjustments need be made only when the fundamental relations between some parts or lines are disturbed.

The temporary adjustments for a level consist of the following.

- Setting up the level.
- Levelling up.
- Elimination of parallax.
- ***Setting up the level:***

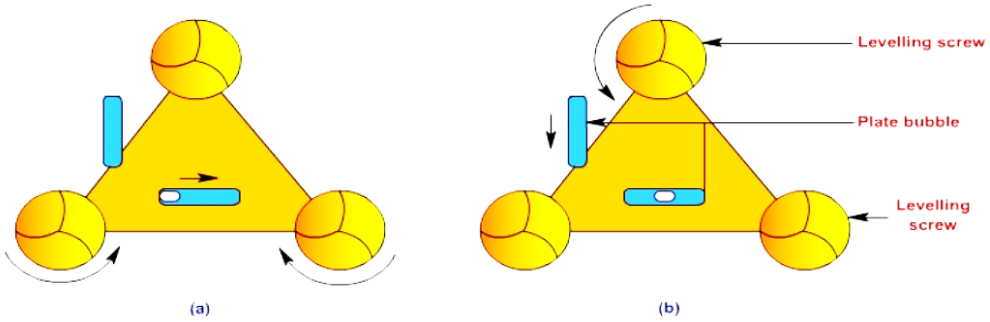
The operation of setting up includes fixing the instrument on stand and levelling the instrument approximately by leg adjustment. To fix the level to the tripod, the clamp is released, instrument is held in the right hand and is fixed on the tripod by turning round the lower part with the left hand. The tripod legs are so adjusted that the instrument is at the convenient height and the tribrach is approximately horizontal. Some instruments are also provided with a small circular bubble on the tribrach.



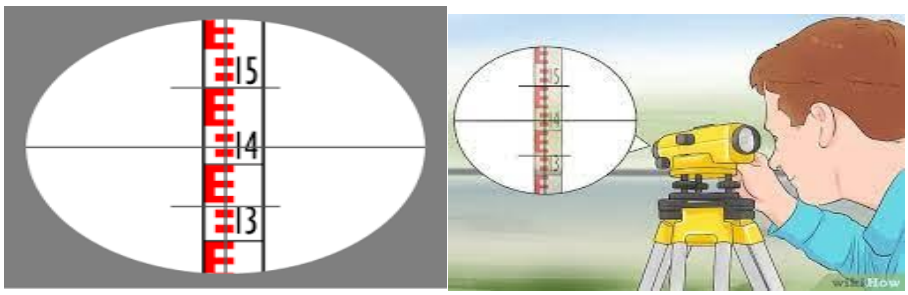
- ***Levelling up:*** After having levelled the instrument approximately, accurate levelling is done with the help of foot screws and with reference to the plate levels. The purpose of levelling is to make the vertical axis truly vertical. The matter of levelling the instrument by the plate levels depends upon whether there are three levelling screws or four levelling screws.

✓ ***Three Screw head:***

- Loose the clamp. Turn the instruments until the longitudinal axis of the plate level is roughly parallel to a line joining any two (Such as A & B) of the levelling screws.
- Hold these two levelling screws between the thumb and first finger of each hand and turn them uniformly so that the thumbs move either towards each other or away from each other until the bubble in central. It should be noted that the bubble will move in the direction of movement of the left thumb.
- Turn the upper plate through 90º until the axis on the level passes over the position of the third levelling screw C.
- Turn this levelling screw until the bubble is central.
- Return the upper part through 90º to its original position and repeat step 2 till the bubble is central.
- Turn back again through 90º and repeat step 4.
- Repeat steps 2 and 4 till the bubble is central in both the positions.
- Now rotate the instrument through 180º. The bubble should remain in the centre of its run, provided it is in correct adjustment. The vertical axis will then be truly vertical.



➢ ***Elimination of Parallax:*** Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. Unless parallax is eliminated, accurate sighting is impossible. Parallax can be eliminated in two steps. By focusing the eye piece for distinct vision of the cross hairs and by focusing the objective to bring the image of the object in the plane of cross hairs.



- ✓ ***Focusing the eye piece:*** to focus the eye piece for distinct vision of the cross hairs. Point the telescope towards the sky or hold a sheet of white paper in front of the objective and move eye piece in or out till cross hairs are seen sharp and distinct. In some telescopes, graduations are provided at the eye piece so that one can always remember the particular graduations positions suit his eyes. This may save much of time.
- ✓ ***Focusing the objective:*** The telescope is now directed towards the staff and the focusing is turned till the image appears clear and sharp. The image so formed is in the plane of cross hairs.

EXAMPLE:


190
180
170
160
150
140

RESULT: The temporary adjustment of dumpy level was carried out over an instrument station.

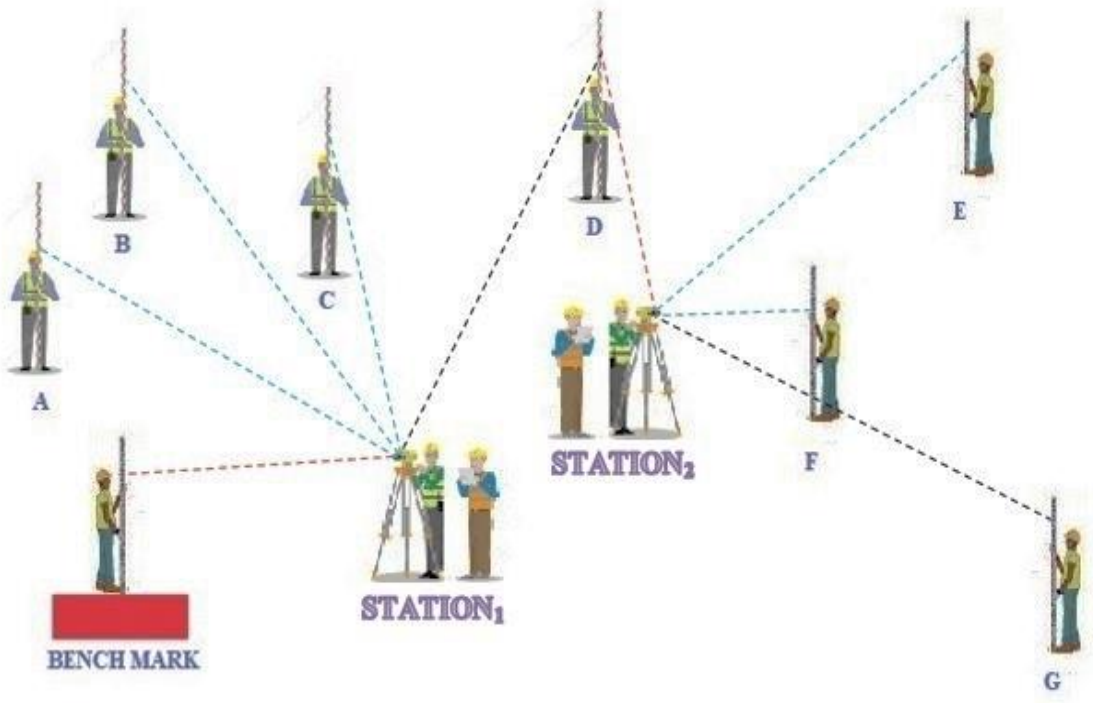
Name of the Practical - 17: Take level of various points and recording it in a level book

AIM: To take levels of various points and recording staff reading in a leveling book.

EQUIPMENTS REQUIRED:

- Dumpy Level.
- Stand.
- Plumb Bob.
- Levelling Staff.
- Levelling Book.

OBSERVATION:



PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. From same setup of instrument take Intermediate Sight reading on station A, B & C and note down the reading in IS column of level page book.
4. With instrument setup @ Station 1 take Fore Sight reading on station D and note down the reading in FS column of level page book, since it is a Turning point or Change point.

5. Holding the levelling staff @ Station D, shift the instrument to station 2 and complete all the necessary temporary adjustment & take reading on staff held at D and note it as Back sight in level page book.
6. Repeat the same procedure & note down the readings in level page book.

BACK SIGHT	INT SIGHT	FORE SIGHT	HEIGHT OF iNST	REDUCED LEVEL	DISTANCE	TOTAL DISTANCE	STATION	FORE BEARING	BACK BEARING	REMARKS
👍							BM			BM
	👍						A			
	👍						B			
	👍						C			
👍		👍					D			TP_1
	👍						E			
	👍						F			
		👍					G			

RESULT: The levels of various points are taken and recorded staff reading in a levelling book.

Name of the Practical - 18: Undertake simple leveling and using dumpy level/ Auto level and leveling staff.

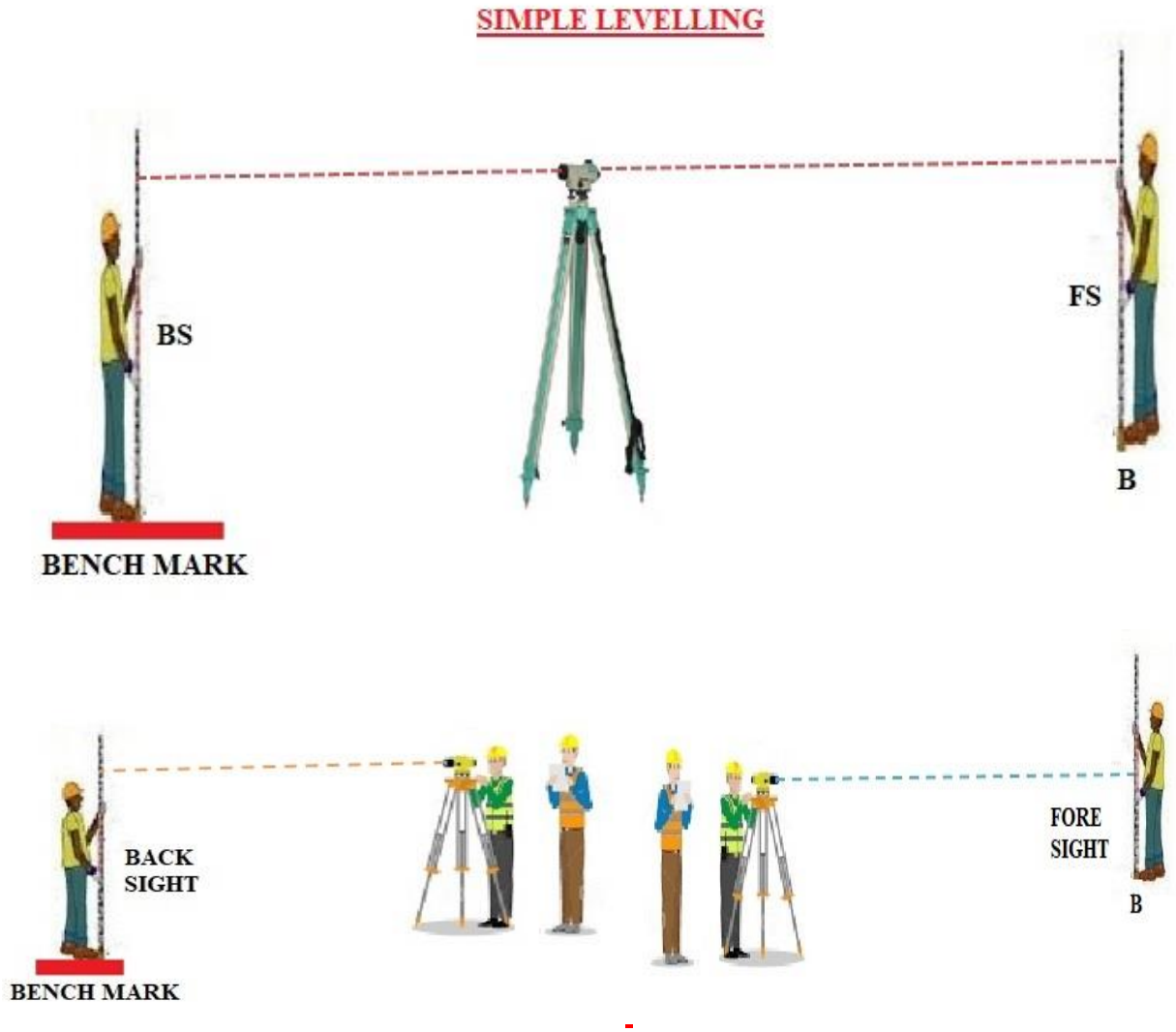
AIM: To Perform simple leveling using dumpy level and leveling staff and determine difference in elevation between those points.

EQUIPMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Levelling Staff.
- Levelling Book.

THEORY: It is a simple and basic form of leveling in which the leveling instrument is placed between the points which elevation is to be find. Leveling rods are placed at that points and sighted them through leveling instrument. It is performed only when the points are nearer to each other without any obstacles.

OBSERVATION:



PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. From same setup of instrument take Fore Sight reading on station B and note down the reading in FS column of level page book, since it is an End point.
4. Calculate the Height of the instrument at Station 1 & Determine reduced level of Station B.
5. Calculate the difference in elevation between Bench mark and Station B.

HEIGHT OF INSTRUMENT METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	STATION	REMARKS
👍					BM	RL OF BM = 100.000 M
		👍			A	

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

RISE AND FALL METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	RISE	FALL	REDUCED LEVEL	STATION	REMARKS
👍						BM	RL OF BM = 100.000 M
		👍				A	

Arithmetic Check = ΣBS – ΣFS = Σ Rise – Σ Fall = Last RL – First RL

RESULT:

- The Reduced level of station B = _____ M
- The difference in elevation between bench mark & station B is = _____ M

Name of the Practical - 19: Undertake differential leveling and determine Reduced Levels by Height of instrument method and Rise and fall method using dumpy level / Auto Level and leveling staff.

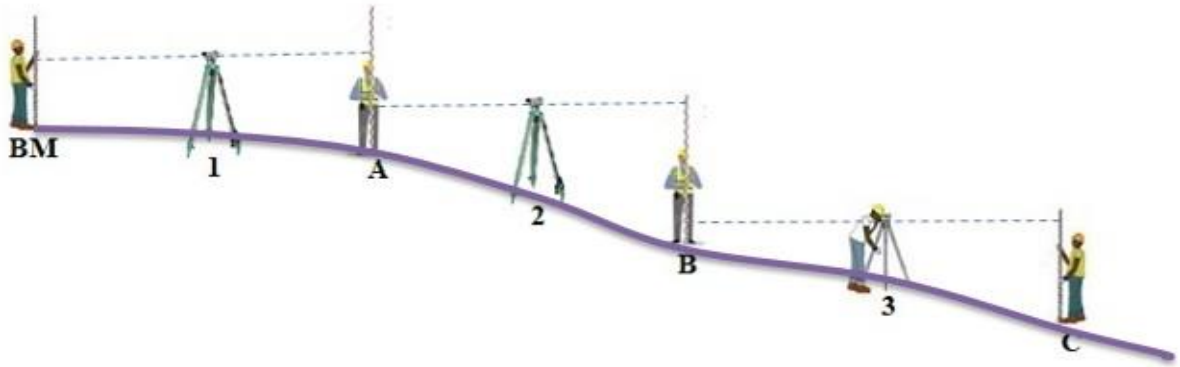
AIM: To determine Reduced level of a given points by differential leveling by H.I method and Rise and Fall method.

EQUIPMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Levelling Staff.
- Levelling Book.

THEORY: It is the method of levelling which requires more than one setting up of the instrument to determine the difference between two points which are quite distant apart. This method is also used when the difference in elevations is large or there are intervening obstacles and the levels could not be found from a single setup of the instrument. At each setup of instrument, the principle of simple levelling is employed to find the level differences it is also known as series or compound levelling.

OBSERVATION:



PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. From same setup of instrument take Fore Sight reading on station A and note down the reading in FS column of level page book, since it is a Turning or Change point.

4. With staff held @ A, Instrument is now set up @ Station 2 & do all necessary temporary adjustments and take Back sight reading on Station A.
5. From same setup of instrument take Fore Sight reading on station B and note down the reading in FS column of level page book, since it is a Turning or Change point.
6. Repeat the same procedure until you reach station C and note down the reading in FS column of level page book.
7. Calculate the Height of the instrument at Station & Determine reduced level of Station A, B & C.
8. Calculate the difference in elevation between Bench mark and Station C.

HEIGHT OF INSTRUMENT METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	STATION	REMARKS
👍					BM	RL OF BM
👍		👍			A	CP_1
👍		👍			B	CP_2
		👍			C	

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

RISE AND FALL METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	RISE	FALL	REDUCED LEVEL	STATION	REMARKS
👍						BM	RL OF BM
👍		👍				A	CP_1
👍		👍				B	CP_2
		👍				C	

Arithmetic Check = ΣBS – ΣFS = Σ Rise – Σ Fall = Last RL – First RL

RESULT:

- The Reduced levels of a given points by differential levelling by Height of Instrument method and Rise and Fall method has carried out & results are tabulated.
- The difference in elevation by Height of Instrument Method = _____ M
- The difference in elevation by Rise & Fall Method = _____ M

Name of the Practical - 20: Undertake fly leveling with double check using dumpy level/Auto level and leveling staff to establish a Temporary BM.

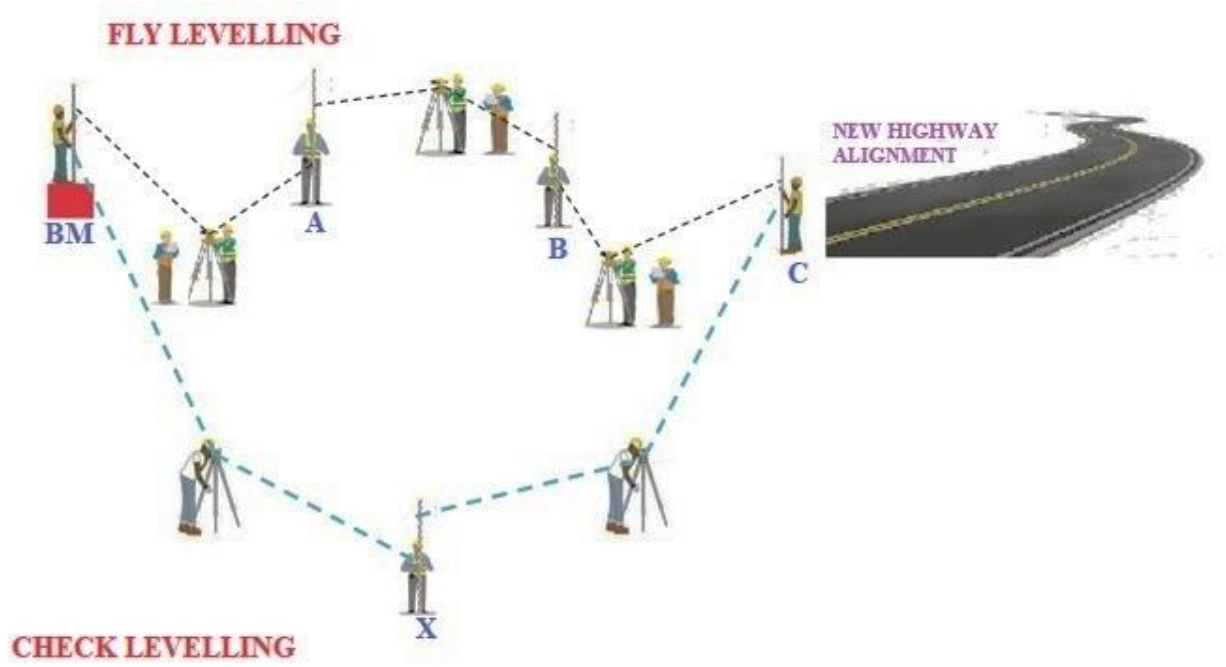
AIM: To establish new bench mark from existing temporary bench mark by fly levelling.

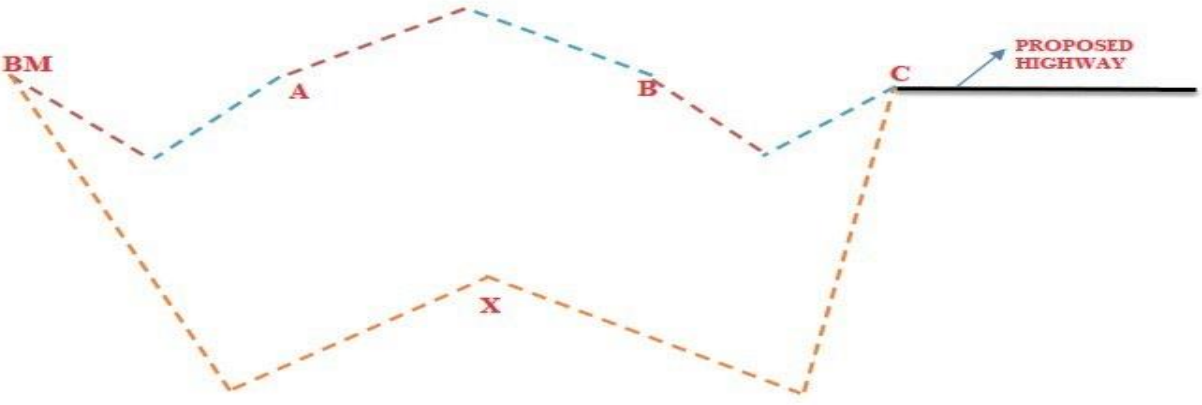
INSTRUMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Levelling Staff.
- Levelling Book.

THEORY: Fly leveling is conducted when the benchmark is very far from the work station. In such case, a temporary bench mark is located at the work station which is located based on the original benchmark. Even it is not highly precise it is used for determining approximate level. Here only BS and FS readings are taken to determine reduced level of different stations.

OBSERVATION:





PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. From same setup of instrument take Fore Sight reading on station A and note down the reading in FS column of level page book, since it is a Turning or Change point.
4. With staff held @ A, Instrument is now set up @ Station 2 & do all necessary temporary adjustments and take Back sight reading on Station A.
5. From same setup of instrument take Fore Sight reading on station B and note down the reading in FS column of level page book, since it is a Turning or Change point.
6. Repeat the same procedure until you reach station C and note down the reading in FS column of level page book.
7. Calculate the Height of the instrument at Station & Determine reduced level of Station A, B & C.
8. After obtaining RL of station C establish a Temporary Bench Mark @ Station C.
9. By conducting check levelling from Bench mark to Station C, double check the Reduced level of Temporary Bench Mark established @ C.

FLY LEVELLING

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	STATION	REMARKS
👍					BM	RL OF BM
👍		👍			A	CP_1
👍		👍			B	CP_2
		👍			C	TBM

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

CHECK LEVELLING

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	STATION	REMARKS
👍					BM	RL OF BM
👍		👍			X	CP_1
		👍			C	TBM

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

RESULT:

- The Reduced level of Station C by Fly Levelling = _____ M
- The Reduced level of Station C by Check Levelling = _____ M

Name of the Practical - 21: Find RL of given point by taking Inverted Staff Reading

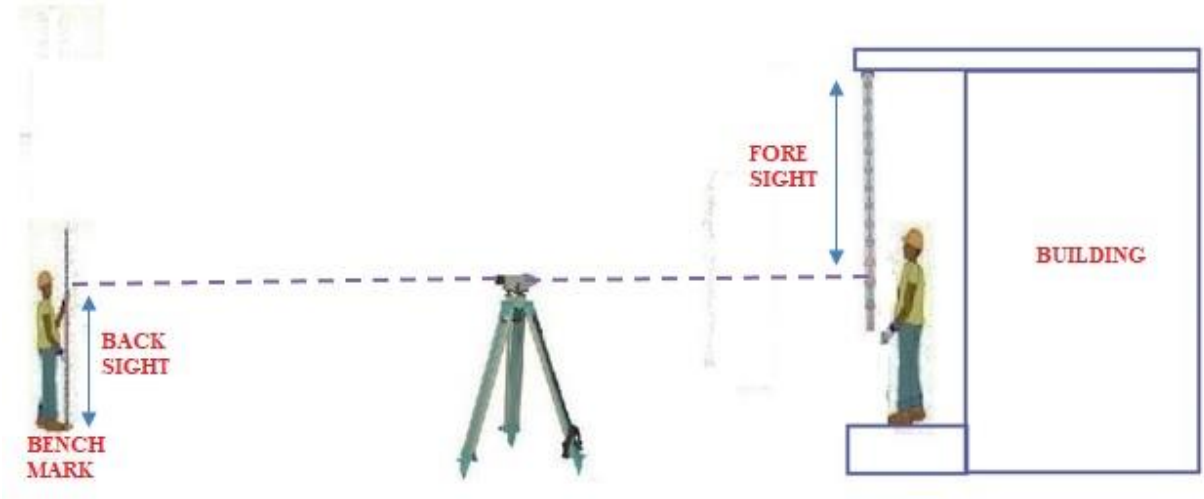
AIM: To determine RL of given point when the staff held inverted.

EQUIPMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Levelling Staff.
- Levelling Book.

THEORY: When the point under consideration is higher than the line of sight, staff should be kept inverted on the overhead point keeping the foot of the staff touching the point, and reading should be taken. Such reading will show height of that point above the line of sight and should be added to the H.I to get the R. L of the point.

OBSERVATION:



PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. From same setup of instrument take Fore Sight reading on Ceiling of a Building with staff held inverted and note down the reading in FS column of level page book.
4. Determine the Reduced level of ceiling.

HEIGHT OF INSTRUMENT METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	HEIGHT OF INSTRUMENT	REDUCED LEVEL	STATION	REMARKS
👍					BM	RL OF BM
		👍			CEILING	CP_1

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

$$Height\ of\ the\ instrument = RL\ of\ Bench\ Mark + Staff\ reading\ on\ bench\ mark$$

$$\boldsymbol{Reduced\ level\ of\ Ceiling = Height\ of\ the\ Instrumental\ Axis + Reading\ on\ staff\ held\ inverted}$$

RISE AND FALL METHOD

BACK SIGHT	INTERMEDIATE SIGHT	FORE SIGHT	RISE	FALL	REDUCED LEVEL	STATION	REMARKS
👍						BM	RL OF BM
		👍				CEILING	CP_3

Arithmetic Check = ΣBS – ΣFS = Σ Rise – Σ Fall = Last RL – First RL

RESULT:

- The Reduced level of Ceiling when staff held inverted is = _____ M

Name of the Practical – 22: Undertake Profile leveling and cross-sectioning for a given road length and interval.

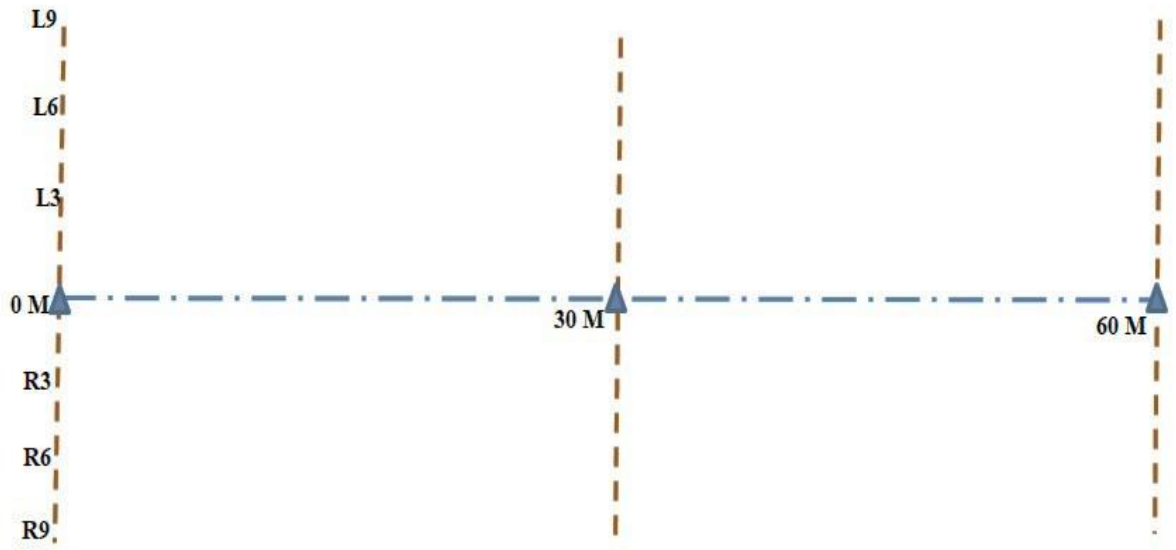
AIM: To perform profile leveling or longitudinal leveling and cross-sectioning for a given road length and interval

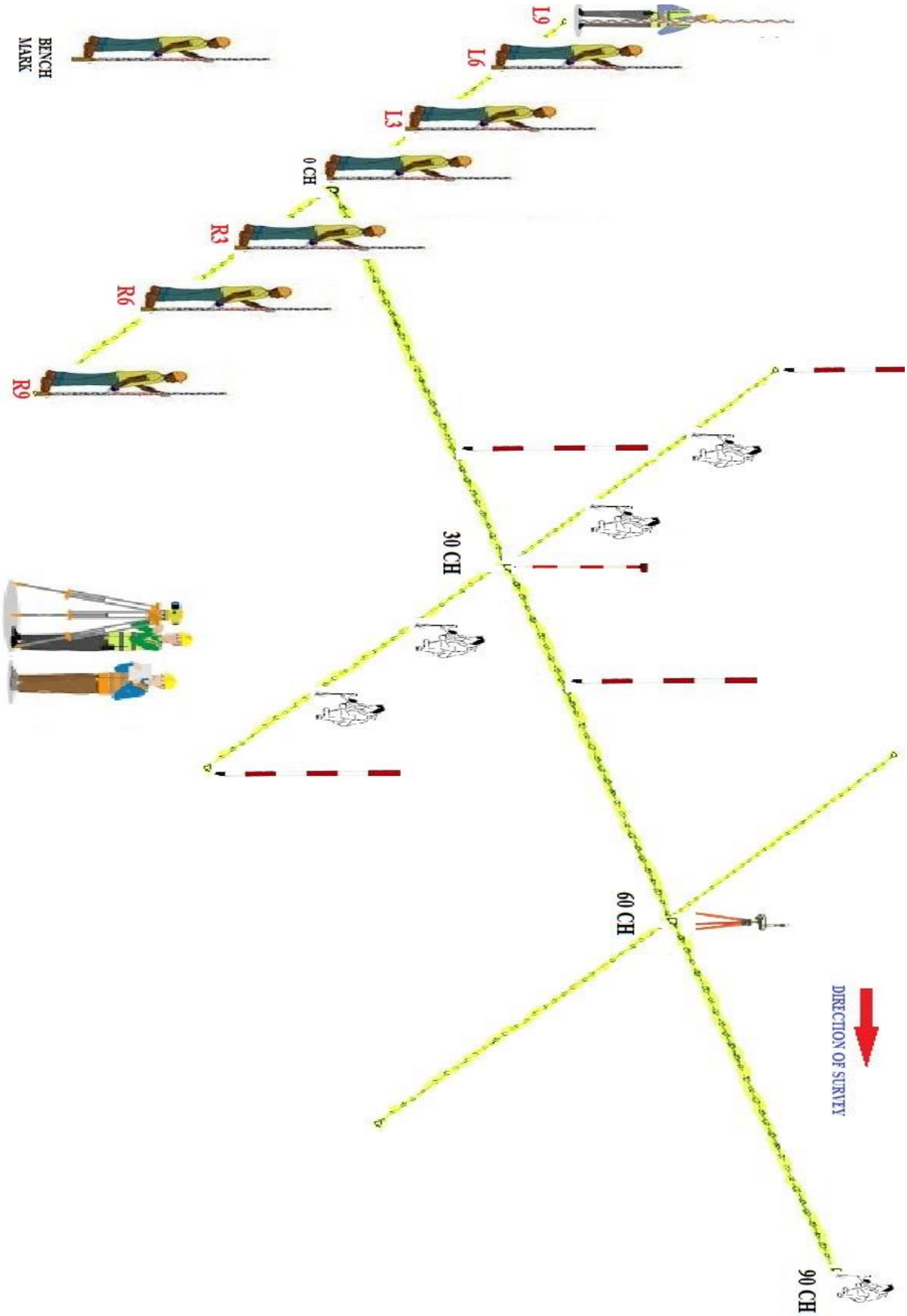
EQUIPMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Prismatic compass.
- Ranging Rods.
- Arrows.
- Tapes.
- Chain.
- Levelling Staff.
- Levelling Book.

THEORY: ***Profile leveling*** is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn. ***Cross sectioning:*** It is a method of leveling to know the nature of Ground on either side of the centerline of the proposed route. Levels are taken at right angles to the proposed Direction of the road end at suitable distances and leveling is carried out along this cross Section.

OBSERVATION:




BENCH MARK
L9
L6
L3
0 CH
R3
R6
R9
30 CH
60 CH
90 CH
DIRECTION OF SURVEY

BACK SIGHT	INT SIGHT	FORE SIGHT	HEIGHT OF iNST	REDUCED LEVEL	DISTANCE	TOTAL DISTANCE	STATION	FORE BEARING	BACK BEARING	REMARKS
					-	-	BM	-	-	BM
					0.00	0.00	0 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	30.00	30 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	60.00	60 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	90.00	90 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. Stretch chain line from starting of point the chainage, drive pegs or arrows at the end of the chain length.
4. Mark first point as 0.00 CH and set out a perpendicular on both side of the chain line for required lengths say 3, 6 & 9 for taking cross section levels & drive arrows at those points.
5. Measure the bearing of chain line from 0.00 chainage to 30.00 chainage & note it down in level page book.
6. From same setup of instrument take Intermediate sights on cross sectioning points and profile levelling points & note down the reading in IS column of level page book.
7. Measure the bearing of chain line from 30.00 chainage to 0.00 chainage & note it down in level page book. The difference in bearings should be 180º.
8. Repeat the same procedure for required length.
9. Determine the Reduced levels of each points and record in level page book.

RESULT:

- Profile levelling and cross sectioning has been performed for a given road length and results are tabulated in level page book.

Name of the Practical – 23/24: Undertake Survey Project with Leveling instrument for Profile leveling and cross-sectioning for a road length of 500 m with cross-section at 30 m interval. (Compulsory)

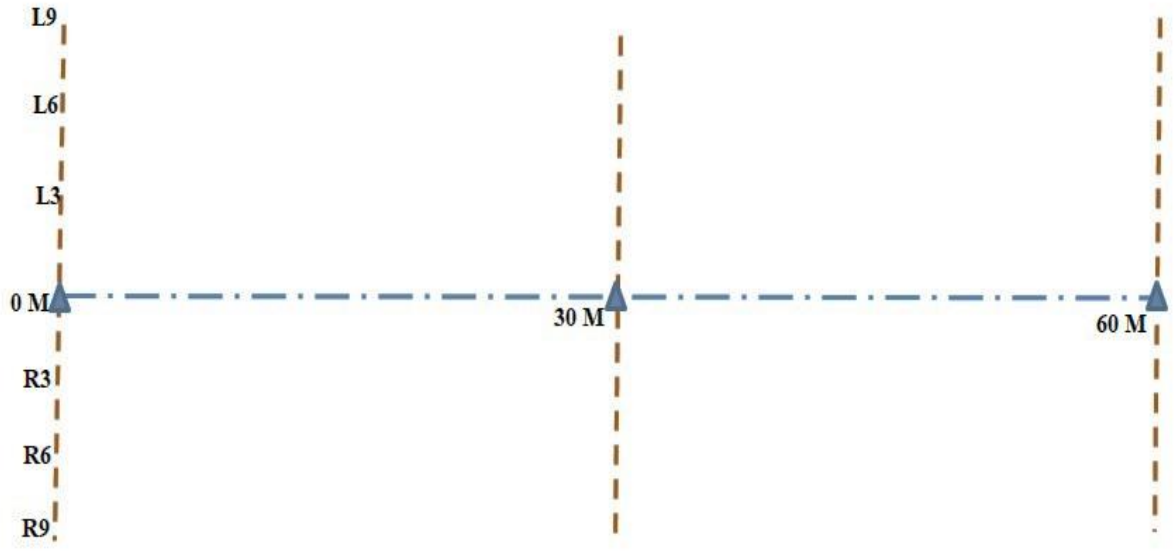
AIM: To perform Survey Project with Leveling instrument for Profile leveling and cross sectioning for a road length of 500 m with cross-section at 30 m interval. (Compulsory)

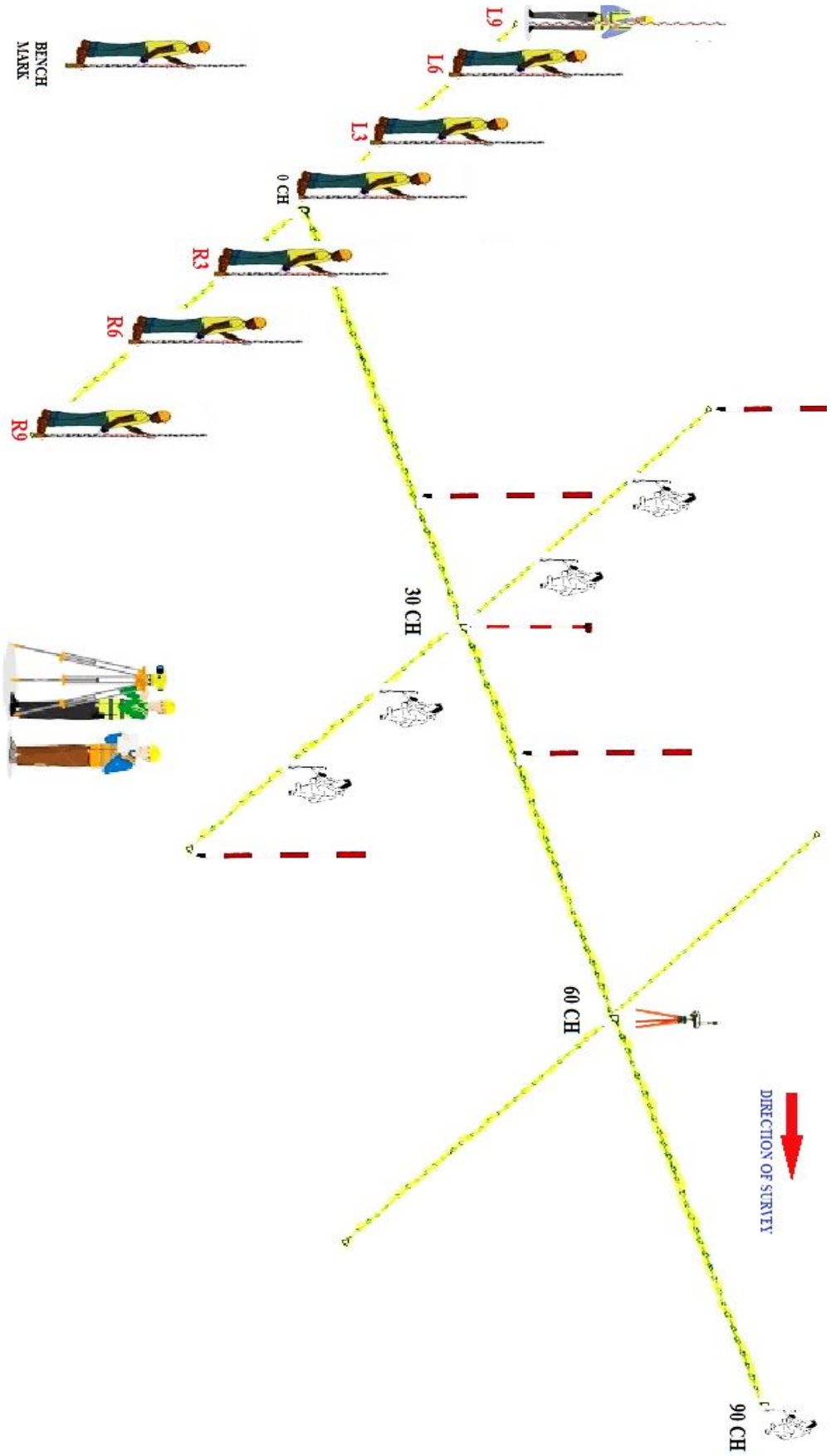
EQUIPMENTS REQUIRED:

- Dumpy Level.
- Tripod.
- Prismatic compass.
- Ranging Rods.
- Arrows.
- Tapes.
- Chain.
- Levelling Staff.
- Levelling Book.

THEORY: ***Profile leveling*** is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn. ***Cross sectioning:*** It is a method of leveling to know the nature of Ground on either side of the centerline of the proposed route. Levels are taken at right angles to the proposed Direction of the road end at suitable distances and leveling is carried out along this cross Section.

OBSERVATION:




BENCH MARK
L9
L6
L3
0 CH
R3
R6
R9
30 CH
60 CH
90 CH
DIRECTION OF SURVEY

BACK SIGHT	INT SIGHT	FORE SIGHT	HEIGHT OF iNST	REDUCED LEVEL	DISTANCE	TOTAL DISTANCE	STATION	FORE BEARING	BACK BEARING	REMARKS
					-	-	BM	-	-	BM
					0.00	0.00	0 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	30.00	30 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	60.00	60 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			
					30.00	90.00	90 CH			
					3.00		L3			
					3.00		L6			
					3.00		L9			
					3.00		R3			
					3.00		R6			
					3.00		R9			

Arithmetic Check = ΣBS – ΣFS = Last RL – First RL

PROCEDURE:

1. Set the instrument at a Station 1 and complete temporary adjustments.
2. Take Back Sight reading on Bench Mark (BM) and note down the reading in BS column of level page book.
3. Stretch chain line from starting of point the chainage, drive pegs or arrows at the end of the chain length.
4. Mark first point as 0.00 CH and set out a perpendicular on both side of the chain line for required lengths say 3, 6 & 9 for taking cross section levels & drive arrows at those points.
5. Measure the bearing of chain line from 0.00 chainage to 30.00 chainage & note it down in level page book.
6. From same setup of instrument take Intermediate sights on cross sectioning points and profile levelling points & note down the reading in IS column of level page book.
7. Measure the bearing of chain line from 30.00 chainage to 0.00 chainage & note it down in level page book. The difference in bearings should be 180º.
8. Repeat the same procedure for required length of 500 metres.
9. Determine the Reduced levels of each points and record in level page book.

RESULT:

- Profile levelling and cross sectioning has been performed for a given road length and results are tabulated in level page book.

Name of the Practical – 25/26: Plot the L-section with minimum 3 cross-sections on A1 size drawing sheet for data collected in Survey Project mentioned at practical No.23 & 24

AIM: To Plot the L-section with minimum 3 cross-sections on A1 size drawing sheet for data collected in Survey Project mentioned at practical No.23 & 24.

TOOLS REQUIRED:

- Drawing Board.
- Drawing sheet.
- Mini drafter / T Square.
- Scale.
- Pencil.
- Eraser.
- Protractor.
- Divider.
- Clips / Pins.
- Set Square.

PROCEDURE:

1. Fix the drawing sheet and mini drafter to the drawing board with the help of drawing clips or drawing pins.
2. Draw the borders according to the standards and also draw title block at the bottom right corner of the drawing sheet.
3. By observing the Reduced levels and horizontal distances, choose suitable horizontal & Vertical scale to draw the profile levelling and cross sectioning.
4. First draw the profile levelling of the highway project performed in practice no 23 & 24.
5. Then select a gradient to find out the formation levels at profile levelling chainages.
6. Draw cross sectioning for minimum three chainages in drawing sheet.

RESULT:

- The Profile levelling and minimum of 3 cross sections has been plotted on A1 size drawing sheet for data collected in Survey Project mentioned at practical No.23 & 24.