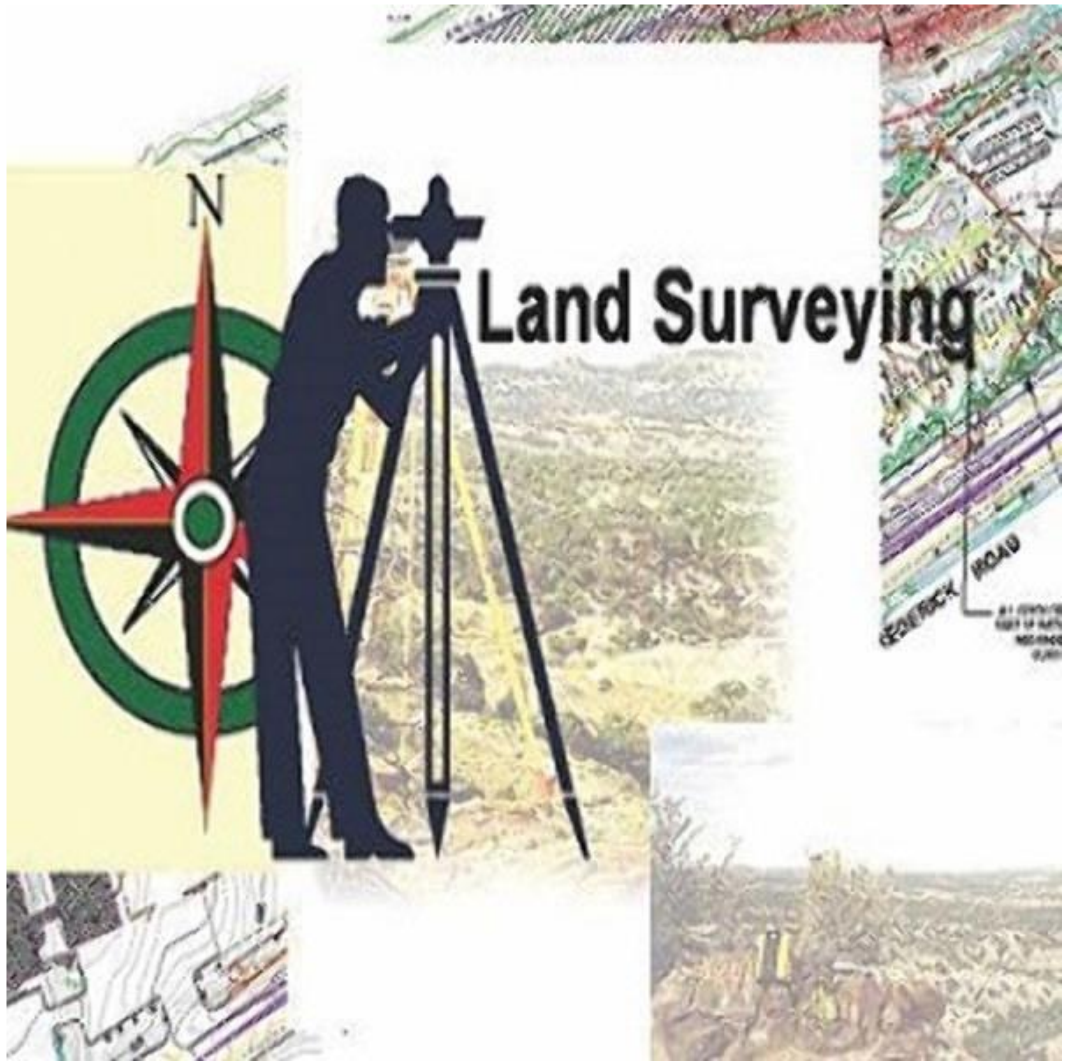
SURVEYING



Introduction, linear and angular measurements

Surveying is the technique of determining the relative position of different features on, above or beneath the surface of the earth by means of direct or indirect measurements and finally representing them on a sheet of paper known as plan or map.

During a survey, surveyors use various tools to do their job successfully and accurately, such as total stations, GPS receivers, prisms, 3D scanners, radio communicators, digital levels, dumpy level and surveying software etc

primary divisions of surveying

Primary Divisions of Surveying

Surveying may primarily be divided into two divisions:

Plane surveying.

The surveys in which earth surface is assumed as plane and the curvature of the earth is ignored, are known as *Plane surveys*.

Geodetic surveying.

The surveys in which curvature of the- earth is taken into account and higher degree of accuracy in linear and angular observations, is achieved, are known as *Geodetic surveys*.

Objectives of Surveying

Objectives 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.

principles of surveying

The main principle of surveying whether plane or geodetic is to work from the whole to part. To achieve this in actual practice, sufficient number of primary control points are established with higher precision in and around the area to be detailed surveyed. Minor control points in between primary control stations, are then established with less precision method. The details are surveyed with the help of these minor control points, adopting any one of the methods of surveying. The main idea of surveying from the whole to the part, is to prevent accumulation of errors and to localize the minor errors in the frame work of the control points.

AGENDA

- The metric chain and tape accessories for chain survey ranging a line

- Measuring along slope corrections to measurements chain triangulation problems in chaining obstacles to chaining Chain survey cross staff survey

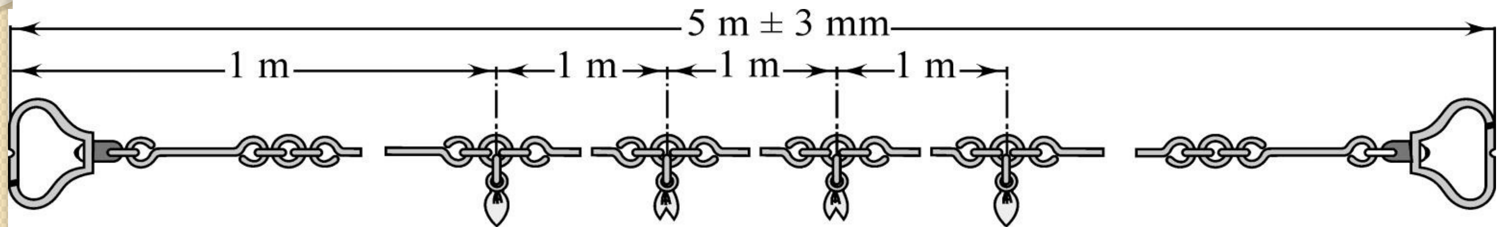
METRIC CHAIN AND TAPE

- Metric chains come in lengths of 5 m, 10 m, 20 m and 30m
- Older chains were in 100 feet(engineers),66 feet (Gunter's) and 33 feet (revenue)
- Chains have tallies and rings to identify intermediate values

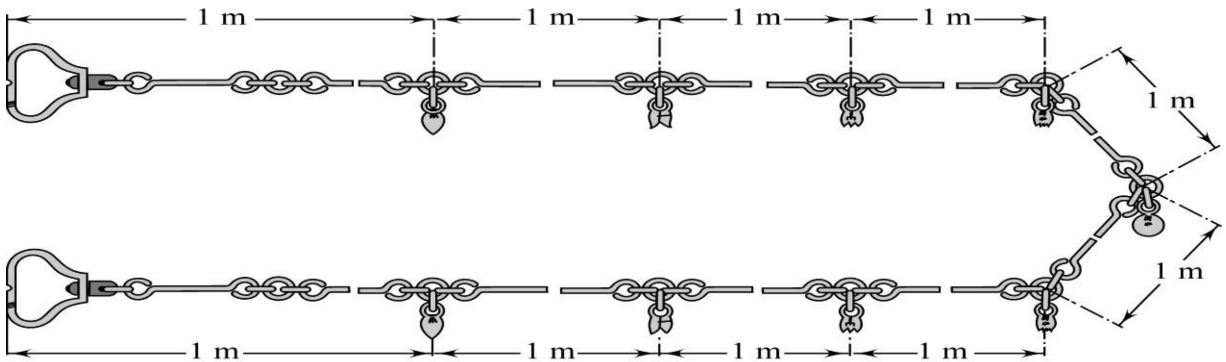
METRIC CHAINS

- BIS standard for chains – is 1492-1964 Made of 4mm galvanized iron wire
- Made of links 200 mm long and connected
  - by circular or oval rings
- End links shorter for providing handles

5M AND 10M CHAINS

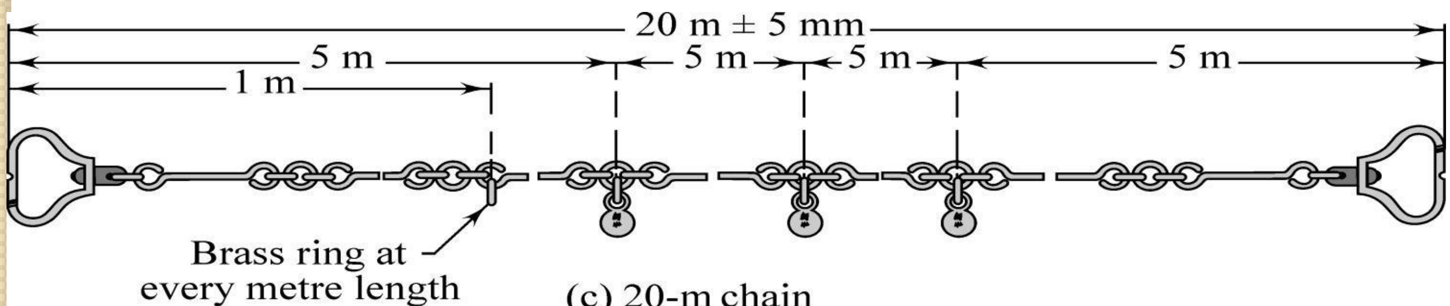


(a) 5-m chain

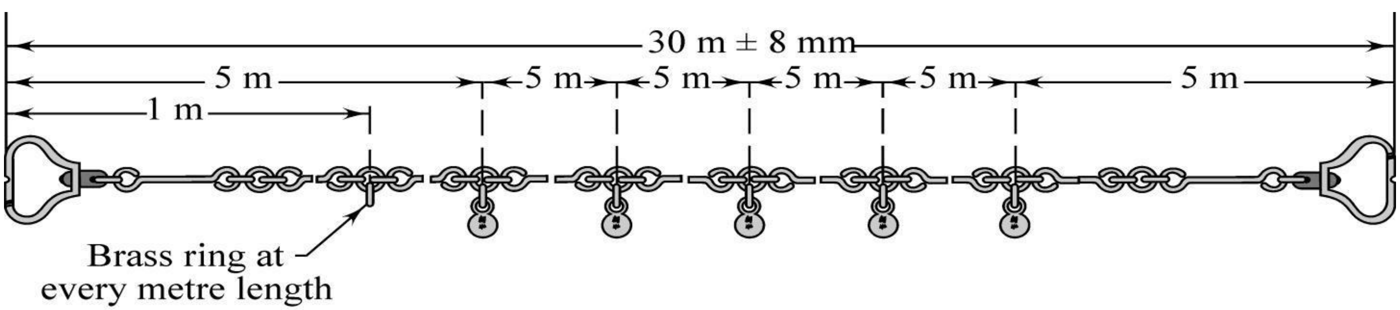


(b) 10-m chain

20M AND 30 M CHAINS



(c) 20-m chain



(d) 30-m chain

TAPES

- Cloth tape
- Metallic tape
- Steel tape
- Invar tape

Cloth or linen tapes are not good for field work as they shrink, tear easily and not used for survey work.

METALLIC TAPES

- Lengths of 2m, 5m, 10 m, 20m, 30m, 50m etc
- Yarn interwoven with metal fibres
- Metal ring to hold at the outer end
- 16 mm wide, marked in cm and m
- Rolled out by pulling and rolled back using rotating handle
- Commonly used for ordinary survey work

STEEL TAPE

- Steel tapes are made of galvanized steel
  or stainless steel
- Lengths from 1 m to 50 m
- Marked in meters, decimeters and centimeters with end section in millimeters
- Costly but very accurate
- Can be pulled out with the handle and rolled back automatically
- Used for accurate survey work

INVAR TAPE

- Made of an alloy of steel and nickel
- About 6 mm wide and in lengths of 30m, 50 m and 100m
- Very low thermal coefficient
- Used for very precise work as in base line measurement
- Should be handled very carefully

ACCESSORIES

1. Ranging rods
2. Ranging poles
3. Arrows
4. Offset rod
5. Wooden pegs
6. Laths and whites
7. Other equipment for clearing bushes, cleaning ground

RANGING

- Ranging required when line is longer than a chain/tape length
- Placing a line along the shortest distance between points
- When end stations are inter-visible, direct ranging can be done
- When end stations not inter-visible, indirect ranging is done

MEASURING ALONG SLOPE

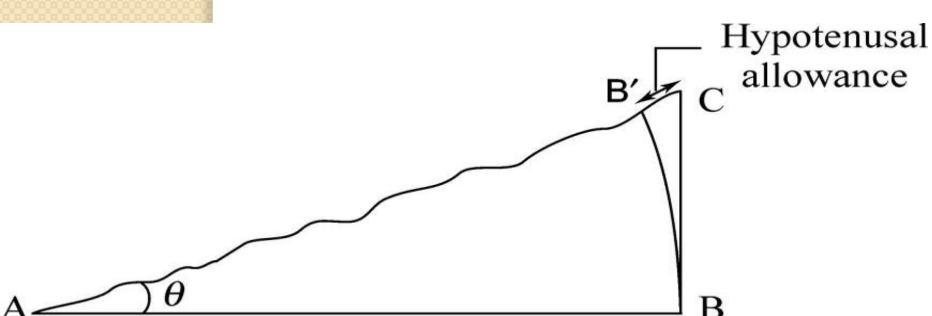
- For plotting, horizontal distances are required
- For a measured distance along slope, horizontal distance can be calculated. Horizontal length is less than length along slope For a given horizontal distance, slope distance can be calculated
- The increase in length along slope is called hypotenusal allowance

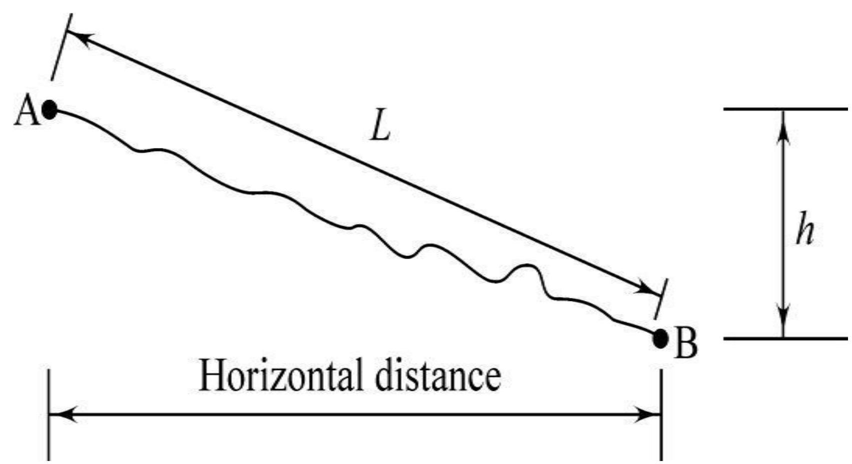
HORIZONTAL DISTANCE

- Horizontal distance = L COS θ, Where L is the slope distance and θ is the slope angle.
- If slope is in gradient, 1:n, then
- Horizontal distance = $L\, n/[\sqrt{(1+n^2)}]$

HYPOTENUSAL ALLOWANCE

Is the additional distance measured along the slope to give a chain length horizontally





HYPOTENUSAL ALLOWANCE

- Hypotenusal allowance is given by

L [sec θ – 1], exactly and

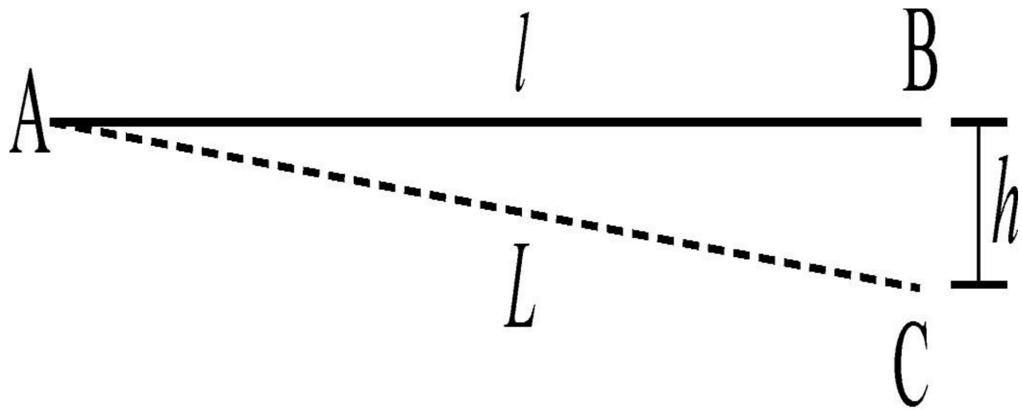
- L $\theta^2/2$, where θ is in radians.

Or

- Hypotenusal allowance = $\sqrt{(L^2 + h^2)} - L$ (exact value) or $h^2/2L$ approximately.

SLOPE MEASUREMENT

- Correction = $h^2/2L$ or = $L\theta/2$
- Where h is the height for length L and
- Θ is the slope angle in radians



INTRODUCTION

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

Traversing

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

Principle of compass surveying

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

Compass

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

Types of compass

- There are two types of magnetic compass they are as follows:-
- The prismatic compass
- The Surveyor’s compass

Elements of prismatic compass

- **Cylindrical metal box**: Cylindrical metal box is having diameter of 8 to 12 cm. It protects the compass and forms entire casing or body of the compass. It protect compass from dust, rain etc.

- **Pivot:** pivot is provided at the center of the compass and supports freely suspended magnetic needle over it.

- **lifting pin and lifting lever:** a lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin. The lifting pin with the help of lifting lever then lifts the magnetic needle out of pivot point to prevent damage to the pivot head.

- **Magnetic needle:** Magnetic needle is the heart of the instrument. This needle measures angle of a line from magnetic meridian as the needle always remains pointed towards north south pole at two ends of the needle when freely suspended on any support.

- **Graduated circle or ring:** This is an aluminum graduated ring marked with 0^{O} to 360^{O} to measures all possible bearings of lines, and attached with the magnetic needle. The ring is graduated to half a degree.

- **Prism :** prism is used to read graduations on ring and to take exact reading by compass. It is placed exactly opposite to object vane. The prism hole is protected by prism cap to protect it from dust and moisture.

- **Object vane:** object vane is diametrically opposite to the prism and eye vane. The object vane is carrying a horse hair or black thin wire to sight object in line with eye sight.
- **Eye vane:** Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.
- **Glass cover:** its covers the instrument box from the top such that needle and graduated ring is seen from the top.

- **Sun glasses:** These are used when some luminous objects are to be bisected.
- **Reflecting mirror:** It is used to get image of an object located above or below the instrument level while bisection. It is placed on the object vane.
- **Spring brake or brake pin:** to damp the oscillation of the needle before taking a reading and to bring it to rest quickly, the light spring brake attached to the box is brought in contact with the edge of the ring by gently pressing inward the brake pin

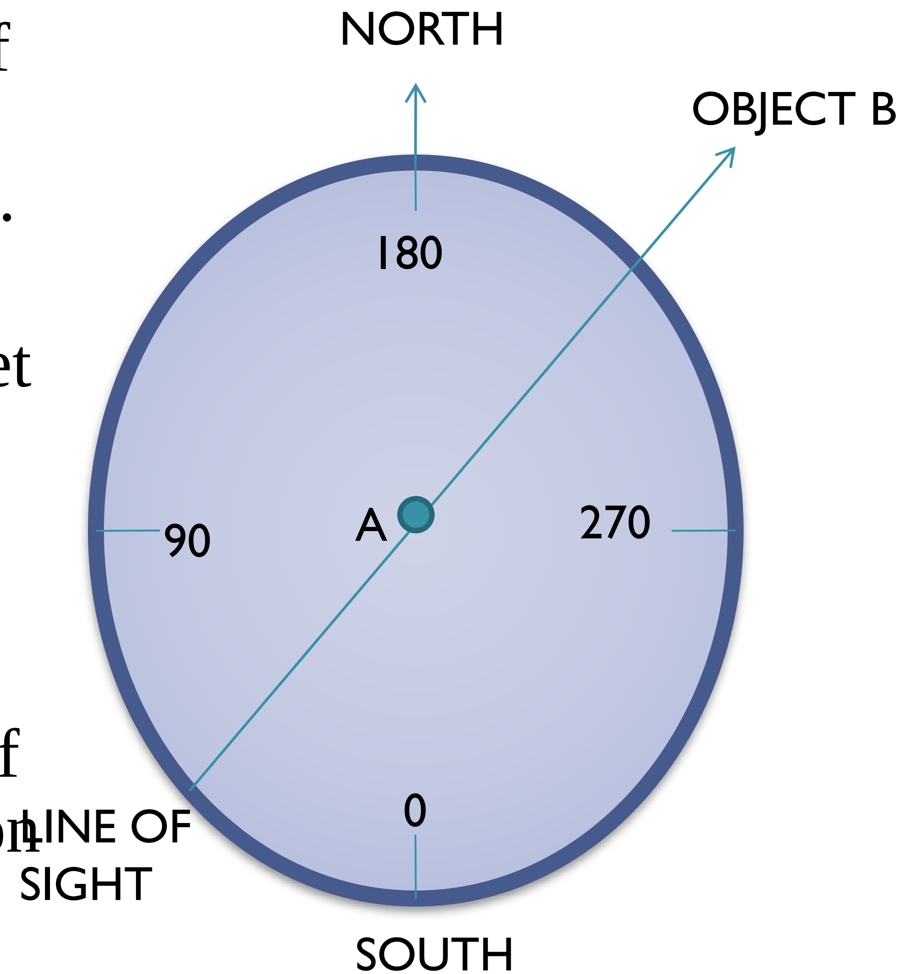
Temporary adjustment of prismatic compass

- The following procedure should be adopted after fixing the prismatic compass on the tripod for measuring the bearing of a line.
- **Centering :** Centering is the operation in which compass is kept exactly over the station from where the bearing is to be determined. The centering is checked by dropping a small pebble from the underside of the compass. If the pebble falls on the top of the peg then the centering is correct, if not then the centering is corrected by adjusting the legs of the tripod.

- **Leveling :** Leveling of the compass is done with the aim to freely swing the graduated circular ring of the prismatic compass. The ball and socket arrangement on the tripod will help to achieve a proper level of the compass. This can be checked by rolling round pencil on glass cover.
- **Focusing :** the prism is moved up or down in its slide till the graduations on the aluminum ring are seen clear, sharp and perfect focus. The position of the prism will depend upon the vision of the observer.

Observing Bearing of Line

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



The Surveyor`s Compass

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

Working of Surveyor`s Compass

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

BEARINGS

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

- **3) <u>Grid Bearing</u>:** The grid bearing of a line is the horizontal angle which the line makes with the grid meridian.

- **4) <u>Arbitrary Bearing</u>:** The arbitrary baring of a line is the horizontal angle which the line makes with the arbitrary meridian.

Designation of bearing

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

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

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

EQUIPMENTS AND ACCESSORIES FOR PLANE TABLING

The following instruments are used in plane table surveying.

1. Equipments
2. Plane Table
3. Tripod
4. Alidade

EQUIPMENTS AND ACCESSORIES FOR PLANE TABLING

- Trough Compass
- Spirit levelU-Fork with Plumb bob
- Water proof cover
- Drawing paper
- Pins
- Drawing accessories

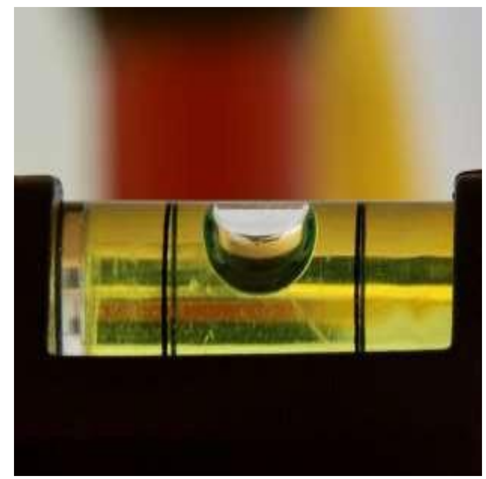
ACCESSORIES

Trough Compass:

- The trough compass is required for drawing the line showing magnetic meridian on the paper. It is used to orient the table to the magnetic meridian.
- When the freely suspended needle shows 0^0 at each end, a line is drawn on the drawing paper which represents the magnetic north.

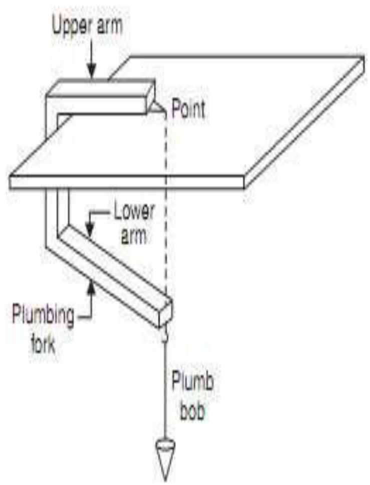
SPIRIT LEVEL

- A Spirit Level is used for ascertaining If the table is properly level.
- The Table is leveled by placing the level on the board in two positions at right angles and getting the bubble central in both positions.



U-FORK WITH PLUMB BOB

- U-fork with plumb bob is used for centering the table over the point or station occupied by the plane table when the plotted position of that point is already on the sheet.
- Also, in the beginning of the work, it is used for transferring the ground point on the sheet.



WATER PROOF COVER & DRAWING PAPER

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

- The plan is drawn by the surveyor himself while the area to be surveyed is before his eyes. Therefore, there is no possibility of omitting the necessary measurements.
- The surveyor Can compare the plotted work with the actual features of the area.

METHOD OF SETTING UP THE PLANE TABLE

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

LEVELING AND CENTERING

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

LEVELING AND CENTERING

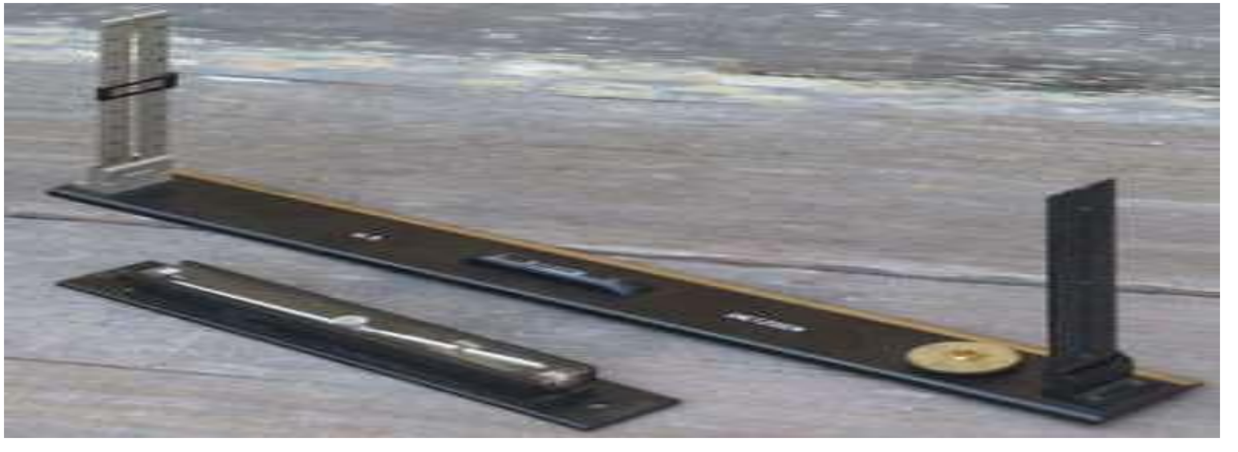
- The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground. The operation is known as centering the plane table. It is done by U-fork and plumb bob.
- For leveling the table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

ORIENTATION

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

BY MAGNETIC NEEDLE

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



BY BACK SIGHTING

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

METHODS OF PLANE TABLING

There are four distinct methods of plane tabling:

- Method of Radiation
- Method of Intersection
- Method of Traversing
- Method of Resection

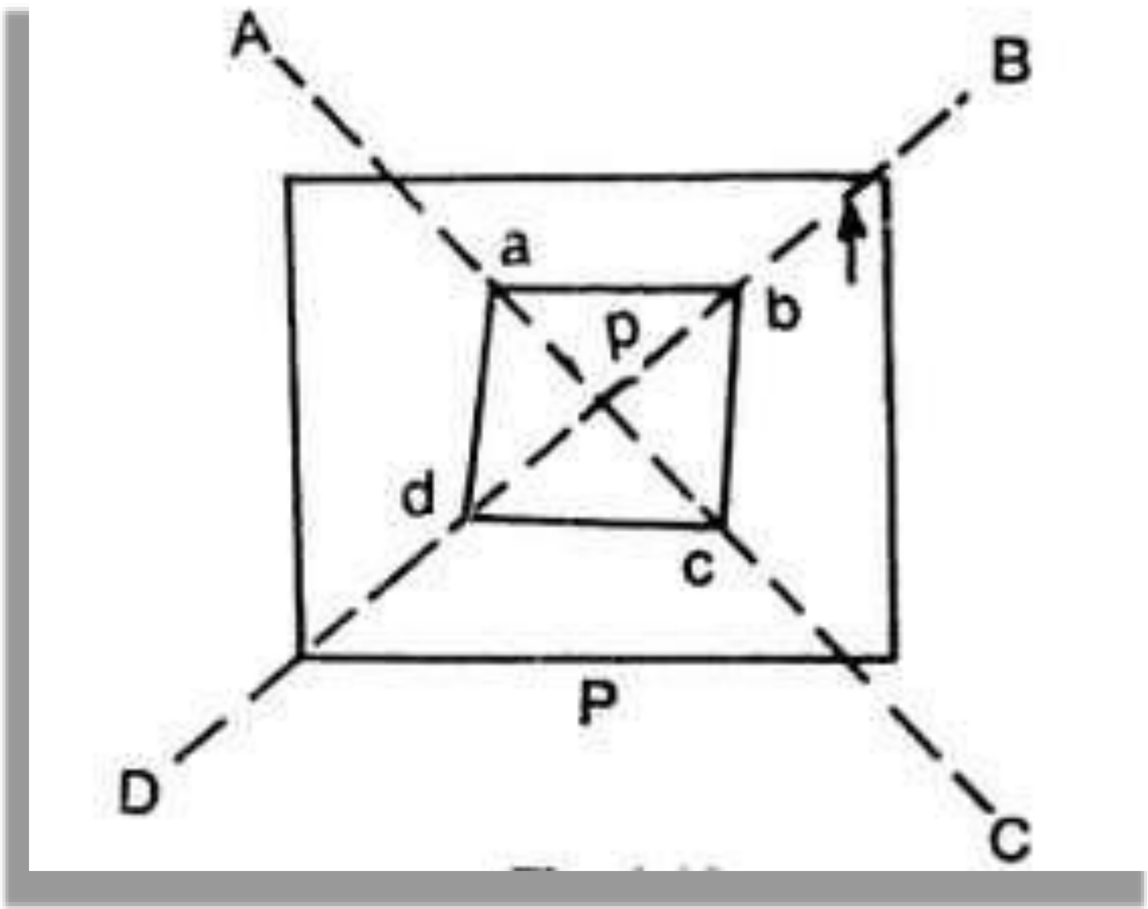
RADIATION METHOD

- In the radiation method of plane table surveying, the direction of the objects or points to be located are obtained by drawing radial lines along fiducially edge of alidade after getting the objects or points bisected along the line of sight of the alidade. The horizontal distances are then measured and scaled off on the corresponding radial lines to mark their positions on the drawing.

RADIATION METHOD

- Suppose P is a station on the ground from where the object A, B, C and D are visible.
- The plane table is set up over the station P. A drawing is fixed on the table, which is then leveled and centered. A point p is selected on the sheet to represent the station P.
- The north line is marked on the right-hand top corner of the sheet with trough compass or circular box compass.
- With the alidade touching p, the ranging rod at A,B, C and D are bisected and the rays are drawn.
- The distances PA, PB, PC and PD are measured and plotted to any suitable scale to obtain the points a, b, c and d representing A,B,C,D on paper.

RADIATION METHOD



METHOD OF INTERSECTION

- In intersection method of plane table surveying, the objects or points to be located are obtained at the point of intersection of radial lines drawn from two different stations.
- In this method, the plotting of plane table stations are to be carried out accurately. Checking is important and thus done by taking third sight from another station.
- The intersection method is suitable when distances of objects are large or cannot be measured properly. Thus, this method is preferred in small scale survey and for mountainous regions.

METHOD OF INTERSECTION

- Suppose A and B are two station and P is the object on the far bank of a river. Now it is required to fix the position of P on the sheet by the intersection of rays, drawn from A and B.
- The table is set up at A. It is leveled and centered so that a point a on the sheet is just over the station A. The north line is marked on the right-hand top corner, the Table is then clamped.
- With the alidade touching a, the object P and the ranging rod at B are bisected, and rays are drawn through the fiducially edge on alidade,

METHOD OF INTERSECTION

The distance AB is measured and plotted to any suitable scale to obtain point b.

The table is shifted and centered over B and leveled properly. Now the alidade is placed along the line ba and orientation is done by back sighting

With the alidade touching b, the object P is bisected and a ray is drawn, suppose this ray intersects the previous rays at point p. the point p is the required plotted position of P

THE THREE POINT PROBLEM

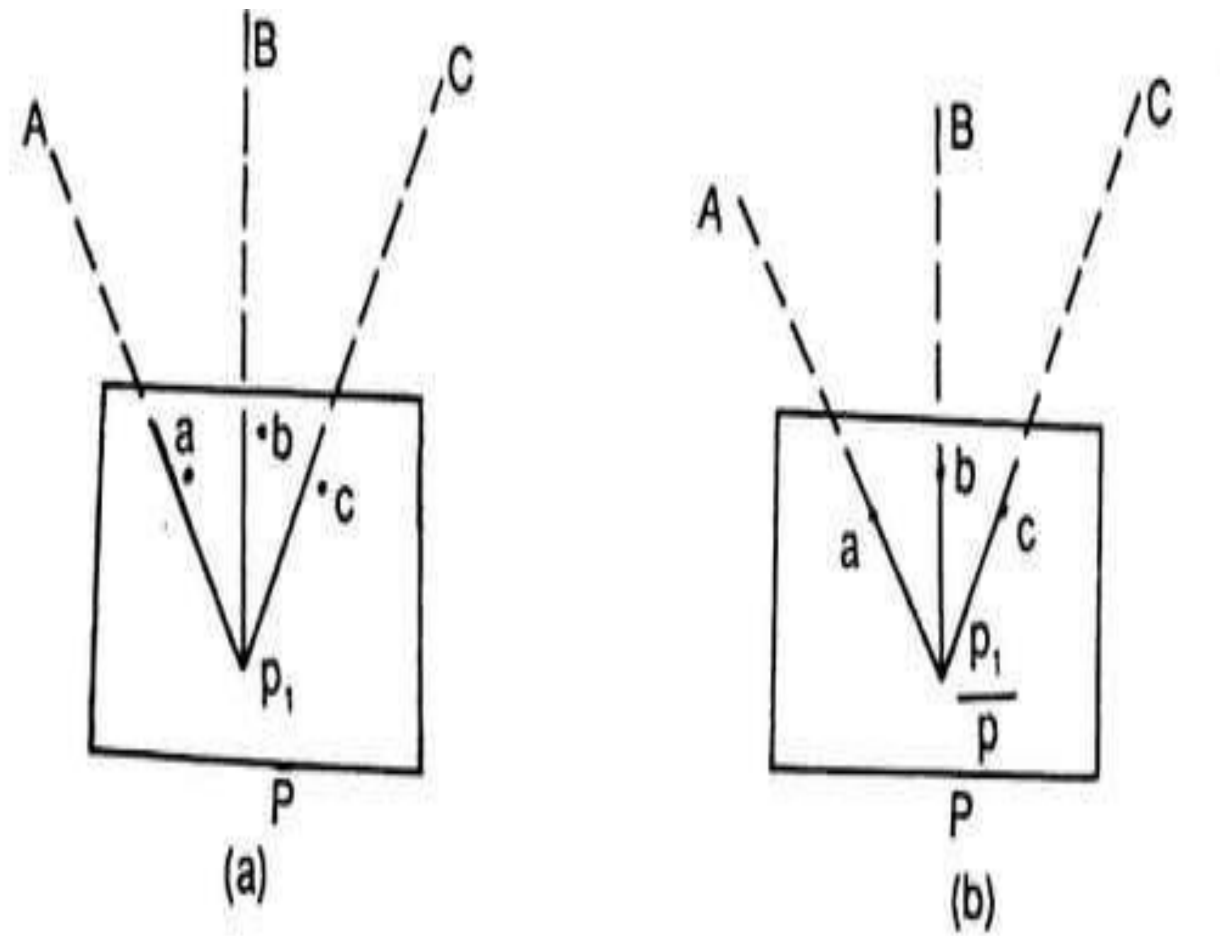
- Again the alidade is placed along the line ac and the point C is bisected and the table is clamped. With the alidade touching a, the point B is bisected and a ray is drawn. Suppose this ray intersects the previous ray at a point d
- The alidade is placed along db and the point B is bisected. At this position the table is said to be perfectly oriented. Now the rays Aa, Bb and Cc are drawn. These three rays must meet at a point p which is the required point on the map. This point is transferred to the ground by U-fork and plumb bob.

THE THREE POINT PROBLEM

The Mechanical Method

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

THE MECHANICAL METHOD



THE THREE POINT PROBLEM

- Now a tracing paper is unfastened and moved over the map in such a way that the three rays simultaneously pass through the plotted positions a, b and c. Then the points p is pricked with a pin to give an impression p on the map. P is the required points on the map. The tracing paper is then removed.
- Then the alidade is centered on p and the rays are drawn towards A, B and C. These rays must pass through the points a, b and c

THE THREE POINT PROBLEM

The method of Trial and error

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

Plane table survey equipment is arranged in 4 steps as follows

- **Fixing of Plane Table**
- Fix the plane table to the tripod stand. Arrange the drawing sheet on the plane table using paper clips or thumb screws. The sheet should be in one position from first to last.
- **Leveling of Plane Table**
- Plane table should be leveled using spirit level. For small works, eye estimation can be ok.

- **Centering of Plane Table**
- The table should be centered by using plumbing fork. By which we can arrange the plotted point exactly over the ground point.
- **Orientation of Plane Table**
- Whenever we are using more than one instrument station, orientation is essential. It can be done by using compass or back sighting. In this case, the plane table is rotated such that plotted lines in the drawing sheet are parallel to corresponding lines on the ground.

Methods of Plane Table Surveying

- Generally there are four methods are available to perform plane table surveying. They are
- Radiation
- Intersection
- Traversing
- Resection

Unit 2

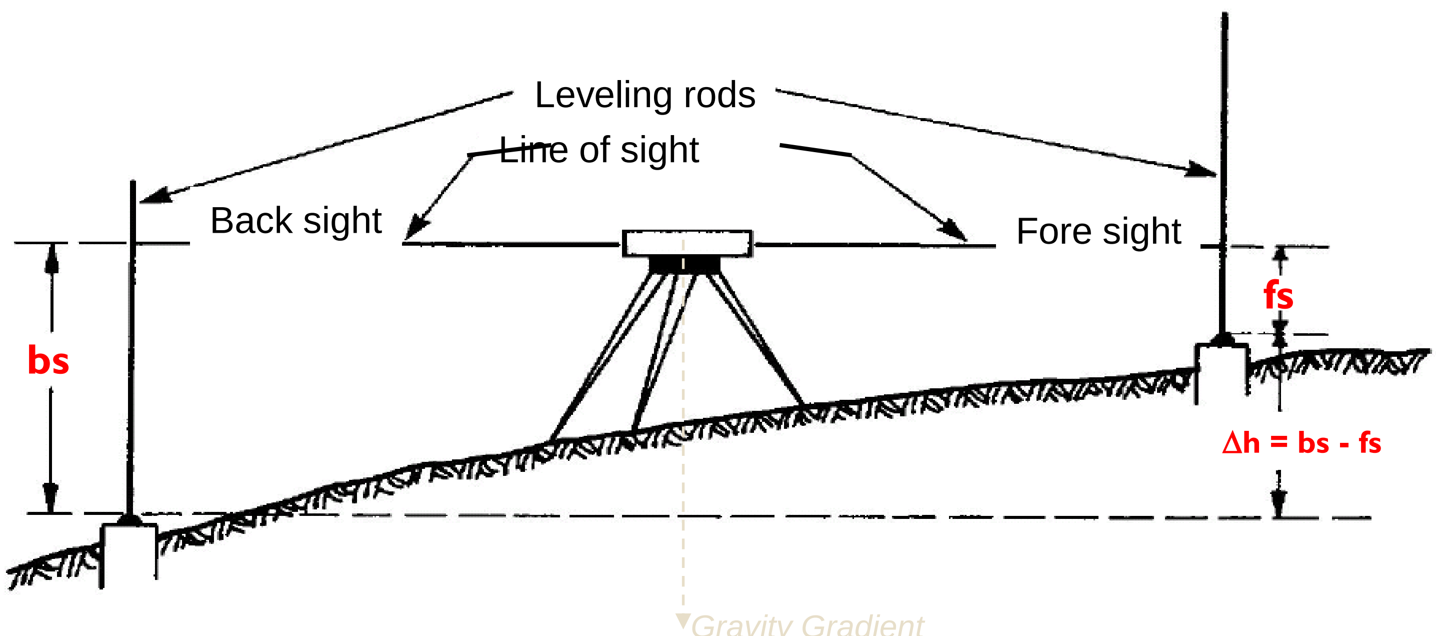
LEVELING
AND
CONTOURING

What is “Leveling?”

- Levelling is the process by which differences in height between two or more points can be determined.
- Leveling is a branch of surveying, the object of which is to find or establish the elevation of a given point with respect to the given or assumed Datum (reference point).
- Common leveling instruments include the spirit level, the dumpy level, the digital level, and the laser level.

Basic Principle of Leveling

- Measures height differences between points
  - Along a line
  - Several points from one occupation



Vertical line: A line that follows the local direction of gravity as indicated by a plumb line.

Level surface: A curved surface that, at every point is perpendicular to the local plumb line (the direction in which gravity acts).

Level line: A line in a level surface

Horizontal plane: A plane perpendicular to the local direction of gravity. In plane surveying, it is a plane perpendicular to the local vertical line.

- *Horizontal line*. A line in a horizontal plane. In plane surveying, it is a line
- perpendicular to the local vertical.
- *Vertical datum*. Any level surface to which elevations are referenced. This is the surface that is arbitrarily assigned an elevation of zero.
- Elevation. The distance measured along a vertical line from a vertical datum
- to a point or object.

Old Datum: Mean Sea Level

- Mean Sea Level (MSL)
- Average height over a 19-year period
- 26 gauging stations along the Atlantic Ocean, Pacific Ocean and the Gulf of Mexico

Devices are classified leveling in terms of accuracy into three categories

1Precision: the settlement where the bubble is very sensitive as are high magnification power and uses this type of work and Geodetic Survey businesses that require high precision.

2- Precision medium: It is less accurate than the first category and dominated the use of this type in most engineering projects.

3- low-precision devices: and make this kind of hardware specifically for the purposes of settlement approximate as in building projects Ltd. and settlement cases within short distance.

Definitions

Datum line (M.S.L.) :- Is the level (line), which are attributed to it points levels on the surface of the Earth. Which is the average sea level.

Reduced level (R.L) :- Is the high point from datum line. Benchmark (B .M) :- Are fixed points information site and attributed placed in different places until you start racing

them when conducting settlement .

Back sight (B.S.) :- Is the first reading taken after placing the device in any position so that we see the greatest possible number of points required to find the elevation .

Fore sight (F.S) :- Is the last reading taken before the transfer device

Leveling of the instrument is done to make the vertical axis of the instrument truly vertical. It is achieved by carrying out the following steps:

Step 1: The level tube is brought parallel to any two of the foot screws, by rotating the upper part of the instrument.

Step 2: The bubble is brought to the centre of the level tube by rotating both the foot screws either inward or outward. (The bubble moves in the same direction as the left thumb.)

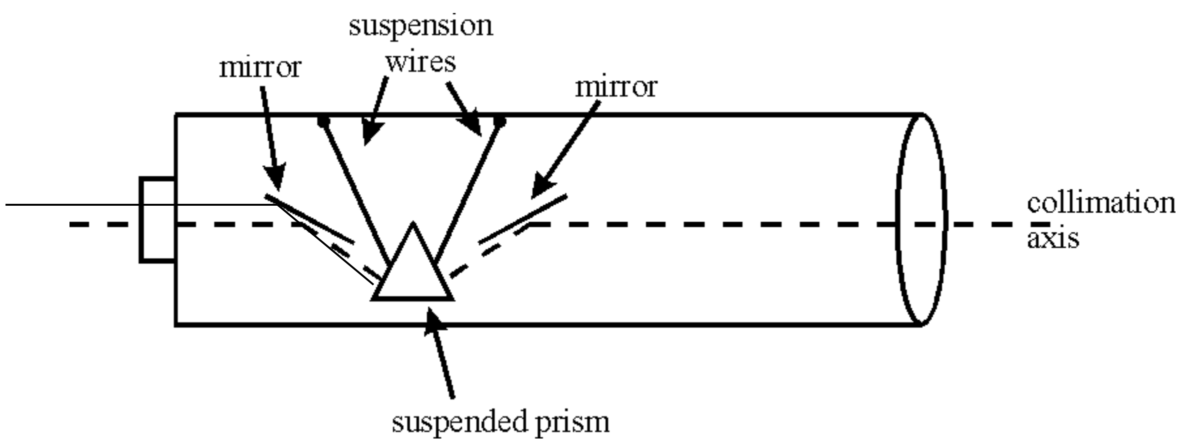
Step 3: The level tube is then brought over the third foot screw again by rotating the upper part of the instrument. Step 4: The bubble is then again brought to the centre of the level tube by rotating the third foot screw either inward or outward.

Leveling Errors

- There are a large number of potential sources of errors in leveling. Many of these are only significant for precise leveling over long distances. For the short segments of leveling that will occur in connecting a TGBM to nearby benchmarks there are only four worth mentioning:
- · Collimation Error
- · Error due to Earth Curvature
- · Error due to Parallax Error
- · Error due to Refraction

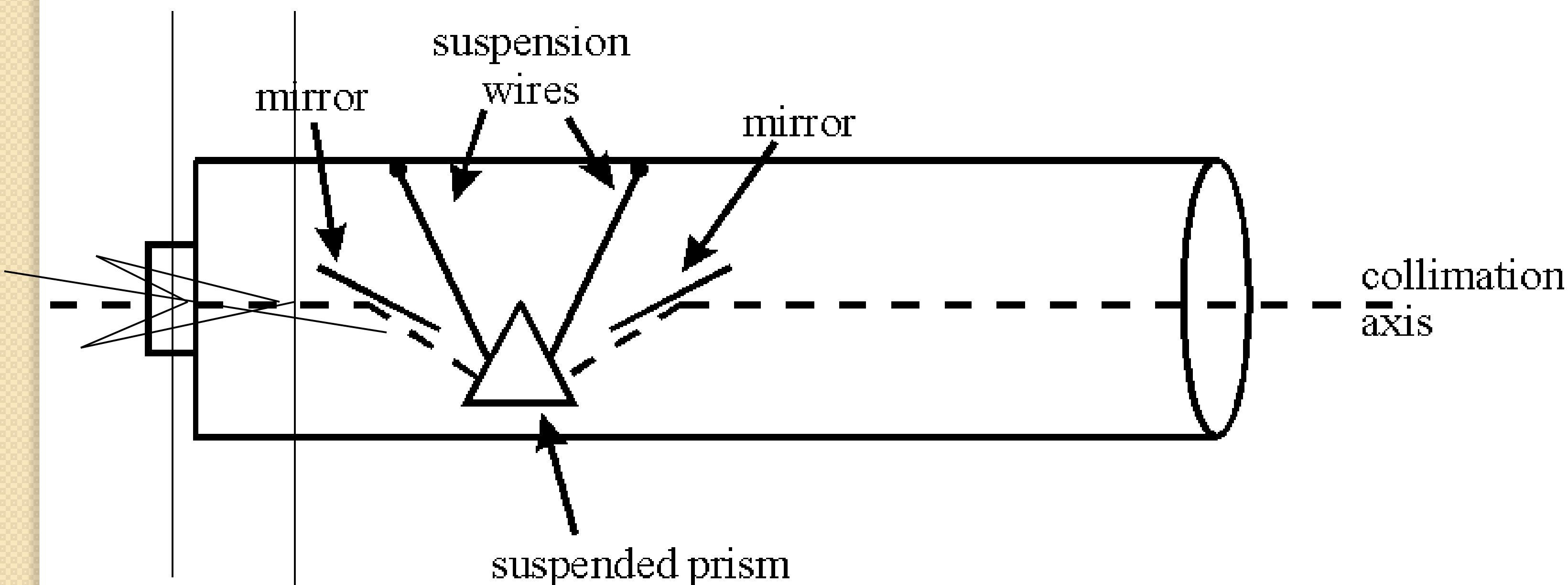
Collimation Error

- The Automatic Prism compensator goes out of alignment.
- The level provides readings outside of its specification



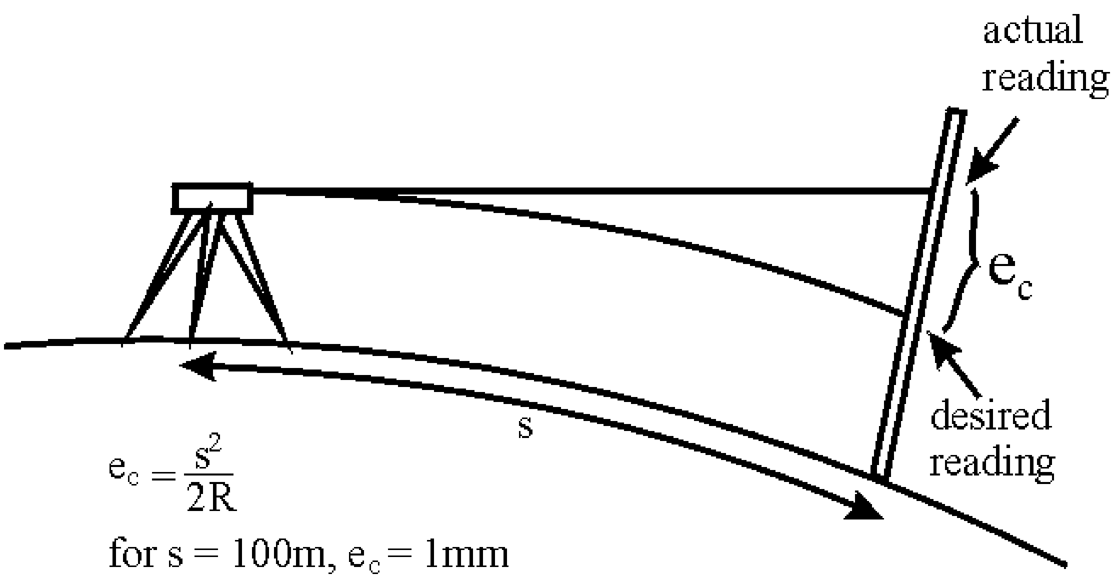
Parallax Error

- When using an optical instrument — both the image and cross hairs can be focused- if either is imprecisely focused, the cross hairs will appear to move with respect to the object focused, if one moves one's head horizontally in front of the eyepiece.



Curvature of the Earth

- Due to the curvature of the Earth, the line of sight at the instrument will deviate from a horizontal line as one moves away from the level



Contour: An imaginary line on the ground surface joining the points of equal elevation is known as contour.

In other words, contour is a line in which the ground surface is intersected by a level surface obtained by joining points of equal elevation. This line on the map represents a contour and is called contour line.

Contour Map

A map showing contour lines is known as Contour map.

A contour map gives an idea of the altitudes of the surface features as well as their relative positions in plan serves the purpose of both, a plan and a section.

PURPOSE OF CONTOURING

- Contour survey is carried out at the starting of any engineering project such as a road, a railway, a canal, a dam, a building etc.

i) For preparing contour maps in order to select the most economical or suitable site.

ii) To locate the alignment of a canal so that it should follow a ridge line.

iii) To mark the alignment of roads and railways so that the quantity of earthwork both in cutting and filling should be minimum.

CONTOUR INTERVAL

- The constant vertical distance between two consecutive contours is called the contour interval.

HORIZONTAL EQUIVALENT

The horizontal distance between any two adjacent contours is called as horizontal equivalent.

The contour interval is constant between the consecutive contours while the horizontal equivalent is variable and depends upon the slope of the ground.

FACTORS ON WHICH CONTOUR - INTERVAL DEPENDS

The contour interval depends upon the following factors:-

i) The Nature of the Ground In flat and uniformly sloping country, the contour interval is small , but in broken and mountainous region the contour interval should be large otherwise the contours will come too close to each other.

ii) The Purpose and extent of the survey. Contour interval is small if the area to be surveyed is small and the maps are required to be used for the design work or for determining the quantities of earth work etc. while wider interval shall have to be kept for large areas and comparatively less important works.

COMMON VALUES OF THE CONTOUR - INTERVAL

The following are the common values of the contour interval adopted for various purposes:-

i) For large scale maps of flat country, for building sites, for detailed design work and for calculation of quantities of earth work;

0.2 to 0.5 m.

COMMON VALUES OF THE CONTOUR - INTERVAL

ii) For reservoirs and town planning schemes; 0.5 to 2m.

iii) For location surveys. 2 to 3m.

iv) For small scale maps of broken country and general topographic work; 3m,5m,10m,or 25m.

CHARACTERISTICS OF CONTOURS

i) All points in a contour line have the same
elevation.

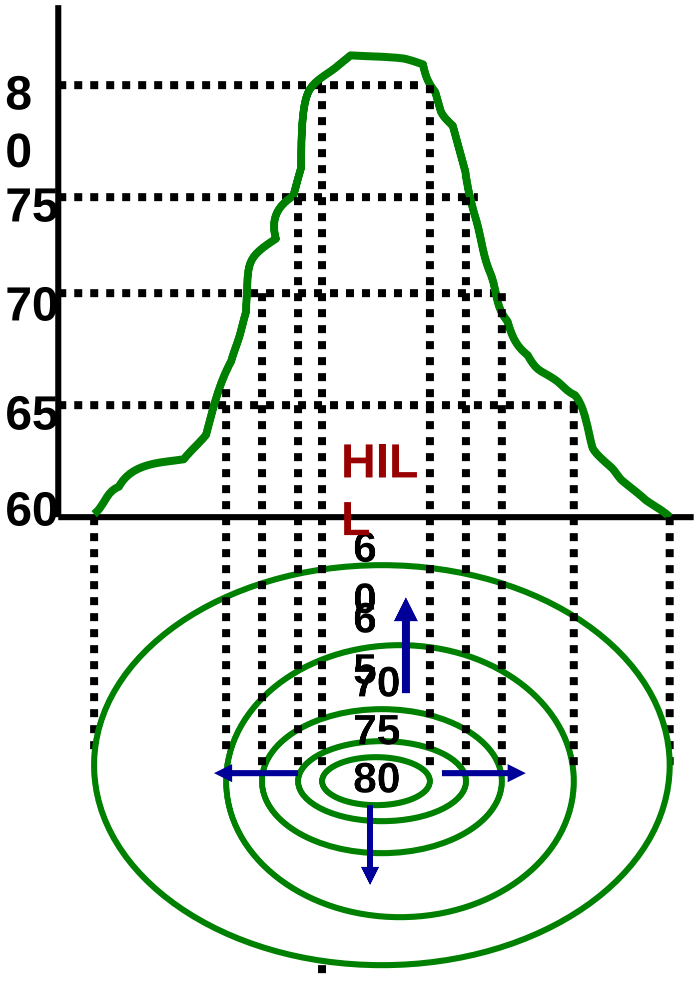
ii) Flat ground is indicated where the …contours are widely separated and steep-
slope where they run close together.

iii) A uniform slope is indicated when the
contour lines are uniformly spaced and

iv) A plane surface when they are straight,
parallel and equally spaced.

CHARACTERISTICS OF CONTOURS

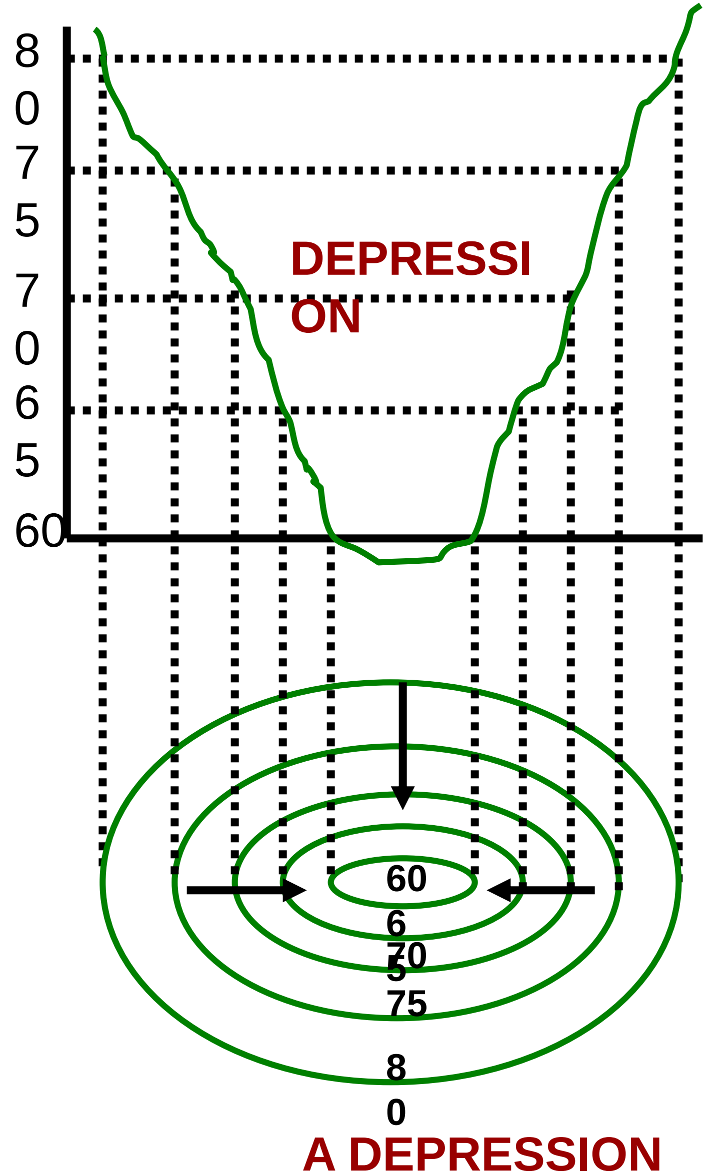
v) A series of closed contour lines on the map represent a hill , if the higher values are inside



A HILL

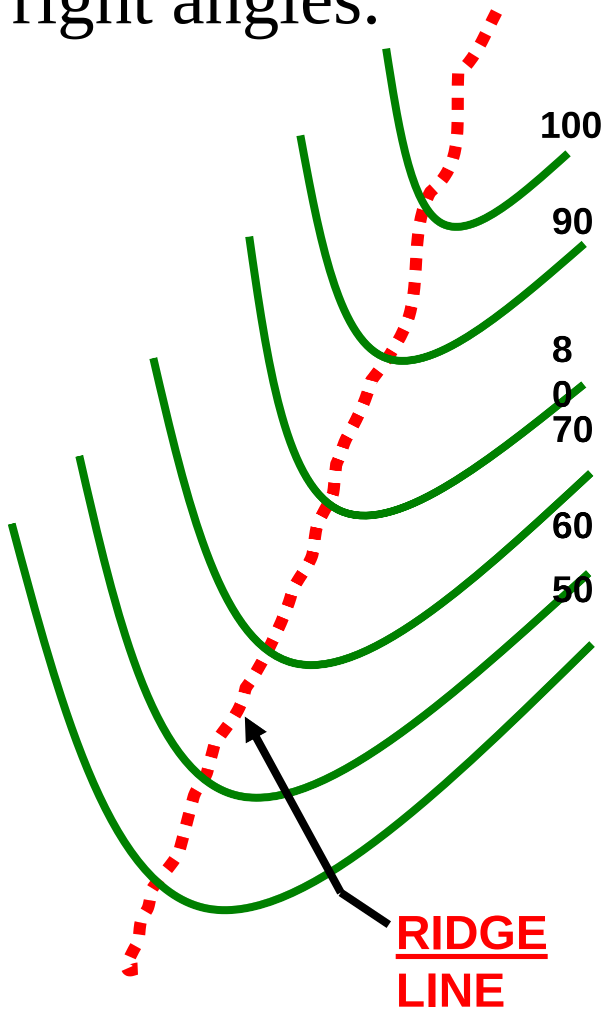
CHARACTERISTICS OF CONTOURS

vi) A series of closed contour lines on the map indicate a depression if the higher values are outside



CHARACTERISTICS OF CONTOURS

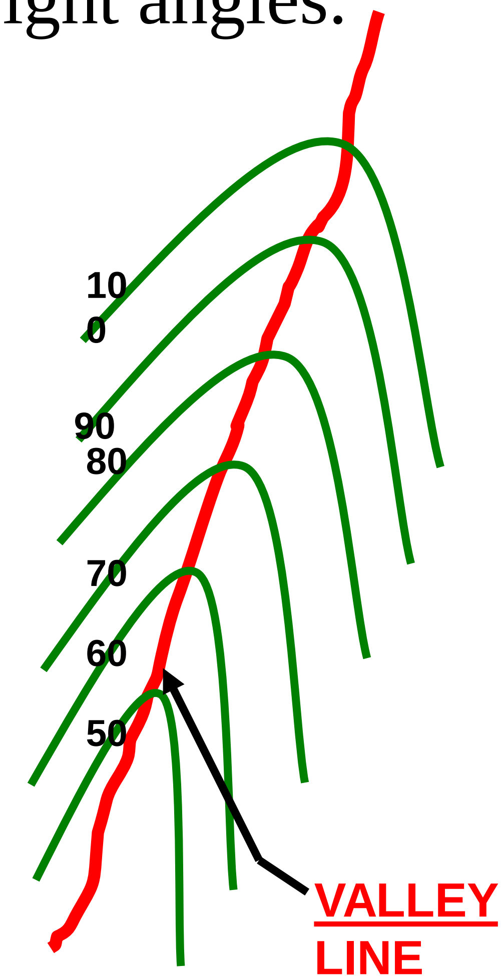
vii) Contour line cross ridge or valley line at right angles.



If the higher values are inside the bend or loop in the contour, it indicates a Ridge.

CHARACTERISTICS OF CONTOURS

vii) Contour line cross ridge or valley line at right angles.



If the higher values are outside the bend, it represents a Valley

CHARACTERISTICS OF CONTOURS

viii) Contours cannot end anywhere but close on themselves either within or outside the limits of the map.

Unit 3

COMPUTATION OF AREAS AND VOLUMES

COMPUTATION OF AREAS AND VOLUMES

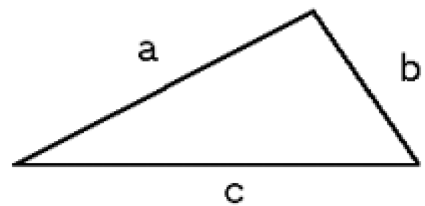
Introduction and methods

Introduction

Areas and Volumes are often required in the context of design, eg. we might need the surface area of a lake, the area of crops, of a car park or a roof, the volume of a dam embankment, or of a road cutting. Volumes are often calculated by integrating the area at regular intervals eg. along a road centre line, or by using regularly spaced contours. We simply use what you already know about numerical integration from numerical methods).

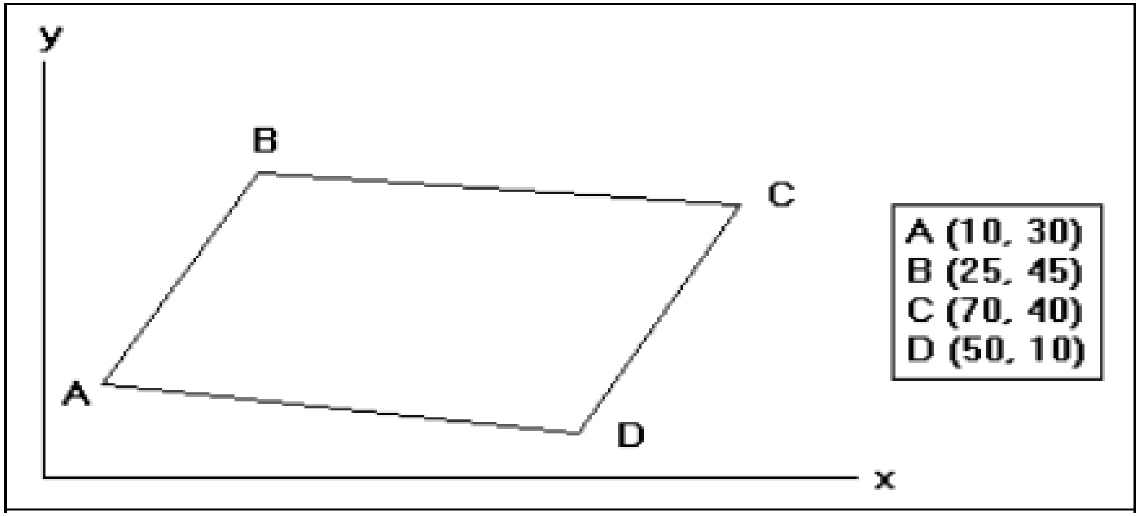
Objectives

After completing this topic you should be able to calculate the areas of polygons and irregular figures and the volumes of irregular and curved solids



Triangles if s = (a + b + c) / 2 then area = S.(S-a)(S-b)(S-c)

Calculating area of a polygon from Coordinates: If the coordinate points are numbered clockwise: area $= \frac{1}{2} \sum_{i=1}^{n} (N_i \cdot E_{i+1} - E_i \cdot N_{i+1})$ This formula is not easy to remember, so let's look at a practical application



Arrange the data in columns as shown below, repeating the last line at the top.

D	50	10
A	10	30
B	25	45
C	70	40
D	50	10

Diagram to go in here

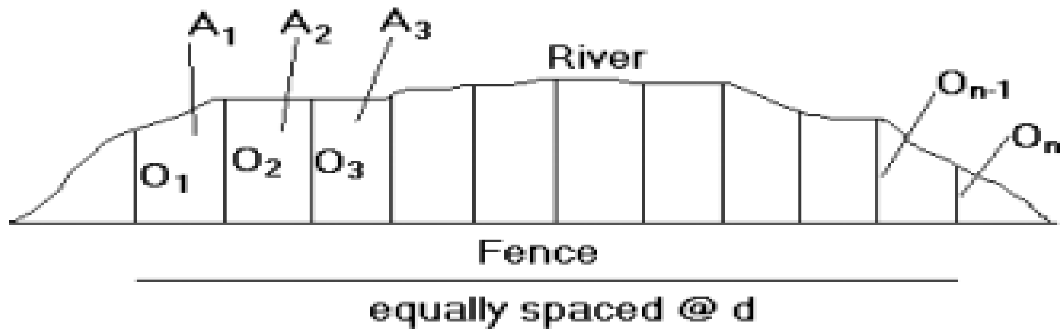
area = (1/2) x (10 x 10 + 25 x 30 + 45 x 70 + 40 x 50
– 50 x 30 - 10 x 45 - 25 x 40 - 70 x 10)
= 1175

COMPUTATION OF AREAS AND VOLUMES

The computation of volumes of various quantities from the measurements done in the field is required in the design and planning on many engineering works. The volume of earth work is required for suitable alignment of road works, canal and sewer lines, soil and water conservation works, farm pond and percolation pond consent. The computation of volume of various materials such as coal, gravel and is required to check the stock files, volume computations are also required for estimation of capacities of bins tanks etc.

Calculating areas with the Trapezoidal Rule

(as used in integrating functions)



$$A_1 = d\ .\ (O_1 + O_2)\ /\ 2$$
$$A_2 = d\ .\ (O_2 + O_3)\ /\ 2$$
$$A_3 = d\ .\ (O_3 + O_4)\ /\ 2$$

Hence, the total area is:

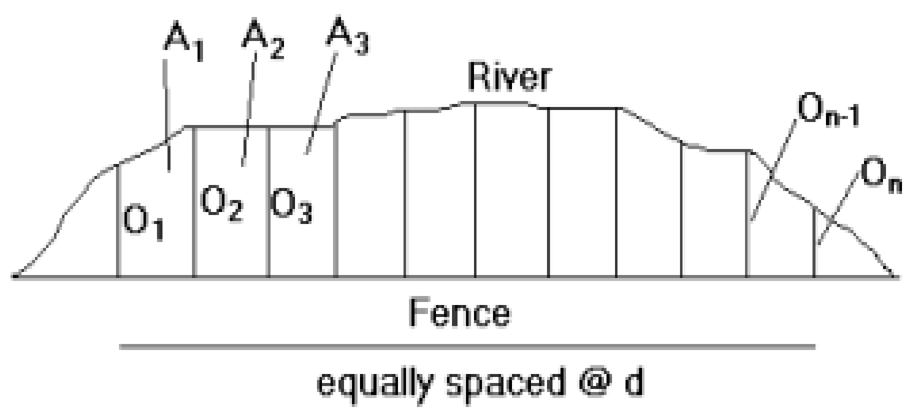
$$A = (d/2)\ .\ [O_1 + 2.O_2 + 2.O_3 + \ldots + 2.O_{n-1} + O_n]$$

The Trapezoidal Rule assumes **straight line segments** on the boundary.

Doing better with Simpson's Rule

Simpson's Rule assumes a parabola fitted to 3 adjacent points, rather than the straight lines between adjacent points assumed by the Trapezoidal Rule.

This may be more accurate than the Trapezoidal Rule because boundaries are often curved.

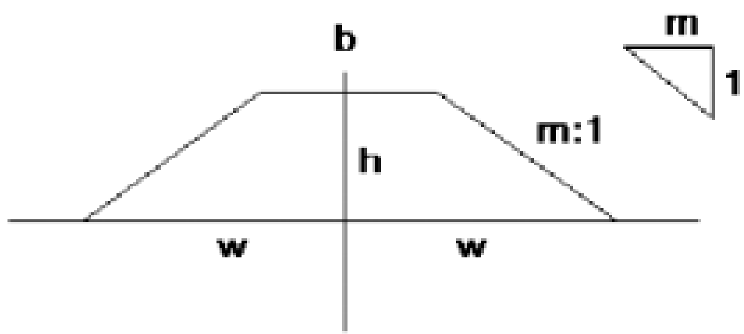


Volumes can be calculated in a number of ways. It is common to calculate the area of each of several equally spaced slices (either vertical cross-sections, or horizontal contours), and integrate these using Simpson's Rule or similar. A second method is to use spot levels, and calculate the volume of a series of wedges or square cells

Cross-sections are well suited for calculating volumes of roads, pipelines, channels, dam embankments, etc. Formulae are given below for the most common cross-section cases.

Horizontal ground

Man-made structures usually have constant side slopes : eg (simple case)



$w = b/2 + m.h$

\ Area $= h\ .\ [\ 2.w + b\ ]\ /\ 2 \quad = h.(b + m.h)$

Computation of area using different methods

1. The following offsets were taken from a chain line to an irregular boundary line at an interval of 10 m. 0, 2.50, 3.50, 5.00, 4.60, 3.20, 0 m. Compute the area between the chain line, the irregular boundary line and the end offsets by:

   (a) Trapezoidal Rule

   (b) Simpson's Rule

(a) Trapezoidal Rule

Here d = 10

$$\text{Area} = \frac{10}{2}\{0+0+2(2.50+3.50+5.00+4.60+3.20)\} = 5 * 37.60 = \mathbf{188\ m^2}$$

(b) Simpson's Rule

D = 10

$$\text{Area} = \frac{10}{3}\{0+0+4(2.50+5.00+3.20)+2(3.50+4.60)\} = \frac{10}{3} * 59.00 = \mathbf{196.66\ m^2}$$

2. The following offsets were taken from a survey line to a curved boundary line:

Distance (m)	0	5	10	15	20	30	40	60	80
Offset (m)	2.50	3.80	4.60	5.20	6.10	4.70	5.80	3.90	2.20

Find the area between the survey line, the curved boundary line and the first and last offsets by (a) Trapezoidal Rule and (b) Simpson's Rule.

Here, the intervals between the offsets are not regular throughout the length. Soothe section is divided into three compartments.

Let,

Δ_1 = Area of the 1st section

Δ_2 = Are of the 2nd section

Δ_3 = Area of the 3rd section

Here,

$d_1 = 5$ m

$d_2 = 10$ m

$d_3 = 20$ m

(a) Trapezoidal Rule:

$$\Delta_1 = \frac{5}{2}\{2.50 + 6.10 + 2(3.80 + 4.60 + 5.20)\} = 89.50 \text{ m}^2$$

$$\Delta_2 = \frac{10}{2}\{6.10 + 5.80 + 2(4.70)\} = 106.50 \text{ m}^2$$

$$\Delta_3 = \frac{20}{2}\{5.80 + 2.20 + 2(3.90)\} = 158.00 \text{ m}^2$$

Total Area = 89.50 + 106.50 + 158.00 = **354.00 m²**

(b) By Simpson's Rule

$$\Delta_1 = \frac{5}{3}\{2.50 + 6.10 + 4(3.80 + 5.20) + 2(4.60)\} = 89.66 \text{ m}^2$$

$$\Delta_2 = \frac{10}{3}\{6.10 + 5.80 + 4.70\} = 102.33 \text{ m}^2$$

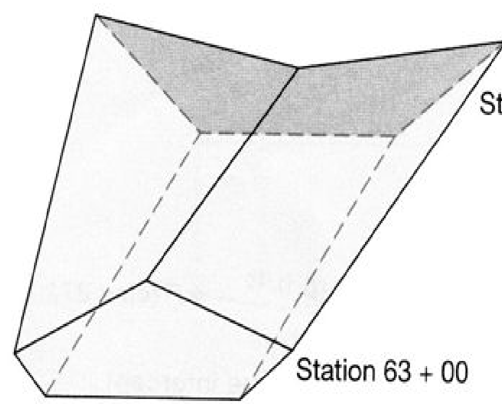
$$\Delta_3 = \frac{20}{3}\{5.80 + 2.20 + 4(3.90)\} = 157.33 \text{ m}^2$$

Total area = 89.66 + 102.33 + 157.33 = **349.32 m²**

Prismoidal Method

- The prismoidal formula applies to volumes of all geometric solids that can be considered prismoids.

$$V = \frac{2d}{6}\left[A_1 + A_n + 4\left(A_2 + A_4 + \dots + A_{n-2}\right) + 2\left(A_3 + A_5 + \dots + A_{n-1}\right)\right]$$



Simpson's rule

In this rule, the boundaries between the ends of ordinates are assumed to form an arc of a parabola. Hence Simpson's rule is sometimes called the parabolic rule.

Refer to Fig. 7.13.

Let

O_1, O_2, O_3 = three consecutive ordinates

d = common distance between the ordinates

Area AFeDC = area of trapezium AFDC + area of segment FeDEF

Simpson's Rule

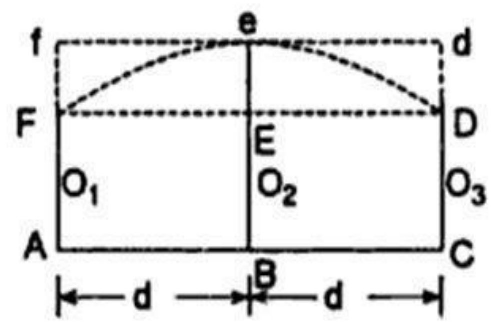


Fig. 7.13

Here,

$$\text{Area of trapezium} = \frac{O_1 + O_3}{2} \times 2d$$

$$\text{Area of segment} = \frac{2}{3} \times \text{area of parallelogram FfdD}$$

$$= \frac{2}{3} \times \text{Ee} \times 2d = \frac{2}{3} \times \left\{O_2 - \frac{O_1 + O_3}{2}\right\} \times 2d$$

Trapezoidal rule

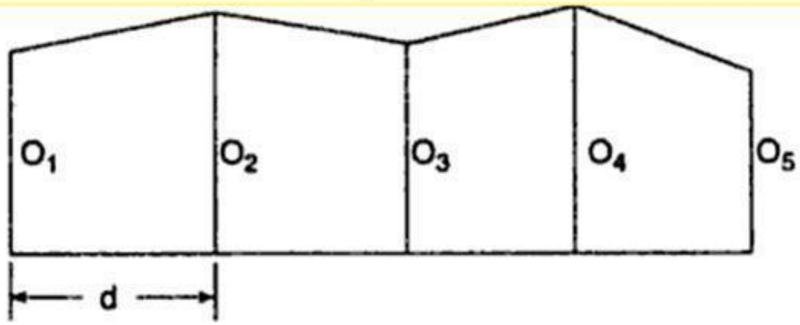


Fig. 7.12

Let $O_1, O_2, \ldots, O_n$ = ordinates at equal intervals

d = common distance

$$\text{1st area} = \frac{O_1 + O_2}{2} \times d$$

$$\text{2nd area} = \frac{O_2 + O_3}{2} \times d$$

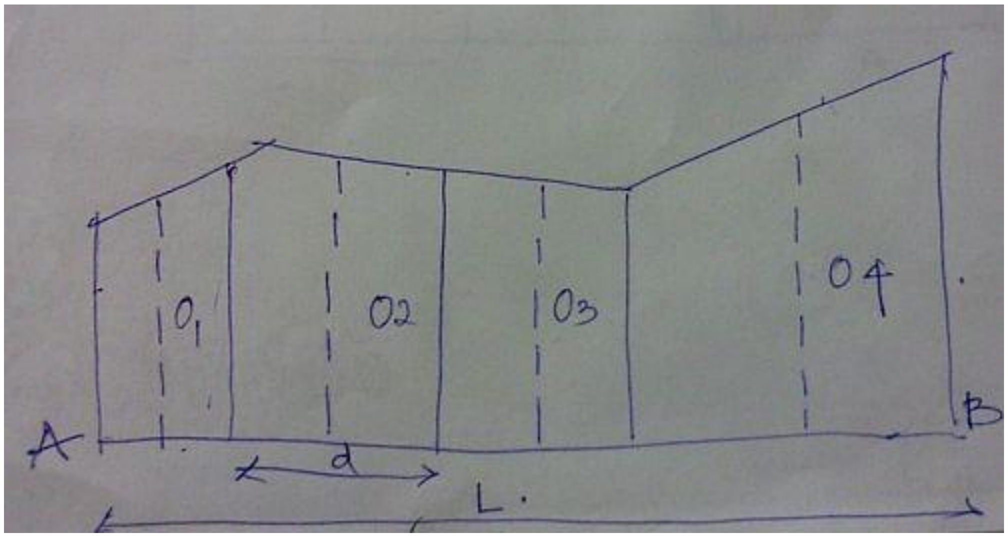
$$\text{3rd area} = \frac{O_3 + O_4}{2} \times d$$

$$\text{Last area} = \frac{O_{n-1} + O_n}{2} \times d$$

$$\text{Total area} = \frac{d}{2}\{O_1 + 2O_1 + 2O_2 + \ldots + 2O_{n-1} + O_n\}$$

$$= \frac{\text{common distance}}{2}\{(\text{1st ordinate} + \text{last ordinate} + 2\ (\text{sum of other ordinate})\}$$

Computation of area using different methods



Midpoint-ordinate rule

The rule states that if the sum of all the ordinates taken at midpoints of each division multiplied by the length of the base line having the ordinates (9 divided by number of equal parts).

Problems

The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line. The ordinates are measured at midpoint of the division are 10, 13, 17, 16, 19, 21, 20 and 18m. Calculate the are enclosed by the midpoint ordinate rule.

Given:

Ordinates

O1 = 10

O2 = 13

O3 = 17

O4 = 16

O5 = 19

O6 = 21

O7 = 20

O8 = 18

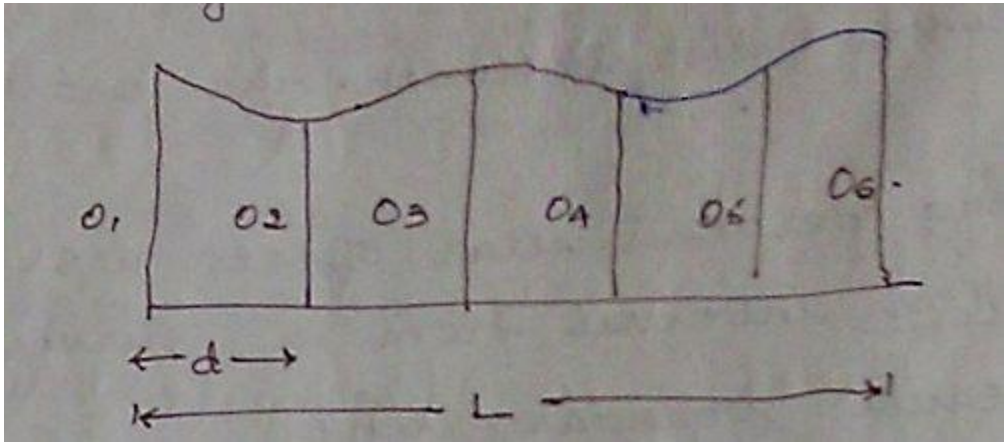
Common distance, d =10m

Number of equal parts of the baseline, n = 8

Length of baseline, L = n *d = 8*10 = 80m

Area = [(10+13+17+16+19+21+20+18)*80]/8

Average Ordinate Rule



Average Ordinate Rule

The rule states that (to the average of all the ordinates taken at each of the division of equal length multiplies by baseline length divided by number of ordinates).

Problems

The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line.

9, 12, 17, 15, 19, 21, 24, 22, 18

Calculate area enclosed between the survey line and irregular boundary line.

Area = [(O1+ O2+ O3+ …. + O9)*L]/(n+1)

=

[(9+12+17+15+19+21+24+22+18)*8*10]/(8+1)

= 139538sqm

Simpson's Rule Statement

It states that, sum of first and last ordinates has to be done. Add twice the sum of remaining odd ordinates and four times the sum of remaining even ordinates. Multiply to this total sum by 1/3rd of the common distance between the ordinates which gives the required area.

Problem

Chainage	0	25	50	75	100	125	150
Offset 'm'	3.6	5.0	6.5	5.5	7.3	6.0	4.0

The following offsets are taken from a chain line to an irregular boundary towards right side of the chain line.

Common distance, d = 25m

Area = $d/3[(O_1+O_7) + 2\ (O_3+O_5)+4(O_2+O4+O_6)]$

$= 25/3[(3.6+4)+2(6.5+7.3)+4(5+5.5+6)]$

Area = 843.33sqm

COMPUTATION OF VOLUMES

- The computation of volumes of various quantities from the measurements done in the field is required in the design and planning on many engineering works. The volume of earth work is required for suitable alignment of road works, canal and sewer lines, soil and water conservation works, farm pond and percolation pond consent. The computation of volume of various materials such as coal, gravel and is required to check the stock files, volume computations are also required for estimation of capacities of bins tanks etc.

COMPUTATION OF VOLUMES

- For estimation of volume of earth work cross sections are taken at right angles to a fixed line, which runs continuously through the earth work. The spacing of the cross sections will depend upon the accuracy required. The volume of earth work is computed once the various cross-sections are known, adopting Prismoidal rule and trapezoidal rule

Problem

1.Compute the cost of earth work involved in cutting open a trench of following size. Length 200 m, side slope 2: 1, depth of trench 4 m, bottom, width of trench 1.5 m. Cost of earth work Rs. 50 per m3 . Cross sectional area of trench, A = (b + sh)*h

A = (1.5 + 2*4)*4 A = 9.5 * 4 = 38 m2

∴ Volume of earth work, V = A*L = 38 * 200 = 7600 m3

∴ Cost of earth work = 7600 * 50 = Rs. 3,80,000.00

Problem

Compute the volume of earth work involved in constructing a farm pond of the following size: size, at bottom 6 x 4 m. Side slope 2: 1, depth of pond 4 m work out the cost of earth work also if it costs Rs. 50 per cubic metre.

Size of pond at bottom = 6 x 4 m

Area at bottom = 24 m^2 (a_1)

Size of pond at ground level:

Length of pond = 6 + 8 + 8 = 22 m

Breadth of pond = 4 + 8 + 8 = 20 m

Cross sectional area of pond at ground level = 20 * 22 = 440 m^2 (a_3)

Area of pond at mid height = $\frac{(22+6)}{2} * \frac{(20+4)}{2} = 14 * 12 = 168\, m^2$ (a_2)

Using prismoidal rule, $V = \frac{D}{2}[a_2 + a_3 + 2(a_2)]$

$$V = \frac{D}{2}[24 + 440 + 2(168)]$$

$$V = \frac{2}{2}[464 + 336] = 800\ m^3$$

∴ Cost of earth work = 50 * 800 = **Rs. 40, 000**

A level section, two level section and respective problems

Measurement of Volume of Earth work from Cross-Sections:

The length of the project along the centre line is divided into a series of solids known as prismoids by the planes of cross-sections. The spacing of the sections should depend upon the character of ground and the accuracy required in measurement.

They are generally run at 20m or 30m intervals, but sections should also be taken at points of change from cutting to filling, if these are known, and at places where a marked change of slop occurs either longitudinally or transversely.

The areas of the cross-sections which have been taken are first calculated and the volumes of the prismoids between successive cross- sections are then obtained by using the Trapezoidal formula or the prismoidal formula. The former is used in the preliminary estimates and for ordinary results, while the latter is employed in the final estimates and for precise results.

Formulae for Areas of Cross-Sections:

- The following are the various cross-sections usually met with whose areas are to be computed:
- 1. Level section.
- 2. Two-level section.
- 3. Side-hill two-level section.
- 4. Three-level section.
- 5. Multi-level section.

Level section

1. Level-Section (Fig. 12.2):

In this case the ground is level transversely.

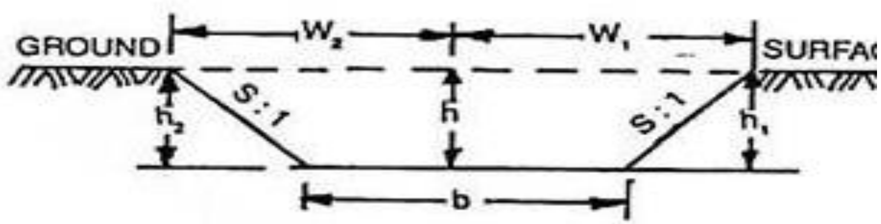


Fig. 12.2

$$h_1 = h_2 = h$$
$$w_1 = w_2$$
$$= \frac{b}{2} + sh$$
$$A = \tfrac{1}{2}[b + (b + 2sh)]h$$
$$= (b + sh)\,h \quad \ldots \quad \ldots \quad \ldots$$

Two level section

2. Two-Level Section (Fig. 12.1):

In this case, the ground is sloping transversely, but the slope of the ground does not intersect the formation level.

$$w_1 = \frac{b}{2} + \frac{rs}{r-s}\left(h + \frac{b}{2r}\right)$$

$$w_2 = \frac{b}{2} + \frac{rs}{(r+s)}\left(h - \frac{b}{2r}\right)$$

$$h_1 = h + \frac{w_1}{r}$$

$$h_2 = h - \frac{w_2}{r}$$

$$A = \frac{1}{2}\left[(w_1 + w_2)\left(h + \frac{b}{2s}\right) - \frac{b^2}{2s}\right]$$

$$= \left[\frac{s(\frac{b}{2})^2 + r^2bh + r^2sh^2}{(r^2 - s^2)}\right] \quad \ldots \quad \ldots \quad \text{(Eqn. 12.2)}$$

A level section, two level section and respective problems

4. Three-Level Section (Fig. 12.4):

In this case, the transverse slope of the ground is not uniform.

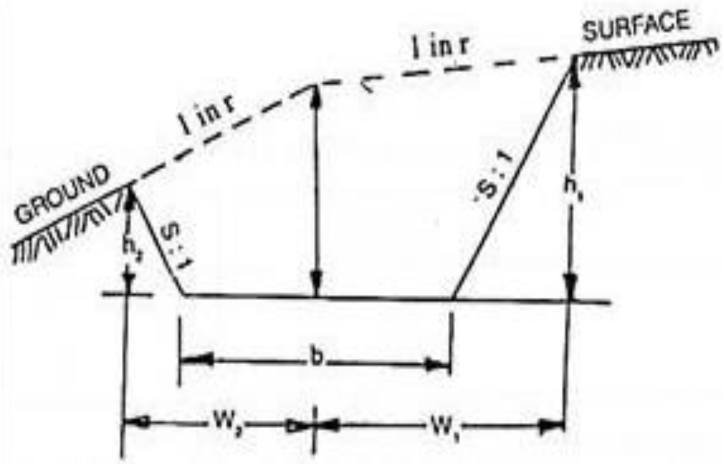


Fig. 12.4

$$w_1 = \frac{r_1 s}{(r_1 - s)}\left(h + \frac{b}{rs}\right)$$

$$w_2 = \frac{r_2 s}{(r_2 + s)}\left(h + \frac{b}{2s}\right)$$

The formulae for w_1 and w_2 may apply to both side widths according as the ground rises or falls from the centre to both sides.

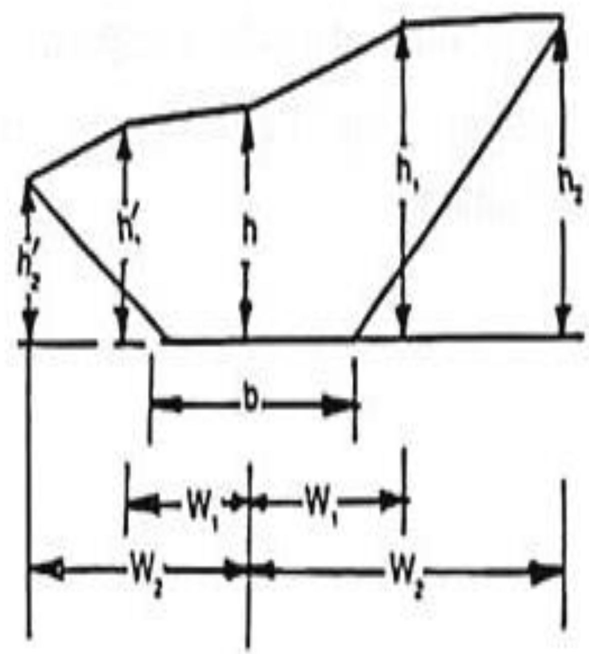
$$h_1 = \left(h + \frac{w_1}{r_1}\right)$$

$$h_2 = \left(h - \frac{w_2}{r_2}\right)$$

$$A = \left[\frac{1}{2}h(w_1 + w_2) + \frac{b}{4}(h_1 + h_2)\right] \quad \ldots \quad \ldots \quad \text{(Eqn. 12.5}$$

5. Multi-Level Section (Fig. 12.5):

In this case, the transverse slope of the ground is not uniform but-has multiple cross-slopes as is clear from the figure.



The notes regarding the cross-section are recorded as follows:

Left	*Centre*	*Right*
$\frac{\pm h'_2}{w'_2}\ \frac{\pm h'_1}{w'_1}$	$\frac{\pm h}{0}$	$\frac{\pm h_1}{w_1}\ \frac{\pm h_2}{w_2}$

The numerator denotes cutting (+ve) or filling (-ve) at the various points, and the denominator their horizontal distances from the centre line of the-section. The area of the section is calculated from these notes by coordinate method. The co-ordinates may be written in the determinant form irrespective of the signs.

$$\frac{o}{b/2} \times \frac{h'_2}{w'_2} \times \frac{h'_1}{w'_1} \times \frac{h}{o} \times \frac{h_1}{w_1} \times \frac{h_2}{w_2} \times \frac{o}{b/2}$$

Formula

Let Σ F= sum of the product of the co-ordinates joined by full lines.

Σ D= sum of the products of the co-ordinates joined by dotted lines.

Then, A= 1/2 (ΣF- ΣD)

Unit 4

THEODOLITE
AND
TRAVERSE SURVEYING

THEODOLITE AND TRAVERSE SURVEYING:-

Types of Theodolites

- There are two different kinds of theodolites: digital and non digital. Non digital theodolites are rarely used anymore. Digital theodolites consist of a telescope that is mounted on a base, as well as an electronic readout screen that is used to display horizontal and vertical angles. Digital theodolites are convenient because the digital readouts take the place of traditional graduated circles and this creates more accurate readings.

Theodolite

- Theodolites are mainly used for surveying, but they are also useful in these applications:
- Navigating
- Meteorology
- Laying out building corners and lines
- Measuring and laying out angles and straight lines
- Aligning wood frame walls
- Forming panels
- Plumbing a column or building corner

Surveying

Terminology of Theodolite

- It is important to clearly understand the terms associated with the theodolite and its use and meaning. The following are some important terms and their definitions.
- **Vertical axis** It is a line passing through the centre of the horizontal circle
and perpendicular to it. The vertical axis is perpendicular to the line of sight and the trunnion axis or the horizontal axis. The instrument is rotated about this axis for sighting different points

- **Horizontal axis** It is the axis about which the telescope rotates when rotated in a vertical plane. This axis is perpendicular to the line of collimation and the verti-cal axis.
- **Telescope axis** It is the line joining the optical centre of the object glass to the centre of the eyepiece

- **Line of collimation** It is the line joining the intersection of the cross hairs to the optical centre of the object glass and its continuation. This is also called the line of sight.
- **Axis of the bubble tube** It is the line tangential to the longitudinal curve of the bubble tube at its centre

- **Centring** Centring the theodolite means setting up the theodolite exactly over the station mark. At this position the plumb bob attached to the base of the instrument lies exactly over the station mark.

- **Transiting** It is the process of rotating the telescope about the horizontal axis through 180 o . The telescope points in the opposite direction after transiting. This process is also known as *plunging* or *reversing*.

- **Swinging** It is the process of rotating the telescope about the vertical axis for the purpose of pointing the telescope in different directions. The right swing is a rotation in the clockwise direction and the left swing is a rotation in the counter-clockwise direction.
- **Face-left or normal position** This is the position in which as the sighting is done, the vertical circle is to the left of the observer.

- **Face-right or inverted position** This is the position in which as the sighting is done, the vertical circle is to the right of the observer.

- **Changing face** It is the operation of changing from face left to face right and vice versa. This is done by transiting the telescope and swinging it through 180 o .

- **Face-left observation** It is the reading taken when the instrument is in the normal or face-left position.

- **Face-right observation** It is the reading taken when the instrument is in the inverted or face-right position

Problems on Trigonometric leveling

Surveying

- **Case 1)**
  Determination of elevation of object when the base is accessible the object is Vertical
  It is assumed that the horizontal distance between the instrument and the object can be measured accurately. In Fig. 1, let B = instrument station F = point to be observed
  = center of the instrument AF = vertical object D = CE
  = horizontal distance 1
  = height of the instrument at Bh = height FES = reading on the levelling staff held vertical on the Bench Mark (B.M)
  = angle of elevation of the top of the object
  so, H=D tan z

Surveying

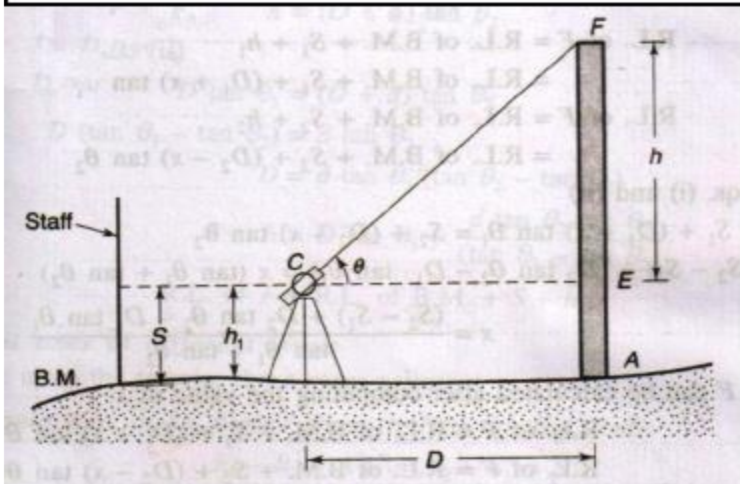


Fig. 1

R.L of F= R.L of B.M. + h + D tan z

Corrections for curvature and refraction

C =0.06735(D*D) so the true R.L is R.L of B.M. + h +D tanz + C

Surveying

- If the both the angle of depression and elevation are given to us then we can directly find the height of the whole building.
- Let us assume the angle of elevation is z1 and angle of depression is z2 and the object is accessible and the distance between instrument and foot of building is D
- then,

$$\text{Height of building} = D \tan z1 + D \tan z2$$

Surveying

- Case 2

Base of the object is not accessible

Case 2. Base of the object inaccessible, Instrument stations in the vertical plane as the elevated object.

(a) Instrument axes at the same level

Δ PA'P', h= D tan α1

Δ PB'P', h= (b+D) tan α2

D tan α1 = (b+D) tan α2

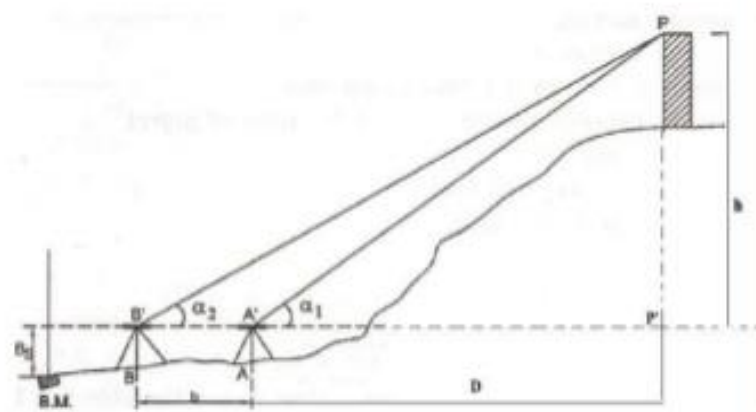
D tan α1 = b tan α2 + D tan α2

D(tan α1 - tan α2) = b tan α2

$$D = \frac{b \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$$

$$h = \frac{b \tan \alpha_2 . \tan \alpha_2}{(\tan \alpha_1 - \tan \alpha_2)}$$

R.L of P = R.L of B.M + Bs + h



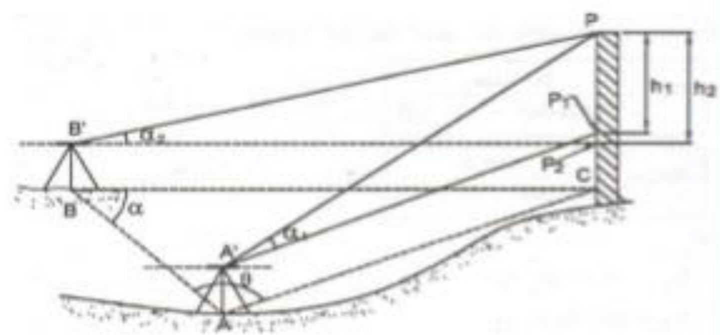
Surveying

- **Base of the object is not accessible**

Case 3. Base of the object inaccessible, Instrument stations not in the same vertical plane as the elevated object.

Set up instrument on A
Measure $\alpha 1$ to P
$\angle BAC = \theta$

Set up instrument on B
Measure $\alpha 2$ to P
$\angle ABC = \alpha$



$\angle ACB = 180 - (\theta + \alpha)$

Sin Rule:

BC=	$\dfrac{b \cdot \sin\theta}{\sin\{180^\circ - (\theta + \alpha)\}}$
AC=	$\dfrac{b \cdot \sin\alpha}{\sin\{180^\circ - (\theta + \alpha}$

$h1 = AC \tan \alpha 1$

$h2 = BC \tan \alpha 2$

Problems on Trigonometric leveling

Surveying

- **Principles**
- Trigonometric leveling is so named because it uses a total station instrument's (TSI) slope distance and zenith angle meeasurements to mathematically compute an elevation difference which, with a few more bits of information, can be used to determine a point's elevation. Using appropriate procedures, and controlling errors, elevation accuraciy can be better than 0.1 ft. Because trigonometric leveling is not limited to a horizontal line of sight, it is more flexible and provides faster elevation data collection than differential leveling.

Surveying

- **Base of the object is not accessible**
- The instrument stations and the elevated object not in the same vertical plane
- This is the most practical case on field if we consider in comparison with other cases
- In this case we use the sine law for finding the distances example D1 and D2

For example

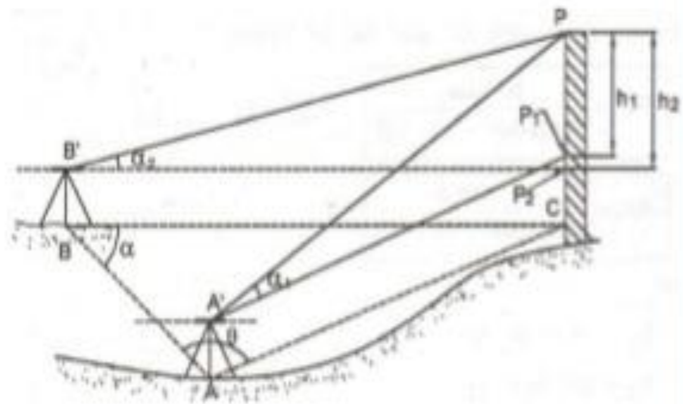
$$(d \sin z1)/\sin z3 = D2$$

Surveying

Case 3. Base of the object inaccessible, Instrument stations not in the same vertical plane as the elevated object.

Set up instrument on A
Measure $\alpha 1$ to P
$\angle BAC = \theta$

Set up instrument on B
Measure $\alpha 2$ to P
$\angle ABC = \alpha$



$\angle ACB = 180 - (\theta + \alpha)$

Sin Rule:

BC=	$b \cdot \sin\theta$
	$\sin\{180^\circ - (\theta + \alpha)\}$
AC=	$b \cdot \sin\alpha$
	$\sin\{180^\circ - (\theta + \alpha$

$h1 = AC \tan \alpha 1$

$h2 = BC \tan \alpha 2$

Surveying

- HEIGHTS And DISTANCES
- When the distance btw the stations is not large, the distance btw the stations measured on the surface of the earth or computed trigonometrically may be assumed as a plane distance.
- The amount of correction due to curvature of the earth surface an refraction just be ignored.
- Depending on field conditions, the following three cases are involved

Unit 5

TACHEOMETRIC
AND
ADVANCED SURVEYING

SURVEYING

Tacheometric and advanced surveying

SURVEYING

- Tacheometric surveying is a method of angular surveying in which the horizontal distance from the instrument to the staff stations and the elevations of the staff stations concerning the line of collimation of the instrument are determined from instrumental observations only
- Thus the chaining operations are eliminated. Field Work can be completed very rapidly Tacheometry is mainly used for preparing the contour plans of areas

SURVEYING

- **Methods of Tachometric Survey**
- Various methods of tacheometry survey are based on the principle that the horizontal distance between an instrument Station "A" and a staff station "B" and the elevation of point "B" with reference to the line of sight of the instrument at point "A" depend on the angle subtended at point "A" by a known distance at point "B" and the vertical angle from point "B" to point "A" respectively.

SURVEYING

- This principle is used in different methods in different ways. Mainly there are two methods of tachometry survey

(1)Stadia system, and

(2) tangential system.

(1) Stadia System of Tacheometry;

In the stadia system, the horizontal distance to the staff Station from the instrument station and the elevation of the staff station concerning the line of sight of the instrument is obtained with only one observation from the instrument Station

SURVEYING

- In the stadia method, there are mainly two systems of surveying.
- *(1) fixed hair method and,*
- *(2) movable hair method.*
- **(i) Fixed Hair Method:**
- In the fixed hair method of tacheometric surveying, the instrument employed for taking observations consist of a telescope fitted with two additional horizontal cross hairs one above and the other below the central hair. These are placed equidistant from the central hair and are called stadia hairs.

SURVEYING

- When a staff is viewed through the telescope, the stadia hairs are seen to intercept a certain length of the staff and this varies directly with the distance between the instrument and the stations.
- As the distance between the stadia hair is fixed, this method is called the “fixed hair method.”

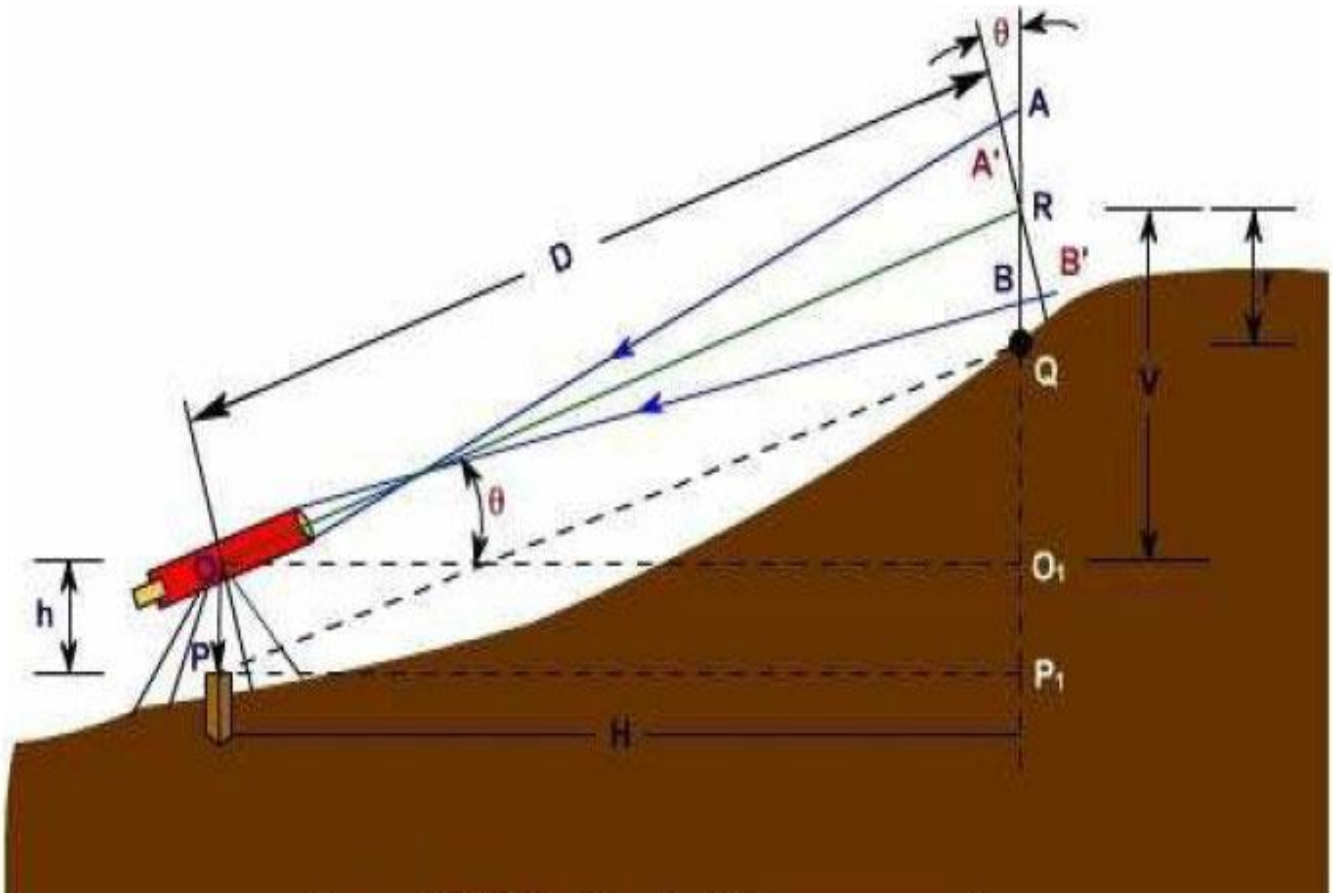
SURVEYING

Problems on Tachometric leveling and curves

SURVEYING

- **Movable Hair Method;**
- In the movable Hair method of tacheometric surveying, the instrument used for taking observations consist of a telescope fitted with stadia hairs which can be moved and fixed at any distance from the central hair (within the limits of the diaphragm).
- The staff used with this instrument consists of two targets (marks) at a fixed distance apart (say 3.4 mm).
- The Stadia interval which is variable for the different positions of the staff is measured, and the horizontal distance from the instrument station to the staff station is computed.

SURVEYING



SURVEYING

- **Tangential System of Tacheometric Surveying:**
- In this system of tacheometric surveying, two observations will be necessary from the instrument station to the staff station to determine the horizontal distance and the difference in the elevation between the line of collimation and the staff station.

SURVEYING

- The only advantage of this method is that this survey can be conducted with ordinary transit theodolite. As the ordinary transit theodolite are cheaper than the intricate and more refined tacheometer, so, the survey will be more economical.
- So, far as the reduction of field notes, distances and elevations are concerned there is not much difference between these two Systems.
- But this system is considered inferior to the stadia system due to the following reasons and is very seldom used nowadays.

SURVEYING

ADVANCED SURVEYING

SURVEYING

- Total Station Setup and Operation

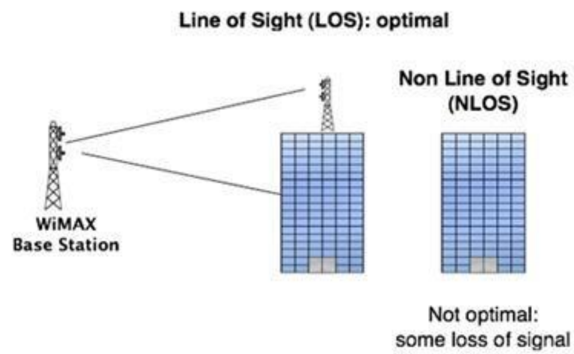
SURVEYING

ADVANTAGES OF TOTAL STATION SURVEYING

- Accurately gathers enormous amount of survey measurements quickly
- Receiving and transmitting measured or layout data increases processing efficiency
- Read and write errors are eliminated
- Data is saved and managed on a PC
- Designs can be implemented from planning stage
- Overall reduction in man hours spend on the job

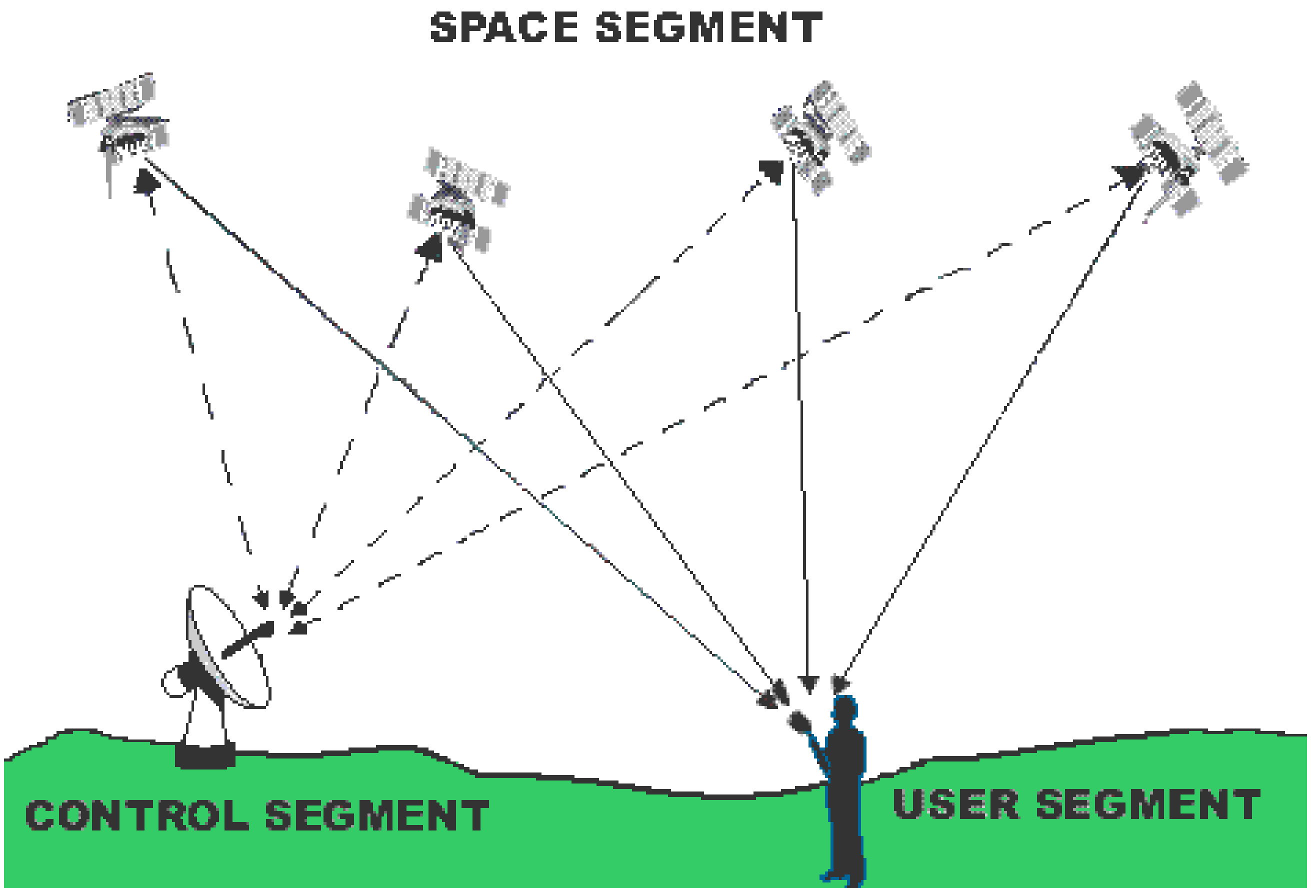
SURVEYING

Disadvantages

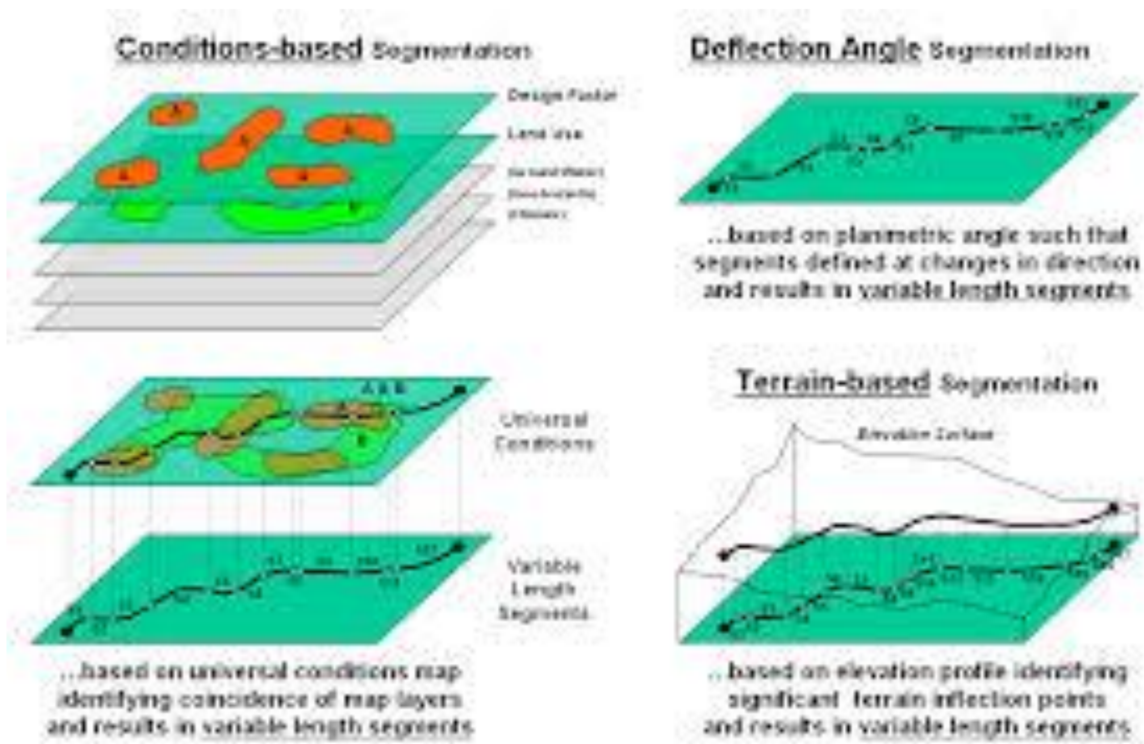


- Line-of-sight (*LOS*) is required for long distance (5-30 mile) connections.
- Heavy rains can disrupt the service.
- Other wireless electronics in the vicinity can interfere with the WiMAX connection and cause a reduction in data throughput or even a total disconnect.

SURVEYING



Surveying


Conditions-based Segmentation
Design Factor
Land Use
Universal Conditions
Variable Length Segments
...based on universal conditions map identifying coincidence of map layers and results in variable length segments
Deflection Angle Segmentation
...based on planimetric angle such that segments defined at changes in direction and results in variable length segments
Terrain-based Segmentation
...based on elevation profile identifying significant terrain inflection points and results in variable length segments

Surveying

- Total station is a surveying equipment combination of Electromagnetic Distance Measuring Instrument and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument

Surveying

- **Capability of a Total Station**
- Microprocessor unit in total station processes the data collected to compute:
- Average of multiple angles measured.
- Average of multiple distance measured.
- Horizontal distance.
- Distance between any two points.
- Elevation of objects and
- All the three coordinates of the observed points

Surveying

- Important Operations of Total Station
- Distance Measurement
- Angle Measurements
- Data Processing
- Display
- Electronic Book

Surveying

- **Uses of Total Station**
- When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen.
- This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers