



## UNIT I

### INDRODUCTION AND CHAIN SURVEYING

1. Define Surveying. What are the fundamental principles of surveying?

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.

The principles of surveying are:

- (i). Working from whole to part.
- (ii). To locate a new station by at least two measurements (angular, linear) from fixed reference points.

2. What is the object or purpose of surveying?

The primary object of surveying is to prepare a plan or map to show the relative position of the objects on the surface of the earth. It is also used to determine the areas, volumes and other related quantities.

3. Name the different ways of classification of surveys.

- a. Primary classification
  - (i). Plane surveying
  - (ii). Geodetic surveying.
- b. Secondary classification
  - (i). Based on instruments used
  - (ii). Based on methods.
  - (iii). Based on object
  - (iv). Based on nature of the field

4. Differentiate between plane and geodetic surveying.

Sl.No.	Plane surveying	Geodetic surveying.
1.	The curvature of the earth is neglected.	The curvature of the earth is taken.
2.	A line joining any two points is considered straight.	A line joining any two points is considered as curved line.
3.	The triangle formed by any three points is considered as plane triangle.	The triangle formed by any three points is considered as spherical triangle.
4.	It is done on a area less than 250 Km <sup>2</sup>	It is done on a area greater than 250 Km <sup>2</sup>

5. Classify surveying based on the equipments.

1. Chain surveying
2. Compass surveying
3. Plane table surveying

4. Theodolite surveying
5. Tacheometric surveying
6. Photogram metric surveying
7. Aerial surveying

6. Explain the constructions of a diagonal scale.

For a given short length (  $PQ=PR$ ), draw a right angle triangle. Its base(  $PR$ ) and height (  $PQ$ ) are equal. A short length is divided into a number of parts by using the principle of similar triangles in which like sides are proportional.

Thus,

1-1 represents  $1/10$   $PQ$

9-9 represents  $9/10$   $PQ$

7. Define chain surveying. What is the fundamental principle of chain surveying?

Chain surveying is the type of surveying in which only linear measurements are made in the field.

The main principle of chain surveying or chain triangulation is to provide a framework consist of number of well-conditioned triangles or nearly equilateral triangles. It is used to find the area of the field.

8. What is a well-conditioned triangle? What is its specific advantage?

A triangle is said to be well- conditioned or well proportioned when it contains no angle smaller than  $30^\circ$  and no angle greater than  $120^\circ$ .

The main principle of chain surveying is chain triangulation. It consists of frame work of triangles. To plot the network of triangles accurately, the triangles must be nearly equal to equilateral or well-conditioned. The distortion due to errors in measurement and plotting should be minimum.

9. What are the operations involved in chain survey?

(i). Ranging: The process of locating intermediate points on a straight line between two end points in a straight line.

(ii). Chaining: The process of measuring the distance with a chain or tape.

(iii). Offsetting: The process of measuring the lateral distance of the object from the survey line to the left or right according to their positions.

10. What are the instruments required for a chain survey?

Chain or tape, Arrows, Pegs, Ranging rods, Offset rods, Laths or whites, Plumb bob, Cross staff and Mallet.

11. Write the different types of Chain.

- (i). Metric chain
- (ii). Non-Metric chain
  - (a). Gunter's chain or Surveyor's chain
  - (b). Engineer's chain
  - (c). Revenue chain
  - (d). Steel band.

12. Differentiate between Gunter's chain and Engineer's Chain

Sl.No.	Gunter's chain or Surveyor's chain	Engineer's chain
1.	It is 66 feet long and divided in to 100 links. 1link = 0.66 feet	It is 100 feet long and divided in to 100 links. 1link = 1 feet
2.	Measurements are in miles and furlongs.	Measurements are in feet and decimals

13. Define: (a). Main stations.

Main station is a prominent point on the chain line and can be either at the beginning of the chain line or at the end or along the boundary.

(b). Subsidiary stations:

The stations located on the main survey lines are known as Subsidiary stations.

(c). Tie stations:

These are also subsidiary stations taken on the main survey lines to locate the details of the object.

14. Distinguish between a check line and a tie line.

Sl.No	Check line	Tie line
1.	Check lines or Proof lines are the lines which are run in the field to check the accuracy of the work	The main object of running a tie line is to take the details of the objects.
2.	The length of the check line measured in the field must agree with its length of the plan.	Tie line is a line which joints subsidiary stations or tie stations on the main line.

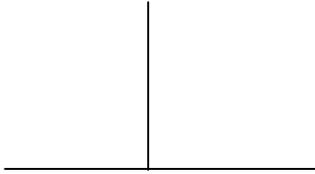
15. What are the instruments used for setting out right angles to a chain line?

- (i). Cross staff.
  - a. Open cross staff
  - b. French cross staff
  - c. Adjustable cross staff
- (ii). Optical square.
- (iii). Prism square
- (iv). Site square.

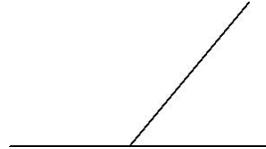
16. What are offsets? Classify them.

An offset is the lateral distance of an object or ground feature measured from a survey line. The two types of offsets are,

- (i). Perpendicular offset: The angle of offset from a point on a chain line is  $90^{\circ}$ .
- (ii). Oblique offset: When the angle of offset is other than  $90^{\circ}$ .



Perpendicular offset



Oblique offset

17. What is the use of a line Ranger?

The line Ranger is a small reflecting instrument used for fixing intermediate points on the chain lines. Without going to either end, we can fix the intermediate points.

18. What are the stages of fieldwork in chain surveying? Or What are the steps involved in chain survey?

1. Reconnaissance: It is the preliminary inspection of the area to be surveyed.
2. Marking and fixing Survey lines.
3. Running survey lines.
4. Taking Offsets.

19. What are the different tape corrections?

1. Correction for absolute length or standardisation.
2. Correction for temperature.
3. Correction for pull or tension.
4. Correction for sag. (- ve)
5. Correction for slope. (- ve)

20. What are the errors in chaining?

(i). Compensating Errors: Which are liable to occur in either direction and tend to compensate.

(ii). Cumulative Errors: Which occur in the same direction and tend to add or subtract. It may be positive (measured lengths more than the actual length) or negative (measured lengths less than the actual length).

21. What are the different sources of errors in chain surveying?

- (i). Instrumental errors: incorrect length of the chain (Cumulative Errors).

- (ii). Personal error: Bad ranging (Cumulative Errors).
  - Careless holding (Compensating Errors).
  - Bad straightening (Cumulative Errors).
  - Non- horizontality (Cumulative Errors).
  - Sag in chain (Cumulative Errors).
  - Miscounting and misreading and booking.
- (ii). Natural Errors: Variation in temperature. (Cumulative Errors).

22. Enumerate the instruments used for measurement of lengths of survey lines.

- (i). Chain or tape.
- (ii). Passometer.
- (iii). Pedometer
- (iv). Odometer
- (v). Speedometer.

## UNIT II

### COMPASS SURVEYING AND PLANE TABLE SURVEYING

1. Define: Compass surveying. What are the objects of compass surveying?

Compass surveying is the type of surveying in which the direction of the survey lines are measured with a compass and the length of the survey lines are measured with a tape or chain in the field.

2. Write the names of the instruments used in chain surveying.

(i). Instruments for the direct measurement of directions:

1. Surveyor's compass.
2. Prismatic compass.

(ii). Instruments for the measurement of angles:

1. Sextant.
2. Theodolite.

3. Define: (a). True meridian and bearing.

True meridian:

The line or plane passing through the geographical North Pole, South Pole and any point on the surface of the earth, is known as true meridian or geographical meridian. True meridian at a point is constant.

True bearing:

The angle between the true meridian and a survey line is known as true bearing or Azimuth of the line.

(b). Magnetic meridian and Bearing. Magnetic meridian :

Magnetic meridian at a point is the direction indicated by freely suspended, properly balanced and unaffected magnetic needle at that point.

Magnetic Bearing:

The angle between the magnetic meridian and a survey line is known as magnetic bearing or bearing .of the line. It changes with time.

4. What do you understand by Whole circle bearing and quadrantal bearing of a line?

Magnetic Bearings are designated by Whole circle bearing system and quadrantal bearing system.

In Whole circle bearing system (WCB), the bearing of the line is measured with magnetic north in clockwise direction. It varies from  $0^{\circ}$  to  $360^{\circ}$  .

In quadrantal bearing system (Q.B or R.B) the bearing of the line is measured eastward or westward from north or south, whichever is nearer. The directions can be either clockwise or anticlockwise. It varies from  $0^{\circ}$  to  $90^{\circ}$  .

5. Convert the whole circle bearing into reduced bearing:  $50^{\circ}$ ,  $176^{\circ}$ ,  $210^{\circ}$ ,  $232^{\circ}$ ,  $150^{\circ}$ ,  $76^{\circ}$ ,  $310^{\circ}$ ,  $242^{\circ}$ .

Whole circle bearing WCB	Reduced bearing RB
$50^{\circ}$	N $50^{\circ}$ E.
$176^{\circ}$	S $(180^{\circ} - 176^{\circ})$ E = S $4^{\circ}$ E
$210^{\circ}$	S $(210^{\circ} - 180^{\circ})$ W = S $30^{\circ}$ W
$232^{\circ}$	S $(232^{\circ} - 180^{\circ})$ W = S $52^{\circ}$ W
$150^{\circ}$	S $(180^{\circ} - 150^{\circ})$ E = S $30^{\circ}$ E
$76^{\circ}$	N $76^{\circ}$ E
$310^{\circ}$	N $(360^{\circ} - 310^{\circ})$ W = N $50^{\circ}$ W
$242^{\circ}$	S $(242^{\circ} - 180^{\circ})$ W = S $62^{\circ}$ W

6. Differentiate between Prismatic compass and Surveyor's compass with reference to reading and tripod.

SI.No.	Item	Prismatic compass	Surveyor's compass
1.	Reading	(i). The reading is taken with a help of prism provided at the eye slit. (ii). Sighting and reading taking can be done simultaneously from one position of the observer.	(i). The reading is taken by directly seeing through the top of the glass. (ii). Sighting and reading taking cannot be done simultaneously from one position of the observer.
2.	Tripod	Tripod may or may not be provided.	The instrument cannot be used without a tripod.

7. The fore bearing of a line PQ is N  $28^{\circ}$  W. What is its back bearing?

In quadrantal bearing (RB) system, the FB and BB are numerically equal but the quadrants are just opposite.

The FB of a line PQ is N  $28^{\circ}$  W, Then its BB is S  $28^{\circ}$  E.

8. Define: Fore and Back bearing.

The bearing of a line is measured in the direction of the progress of the survey is called the fore bearing of the (FB) line.

The bearing of a line is measured in the direction opposite to the survey is called the back bearing of the (BB) line.

$$BB = FB \pm 180^{\circ} . \text{ (FB greater than } 180^{\circ} \text{, use - sign) (FB smaller than } 180^{\circ} \text{, use + sign)}$$

9. The fore bearing of line AB is  $155^{\circ} 25' 20''$ . Identify the back bearing of the line AB in quadrantal system.

The fore bearing of line AB =  $155^{\circ} 25' 20''$ . The back bearing of line AB ,  $BB = FB + 180^{\circ}$

$$= 155^{\circ} 25' 20'' + 180^{\circ}$$

$$= 335^{\circ} 25' 20'' \text{ (WCB)}$$

$$= N (360^{\circ} - 335^{\circ} 25' 20'') W$$

$$= N 24^{\circ} 34' 40'' W$$

10. Define and distinguish between magnetic dip and magnetic declination.

Magnetic dip:

Due to the magnetic influence of the earth, the needle does not remain in the balanced position. This inclination of the needle with the horizontal is known as the dip of the magnetic needle. To balance the dip of the needle, a rider (brass or silver coil) is provided along with it.

Magnetic declination:

The magnetic meridian of a place is variable one due to some local attractive forces. Therefore, the true meridian and the magnetic meridian at a place do not coincide. The horizontal angle between the magnetic meridian and the true meridian is known as magnetic declination.

11. The magnetic bearing of a line is  $48^{\circ} 24'$ . Calculate the true bearing if the magnetic declinations are  $5^{\circ} 38'$  East and  $5^{\circ} 38'$  West.

$$\text{True bearing} = \text{Magnetic bearing} + \text{Eastern magnetic declination}$$

$$= 48^{\circ} 24' + 5^{\circ} 38'$$

$$= 54^{\circ} 02'$$

$$\text{True bearing} = \text{Magnetic bearing} - \text{Western magnetic declination}$$

$$= 48^{\circ} 24' - 5^{\circ} 38'$$

$$= 42^{\circ} 46'$$

12. The magnetic bearing of a line is  $S 28^{\circ} 30' E$ . Calculate the true bearing if the magnetic declinations are  $5^{\circ} 38'$  East and  $5^{\circ} 38'$  West.

Convert the reduced bearing into Whole circle bearing.

$$\text{Magnetic bearing} = S 28^{\circ} 30' E. \text{ (RB)}$$

$$= 180^{\circ} - 28^{\circ} 30'$$

$$= 151^{\circ} 30'$$

$$\begin{aligned}
\text{True bearing} &= \text{Magnetic bearing} + \text{Eastern magnetic declination} \\
&= 151^{\circ}30' + 7^{\circ}30' \\
&= 159^{\circ}00'. \text{ (WCB)} \\
&= S(180^{\circ} - 159^{\circ}00')E \text{ (RB)} \\
&= S 21^{\circ} E.
\end{aligned}$$

$$\begin{aligned}
\text{True bearing} &= \text{Magnetic bearing} - \text{Western magnetic declination} \\
&= 151^{\circ}30' - 7^{\circ}30' \\
&= 144^{\circ}00'. \text{ (WCB)} \\
&= S(180^{\circ} - 144^{\circ}00')E \text{ (RB)} \\
&= S 36^{\circ} E.
\end{aligned}$$

13. What is local attraction? What are the sources of local attractions?

Local attraction is a term used to denote any influence, such as magnetic substances, which prevents the needle from pointing to the magnetic north in a given locality.

The sources of local attractions are : magnetite in the ground, wire carrying electric current, steel structures, rails, underground iron pipes, chain etc.,

14. Distinguish between closed traverse and open traverse.

SI.No.	Closed traverse	Open traverse
1.	When the lines form a circuit, which ends at the starting point, it is known as closed traverse.	If the circuit ends elsewhere, it is known as open traverse.
2.	It is suitable for locating the boundaries of lakes, woods etc.,	It is suitable for surveying a long narrow strip of land required for road canal etc.,
3.	Check: Sum of interior angles = $(2n - 4) 90$ Sum of exterior angles = $(2n + 4) 90$ Where, n= number of sides of the traverse.	No direct check on angular measurements.

15. What is plane table surveying? When is it preferred? Write its principle.

Plane tabling is the graphical method of surveying in which the field observations and plotting proceed simultaneously.

It is mainly suitable for filling the interior details between the control stations and also in magnetic areas.

The main principle of plane table surveying is that the lines joining the points on the plane table are made to lie parallel to the corresponding lines joining the points on the ground while working at each station.

16. Name four methods of plane surveying.

1. Radiation

2. Intersection.
3. Traversing
4. Resection.
  - (i). Resection after orientation by compass.
  - (ii). Resection after orientation by back sighting.
  - (iii). Resection after orientation by three point problem.
    - a. Mechanical method.(Tracing paper method)
    - b. Graphical method. ( Bessel's method)
    - c. Lehman's method. (Trial and error method)
  - (iv). Resection after orientation by two point problem

17. When a three- point problem resorted to in plane table surveying?

It is the method of orientation when the table occupies a position not yet located on the drawing sheet.

This method is employed when during surveying the surveyor feels that some important details can be plotted easily by choosing any stations.

18. State the First and second Lehman's rule.

First rule: The distance of the point "p" (position of plane table on the drawing sheet) to be fixed from each rays Aa (paper a, to ground A), Bb (paper ,b to ground B) and Cc (paper c, to ground C) is proportional to the respective distances of the stations A, B and C from the ground station P.

Second rule: While looking towards the stations the point "p" to be fixed, will be either to the left or to the right of each of the rays.

19. What are the Advantages of plane table surveying?

1. It is useful in magnetic areas.
2. It is cheaper than the theodolite surveying.
3. It is most suitable for small-scale maps.
4. The surveyor can compare plotted work with the actual features.
5. No skill is required .

20. Name some of the errors in plane tabling.

1. Instrumental error.
2. Errors of plotting
3. Errors due to manipulation and sighting.
  1. Non horizontality of the board.
  2. Defective sighting.
  3. Defective orientation.
  4. Movement of board between sights.

## UNIT III

### LEVELLING AND APPLICATIONS

1. Define Levelling. What are the uses of leveling?

Levelling is a branch of surveying, the object of which is; (i). To find the elevations of given points with respect to a given or assumed datum, and (ii). To establish points at a given elevation or at different elevations with respect to a given or assumed datum.

2. Define benchmark and reduced level.

Benchmark:

Benchmark is a relatively permanent point of reference whose elevation with respect to some assumed datum is known.

Reduced level or Elevation:

The vertical distance of a point above or below the datum is known as the elevation or R.L of that point. R.L of a point may be positive or negative according as the point is above or below the datum.

3. What are the different kinds of bench marks?

A BM is the reference point of known elevation. It may be classified into following types.

(i). 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.

(ii). 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,.

(iii). Temporary Bench Mark: These are established temporarily whenever required. These are generally chosen to close the day's work and to start the next days. Points on roofs, walls, basements, etc,.

(iv). Arbitrary Bench Mark: When the RL of some fixed points are assumed, they are termed arbitrary benchmark.

4. What do you mean by datum surface?

It is any surface, to which elevations are taken as a reference for the determination of elevations of various points. In India the datum adopted for the great trigonometrical survey (G.T.S) is the mean sea level at Bombay port.

5. What is mean by line of collimation and height of collimation?

Line of collimation (Line of sight): 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.

Height of collimation(HOC): The elevation of the Line of collimation (Line of sight) is known as Height of collimation.  $HOC = RL \text{ of BM} + BS$ .

6. Write the different types of levels.

1. Dumpy level
2. Tilting level
3. Quick setting level.
4. Y-level.
5. Reversible level.
6. Automatic level
7. Lazer level.

7. List the essential parts of a Level.

Telescope, Eyepiece, Objective  
 Focusing screws. Longitudinal bubble  
 Foot screws, Upper parallel plate ( Tribrach), Foot plate( Trivet).  
 Diaphragm adjusting screws, Bubble adjusting screws, Tripod.

8. What are the different type's leveling staffs?

1. Target Staff
2. Self reading Staff.
  - a. Solid Staff
  - b. Folding Staff
  - c. Telescopic Staff.

9. Define and distinguish between 'Back sights' and 'Fore sight' in the process of fly Levelling.

Sl.No	Back sights (BS)	Fore sight (FS)
1.	This is the first staff reading taken in any setup of the instrument. It is always taken on a point of known elevation( BM).	This is the last staff reading taken in any setup of the instrument and,afterthat instrument is shifted.
2.	It is used to determine the height of the instrument. $HI = \text{known RL} + BS$	It is used to determine the elevation (RL) of the staff station. $RL = HI - FS$ .

10. Explain the theory of direct leveling.

It is the branch of leveling in which the vertical distances with respect to a horizontal line may be used to determine the relative difference in elevation between two adjacent points. Steps involved:

$$HI = \text{known RL(BM)} + BS$$

$$RL = HI - FS.$$

11. Distinguish between differential levelling and reciprocal levelling.

Sl.No.	Differential levelling	Reciprocal levelling
1.	Difference in elevation between two or more points is determined by without any regard to the alignment of the points is called differential leveling.	Difference in elevation between two points is accurately determined by two sets of reciprocal observations..
2.	It is used when: (i). two points are a large distance apart. (ii). The difference in elevation between two points is large. (iii). Some obstacles intervenes between the points.	It is used when: (i). The instrument cannot be setup between the two points due to an obstruction such as a valley, river, etc.,.

12. Reduced level of Bench Mark A - 50.000m

Reading on staff held at A - 2.435m

Reading on staff held at station point B - 1.650m

- Find: (a) Height of collimation.  
(b) Reduced level of station point B.  
(c) Rise/fall of B with respect to A.

$$\begin{aligned} \text{(a). Height of collimation} &= \text{RL of BM A} + BS \\ \text{(HOC)} &= 50.000 + 2.435 \\ &= 52.435\text{m} \end{aligned}$$

$$\begin{aligned} \text{(b) Reduced level of station point B.} & \\ &= \text{HOC} - FS. \\ &= 52.435 - 1.650 \\ &= 50.785 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{(c) Rise/fall of B with respect to A.} & \\ &= 2.435 - 1.65 \text{ ( Lower staff reading being higher)} \\ &= 0.785\text{m,} \\ &= \text{with compare to A, the station point B being 0.785m higher.} \end{aligned}$$

13. Compare height of collimation method and rise and fall method.

Sl.No	Height of collimation method	Rise and fall method
1.	It is more rapid, less tedious and simpler as it involves few calculation.	It is more laborious and tedious , involving several calculations.
2.	There is no check on the RL of the intermediate points.	There is a check on the RL of the intermediate points.
3.	Errors in intermediate RL's cannot be detected.	Errors in intermediate RL's can be detected.
4.	There are two arithmetic checks on the accuracy of RL calculation. $\sum BS - \sum FS = \text{Last RL} - \text{First RL}.$	There are three arithmetic checks on the accuracy of RL calculation. $\sum BS - \sum FS = \sum \text{Rise} - \sum \text{Fall} = \text{Last RL} - \text{First RL}.$
5.	It is suitable in the case of L.S and C.S, Contour etc.	It is suitable in fly leveling where I intermediate sights are less.

14. Write the formula for curvature correction, refraction correction and combined correction.

Curvature correction  $C_C = 0.07849 d^2$  ( negative) m

Refraction correction  $Cr = 0.01121 d^2$  (positive) m Combined

correction.  $C = C_C - Cr = 0.06728 d^2$  (negative) m.

Note: 'd' is to be substituted in Km, while the corrections will be in m.

15. List out the various sources of errors in levelling.

Three principal sources:

(i). Instrumental error

- a. Error due to imperfect adjustment
- b. Error due to sluggish bubble.
- c. Error due to movement of objective slide.
- d. Error due to defective joint.
- e. Error due to incorrect length of staff.

(ii). Natural error.

- a. Earth's curvature.
- b. Atmospheric refraction.
- c. Variations in temperature.
- d. Settlement of tripod.
- e. Wind vibrations.

(iii). Personal errors.

- a. Mistakes in manipulation.
- b. Mistake in staff handling
- c. Mistake in reading the staff.
- d. Error's in sighting.
- e. Mistakes in recording.

16. List out the leveling problems.

1. Levelling on Steep Slope.
2. Levelling on Summits and Hollows.
3. Taking Level of an Overhead Point.
4. Levelling Ponds and Lakes too Wide to be Sighted across.
5. Levelling across River.
6. Levelling on Past High Wall.

17. Define sensitivity of a bubble. State any two factors affecting the same.

The sensitiveness of a bubble is defined the angular value of one division of the bubble tube. It means the capability of showing small angular movements of the tube vertically. It can be increased by:

1. Increasing the internal radius of the tube.
2. Increasing the diameter of the tube.
3. Increasing the length of the tube.
4. Decreasing the roughness of the walls.
5. Decreasing the viscosity of the liquid.

18. What is a spire test?

It is used to make the horizontal axis perpendicular to the vertical axis. This test is also known as the test for the adjustments of the standards. It is done by means of the adjustments of the vertical hair. It is one of the permanent adjustment of the level and theodolite.

19. Define Contour, contour interval and, horizontal equivalent.

Contour: A contour is an imaginary line on the ground joining the points of equal elevation.

Contour interval: It is the vertical distance between any two consecutive contours. It depends upon the nature of the ground, the scale of the map and the purpose of the survey.

Horizontal equivalent: It is the horizontal distance between any two consecutive contours. It varies according to the steepness of the ground.

20. What are the different Characteristics of contour?

1. Contour lines are closed curves. They may either within the map itself or outside the map depending upon the topography.
2. Uniformly spaced, contour lines indicate a uniform slope.
3. A series of closed contours with increase in elevation from outside to inside in plan denotes a hill.
4. A series of closed contours with increase in elevation from inside to outside in plan denotes a depression.
5. The spacing between the contour lines depends upon the slope of the ground. In steep slopes, the spacing is small and for gentle slope, the spacing is large.

21. What are the uses of contours?

1. Volume of earthwork for any work can be estimated.
2. The capacity of the reservoir or the area of the catchments can be calculated.
3. Very useful in military operations to decide the position of the guns, the line of march.
4. Longitudinal and cross section can be drawn along any direction to know the nature of the ground.

22. Write the different formulae to calculate the area of the irregular plate.

1. By computations based directly on the field measurements:

(i). By dividing the area into number of triangles. (ii). By offsets to base line.

a. Mid ordinate rule =  $\sum O \cdot d$

b. Average ordinate Rule =  $\frac{nd \cdot \sum O}{n+1}$

c. Trapezoidal rule =  $\left( \frac{O_0 + O_n}{2} + O_1 + O_2 + O_3 + \dots + O_{n-1} \right) d$

d. Simpson's rule =  $\left[ \left( O_0 + O_n \right) + 4 \left( O_1 + O_3 + \dots + O_{n-1} \right) + 2 \left( O_2 + O_4 + \dots + O_{n-2} \right) \right] (d/3)$

$O_0$  = Ordinate at one end.

$O_n$  = Ordinate at other end.

$O_1 + O_2 + O_3 + \dots + O_{n-1}$  = Ordinate at end of each division.  $d$  = Length of the base

(iii). By latitudes and Departures:

a. By double meridian distance (D.M.D. method).

b. By double parallel distance (D.P.D. method).

(iv). By co-ordinates.

2. By computations based on measurements scaled from a map.

3. By mechanical method: By means of planimeter.

23. How do you calculate the capacity of the reservoir from the contour map?

From the contour map, the capacity of the reservoir is calculated by the following formulas.

1. Trapezoidal rule =  $\left( \frac{A_0 + A_n}{2} + A_1 + A_2 + A_3 + \dots + A_{n-1} \right)$

2. Prismoidal rule =  $\left[ \left( A_0 + A_n \right) + 4 \left( A_1 + A_3 + \dots + A_{n-1} \right) + 2 \left( A_2 + A_4 + \dots + A_{n-2} \right) \right] (d/3)$

$A_0, A_1, A_2, A_3, \dots, A_n$  = Areas enclosed by successive contours.  $d$  = contour interval.