[TIME ALLOWED — 3 HOURS]

(MARKS — 100)

SURVEYING AND LEVELING (THEORY-III)

Instructions:

(1) Attempt all questions.

(2) Illustrate your answer with neat sketches wherever necessary.

A. Fill in the blanks (any five):

(i) Optical square is used for **SETTING PERPENDICULAR AT A POINT TO REQUIRED LINE**

(ii) Least count of levelling staff is **5MM**

(iii) When WCB in between 180° to 270°, RB of any line in **THIRD** quadrant.

(iv) Metric chain having 20 m. length there are **100** nos. links.

(v) After shifting of instrument, this point is **CHANGE POINT**

(vi) Ranging rod having length of **2-3M** meters.

B. Match the pairs:

'A' Group	'B' Group
1. Ranging	a) Distance measurement
2. Levelling	b) Angle measurement
3. Bearing	c) Maps preparation
4. Chaining	d) Height and depth measurement
5. Contouring	e) Locating straight line
	f) Ground levelling.

C. State true or false (any five):

(b) Vertical angle can be measured by dumpy level. **FALSE**

(c) Planimeter used for calculating irregular surface area. **TRUE**

(d) Line ranger can set perpendicular offset. **FALSE**

(e) Tally should be given for chain at 1 meter interval. **WRONG**

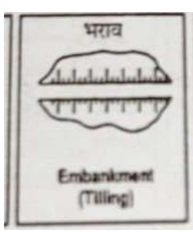
(f) Cross staff used for setting of offsets. **TRUE**

(g) Steel tape is used for measurement of higher precision. **TRUE**

D. Draw conventional symbols (any five):

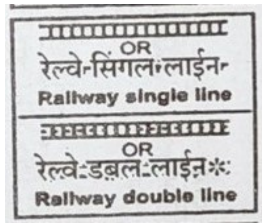
I. Tunnel

II. Embankment

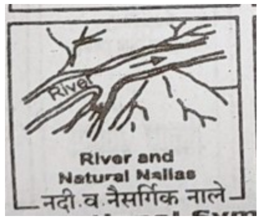


III. Church

IV. Railway



V. River



VI. Orchard.

E. Answer any two of the following:

(a) State objects of surveying.

- **The main purpose of surveying is to obtain map or plan of the area.**
- **The earliest surveying were performed only for the purpose of establishing the boundary of land.**
- **But nowadays for the purpose of designing any engineering project such as a road, railway. canal, water supply or sanitary scheme etc., an engineer would required to study , as the very first item, the features of the earth's surface in which the project is to be located and prepared a map of that area.**
- **The successful completion of any engineering project mainly depends upon accurate surveying.**

(b) Explain errors in chain and testing with corrections.

If the chain that is employed for measuring length is not equal to the true length, then the length measured won't be correct.

This measurement hence requires correction.

- **A chain that is very long, gives a distance that is lesser in value than actual. This means the error is negative and the correction is positive.**
- **A chain that is short, gives larger distance value than actual. In this case, the error is positive and the correction is negative.**

If,

L = True length or designated length of the chain or tape

L' = Incorrect or Actual Length of the chain or tape used

The correction for length can be given by the following formula.

Correction to Measured Length

If 'l' is the actual or true length of the line and l' is the measured length of the line then,

True length of the line = Measured length x [L'/L]

l = l' x (L'/L)

(c) Bearings & its tpes

Bearing in surveying- Types and designation

The direction of a survey line can either be established with relation to each other or with relation to any meridian. The first will give the angle between two while the second will give the bearing of the line.

Bearing in surveying

Bearing of a line is its direction relative to a given meridian. A meridian is any direction such as true meridian, magnetic meridian and arbitrary meridian.

1.True meridian

True meridian through a point is the line in which a plane, thus passes through the true north and south poles, intersects with the surface of the earth. It thus passes through the true north and south. The direction of the true meridian through a point can be established by astronomical observations.

True Bearing: True bearing of a line is the horizontal angle which it makes with the true meridian through one of the extremities of the line. Since the direction of the true meridian through a point remains fixed, the true bearing of a line is a constant quantity.

2. Magnetic Meridian

The magnetic bearing through a point is the direction shown by a freely floating and balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of a magnetic compass.

Magnetic bearing: The magnetic bearing of a line is the horizontal angle which it makes with the magnetic meridian passing through one of the extremities of the line. A magnetic compass is used to measure it.

3. Arbitrary meridian

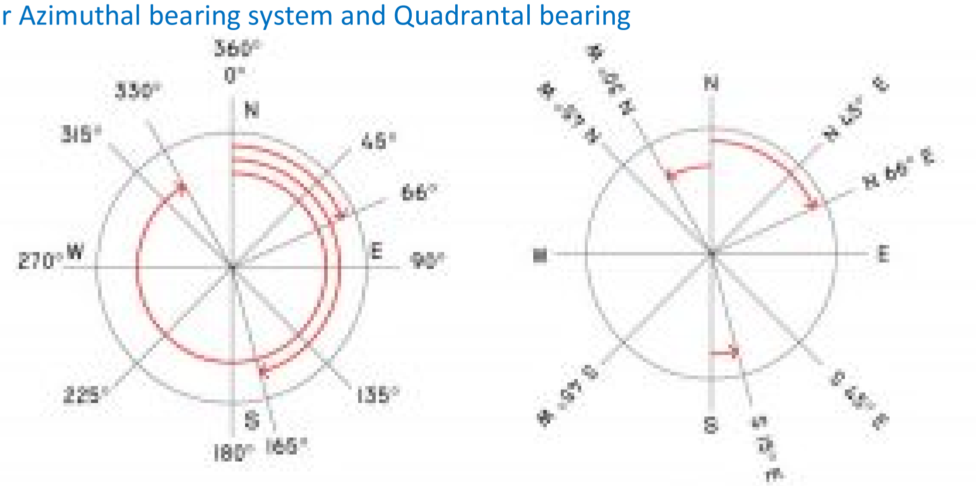
Arbitrary meridian is any convenient direction towards a permanent and prominent mark or signals, such as a church spire or top of a chimney. Such meridians are used to determine the relative positions of lines in a small area

Arbitrary bearing: Arbitrary bearing of a line is the horizontal angle which it makes with any arbitrary meridian passing through one of the extremities. A theodolite or sextant is used to measure it.

These are the bearings in surveying. Now we are going through designations of bearings.

Designations of bearings(Whole circle bearing system or Azimuthal and Quadrantal Bearing}

The common systems of notation for bearings in surveying are whole circle bearing system or Azimuthal bearing system and Quadrantal bearing



Whole Circle Bearing   Quadrantal Bearing

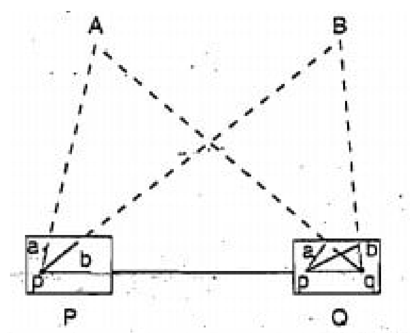
1.Whole circle bearing system

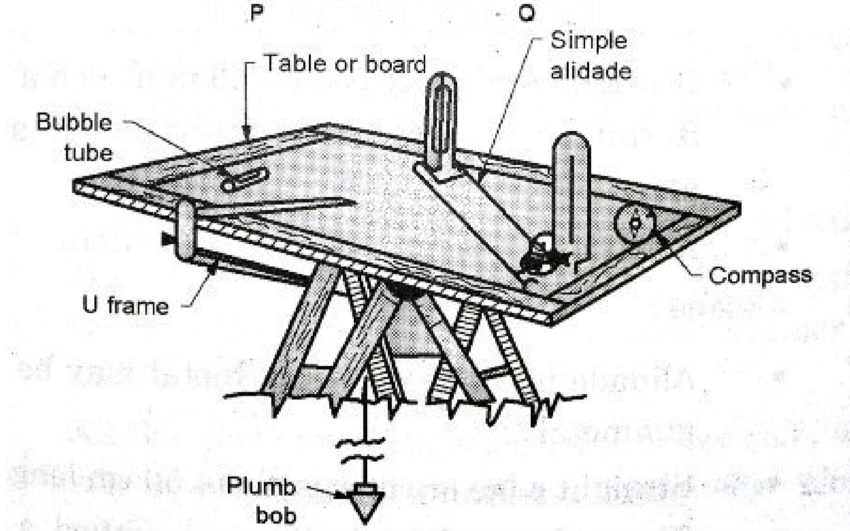
In this system, the bearing of a line is measured with magnetic north in a clockwise direction. The value of the bearing thus varies from 0 degrees to 360 degrees. Prismatic compass is graduated in this system

2. Quadrantal bearing system

In this system, the bearing of a line is measured eastward or westward from north or south, whichever is neared. Thus, both north and south are used as reference meridians and the direction can be either clockwise of anticlockwise depending upon the position of the line. In a quadrantal bearing system, the quadrant in which lines lies will have to be mentioned. These bearings are observed by surveyors compass.

(d) What are the principles of plane table survey?





Plane Table

1. The principle of plane tabling is parallelism, meaning that the rays drawn from stations to objects on the paper are parallel to the lines from the stations to the objects on the ground. The relative positions of the objects on the ground are represented by their plotted positions on the paper and lie on the respective rays. The table is always placed at each of the successive stations parallel to the position it occupied at the starting station. Plane tabling is a graphical method of surveying. Here, the fieldwork and plotting are done simultaneously and such survey does not involve the use of a field book.
2. Plane table survey is mainly suitable for filling interior details when traversing is done by theodolite. Sometimes traversing by a plane table may also be done. But this survey is recommended for work where great accuracy is not required. As the fitting and fixing arrangement of this instrument is not perfect, most accurate work cannot be expected.

F. Answer any two of the following:

a) Write following to question answer

I. Convert fore bearing in back bearing:

• 63° 30‘	**N 63⁰30’ E**
• 112° 45‘	**E 22⁰45’ S**
• 203° 45'	**S 23⁰45’ W**
• 320° 30'	**W50⁰30’ N**

II. Convert reduced bearing in WCB:

• S 80° 45‘E	**=180⁰0’ - 80⁰45’ = 99⁰25’**
• N 66° W	**= 360⁰0’ - 66⁰0’ = 294⁰0’**
• S 60° 40° W	**= 180⁰0’ + 60⁰40’ = 240⁰40’**
• N 45° 30' E.	**= 45⁰30’**

b) The chain was tested before commencement of work it is correct. After chaining 840 m. The chain was found to be 0.08 m. too long. At the end of days work after total distance 1376 m. chain was found to be 0.12 m. long. What was true distance measured.

Here chain length is not given, So assume chain length as 30.00m

The work is devided in 2.00 stages That is 840m & (1376-840= 536m)

So calculate actual lengths for both distances step by step

1st Distance :

Error found is 0.08m, So average error = (0+0.08)/2 = 0.04m this is elongation

So faulty length of chain = 30 + 0.04 = 30.04m

Distance measured = 840.00m

So actual length = (Faulty length/Actual length)x Distance measuref

= (30.04/30) x 840

= 841.120m

2nd Distance :

Error found is 0.12m, So average error = (0.08+0.12)/2 = 0.10m this is elongation

So faulty length of chain = 30 + 0.10 = 30.10m

Distance measured = 536.00m

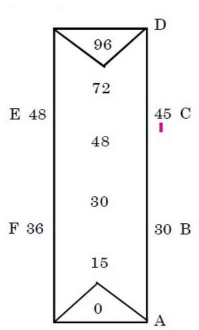
So actual length = (Faulty length/Actual length)x Distance measuref

= (30.10/30) x 536

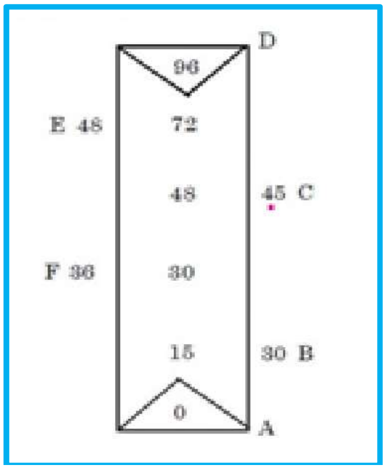
= 537.790m

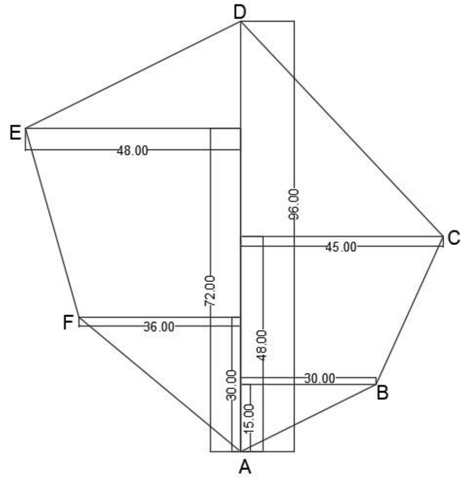
So actual distance measured = 841.12 + 537.79 = 1378.91m

c) Plot the cross-staff survey of field and calculate its area as shown in fig.

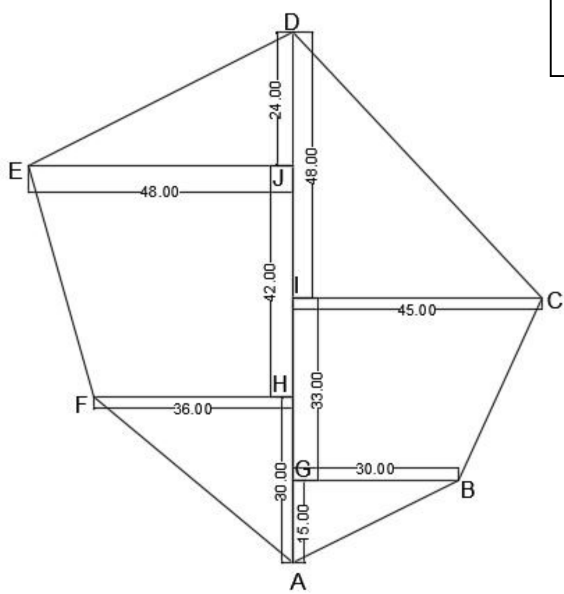


Above drawing needs some correction as chain distances & perpendicular readings are not matching. So here is corrected drawing





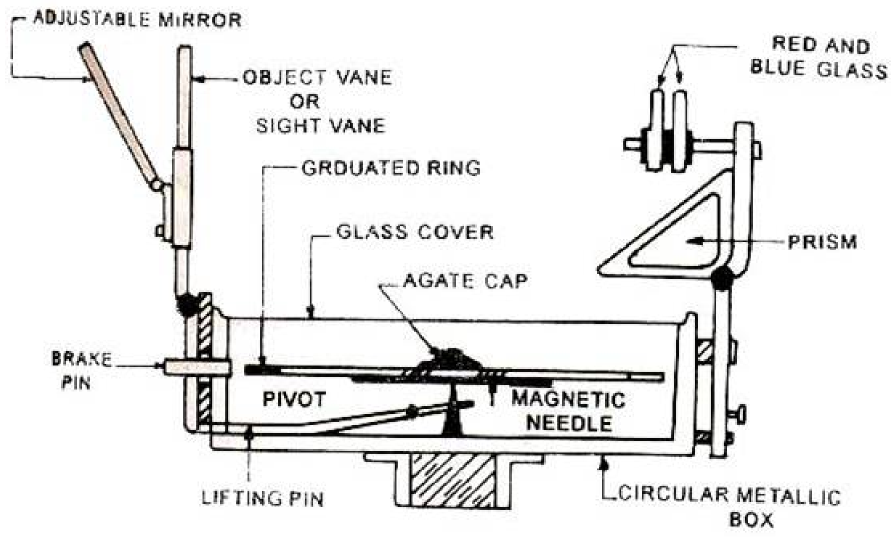
INITIAL SKETC



DRAWING TO MAKE AREA CALCULATION

Area Calculation									
Sr no	Description	Chainage		Base	Offset			Area	Unit
		From	To		1	2	Avg		
1	Triangle ABG	-	15.00	15.00	-	30.00	15.00	225.00	
2	Rectangle BGIC	15.00	48.00	33.00	30.00	45.00	37.50	1,237.50	
3	Triangle CID	48.00	96.00	48.00	45.00	-	22.50	1,080.00	
4	Triangle FAH	-	30.00	30.00	-	36.00	18.00	540.00	
5	Rectangle FHJE	30.00	72.00	42.00	36.00	48.00	42.00	1,764.00	
6	Triangle EJD	72.00	96.00	24.00	48.00	-	24.00	576.00	
							Total=	5,422.50	Sqm

d) Sketch and describe the prismatic compass. How would you use it?



PRISMATIC COMPASS

A prismatic compass is a navigation and surveying instrument which is extensively used to find out the bearing of the traversing and included angles between them, waypoints (an endpoint of the lcourse) and direction.
Compass surveying is a type of surveying in which the directions of surveying lines are determined with a magnetic compass, and the length of the surveying lines are measured with a tape or chain.
The compass is generally used to run a traverse line. The compass calculates bearings of lines with respect to magnetic needle.
The included angles can then be calculated using suitable formulas in case of clockwise and anti-clockwise traverse respectively.
For each survey line in the traverse, surveyors take two bearings that is fore bearing and back bearing which should exactly differ by 180° if local attraction is negligible.
The name *Prismatic compass* is given to it because it essentially consists of a prism which is used for taking observations more accurately.

G. Answer the following (any four):

a) What are the uses of theodolite?

Theodolite uses for many purposes, but mainly it is used for measuring angles, scaling points of constructional works. For example, to determine road highway direction points, huge building setting layouts theodolite is used. Depending on the job nature and the accuracy required, theodolite produces more accurate readings, using paradoxical faces and swings or different positions for perfect measuring survey. Followings are the major uses of theodolite:

- **Measuring horizontal and vertical angles**
- **Locating points on a line**
- **Finding the difference in the level**
- **Prolonging survey lines**
- **Ranging curves**
- **Setting out grades**
- **Tachometric surveying**

The theodolite helps us a good within the engineering field. This instrument plays a major role in measurement horizontal angles, vertical angles, bearing, etc.

b) What are the characteristics of contours?

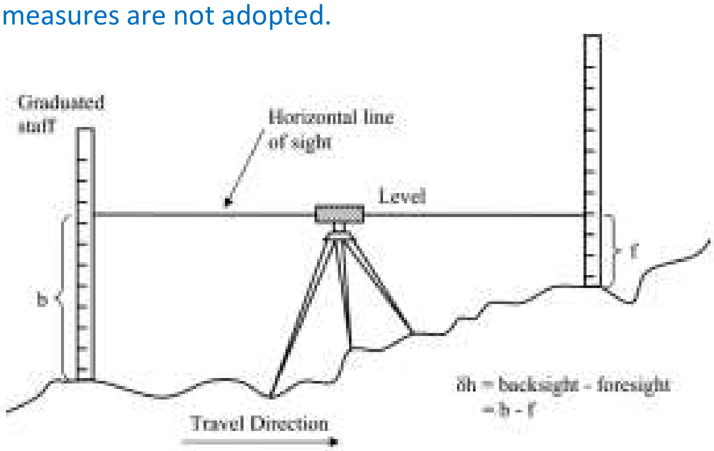
Contours show distinct characteristic features of the terrain as follows:

1. **All points on a contour line are of the same elevation.**
2. **No two contour lines can meet or cross each other except in the rare case of an overhanging vertical cliff or wall**
3. **Closely spaced contour lines indicate steep slope**
4. **Widely spaced contour lines indicate gentle slope**
5. **Equally spaced contour lines indicate uniform slope**
6. **Closed contour lines with higher elevation towards the centre indicate hills**
7. **Closed contour lines with reducing levels towards the centre indicate pond or other depression.**
8. **Contour lines of ridge show higher elevation within the loop of the contours. Contour lines cross ridge at right angles.**
9. **Contour lines of valley show reducing elevation within the loop of the contours. Contour lines cross valley at right angles.**
10. **All contour lines must close either within the map boundary or outside.**

c) What are the errors in levelling?

Leveling is defined as the branch of surveying that is essentially used for determining the relative height of the different points on, above and below the surface of the ground.

The basic **principle of leveling** is to determine the horizontal line of sight with respect to which the vertical distances of the points below or above this line of sight are determined. However, certain errors in **leveling** may be encountered if proper measures are not adopted.



Types of Errors In Levelling

There are mainly 5 types of errors in levelling. They are:

i. Instrumental Error

The error that arises on account of the defects or certain problems associated with the instruments that are used for the levelling is called Instrumental Error.

The instrumental error may be further classified into the following types:

a. Imperfect Adjustment

The error due to the imperfect adjustment of the instrument is one of the most common types of error in levelling.

The levelling equipment must be properly adjusted before the readings are taken.

The temporary adjustment of the instrument is done such that the line of collimation is horizontal.

When the adjustment is done properly, the line of collimation lies exactly parallel to the bubble axis of the instrument such that it becomes perfectly horizontal when the bubble is

On the other hand, when the instrument is not adjusted properly, the line of collimation is inclined even though the bubble is centred. Thus, errors may be encountered.
The errors due to the imperfect adjustment can be eliminated by adopting the following steps:
~ Proper adjustment and testing of the instrument before use.
~ Equalization of the backsight and foresight distances.

b. Defective Level Tube

Sometimes, if the bubble is sluggish, it tends to remain in the centre even when the bubble axis is not perfectly horizontal.
The over-sensitive tube may also pose significant difficulty in levelling the instrument.
Hence, it must be checked beforehand that the level tube of the instrument has the required suitable sensitiveness only.

c. Incorrect Graduations of the Staff

The errors may be encountered when the levelling staff is incorrectly graduated.
The graduations of the new staff must be checked utilizing an invar tape to ensure that the graduations are correct.

d. Shaky Tripod

When a shaky tripod is used, it makes the instrument unstable and the readings taken may contain many errors i.e. the possibility of erroneous readings increases.
To prevent this, the tripod must be properly checked and tested before use. If loose joints are present in the tripod, they must be tightened properly.

e. Telescope not Parallel to the Bubble Tube

When the telescope of the instrument is not parallel to the bubble tube, errors may be encountered during levelling.
Such an error can be prevented by the **permanent adjustment** of the instrument.

f. Telescope not at Right Angles to the Vertical Axis

When the telescope of the instrument is not at right angle to the vertical axis, errors may be encountered during levelling.
Such an error also can be prevented by the permanent adjustment of the instrument.

ii. Error of Collimation

The error of Collimation or simply the collimation error is a common type of error in reciprocal levelling.
This type of error occurs when the axis of collimation is not truly horizontal when the instrument is level.
The axis of collimation is tilted concerning the horizontal by a certain angle.
The collimation error can be eliminated by balancing the back sight and the foresight.

iii. Errors due to Settlement of Level and Staff

Sometimes, errors may occur when the settlement of the level or the staff occurs.
They are further described in brief below.

a. Settlement of Level

The settlement of level is most likely to occur when the levelling has to be done in soft ground.
When the instrument is set up on the soft ground, subsequent settlement of the level may occur while the back sight and the foresight reading are taken.
Such settlement makes the fore sight-reading significantly smaller than that it actually must be.
To prevent such error, the level must always be set up on the relatively firm and hard ground and the tripod legs must be pressed into the ground tightly.

Wooden stakes can also be used for such purposes. As far as possible, the foresight reading must be taken immediately after the back sight-reading is noted.

b. Settlement of Staff

Like the settlement of the level; settlement of the staff may also occur in the soft grounds particularly during the change point. But, in this case, the back sight will be greater than fore sight.
Such type of error can be prevented by avoiding the soft ground as a change point or by driving pegs of steel four-plates that can serve as the temporary change points.

iv. Errors of Manipulation

The errors of manipulation include the following:

a. Improper Leveling of the Instrument

Certain errors may arise on account of the careless or improper levelling of the instrument. Proper care must be taken to prevent such errors.

b. Non-Centralization of Bubble while Taking the Reading

When the bubble is not at the centre while taking the reading; errors may occur.
It is one of the common types of error in levelling. To prevent such an error, the position of the bubble must be checked every time before the reading is taken.
The bubble must always be brought at the centre of its run utilizing the levelling screw.

c. Inefficient Removal of the Parallax

The error due to inefficient removal of the parallax is associated with the improper focusing of the eyepiece and the object-glass of the telescope.
Such type of error may be eliminated by proper focusing before taking the readings.

d. Non-Vertical Staff

When the staff is not held vertically, errors may arise while taking the readings.
In such a case, the readings will be greater than they are.
To prevent such error, it must be taken care that the staff is held completely vertical while the reading is being taken.
This error can be fixed utilizing a spirit level or pendulum plumb bob.

v. Errors due to Natural Sources

Some errors that may arise due to natural sources are:

a. Curvature and Refraction : The curvature of the earth may cause the objects to appear slightly smaller than they are; while the refraction may cause the objects to appear slightly bigger than they are.
However, the error due to curvature and refraction may not be taken into consideration, since it is very small and hence negligible i.e. only 0.003 m for a 200 m sight-length. But, for long sights, the correction for curvature and refraction has to be applied.

b. Wind : During the windy climatic condition, the wind may cause subsequent vibration of the instrument leading to reading errors.
In such a case, large readings must not be taken as far as possible.

d) How to record in field books.

1. Booking is commenced at the bottom of the page and worked upwards and carried continuously through the successive pages so that while writing, the centre line of the book and the chain on the ground correspond with the Surveyor's own direction.
2. The number or name of the line and the name of the station from where the line starts are written at the commencement of each line.
3. All distances along the chain line (changes) are entered in the central column.

4. The objects offsetted are sketched with conventional signs towards right or left of the central column according as they are on the right or left of the chain line on the ground. The sketches need not be to the scale but must be drawn proportionately and the names of the objects are written along them. Figures denoting the dimensions of the details of the objects are included between the arrow-heads.
5. Offset measurements are written close to the points offsetted and exactly opposite to and in line with the changes from which they are taken.
6. Sufficient space is allowed between rows of booking along or across the page to avoid congestion. About 1.5cm space is left between the two entries in the central column.
7. When any features such as a road, fence, hedge or a wall etc. crosses the chain line, changes of the point of intersection is entered in the central column and direction of the feature sketched. The line representing the feature is not carried across the central column, but it is drawn meeting the column.
8. To continue it on the other side of the column, a line parallel to its direction is drawn from a point directly opposite on the other side of the column
9. A symbol "Δ" is used to denote a main station in the field-book. The zero chainages at the commencement and the closing chainages at the end of a line are written inside the symbol. The name of the station is written close to the symbol.
10. Tie or subsidiary stations are indicated by circles or ovals round their changes.
11. The directions of the survey lines starting off or ending at any of main or tie stations are clearly shown with their names or numbers.
12. At the commencement of the tie or check line in the field-book, the position of the tie station is described e.g. tie station (T_3) on AC at 30 m from A. Similarly it is described at the finish of the line.

The following points should be kept in view while booking the field-notes:

1. It is one of the most important survey records. It should be carefully and neatly written up with a good quality pencil.
2. Each chain line should be started on a fresh page.
3. The surveyor should always face the direction of chaining while booking.
4. The notes should be complete. Nothing should be left to memory,
5. The notes should be clear, neat and accurate. Over-writing and erasing should be avoided. When a correction is to be made, the figures should be neatly crossed over and fresh entry made above it and the correction initialled and dated. If however, the entire page is to be discarded, it should be marked 'cancelled' and a reference to the other page on which the correct notes are written should be made on this page.
6. Explanatory notes and reference sketches of important objects should be drawn on separate page.
7. **Each survey must indicate the following:**
    - Name of Survey.
    - Site of Survey.
    - Dates of commencement and completion.
    - The length of chain used and whether tested or not.
    - The rough sketch of the area to be surveyed showing north direction, proposed station-points, main and tie lines etc.
    - Line diagram showing the skeleton of survey and the page index.
    - Magnetic bearing of at least one line together with the amount of declination at the time of survey.

e) Which are the types of scales and state uses.

A scale is the ratio of the distance marked on the plan to the corresponding distance on the ground. A good draughtsman can plot a length to accuracy within 0.25 mm. Types of Scales **are generally classified as large, medium and small. There are generally 5 types of scales used in surveying which we will discuss below.**

Plane Scale : **It is possible to measure two successive dimensions only.**

Diagonal Scale : **It is possible to measure three successive dimensions.**

Chord scale : **It is used to set out angles without using a protractor.**

Vernier Scale : **It is a device for measuring accurately the fractional part of the smallest division on a graduated scale. It divided into,**

Micro scale : **It is a device which enables a measurement to be taken to a still finer degree of accuracy.**

Representation of a Scale :

A. Engineer's scale : 1 cm = 50 m

B. Representative Fraction (R.F) :

It is the ratio of the distance on the map to the corresponding distance on the ground taken as same units. Scale of 1 cm = 50 m, 1 cm on the map represents 50 m (5000 cm) on the ground. Therefore, the representative fraction (R.F.) is 1/5000 or 1: 5000.

C. Graphical scale :

A graphical scale is a line drawn on the map so that its map distance corresponds to convenient units of length on the ground.

It has the advantage over the numerical scales that the distances on the maps can be determined by actual scaling even when the map has shrunk.

Purpose of Survey	Scale	R.F
Building Site	1 cm = 10 m	1:1000
Town Planning, Reservoir planning, etc	1 cm = 50 cm to 100 m	1:5000 to 10000
Route Surveys	1 cm = 10 m to 60 m	1:1000 to 1:6000
Longitudinal Sections.	1 cm = 10 m 1 cm = 1 m	1:1000 1:100
Cross- Sections	1 cm = 1 m	1:100
Land Surveys/ Cadastral Surveys	1 cm = 10 m to 50 m	1:1000 to 1:5000
Topographical Maps	1 cm = 0.25 km to 2.5 km	1:25000 to 1:250000
Geographical Maps	1 cm = 5 km to 150 km	1:500000 to 1:15000000
Mine Surveys	1 cm = 10 m to 25 m	1:1000 to 1:2500
Forest Maps	1 cm = 250 m	1:25000

H. Solve (any two):

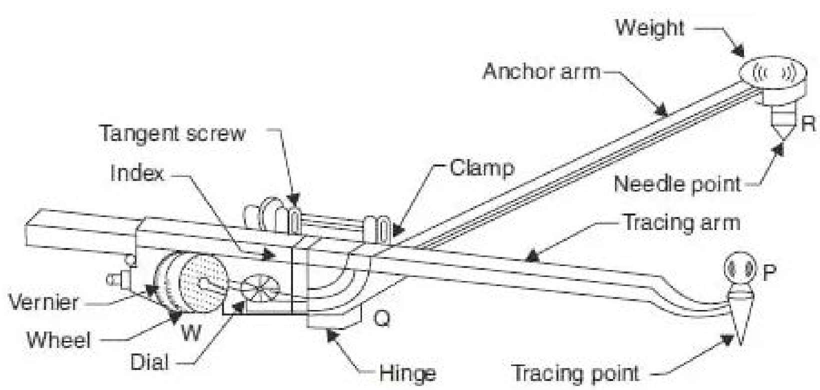
a) The following readings were taken on sloping continuously ground with a level staff. 2.850, 2.000, 1.200, 0.850, 2.750, 1.800, 0.450, 2.300, 1.100. Enter the readings in level book and calculate R.L.S.

Reduced level of first Point 101.000 m.

Station	BS	IS	FS	CP/HI	RL	Remark
				RL+BS		
1st Point	2.850			103.850	101.000	Bench mark
		2.000			101.850	
		1.200			102.650	
		0.850			103.000	
		2.750			101.100	
		1.800			102.050	
		0.450			103.400	
		2.300			101.550	
			1.100		102.750	
Total	2.850		1.100			
		Diff= BS- FS	1.750	Rem: Both are equal means traverse is correct		
		Diff= Last RL- 1st RL	1.750			

b) Write step wise procedure of measuring area of figure with plani meter.

***Planimeter* is an accurate instrumental method used for the computation area.** **For measuring the area of plots with planimeter, two methods are generally adopted.**



Method 1: the area of the figure is measured in square cm and the field area is determined by multiplying the area of the figure by the square of the scale of the plot. Along with the planimeter, the manufactures supply a scale chart. In this, the positions at which the vernier is to be set on the tracing arm for different scales are given. The vernier is set to a scale of 1:1 and the area of the plot is determined. This is multiplied with the square of the scale to get the field area.

Method 2: The filed area is directly obtained from the plot in sq.m. For this, the vernier is set to the position on the tracer bar corresponding to the scale of the plot. The area of the field is directly obtained in sq.m

Procedure for finding area with planimeter

The stepwise procedure for determining the area by method two is given below:

1. **Let the scale of the plot be 1:S**
2. **Set the vernier to the position on the tracer bar for a scale of 1:1**
3. **Fix the anchor point firmly on the paper outside or inside the figure according as the figure is small or large. Then move the tracing point only in the clockwise**

direction around the plot figure. Check whether all the points in the boundary can be reached without any difficulty. If not, change the position of the anchor point. Also note whether the total rotation of the wheel is a forward or a backward motion.

4. Mark a definite point on the outline of the figure and set the tracing point exactly on it.
5. Note the initial reading (I.R) or alternately set the dial and the wheel to zero.
6. Move the tracing point exactly around the outline always in a clockwise direction until it again reaches the starting point exactly. Note the final reading (F.R).
7. Note the number of times the zero mark of the dial passes the fixed point (index mark) in a clockwise or counter clockwise direction, while the tracing point is moved along the outline of the figure.
8. Area of the figure is given by:
   A = M (FR-IR = -10N+ C)
   Where M= the multiplier
   FR= final reading
   IR= initial reading
   N= It is the number of times the zero mark of the dial guage passes the fixed index mark
   C= a constant

The following points are to be noted:

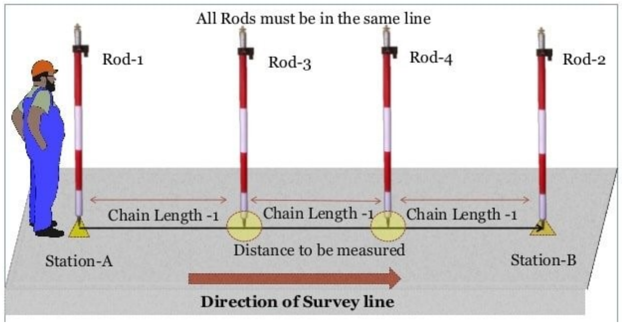
1. Use+ sign when the zero mark of the dial passes the fixed index mark in clockwise direction
2. The constant C is to be used only when the anchor point is fixed inside the figure.
3. When the anchor point is inside the figure, the following points are of importance:
   I. In the case of clockwise rotation, the net rotation of the wheel is always forward, if the area of the figure is greater than that of the zero circle.
   II. In the case of clockwise rotation, the net rotation of the wheel is always backward, if the area of the figure is less than that of the zero circle.

Precautions in the use of planimeter

1. For accuracy, measure the area twice with different positions of the anchor point for each measurement.
2. The area should be checked roughly by estimation/ rough calculation.
3. If the area is too large, divide the area into parts and find the area of the parts and add them together.
4. The plan should be placed horizontally when measurements is done with planimeter.
5. The surface of the paper must be smooth

c) Differentiate between direct and indirect ranging.

The process of fixing or establishing intermediate points to facilitate measurement of the survey lines are called as Ranging. The intermediate points are located by means of ranging rodes, offset rods and ranging poles.



Ranging Out Survey Lines

While measuring the survey lines, the chain or the tape has to be stretched along the survey line along that joins two terminal stations. When the line to be measured has a smaller length compared to the chain, then the measurement goes smooth. If the length of the line is greater, the survey lines have to be divided by certain intermediate points, before conducting the chaining process. This process is called ranging.

The process of ranging can be done by two methods:

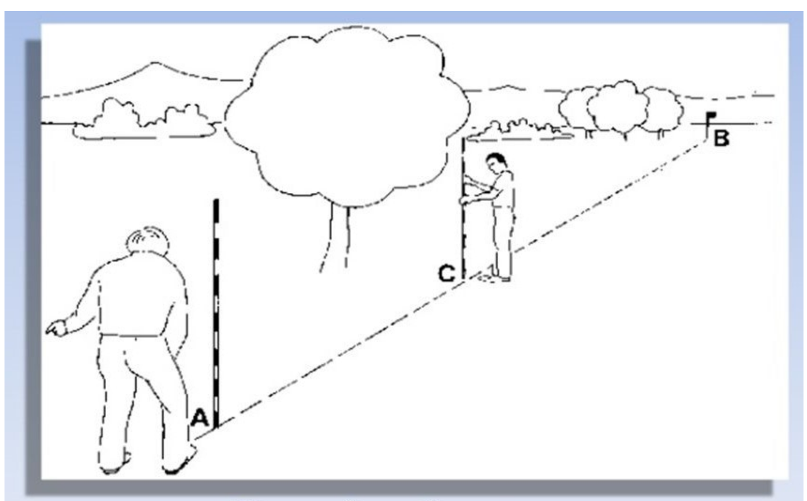
1. Direct Ranging
2. Indirect Ranging

1. Direct Ranging

Direct ranging is the ranging conducted when the intermediate points are intervisible. Direct ranging can be performed by eye or with the help of an eye instrument.

Ranging by Eye

As shown in figure-1 below, let A and B are the two intervisible points at the ends of the survey line. The surveyor stands with a ranging rod at the point A by keeping the ranging rod at the point B. The ranging rod is held at about half metre length.



Ranging by eye

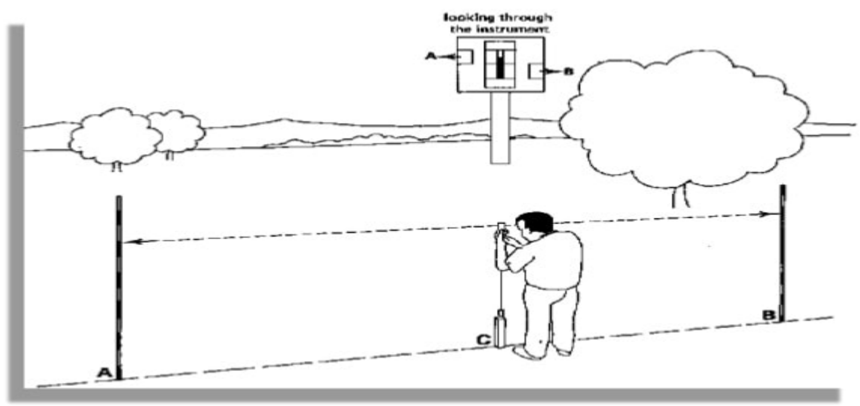
The assistant then takes the ranging rod and establishes at a point in between AB, almost in line with AB. This is fixed at a distance not greater than one chain length from point A.

The surveyor can give signals to the assistant to move traverse till the rod is in line with A and B. In this way, other intermediate points are determined.

Ranging by Line Ranger

The figure-2 below shows a line ranger that has either two plane mirror arrangement or two isosceles prisms that are placed one over the other. The diagonals of the prism are arranged and silvered such that they reflect incident rays.

Ranging by Line Ranger



In order to handle the instrument in hand a handle with hook is provided. The hook is to enable a plumb- bob to help transfer the point to the ground.

In order to range the point 'C', initially two rods are fixed at points A and B. By eye judgment, the surveyor holds the ranging rod at “C” almost in line with AB.

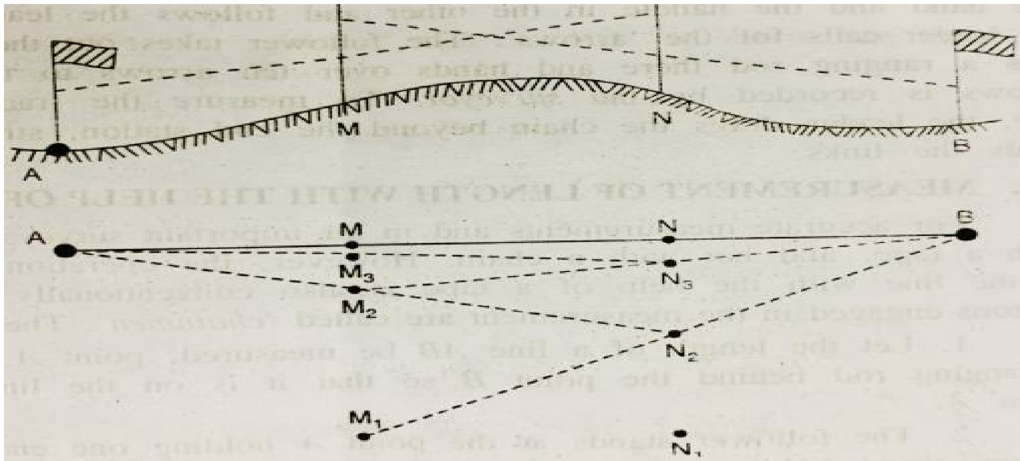
The lower prism abc receives the rays coming from A which is then reflected by the diagonal ac towards the observer. The upper prism dbc receives the rays from B which is then reflected by the diagonal bd towards the observer. Hence the observer can see the images of the ranging rods A and B, which might not be in the same vertical line as shown in figure-2(c).

The surveyor moves the instrument till the two images come in the same vertical line as shown in figure-2(d). With the help of a plumb bob, the point P is then transferred to the ground. This instrument can be used to locate the intermediate points without going to the other end of the survey line. This method only requires one person to hold the line ranger.

2. Indirect Ranging

Indirect ranging is employed when the two points are not intervisible or the two points are at a long distance. This may be due to some kind of intervention between the two points. In this case, the following procedure is followed.

As shown in figure-3, two intermediate points are located M1 and N1 very near to chain line by judgment such that from M1, both N1 and B are visible & from N1 both M1 and A are visible.



At M1 and N1 two surveyors stay with ranging rods. The person standing at M1 directs the person at N1 to move to a new position N2 as shown in the figure. N2 must be inline with M1B.

Next, a person at N2 directs the person at M1 to move to a position M2 such that it is inline with N2A. Hence, the two persons are in points are M2 and N2.

The process is repeated until the points M and N are in the survey line AB. Finally, it reaches a situation where the person standing at M finds the person standing at N in line with NA and vice versa. Once M and N are fixed, other points are fixed by direct ranging.

d) Define change point, reduced level, height of instrument.

Change Point

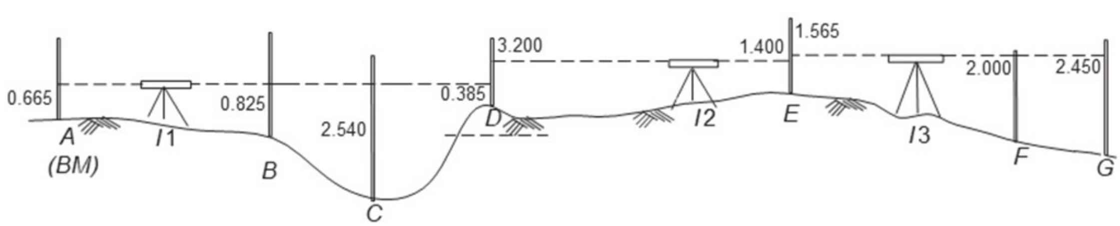
In levelling, a point at which two readings are taken on the staff, one before moving the instrument to a new position, and one after setting the instrument on the new position.

Height of Instrument :

It is the method which deals with the obtaining of RL of the line of collimation by adding BS reading of a known RL point. Thus, RL of the line of collimation is called the Height of Instrument. It is always measured from the benchmark. Hence the benchmark is the point on the sea derived from mean sea level.

method to calculate RL;

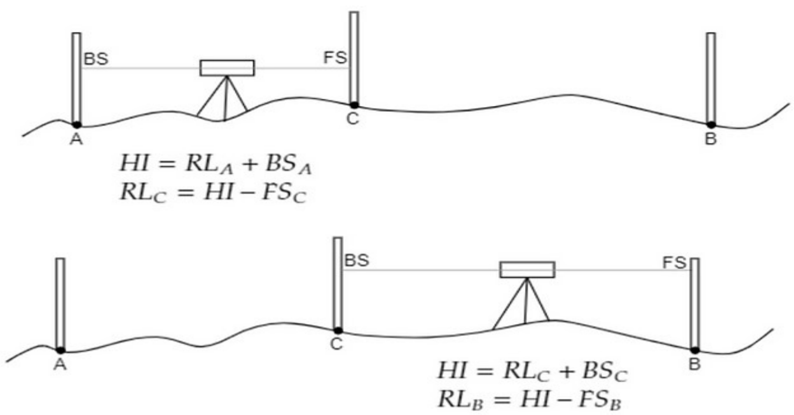
height of collimation (H of C) = reduced level(R.L.) + backsight (B.S.)
reduced level (R.L.) = height of collimation (H of C) – foresight (F.S.)
reduced level (R.L.) = height of collimation (H of C) – intermediate sight (I.S.)



Station	BS	IS	FS	HI	RL	Remarks
A	0.665			100.665	100.00	BM
B		0.825			99.840	
C		2.540			98.125	
D	3.200		0.385	103.480	100.280	CP
E	1.565		1.400	103.645	102.080	CP
F		2.000			101.645	
G			2.450		101.195	

Reduced level :

In Surveying, RL or Reduced Level is a vertical distance or height with reference to assumed datum line. In India we uses mean sea level of chennai as a datum line or datum point. Suppose we are surveying in an area and we have to calculate the elevations of the ground or to find oud the variations like rise or fall we need a reference point whose height or cordinates with reference to assumed datum line is known is called Reduced Level. In some cases for temperory work if RL is too far than we assumed a point or reference to calculate the same is called B.M. (Bench Mark).



$$\text{To check, } \sum BS - \sum FS = (last\ RL) - (first\ RL)$$

I. Write short note (any four):

a) Errors due to local attraction

Local attraction is the phenomenon by which the magnetic needle is constantly prevented to point towards the magnetic north at a place. This is because that these magnetic compass is influenced by other magnetic objects at that locality such as wires carrying electric current, rails, steel and iron structures, steel tapes etc.

The occurrence of local attraction can be detected by observing the difference between the fore and back bearings. If there is no influence of local attraction and other error, this difference will be 180. So we can then conclude that both stations are free from local attraction.

Elimination of local attraction in Compass Surveying

Due to local attraction significant amount of error can be occur in compass surveying observations and they will be same on all the bearings. Local attraction can be minimized using following methods:

Method 1

This method is based on the difference of fore and back bearings. We already know that the difference between fore and back bearing of a line will be 180˚ if there is no errors in measurement. So based on this error free observation of bearings, corrections for other lines can be calculated.

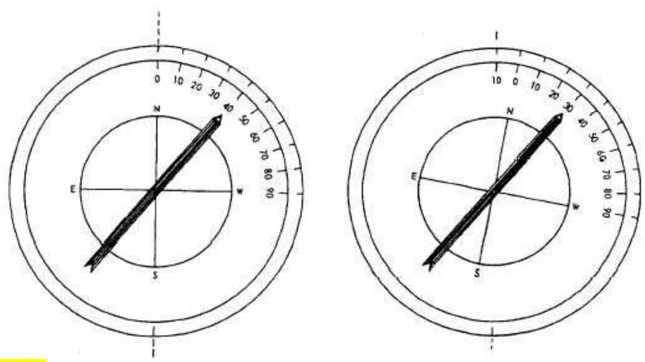
However if there is no two bearing has a difference of 180˚, we can calculate the correction from the mean value of that bearings which may have least error.

Method 2

This method is more faster method for applying correction. This is based on the interior angles of the closed traverse formed. The interior angles measured will be correct on the basis of the fact that these angles are not affected by the local attraction whereas the stations are. So the sum of total interior angles for a closed traverse will be (2n-4) 90˚.

If there is any error exists both sum will not be same. The total error can be distributed among the angles equally because equal error will occur on each interior angle. So starting from the correct observation of bearing which has a difference in fore and back bearing is 180˚, we can calculate all other corrected bearings.

Special Case: this procedure is applied when there is no such observations which has a difference of 180˚ in fore and back bearings of a line. Then two bearings of least discrepancy is selected in such a way that the difference of them is closest to 180˚. The mean value is obtained by adding half of the correction to fore bearing value and half to back bearing. Hence a value which differs by 180˚ can be obtained. So from this corrected bearing value other values can be measured.



Magnetic field of Earth

The earth acts as a powerful magnet and forms a magnetic field around it. The lines of force in this magnetic field are run from south to north. It is found that if a bar magnet is freely suspended, it will align itself parallel to the lines of magnetic force of earth. They are parallel lines near to the equator. The horizontal projections of these lines can be termed as magnetic meridian.

b) Theodolite

Theodolite is a measurement instrument utilized in surveying to determine horizontal and vertical angles with the tiny low telescope that may move within the horizontal and vertical planes.

It is an electronic/mechanical machine which looks sort of a tiny telescope. It is extensively used for the measurement of vertical and horizontal angles. The accuracy with that these angles may be measured ranges from 5mins to 0.1secs.

Theodolites are employed everyplace from construction sites to main road points. It measures angles using age-old principles of pure mathematics and assists surveyors in establishing precise locations.

1. Uses of Theodolite in Surveying

Theodolite uses for many purposes, but mainly it is used for measuring angles, scaling points of constructional works. For example, to determine highway points, huge buildings' escalating edges theodolites are used. Depending on the job nature and the accuracy required, theodolite produces more curved readings, using paradoxical faces and swings or different positions for perfect measuring survey.

2. Followings are the major uses of theodolite:

- Measuring horizontal and vertical angles
- Locating points on a line
- Finding the difference in the level
- Prolonging survey lines
- Ranging curves
- Setting out grades
- Tachometric surveying

The theodolite helps us a good within the engineering field. This instrument plays a major role in measurement horizontal angles, vertical angles, bearing, etc. To use theodolite, it is necessary to know about theodolite parts, types of theodolite, and for what it is used wisely in the field.

3. Technical Terms Used in Theodolite

a. Vertical axis: The axis about which the theodolite rotates in a horizontal plane.
b. Horizontal axis: The axis about which the theodolite rotates in a vertical plane.
c. Centring: Process of setting up the theodolite exactly over the ground station point.
d. Transiting: The process of turning the telescope in the vertical plane.
e. Swing: Continuous motion of the telescope about the vertical plane.
f. Face left observation: Vertical circle is on the left at the time of observation.
g. Face right observation: Vertical circle is on the right at the time of observation.
h. Changing face: Operation of changing the face of the telescope.
i. A set: It consists of two horizontal measures, one on the face left and the other on the face right.

4. Fundamental Axes of Theodolite

1. Vertical axis
2. Horizontal or trunnion axis
3. Line of collimation
4. Axis of plate levels
5. Axis of altitude level

5. Working Mechanism of Theodolite

Theodolite works by the combined mechanism of optical plummets also referred to as the plumb bobs, a spirit or the bubble level and the graduated circles to determine the vertical and horizontal angles.

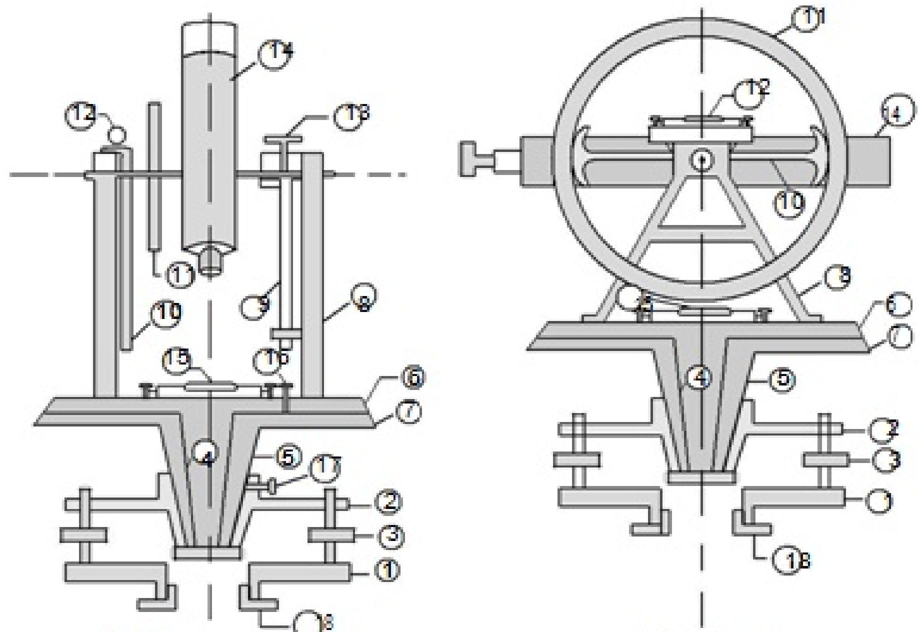
The optical plummets or the plumb bobs ensure that the theodolite is placed as close to exactly vertical above the point of the survey.

The spirit level ensures that the theodolite is exactly levelled to the horizontal.

Two types of graduated circles are provided namely the vertical graduated circle and horizontal graduated circle for measuring the angles.

6. Parts of a Theodolite in Surveying

A theodolite consists of a small telescope that is mounted on it. The telescope consists of sight on the top of it that is used to align the target.
The theodolite also consists of a focusing knob that is used to make the object clear.
The telescope of the theodolite is fitted with an eyepiece that the user looks through to find the target being sighted.
An objective lens is also fitted on the telescope on the opposite end of the eyepiece. The objective lens is provided to sight the object, and also with the help of the mirrors inside the telescope, allows the object to be magnified.
The base of the theodolite is threaded for easy mounting on a tripod.



(a) Sectional view (b) Another view

1. Trivet
2. Tribrach
3. Foot screw
4. Inner axis
5. Outer axis
6. Vernier plate
7. Circle plate
8. A-frame
9. Vertical circle clamp arm
10. Vernier frame
11. Vertical circle
12. Altitude bubble
13. Vertical circle clamp
14. Telescope
15. Plate bubble
16. Upper clamp
17. Lower clamp
18. Tripod head

7. Types of Theodolite in Surveying

The theodolites can be classified on the following basis:

1. Based on the Constituent Parts

Depending upon the constituent parts of a theodolite, the theodolite can be classified into digital theodolite and non-digital theodolite.
The non-digital theodolite is the ancient or the traditional type of theodolite. This type of theodolite is manual and is rarely used nowadays.
Digital theodolite is simply the advancement of a non-digital theodolite.
The digital theodolite consists of a telescope that is mounted on a base and an electronic readout screen that is used to display horizontal and vertical angles.
Digital theodolite is commonly used because the digital readouts take the place of traditional graduated circles and this creates more accurate readings.

2. Primary Classification of Theodolite

The primary classification categorizes the theodolite into transit and non-transit type theodolites.

The theodolite whose telescope can be transited i.e. revolved through a complete revolution about its horizontal axis in the vertical plane is known as a transit type theodolite.
On the other hand, the theodolite whose telescope cannot be transited is known as non-transit type theodolite. The transit type theodolites are the most commonly used type of theodolite.

8. Applications of Theodolite in Surveying

The major application areas of theodolite can be listed as follows:

1. Navigation
2. Meteorology
3. Surveying and its applications
4. Measurement as well as laying out the angles and straight lines
5. Aligning of walls
6. Formation of Panels
7. Plumbing building corners, columns etc.
8. Tacheometric Surveying
9. Finding the difference in the level
10. Ranging Curves

c) Invar tape

Invar tape is made up of an alloy of nickel (36%) and steel (64%). It is less affected by temperature changes when compared to the other tapes due to very low coefficient of thermal expansion. It is highly precise but requires much attention in handling as it is soft and deforms easily.

Invar tape contains a 6mm wide strip and is available in different lengths of 30m, 50m, 100m.

The coefficient of thermal expansion of invar alloy is very low. It is not affected by changes in temperature. Hence, these tapes are used for high precision works in surveying such as baseline measurement, triangulation surveys, etc. Invar tapes are expensive than all the other types of tapes.

d) Metric chain 20 meter

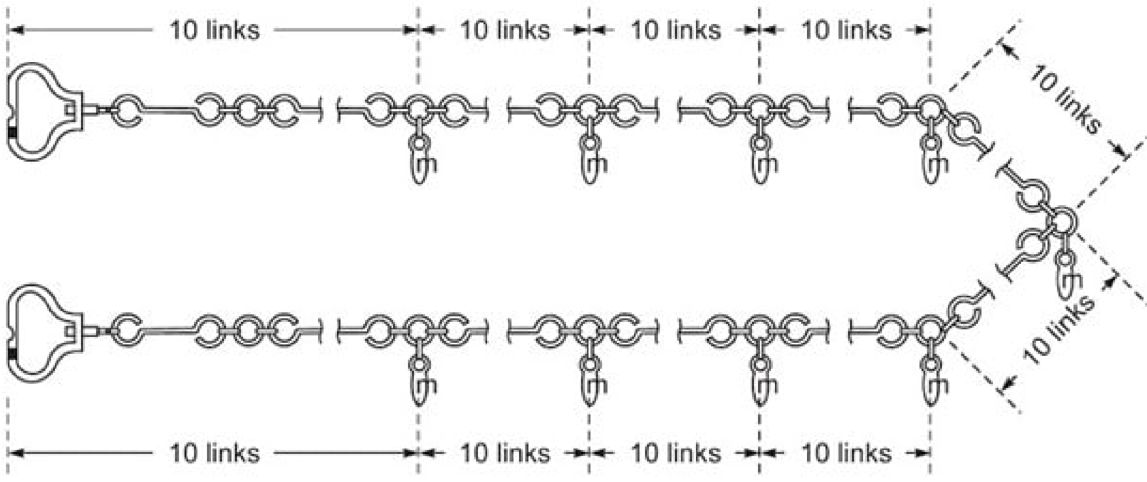
Chains are the measuring instrument used in surveying formed by the 100 links of 4mm galvanized mild steel wire. These links are joined by 3 circular or oval wire rings. These rings provide the flexibility to the chains. Every aspect of the life requires some measuring units. Measurements are used to do the work precisely and accurately. Let it be from kitchen to office, everywhere measurements are used. So as in engineering calculation or measurements holds a very greater role in construction or surveying or any other aspect. There are various units of measurements such as meters, centimeters, feets, inches, acre, yards and the list goes on. Same as units there are various instrument used in the measurements of any entity. One of the instruments used in measurement are chains.

Parts of Chains used in Surveying

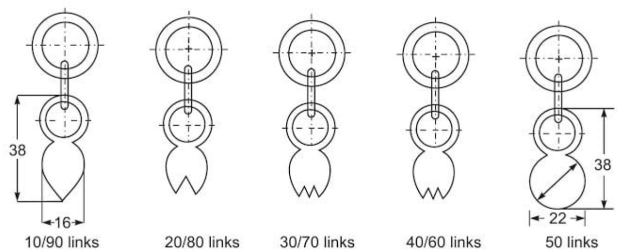
The chain consists of many small parts used for handling or reading the measurements.

- At the ends chain is provided with brass handle with swivel joint so that it can be easy to roll or unroll the chain without twisting and knots.

- At every 10th link is provided with a tally of one teeth, 20th link with a tally of two teeth and so on till 40th link. This is provided for the easy reading of measurements.
- At the center of the chain is provided with a circular talley used for easy reading.



(a) 100 link chain



(b) Talleys

Types of Chains used in Surveying

Depending upon the length of the chain these are divide into following types,

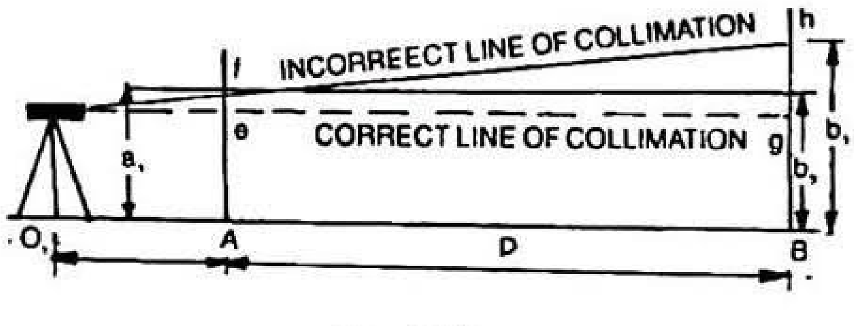
1. Metric chains
2. Steel band or Band chain
3. Gunter's chain or surveyor's chain
4. Engineer's chain
5. Revenue chain

A. Metric chains

Metric chains are the most commonly used chain in India. These types of chains comes in many lengths such as 5, 10, 20 and 30 meters. Most commonly used is 20m chain. Tallies are provided at every 2m of the chain for quick reading. Every link of this type of chain is 0.2m. The total length of the chain is marked on the brass handle at the ends.

e) Line of collimation

It is an imaginary straight line joining the intersection of the cross-hairs at diaphragm to the optical centre of the object- glass and it's continuation. It is also called the line of sight. It is horizontal when the bubble is in the centre.



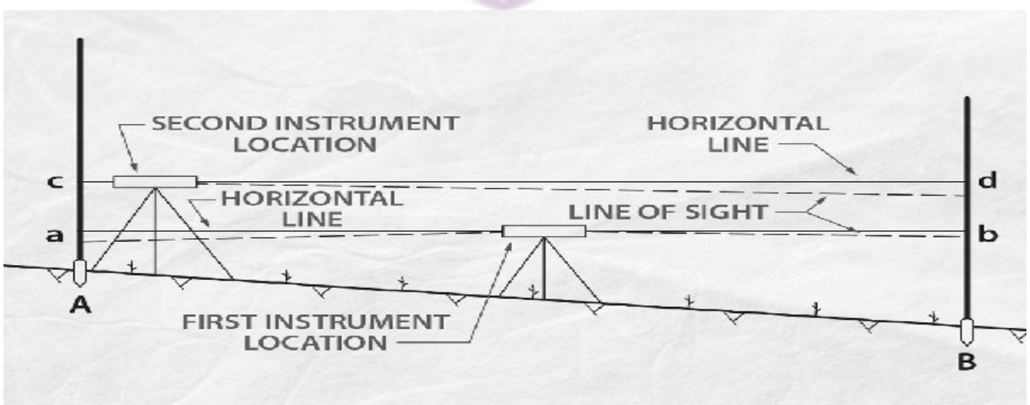
Since the the target is measure with reference to diaphragm (cross hairs +. Even if telescope is truly horizontal but reading is slightly different if diaphragm is up or down from centre. So it introduce error in measurement which we called as line of collimation error

Compensate the error:

To mitigate this error in measurement in theodolite, measurement is taken twice (left face + right face, by transiting and swinging); since if first reading is (r+e) on transiting it will (r-e) so mean is r

Determine the error:

Error is measure with two peg method which have following procedure as. Two predefined positions is taken and there difference in reduce level is determined from instrument at position A with reading (a,b) on staff. then instrument is shifting to random point S distance apart B and same points reading is taken as(c,d)
$e=((a-b)-(c-d))/2$



f) Temporary adjustment of dumpy level.

At each set up of a level instrument, temporary adjustment is required to be carried out prior to any staff observation. It involves some well defined operations which are required to be carried out in proper sequence.

The temporary adjustment of a dumpy level consists of
(1)Setting ,
(2)Leveling and
(3) Focusing .

During Setting, the tripod stand is set up at a convenient height having its head horizontal (through eye estimation). The instrument is then fixed on the head by rotating the lower part of the instrument with right hand and holding firmly the upper part with left hand. Before fixing, the leveling screws are required to be brought in between the tribrach and trivet. The bull's eye bubble (circular bubble), if present, is then brought to the centre by adjusting the tripod legs.

Next, 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.

Step 5: Repeat Step 1 by rotating the upper part of the instrument in the same quadrant of the circle and then Step 2.

Step 6: Repeat Step 3 by rotating the upper part of the instrument in the same quadrant of the circle and then Step 4.

Step 7: Repeat Steps 5 and 6, till the bubble remains central in both the positions. Step 8: By rotating the upper part of the instrument through 180 o , the level tube is brought parallel to first two foot screws in reverse order. The bubble will remain in the centre if the instrument is in permanent adjustment.

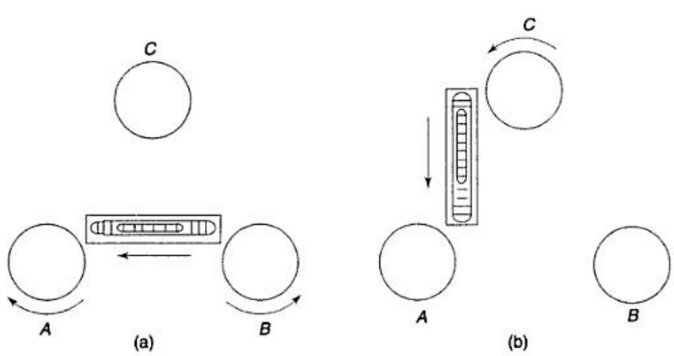


Fig. 6.22 *Levelling with three foot screws*

Focusing is required to be done in order to form image through objective lens at the plane of the diaphragm and to view the clear image of the object through eye-piece. This is being carried out by removing parallax by proper focusing of objective and eye-piece. For focusing the eye-piece, the telescope is first pointed towards the sky. Then the ring of eye-piece is turned either in or out until the cross-hairs are seen sharp and distinct. Focusing of eye-piece depends on the vision of observer and thus required whenever there is a change in observer.

For focusing the objective, the telescope is first pointed towards the object. Then, the focusing screw is turned until the image of the object appears clear and sharp and there is no relative movement between the image and the cross-hairs. This is required to be done before taking any observation.