<u>What is Surveying ? (Not important but need to know) (2 marks)</u>

Surveying is the art of making measurements of objects on, above or beneath the ground to show their relative positions on paper.
The relative position required is either horizontal, or vertical, or both.

<u>Why we do surveying ? (Not important but need to know) (2 marks)</u>

1. Maps prepared for marking boundaries of countries, states, districts etc., avoid disputes.
2. Locality plans help in identifying location of houses and offices in the area.
3. Topographic maps showing natural features like rivers, streams, hills, forests help in planning irrigation projects and flood control measures.
4. For planning and estimating project works like roads, bridges, railways, airports, water supply and waste water disposal surveying is required.

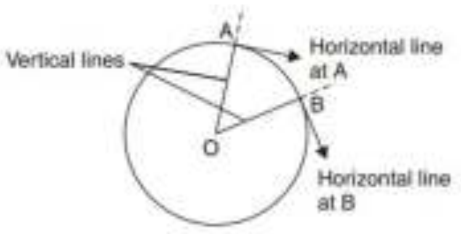


Fig. 11.1. Vertical and horizontal lines

The earth may be treated as a sphere, shows a circular plane passing through a point A on the earth surface.

The gravitational force is always directed towards the centre of the earth. The *<u>plumb-line</u>* shown in Fig. is a *<u>vertical line</u>*. (2 marks)
Line perpendicular to vertical line (tangential to earth surface) is known as <u>horizontal line. (2 marks)</u>
In surveying all measurement at any point are in the direction of these two lines

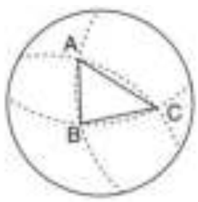


Fig. 11.2. Plane and spherical triangles

If the area to be surveyed is small, the curvature of the earth may be neglected and all plumb lines treated as the same vertical. Hence, the lines normal to plumb line at any point in the area are treated as the same horizontal.
All triangles in the area may be treated as plane triangles.

(2 marks - Define Plane surveying)
The survey in which earth curvature is neglected is called *<u>Plane Surveying</u>*. For small survey area, curvature of earth is neglected.

(2 marks - Define Geodetic surveying)
The survey in which earth's curvature is considered is known as *Geodetic Surveying*. For large suvey area, we cannot ignore earth's curvature in measurement.

(2 marks- Basic fundamental principle in surveying ?)
To get accurate results in surveying one should follow the following fundamental principles :-
1) Work from whole to part
2) Take extra care in fixing new control points

Locating Point C with respect to Point A and B

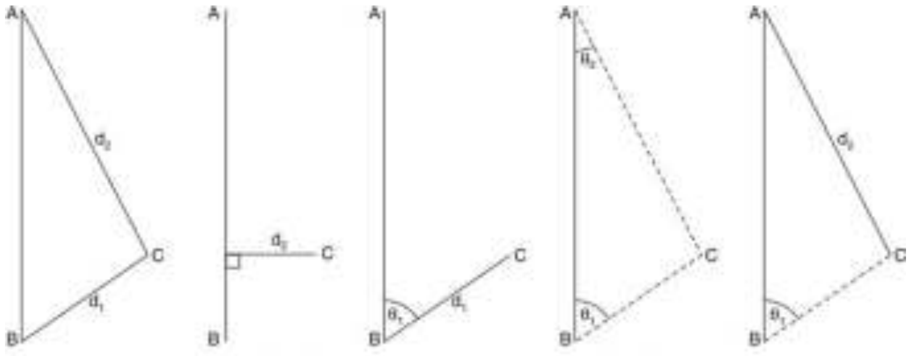


Fig. 11.3. Locating point C w.r.t. points A and B

What is Scale ?(2 marks)
It is not possible and also not desirable to make maps to one to one scale. While making maps all distances are reduced by a fixed proportion. That fixed proportion is called ***scale of the map.***
Thus, if 1mm on the paper represents 1 metre on the ground, then the scale of the map is
1 mm = 1 m or 1 mm =1000 mm or 1 : 1000.

What is Representative factor (RF) (2 marks)
To make scale independent of the units it is preferable to use ***representative factor (RF)*** which may be defined as the ratio of one unit on paper to the number of units it represent on the ground.
Thus 1 mm = 1 m is equivalent to RF = 1 / 1000

Classification of surveying
Based on the instruments used, surveying may be classified as:
(i) Chain survey
(ii) Compass survey
(iii) Plane table survey
(iv) Theodolite survey
(v) Tacheometric survey
(vi) Modern survey using electronic distance meters and total station
(vii) Photographic and Aerial survey

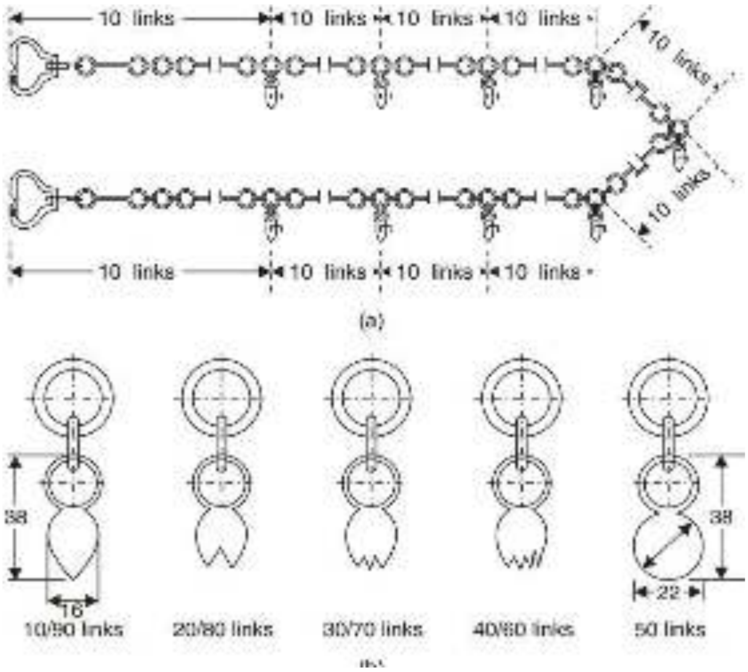
Method of preparing a plan using only linear measurements is by conducting **chain surveying**. (2 marks)
Measurement of distances using chain or tape is termed as **chaining.** (2 marks)

Instruments Used in Chain Survey: (4 marks)

(i) Chain (or) Tape
(ii) Arrows
(iii) Pegs
(iv) Ranging Rods
(v) Offset Rods
(vi) Plasterer's laths and whites
(vii) Plumb bob

1. **Chain**

- They are formed of straight links of Galvanized mild steel wires.
- To facilitate easy reading of the chain, brass tallies are provided.
- It is to be noted that length of a link is the distance between centres of two consecutive middle rings.
- the length of the chain is from outside of one handle to the outside of the other handle.



Types :
Metric chain, Surveyor's chain, Engineer's chain
Metric chains are of 20 m length. They have 100 links with talleys at every 2 m. Each link is of 0.2 m length.

Tapes : Depending upon the materials used, they are classified as:
(i) cloth or linen tape
(ii) metallic tape
(iii) steel tape and
(iv) invar tape.

Cloth or linen tape

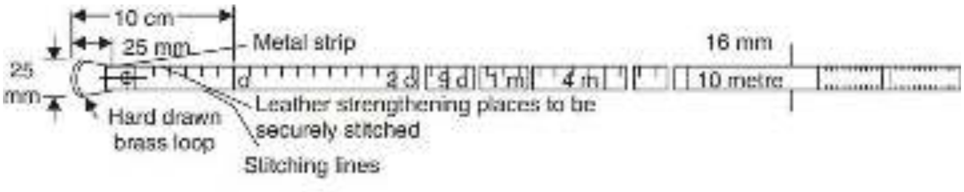
- 12 to 15 mm wide cloth or linen is varnished and graduations are marked.
- They are provided with brass handle at the ends. They are available in length of 10 m, 20 m, 25 m and 30 m.

- These tapes are light and flexible. However because of the following disadvantages they are not popular:

(i) Due to moisture they shrink.
(ii) Due to stretching they extend.
(iii) They are not strong.
(iv) They are likely to twist.

Metallic Tape

- They are made up of varnished strip of waterproof linen inter-wooven with small wires of brass, copper or bronze.
- Tapes of length 10 m, 20 m, 30 m and 50 m are available in a case of leather or corrosion resistant metal fitted with a winding device.
- These tapes are light, flexible and not easily broken.
- These tapes are commonly used in surveying.



- Fig. 12.2. Metallic tape

Steel Tape

- A steel tape consists of 6 to 10 mm wide strip with metal ring at free end and wound in a leather or corrosion resistant metal case.
- Steel tapes are superior to metallic tapes as far as accuracy is concerned.
- They should be oiled regularly to prevent corrosion.

INVAR Tape

- *Invar is an alloy of nickel (36%) and steel.*
- It's coefficient of thermal expansion is low. Hence errors due to variation in temperature do not affect measurements much.
- The width of tape is 6 mm.
- It is available in length 30 m, 50 m and 100 m.
- It is accurate but expensive.

2. **Arrows**

- When the length of the line to be measured is more than a chain length, there is need to mark the end of the chain length.
- Arrows are used for this purpose.

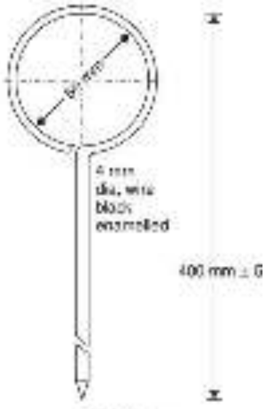


Fig. 12.5. Arrow

3. Pegs

- Wooden pegs are used to mark the positions of the survey stations or the end points of a survey line
- The pegs are made of hard wood of 25 mm × 25 mm section, 150 mm long with one end tapered
- When driven in ground to mark station points they project about 40 mm

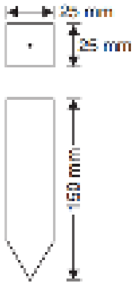


Fig. 12.6. Pegs

4. Ranging Rods and Ranging Poles

- For ranging intermediate points along the line to be measured, ranging rods and ranging poles are used.
- Ranging rods are 2 to 3 m long and are made of hard wood. They are provided with iron shoe at one end
- They are usually circular in section with 30 mm diameter and are painted with 200 mm colour bands of red and white or with black and white.
- Ranging poles are similar to ranging rods except that they are longer.
- Their length varies from 4 m to 8 m and diameter from 60 mm to 100 mm.

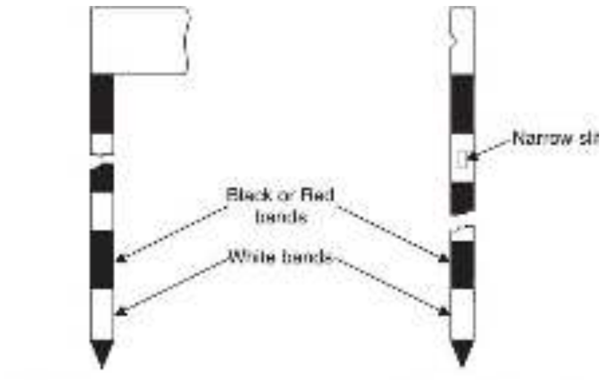


Fig. 12.7 Ranging rod   Fig. 12.8. Offset rod

5. **Offset rod**

- These rods are also similar to ranging rods and they are 3 m long. They are made up of hard wood and are provided with iron shoe at one end.
- A hook or a notch is provided at other end.
- At height of eye, two narrow slits at right angles to each other are also provided for using it for setting right angles.

6. **Laths**

- Laths are 0.5 to 1.0 m long sticks of soft wood.
- They are sharpened at one end and are painted with white or light colours.
- They are used as intermediate points while ranging or while crossing depressions.

7. **Whites**

- Whites are the pieces of sharpened thick sticks cut from the nearest place in the field. One end of the stick is sharpened and the other end is split.
- White papers are inserted in the split to improve the visibility.
- Whites are also used for the same purpose as laths.

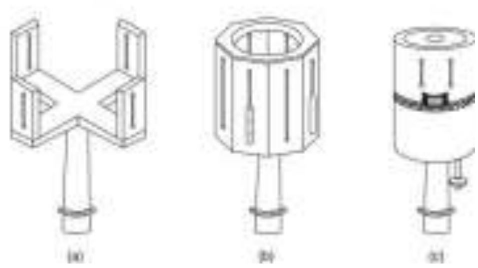
8. **Plumb Bob**

- They are also used to check the verticality of ranging poles
- It is further used in the primary adjustments of all the surveying instruments.

9. **Cross staff:**

- The cross staff is used for
    a) Finding out foot of the perpendicular from a given point to a line
    b) Setting right angle at a given point on a line

Perpendicular Offsets Using Cross Staffs



(Q. List cases where chain Surveying is suitable ? (marks-4))

Chain survey is suitable in the following cases:

(i) Area to be surveyed is comparatively small

(ii) Ground is fairly level

(iii) Area is open and
(iv) Details to be filled up are simple and less.

In chain surveying only linear measurements are made i.e. no angular measurements are made. Since triangle is the only figure that can be plotted with measurement of sides only, in chain surveying the area to be surveyed should be covered with a network of triangles.

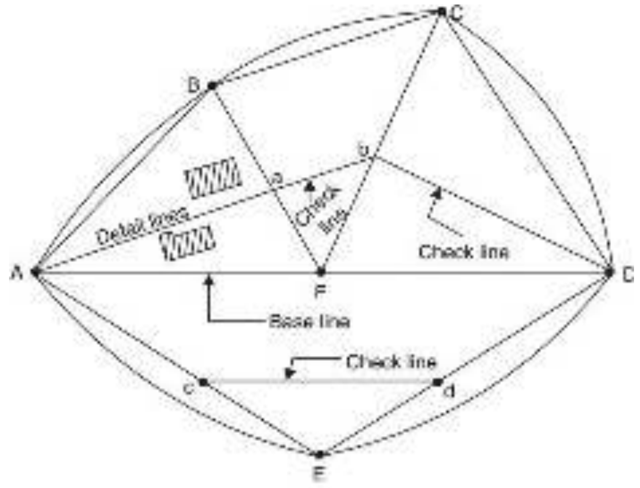


Fig. 12.11. Network of triangles

(definitions- 2 marks each)

Station: Station is a point of importance at the beginning or at the end of a survey line.

Main station: These are the stations at the beginning or at the end of lines forming main skeleton. They are denoted as A, B, C etc.

Subsidiary or tie stations: These are the stations selected on main lines to run auxiliary/secondary lines for the purpose of locating interior details. These stations are denoted as a, b, c, ...,etc., or as 1, 2, 3, ... etc.

Base line: It is the most important line and is the longest.
Usually it is the line plotted first and then frame work of triangles are built on it.

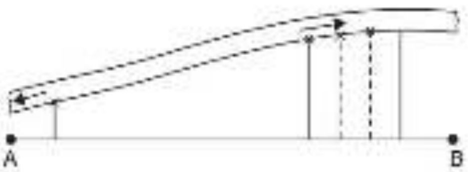
Detail lines: If the important objects are far away from the main lines, the offsets are too long, resulting into inaccuracies and taking more time for the measurements.
In such cases the secondary lines are run by selecting secondary stations on main lines. Such lines are called detail lines.

Check lines: These are the lines connecting main station and a substation on opposite side or the lines connecting to substations on the sides of main lines.
The purpose of measuring such lines is to check the accuracy with which main stations are located.

Offsets (2 Marks)

Lateral measurements to chain lines for locating ground features are known as offsets.
For this purpose :-
1) perpendicular or
2) oblique offsets may be taken.

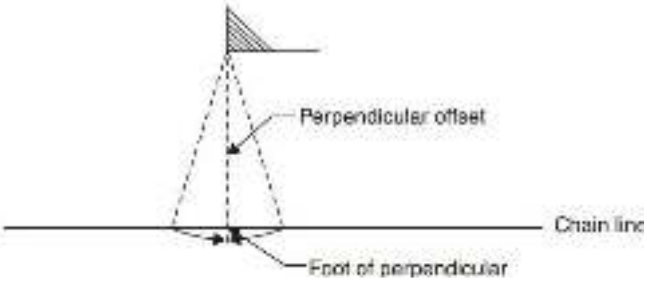
(a)



(b)

For setting perpendicular offsets any one of the following methods are used:
(i) Swinging
(ii) Using cross staffs

Perpendicular Offset by Swinging



<u>The following points should be considered in selecting station points:</u> (4 Marks)

(i) It should be visible from at least two or more stations.
(ii) As far as possible main lines should run on level ground.
(iii) All triangles should be well conditioned (No angle less than 30º).
(iv) Main network should have as few lines as possible.
(v) Each main triangle should have at least one check line.
(vi) Obstacles to ranging and chaining should be avoided.
(vii) Sides of the larger triangles should pass as close to boundary lines as possible.
(viii) Tresspassing and frequent crossing of the roads should be avoided.

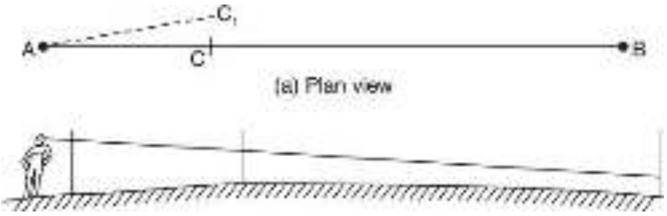
<u>RANGING</u>

When a survey line is longer than a chain length, it is necessary to align intermediate points on chain line so that the measurements are along the line.The process of locating intermediate points on survey line is known as ***<u>ranging.</u>***

There are two methods of ranging viz., direct ranging and reciprocal ranging.

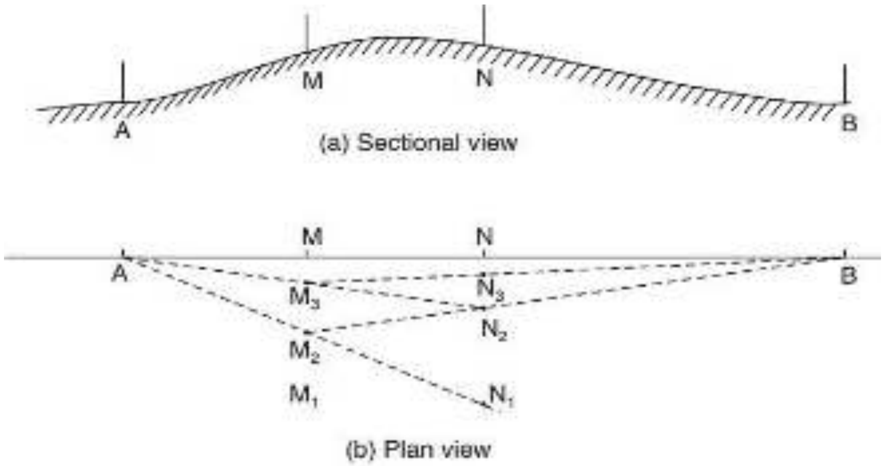
<u>Direct Ranging</u>

If the first and last points are intervisible this method is possible.



Indirect or Reciprocal Ranging

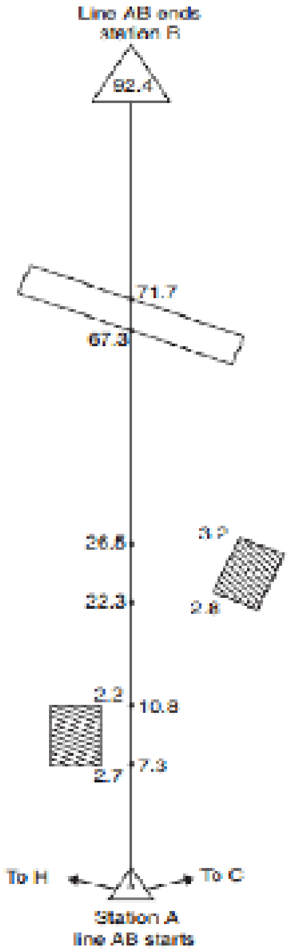
Due to interfering ground, if the ranging rod at B is not visible from station A, reciprocal ranging may be used.

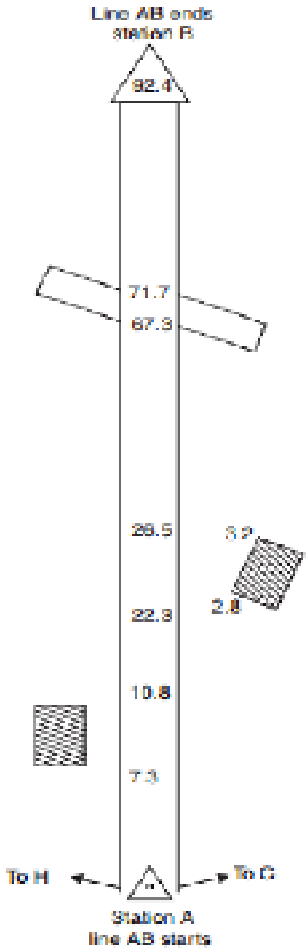


- Due to intervening ground, if the ranging rod at B is not visible from station A, reciprocal ranging may be resorted. Figure shows this scheme of ranging.
- It needs two assistants one at point M and another at point N, where from those points both station A and station B are visible. It needs one surveyor at A and another at B.
- To start with M and N are approximately selected, say M1and N1. Then surveyor near end A ranges person near M to position M2such that AM2N1 are in a line.
- Then surveyor at B directs person at N, to move to N2 such that BN2M2 are in a line.
- The process is repeated till AMNB are in a line.

Field book

- All observations and measurements taken during chain surveying are to be recorded in a standard field book.
- There are two forms of the book (i) single line and (ii) double line.
- The pages of a single book are having a red line along the length of the paper in the middle of the width. It indicates the chain line.
- All chainages are written across it.
- The space on either side of the line is used for sketching the object and for noting offset distances. In double line book there are two blue lines with a space of 15 to 20 mm is the middle of each book.
- The space between the two lines is utilised for noting the chainages.





ERRORS IN CHAINING

(i) Personal errors

(ii) Compensating errors, and

(iii) Cumulating errors.

Personal errors

Wrong reading, wrong recording, reading from wrong end of chain etc., are personal errors. These errors are serious errors and cannot be detected easily.

Care should be taken to avoid such errors.

Compensating Errors

(i) Incorrect marking of the end of a chain.

(ii) Graduations in tape may not be exactly same throughout.

These errors may be sometimes positive and sometimes negative.

Cumulative Errors

The errors, that occur always in the same direction are called cumulative errors.

(i) Bad ranging

(ii) Bad straightening

(iii) Erroneous length of chain

(iv) Temperature variation

(v) Variation in applied pull

(vi) Non-horizontality

(vii) Sag in the chain.

Toposheets or Topographical Maps

- Topographical map is also known as Topographical Survey Sheet or Toposheet.
- It is a multipurpose map drawn on large scale and covers a small area.
- It shows both natural features such as relief, drainage, vegetation, etc. and man made features such as roads, railways, canals, etc.
- It shows even the small features in good details because it is drawn on a large scale.
- Importance
- The are used by large number of professionals including military personnels, administrators,planners,researchers,travellers, etc.
- Most of the military operations are based on the study of topographical maps.
- Future planning of any area also depends upon the study of these maps.

Topographical Maps of survey of India

- The survey of India department was established in 1767 with headquarters at 1767. This department has published many series of toposheets.
- International Series: This is drawn on 1:10,00,000 scale and is also known as one to one million sheet. Each sheet has 4* latitude and 6* longitude. Heights are shown in metres.
- India and Adjacent countries: They are also drawn on 1:10,00,000 scale. Longitude- 4* and Longitude-4*. They have been given serial numbers like 45,46,47 etc which are known as index numbers. This series forms the base for other series.
- Topographical Maps of survey of India
- Quarter Inch to Mile series: I Inch = 4 miles or 1:2,53,440
- Each 1:1 million sheet is divided into 16 parts and each part is labelled from A to P eg. 63A, 63B, 63C etc. Their latitudinal and longitudinal extent is 1* and they are known as degree sheets. The new editions of these sheets have been published in metric scale, 1:2,50,000 scale. Their contour interval is 100 metres.
- Topographical Maps of survey of India
- 1:25,000 series- Each Sheet of 1:50,000 series is further divided into 4 parts. Two parts along latitude and two parts along longitudes.
- They are numbered according to direction, such as 63K/12/NW, 63K/12/NE, 63K/12/SW, 63K/12/SE.

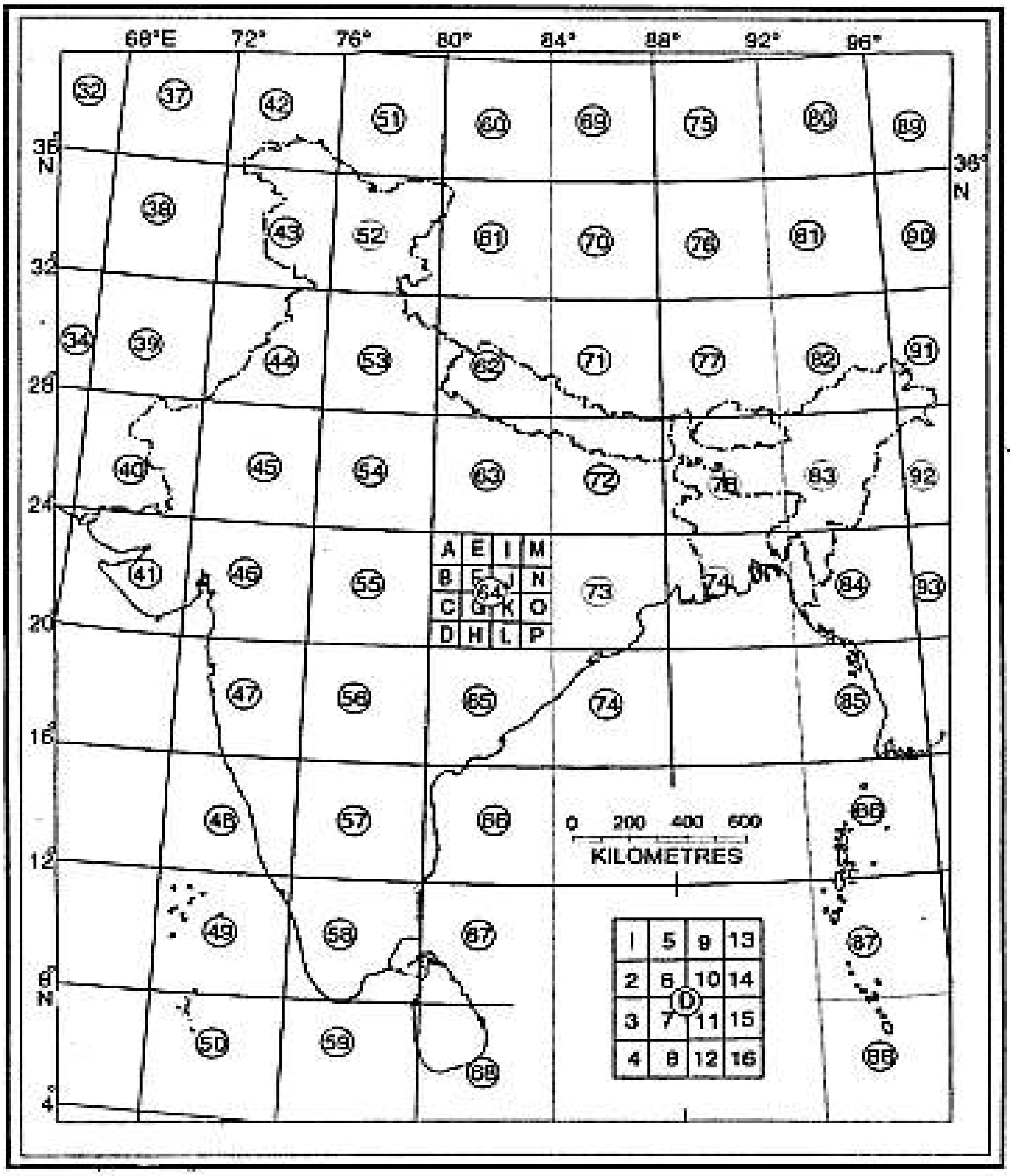
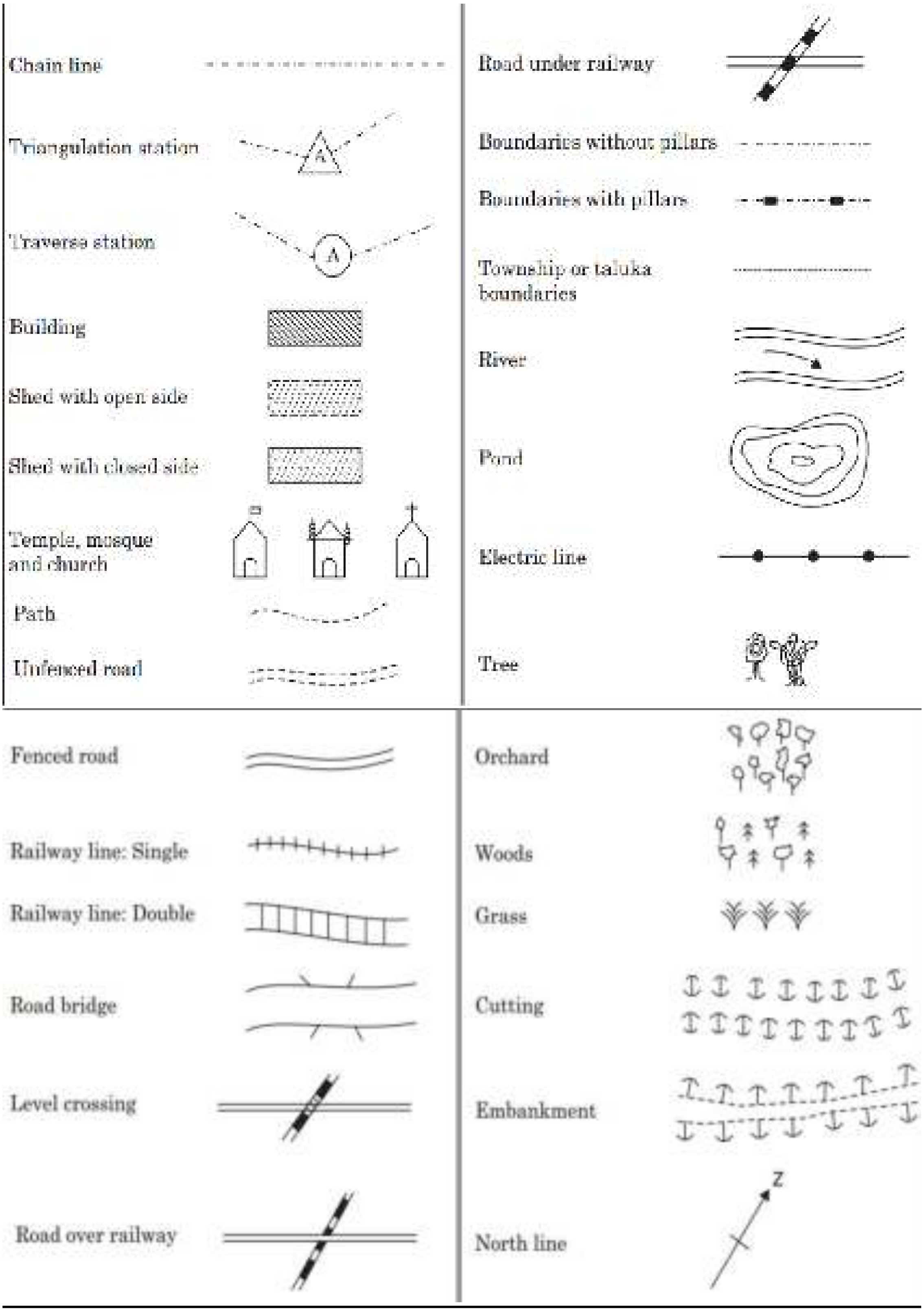


FIG. 6.1. REFERENCE MAP OF TOPOGRAPHIC SHEETS PUBLISHED BY THE SURVEY OF INDIA

CONVENTIONAL SYMBOLS

- If coloured plans are to be made, the code recommends light washes of the following shades:
- For roads – Burnt sienna
- For buildings – Light grey
- For compound walls – Indigo
- For water – Borders edged with Prussian blue
- For trees – Green.

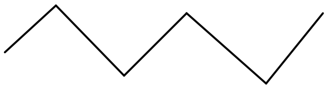

Chain line
Triangulation station
A
Traverse station
A
Building
Shed with open side
Shed with closed side
Temple, mosque and church
Path
Unfenced road
Road under railway
Boundaries without pillars
Boundaries with pillars
Township or taluka boundaries
River
Pond
Electric line
Tree
Fenced road
Railway line: Single
Railway line: Double
Road bridge
Level crossing
Road over railway
Orchard
Woods
Grass
Cutting
Embankment
North line
Z

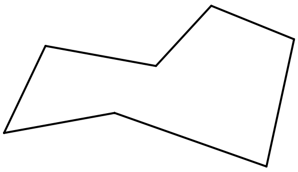
The magnetic north-south direction which is the reference direction is called **meridian** (reference direction) and the angle between the line and the meridian is called **bearing.**

Traverse Survey:

Traverse- A series of connected straight lines is called as traverse. It is of two types:

1) Open Traverse
   Starting and End point are different.





2) Closed traverse.
   Starting and End point are same

Prismatic Compass:

1. Graduation circle is fixed to broad type needle . Hence, it will not rotate with the line of sight.
2. There is a prism at viewing end.
3. Sighting and reading can be done simultaneously.
4. Graduations are marked inverted since its
5. reflection is read through prism.
6. The reading is taken through a prism.

Prismatic Compass

Note: Surveyor's Compass is not in syllabus but comparision should be studied.

Table 13.1. Differences between prismatic and surveyors compass

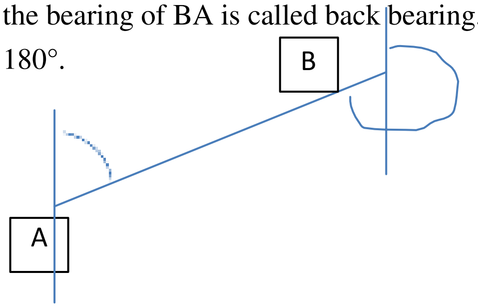
Sr. No.	*Prismatic Compass*	*Surveyors Compass*
1.	Graduation circle is fixed to broad type needle. Hence, it will not rotate with the line of sight.	Graduation circle is fixed to the box. Hence, it rotates with the line of sight.
2.	There is a prism at viewing end.	At viewing end there is no prism. There is only a slit.
3.	Sighting and reading can be done simultaneously.	Sighting and viewing cannot be done simultaneously.
4.	The magnetic needle do not act as an index.	Magnetic needle acts as index while reading.
5.	The graduations are in whole circle bearing.	The graduations are in quadrantal system.
6.	Graduations are marked inverted since its reflection is read through prism.	Graduations are marked directly. They are not inverted.
7.	The reading is taken through a prism.	The reading is taken by directly viewing from top glass.
8.	Tripod may or may not be used. It can be held on a stretched hand also.	Tripod is essential for using it.

The direction shown by a freely suspended and properly balanced magnetic needle is called **magnetic meridian** and the horizontal angle made by a line with this meridian is known as **magnetic bearing.**

The points of intersection of earth's axis with surface of the earth are known as geographic north and south pole. The line passing through geographic north, south and the point on earth is called **true meridian** at that point and the angle made by a line passing through that point is called **true bearing.**

All bearings are angles where as all angles are not Bearings

While traversing along lines A, B, C, D ..., the bearing of lime AB is called fore bearing of AB and the bearing of BA is called back bearing. Fore bearing and back bearing differ by 180°.



Angle of Declination

The magnetic meridian and the true meridian may not coincide with each other in a place. The horizontal angle between these two meridians is known as magnetic declination. The magnetic north at a place may be towards east or west of true north . If it is towards east, it is known as eastern or +ve declination. Western declination is known as –ve declination.

(a) +ve Declination (b) –ve Declination

True Bearing = Magnetic Bearing + - Angle of Declination (+ve for east , -ve for west)

Example 3.6 The magnetic bearing of line PQ is 124°35′. Find its true bearing, if the magnetic declination is 10°10′W.

Solution True bearing of line = magnetic bearing ± magnetic declination E/W. Since, magnetic meridian is to the west.

$$\text{True bearing} = 124°35' - 10°10'$$
$$= 114°25'$$

Example 3.7 The magnetic bearing of line PQ is S40°E and the magnetic declination is 8°5′E. What is the true bearing of the line?

Solution The W.C.B. of line PQ = 180° – 40° = 140°

$$\text{True bearing of PQ} = \text{magnetic bearing} \pm \text{magnetic declination E/W}$$
$$= 140° + 8°5'$$
$$= 148°5'$$

Angle of Dip

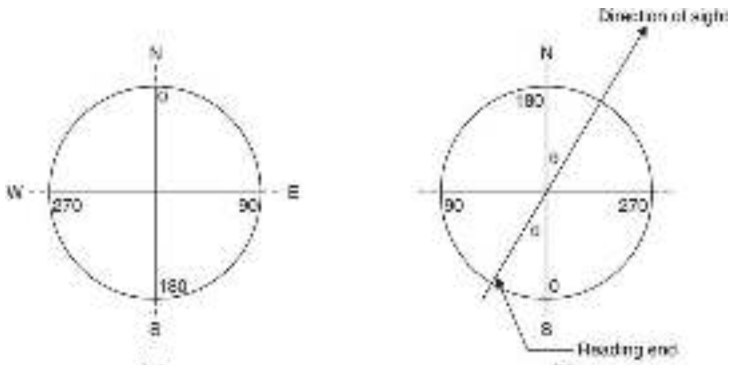
The vertical angle between the horizontal and the direction shown by a perfectly balanced and freely suspended needle is known as the magnetic dip at that place. Its value is 0° at equator and 90° at magnetic poles.

Whole Circle Bearing

In **whole circle bearing (WCB)** the bearing of a line at any point is measured with respect to a meridian.

Its value varies from zero to 360°, increasing in clockwise direction.

Zero is north direction, 90° is east, 180° is south and 270° is west. This type of bearing is used in *prismatic compass.*

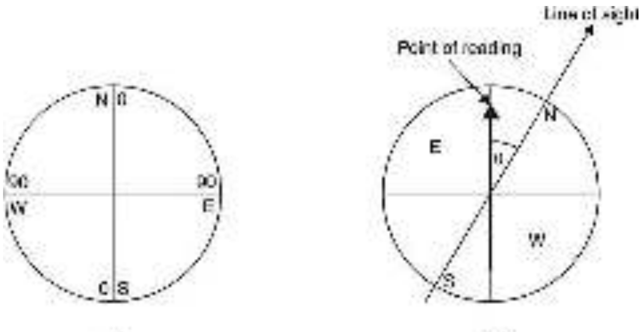


(a) (b)

Reduced Bearing or Quadrantal Bearing (QB)

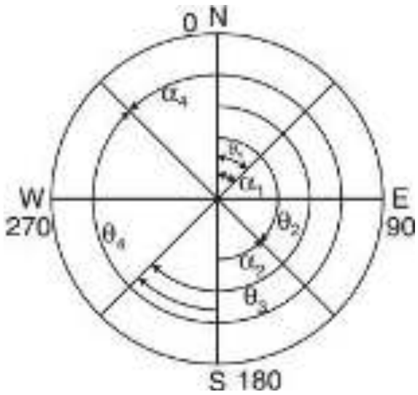
In reduced bearing (RB) system, bearings are measured from north or south direction towards east or west. Hence, angles are from 0 to 90°. This system of measuring bearings is used in *Surveyor's compass* and it is also known **as Quadrantal Bearing (QB).**

The bearing measured is designated with letter N or S in the beginning to indicate whether it is from north or south. The letter E or W written after the angle indicates whether the bearing read is towards east or west, respectively.



(a) (b)

The conversion of the bearing from one system to the other system can be easily carried out by drawing a sketch to indicate WCB or RB as shown



It may be observed that conversion table is as given below:

Quadrant in which bearing lies	*Conversion relation*
NE	$\alpha = \theta$
SE	$\alpha = 180° - \theta$
SW	$\alpha = \theta - 180°$
NW	$\alpha = 360° - \theta$

■ **Example 13.1:** *Convert the following reduced bearings into whole circle bearings:*

(*i*) *N 65° E* (*ii*) *S 43° 15′ E*

(*iii*) *S 52° 30′ W* (*iv*) *N 32° 42′ W*

Solution: Let 'θ' be whole circle bearing.

(*i*) Since it is in *NE* quadrant,

$$\theta = \alpha = \mathbf{65°} \qquad \textbf{Ans.}$$

(*ii*) Since it is in south east quadrant

$$43° \, 15' = 180° - \theta$$

or $$\theta = 180° - 43° \, 15' = \mathbf{136° \, 45'} \qquad \textbf{Ans.}$$

(*iii*) Since it is in SW quadrant

$$52° \, 30' = \theta - 180°$$

or $$\theta = 180° + 52° \, 30' = \mathbf{232° \, 30'} \qquad \textbf{Ans.}$$

(*iv*) Since it is in NW quadrant,

$$32° \, 42' = 360° - \theta$$

or $$\theta = 360° - 32° \, 42' = \mathbf{327° \, 18'} \qquad \textbf{Ans.}$$

■ **Example 13.2:** *The following fore bearings were observed for lines, AB, BC, CD, DE, EF and FG respectively. Determine their back bearings:*

(i) 148° *(ii) 65°*

(iii) 285° *(iv) 215°*

(v) N 36° W *(vi) S 40° E*

Solution: The difference between fore bearing and the back bearing of a line must be 180°. Noting that in WCB angle is from 0° to 360°, we find back bearing = fore bearing ± 180°

+ 180° is used if θ is less than 180° and

– 180° is used when θ is more than 180°.

Hence

(*i*) BB of AB = 145° + 180° = 325°

(*ii*) BB of BC = 65° + 180° = 245°

(*iii*) BB of CD = 285° – 180° = 105°

(*iv*) BB of DE = 215° – 180° = 35°

In case of RB, back bearing of a line can be obtained by interchanging N and S at the same time E and W. Thus

(*v*) BB of EF = S 36° E

(*vi*) BB of FG = N 40° W.

For BB of CD,DE can also be found out by adding 180 degrees and if it exceeds 360 degrees than substract 360 from the answer.

BB of CD = 285 +180 =465 – 360 = 105 BB of
DE = 215+180=395-360=35

Computation of Internal Angles

At any point, if bearings of any two lines are known, the angle between these two lines can be easily found by drawing a neat sketch, and then noting the difference.

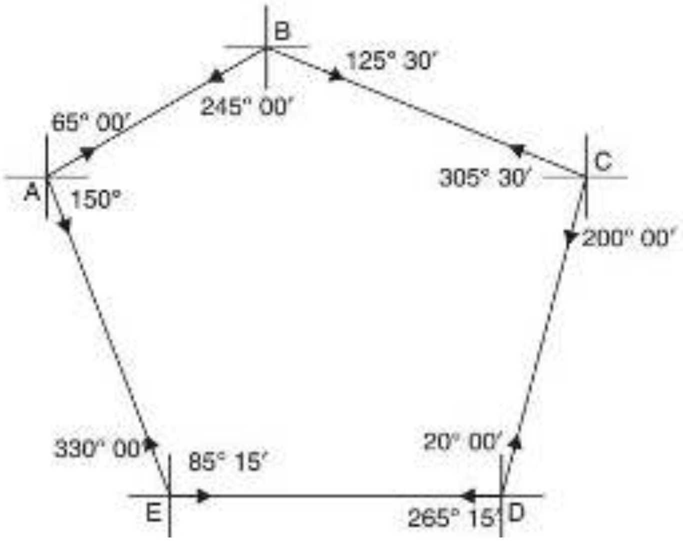
Question Based on Whole Circle Bearing

■ **Example 13.3:** *In a closed traverse the following bearings were observed with a compass. Calculate the interior angles.*

Line	*Fore bearing*
AB	*65° 00′*
BC	*125° 30′*
CD	*200° 00′*
DE	*265° 15′*
EA	*330° 00′*

Solution: We first find the back bearing of different lines
For finding back bearing- Add 180 degrees to forebearing reading. If it is greater than 360 degrees than subtract 360 degrees from answer.

Line	*Fore bearing*	*Back bearing*
AB	65° 00′	245° 00′
BC	125° 30′	305° 30′
CD	200° 00′	20° 00′
DE	265° 15′	85° 15′
EA	330° 00′	150° 00′



Referring to figure:

$$\angle A = 150° \, 00' - 65° \, 00' = \mathbf{85° \, 00'}$$

$$\angle B = 245° \, 00' - 125° \, 30' = \mathbf{119° \, 30'}$$

$$\angle C = 305° \, 30' - 200° \, 00' = \mathbf{105° \, 30'}$$

$$\angle D = (360° - 265° \, 15') + 20° \, 00' = \mathbf{114° \, 45'}$$

$$\angle E = (360° - 330° \, 00') + 85° \, 15' = \mathbf{115° \, 15'}$$

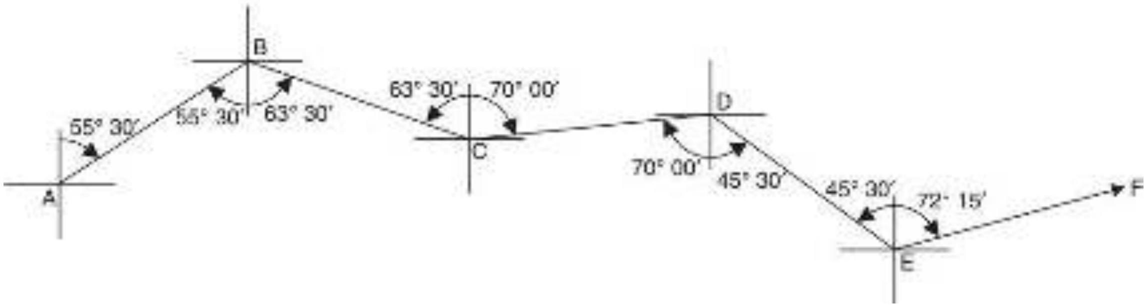
Question Based on Reduced Bearing

Q. The angles observed with a surveyor compass in traversing the lines AB, BC, CD, DE and EF are as given below. Compute the included angles and show them in a neat sketch.

Line	*Fore bearing*
AB	*N 55° 30′ E*
BC	*S 63° 30′ E*
CD	*N 70° 00′ E*
DE	*S 45° 30′ E*
EF	*N 72° 15′ E*

Solution: First Find Back bearing of lines by simply Changing N to S, E to W .
It should be noted that 180 degrees should not be added in Questions of Reduced Bearing readings.

Line	*FB*	*BB*
AB	N 55° 30′ E	S 55° 30′ W
BC	S 63° 30′ E	N 63° 30′ W
CD	N 70° 00′ E	S 70° 00′ W
DE	S 45° 30′ E	N 45° 30′ W
EF	N 72° 15′ E	S 72° 15′ W.



Referring to the figure, we find

$\angle B = 55° 30' + 63° 30' = \mathbf{119° 00'}$ **Ans.**

$\angle C = 63° 30' + 70° 00' = \mathbf{133° 30'}$ **Ans.**

$\angle D = 70° 00' + 45° 30' = \mathbf{115° 30'}$ **Ans.**

$\angle E = 45° 30' + 72° 15' = \mathbf{117° 45'}$ **Ans.**

Local Attraction

- A freely suspended and properly balanced magnetic needle is expected to show magnetic meridian.
  However, local objects like electric wires and objects of steel attract magnetic needle towards themselves.
  Thus, needle is forced to show slightly different direction. This disturbance is called local attraction.

- The list of materials which cause local attraction are:
  (i) magnetic rock or iron ore,
  (ii) steel structures, iron poles, rails, electric poles and wires,
  (iii) key bunch, knife, iron buttons, steel rimmed spectacles, and
  (iv) chain, arrows, hammer, clearing axe etc.

- Detecting Local Attraction
  For detecting local attraction it is necessary to take both fore bearing and back bearing for each line.
  If the difference is exactly 180°, the two stations may be considered as not affected by local attraction.
  If difference is not 180°, better to go back to the previous station and check the fore bearing. If that reading is same as earlier, it may be concluded that there is local attraction at one or both stations.

- if the sum of the interior angles of a closed traverse does not provide (2n - 4) right angles [where n is the number of sides in the traverse], then there is a possibility of local attraction during the observation of the traverse.

Method I:

- It may be noted that the included angle is not influenced by local attraction as both readings are equally affected.

- Hence, first calculate included angles at each station, commencing from the unaffected line and using included angles, the corrected bearings of all lines may be calculated.

Question. In a closed traverse, the following bearings were observed, with a compass. Calculate their interior angles and then compute the corrected magnetic bearings:

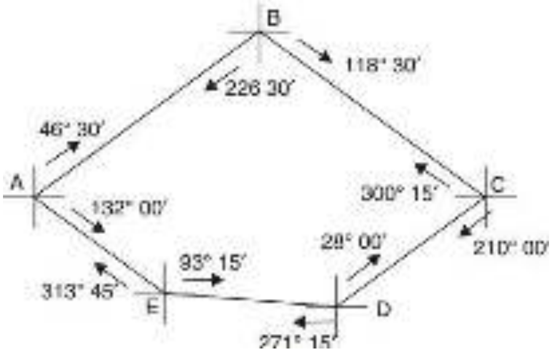
Line	*FB*	*BB*
AB	46° 30'	226° 30'
BC	118° 30'	300° 15'
CD	210° 00'	28° 00'
DE	271° 15'	93° 15°
EA	313° 45'	132° 00'

Solution: Step 1 : Find line which has zero local attraction . This is done by finding difference of Back Bearing and Forebearing of line.

We find that Line AB has zero local attraction.

FB of AB – BB of BA = 226* 30' – 46* 30' = 180*

Step 2: Find Internal Angles from the observed readings given in question.



Correct bearing of AB = 46° 30′

Correct bearing of BA = 226° 30′

From the figure,

$$\angle A = 132^\circ\, 00' - 46^\circ\, 30' = 85^\circ\, 30'$$

$$\angle B = 226^\circ\, 30' - 118^\circ\, 30' = 108^\circ\, 00'$$

$$\angle C = 300^\circ\, 15' - 210^\circ\, 00' = 90^\circ\, 15'$$

$$\angle D = (360^\circ - 271^\circ\, 15') + 28^\circ\, 00' = 116^\circ\, 45'$$

$$\angle E = (360^\circ\, 00' - 313^\circ\, 45') + 93^\circ\, 15' = 139^\circ\, 30'$$

Total Interior Angle $= \angle A + \angle B + \angle C + \angle D + \angle E$

$= 540^\circ\, 00'$.

Sum of Internal angles should be equal to = (2n-4) x 90 = (2 x 5 – 4) x 90 = 540 degrees

The angles found will always be correct.

Step 3:

Start from the Line having Zero Local Attraction :
In this case Line AB has Zero Local Attraction.
Draw Line AB , then write Fore Bearing of AB and Back Bearing of BA.

Since, stations A and B are not affected by local attraction, correct bearings are:

Bearing of AB $= 46^\circ\, 30'$

Bearing of BA $= 46^\circ\, 30' + 180^\circ\, 00' = 226^\circ\, 30'$

Subtract Angle B from Back Bearing BA to Find Fore bearing of Next line that is BC.
Continue above steps for all lines.

Bearing of BC $= 226° 30' - \angle B = 226° 30' - 108° 00' = 118° 30'$

Bearing of CB $= 118° 30' + 180° 00' = 298° 30'$

Bearing of CD $= 298° 30' - \angle C = 298° 30' - 90° 15' = 208° 15'$

Bearing of DC $= 208° 15' - 180° 00' = 28° 15'$

Bearing of DE $= 28° 15' - \angle D = 28° 15' - 116° 45'$

$= -89° 30' = -88° 30' + 360° 00' = 271° 30'$

Bearing of ED $= 271° 30' - 180° 00' = 91° 30'$

Bearing of EA $= 91° 30' - \angle E = 90° 30' - 139° 30'$

$= -48° 00' = -48° 00' + 360° = 312° 00'$

Bearing of AE $= 312° 00' - 180° 00' = 132° 00'$

[Checked. It should be equal to the observed bearing, since station E is not affected].

- 2nd Method

In this method, errors due to local attraction at each of the affected station is found starting from the bearing of a unaffected local attraction, the bearing of the successive lines are adjusted.

Correction = Correct reading – Observed reading

Solve Above Question by 2nd Method.

Solution: Since, the difference between FB and BB of line AB is exactly 180°, stations A and B are not affected by local attraction. Hence, corrections to the observed bearings at A and B are zero.
Hence reading of AB, AE from station A, And reading of BA and BC from Station B will considered to be correct.

Station	Line	Observed Bearing	Correction	Correct Bearing
A	AE	132° 00′	0	132° 00′
	AB	46° 30′	0	46° 30′
B	BA	226° 30′	0	226° 30′
	BC	118° 30′	0	118° 30′
C	CB	300° 15′	– 1° 45′	298° 30′
	CD	210° 00′	– 1° 45′	208° 15′
D	DC	28° 00′	0° 15′	28° 15′
	DE	271° 15′	0° 15′	271° 30′
E	ED	93° 15′	– 1° 45′	91° 30′
	EA	313° 45′	– 1° 45′	312° 00′

Since, the difference between FB and BB of line AB is exactly 180°, stations A and B are not affected by local attraction. Hence, corrections to the observed bearings at A and B are zero.

∴ Correct bearing CB	= 118° 30′ + 180° 00′ = 298° 30′
But observed bearing	= 300° 15′
Hence correction at station C	= 298° 30′ – 300° 15′ = – 1° 45′
∴ Correct bearing of CD	= 210° 00′ – 1° 45′ = 208° 15′
Correct bearing DC	= 208° 15′ – 180° 00′ = 28° 15′
Observed bearing of DC	= 28° 00′
∴ Corrections required at D	= 28° 15′ – 28° 00′ = 0° 15′
∴ Correct bearing of DE	= 271° 15′ + 0° 15′ = 271° 30′
Correct bearing of ED	= 271° 30′ – 180° 00′ = 91° 30′
But observed bearing of ED	= 93° 15′
∴ Correction for observations at E	= 91° 30′ – 93° 15′ = – 1° 45′
∴ Correct bearing of EA	= 313° 45′ – 1° 45′ = 312° 00′
∴ Correct bearing of AE	= 312° 00′ – 180° 00′ = 132° 00′. **[Checked]**

Example 3.11 **The bearings observed in traversing with a compass at a place where local attraction was suspected are given below:**

Line	Fore Bearing	Back Bearing
AB	S45°30′E	N45°30′W
BC	S60°00′E	N60°40′W
CD	N03°20′E	S05°30′W
DA	S85°00′W	N83°30′E

At what stations do you suspect local attraction? Find the corrected bearings of the lines.

Solution **The numerical value of the fore and back bearings of the line AB is the same. Hence stations A and B are free from local attraction and therefore F.B. of BC observed at station B is accepted to be correct.**

Convert the quadrantal bearings to W.C.B.

AB	134°30′	314°30′
BC	120°00′	299°20′
CD	03°20′	185°30′
DA	265°00′	83°30′

F.B. of BC		120°00′	(correct)
Add [illegible]		+ 180°00′	
Correct B.[illegible]	=	300°00′	
Observed B.B. [illegible]	=	299°20′	
Error at C	=	– 40′	
Correction at C	=	+ 40′	
Observed F.B. of C[illegible]		3°20′	
Correction		+ 40′	
Correct F.B. of CD		4°00′	
Add 180°		180°00′	
Correct B.B. of CD	=	184°00′	
Observed B.B. of CD		185°30′	

Error at D		1°30′
Correction at D	=	– 1°30′
Observed F.B. of DA		265°00′
Correction at D		– 1°30′
Correct F.B. of DA	=	263°30′
Subtract 180°		[illegible]°00′
Correct B.B. of DA	=	[illegible]
Observed B.B. of DA	=	[illegible]

Bearings corrected for local attraction are:

Line	F.B.	B.B.	Line	F.B.	B.[illegible]
AB	134°30′	314°30′	AB	S45°30′E	N45°30′W
BC	120°00′	300°00′	BC	S60°00′E	N60°00′W
CD	4°00′	184°00′	CD	N4°00′E	[illegible]
DA	263°30′	83°30′	DA	S83°30′W	

Example 3.12 The following bearings were taken in running a closed compass traverse while surveying in Jhunsi, Allahabad:

Line	F.B.	B.B.
AB	48°25′	230°00′
BC	177°45′	356°00′
CD	104°15′	284°55′
DE	165°15′	345°15′
EA	259°30′	79°00′

(i) State the stations which are affected by local attraction and by how much.

(ii) Determine the correct bearings.

[redacted]

Solution Since F.B. and B.B. of line DE differ by 180°, the stations D and E are free from local attraction. Hence, fore bearing of EA is assumed to be correct.

F.B. of EA		259°30′	(correct)
Subtract 180°		– 180°00′	
Correct B.B. of EA		79°30′	
Observed B.B. of EA		79°00′	
Error at A		– 30′	
Correction at A	=	+ 30′	
Observed F.B. of AB		48°25′	
Correction		+ 30′	
Corrected F.B. of AB		48°55′	
Add 180°		180°00′	
Correct B.B. of AB		228°55′	
Observed B.B. of AB		230°00′	
Error at B		1°05′	
Correction at B	=	– 1°05′	
Observed F.B. of BC		177°45′	
Corrected F.B. of BC	=	176°40′	
Add 180°		180°00′	
Correct B.B. of BC	=	356°40′	
Observed B.B. of BC		356°00′	
Error at C		– 40′	
Correction at C	=	+ 40′	
Observed F.B. of CD		104°15′	
Corrected F.B. of CD	=	104°55′	
Add 180°		+ 180°00′	
Correct B.B. of CD	=	284°55′	
Observed B.B. to CD	=	284°55′	(checked)

The stations affected by local attraction are A, B and C, and by – 30′, + 1°5′ and – 40′, respectively.

Bearings corrected for local attraction are:

Line	F.B.	B.B.
AB	48°55′	228°55′
BC	176°40′	356°40′
CD	104°55′	284°55′
DE	165°15′	345°15′
EA	259°30′	79°30′

Table 3.2 Comparison of chain surveying and compass surveying

S.No.	Chain surveying	Compass surveying
1.	Chain is mainly used for linear measurements.	Compass is mainly used for angular measurements.
2.	The framework consists of triangles, the sides of which are measured by chain. No angular measurements are done.	The Framework consists of a series of connected lines. The lengths of the lines are measured by chain and the angles by compass.
3.	It is easy in performance and the calculations for plotting the area are simple.	It is difficult in performance and the calculations for plotting are also difficult.
4.	Only tape corrections are required.	Tape corrections as well as compass corrections are required.
5.	It is cheap.	It is expensive.
6.	It is done for a small and fairly level area with simple details.	It is done for large areas with rough ground having many details.

What is levelling ?

It may be defined as

1) the art of determining the elevations of given points above or below a datum line or

2) Establishing given points of required heights above or below the datum line.

Uses of levelling

(i) to determine or to set the plinth level of a building.

(ii) to decide or set the road, railway, canal or sewage line alignment.

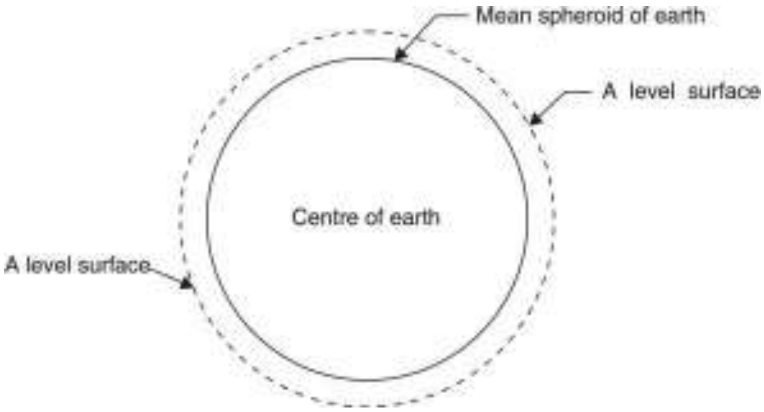
(iii) to determine or set various levels of dams, towers, etc.

(iv) to determine the capacity of a reservoir.

Definitions

Level Surface- A surface parallel to the mean spheroid of the earth is called a level surface. All points lying on a level surface are equidistant from the centre of the earth.

Level Line - The line drawn on the level surface is known as a level line. This line is perpendicular to the direction of gravity at all points



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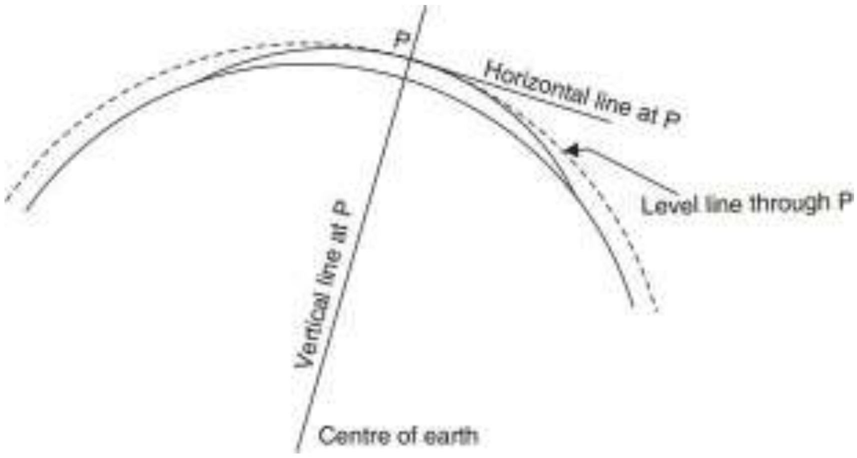
Horizontal Surface/Plane- A surface/plane tangential to level surface at a given point is called horizontal surface/plane at that point.

Horizontal Line/Axis – A horizontal line **through a point** is line drawn on Horizontal surface through that point. This line is perpendicular to the direction of gravity at the point.



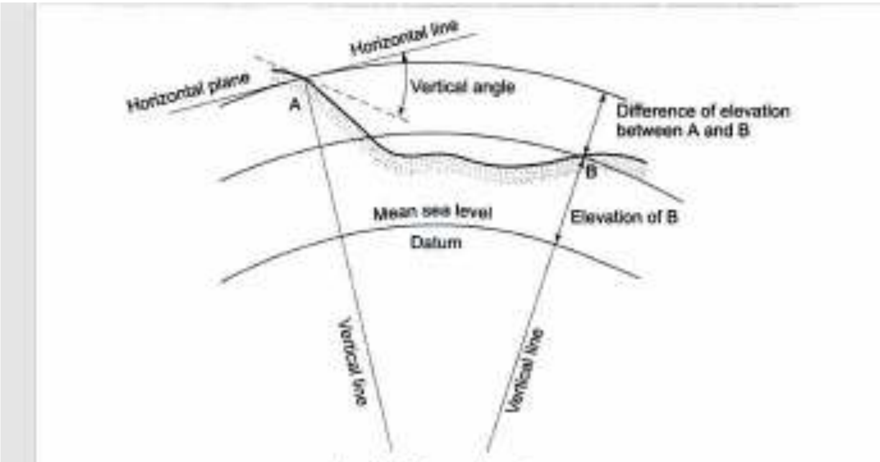


Fig. 6.1 Levelling terms

<u>Datum-</u> Elevations of points are determined relative to reference surface, such reference surface is called a Datum. All the points are at the same altitude. Or
The level of a point or the surface with respect to which levels of other points or planes are calculated, is called a datum or datum surface

*<u>Vertical Line /Axis–</u>*vertical line is the line **<u>passing through point</u>** on earth surface and earth center.

Mean Sea Level (MSL): MSL is the average height of the sea for all stages of the tides. At any particular place MSL is established by finding the mean sea level (free of tides) after averaging tide heights over a long period of at least 19 years.

<u>Reduced Levels (RL):</u> The level of a point taken as height above the datum surface is known as RL of that point.

<u>Benchmarks:</u> A benchmark is a relatively permanent reference point, the elevation of which is known (assumed or known with respect to mean sea level (MSL). It is used as a starting point for levelling or as a point upon which to close for a check.

(a) GTS Benchmark- These benchmarks are established by a national agency such as Survey of India. They are established at several points all over the country with highest precision. In India elevation of all such bench marks are established with respect to mean sea level (MSL) at Karachi. A bronze plate provided on the top of a concrete pedestal with its elevation engraved serves as GTS bench mark. It is well protected so that its position is not disturbed by animals or any unauthorized person.

(b) Permanent Benchmark- These are the benchmarks established by state government agencies like PWD. They are established with reference to GTS benchmarks. They areusually on the corner of plinth of public buildings.

(c) Arbitrary Benchmark- In many engineering projects the difference in elevations of neighbouring points is more important than their reduced level with respect to mean sealevel. In such cases a relatively permanent point, like plinth of a building or corner of aculvert, are taken as benchmarks, their level assumed arbitrarily such as 100.0 m,300.0 m, etc.

(d) Temporary Benchmark: This type of benchmark is established at the end of the day'swork, so that the next day work may be continued from that point. Such point should be on a permanent object so that next day it is easily identified.

Levelling Instruments

1. Level

A **level** is an instrument giving horizontal line of sight and magnifying the reading at a far away distance.

It consists of the following parts:
(i) A telescope to provide a line of sight
(ii) A level tube to make the line of sight horizontal and
(iii) A levelling head to level the instrument.

Types of levels:-

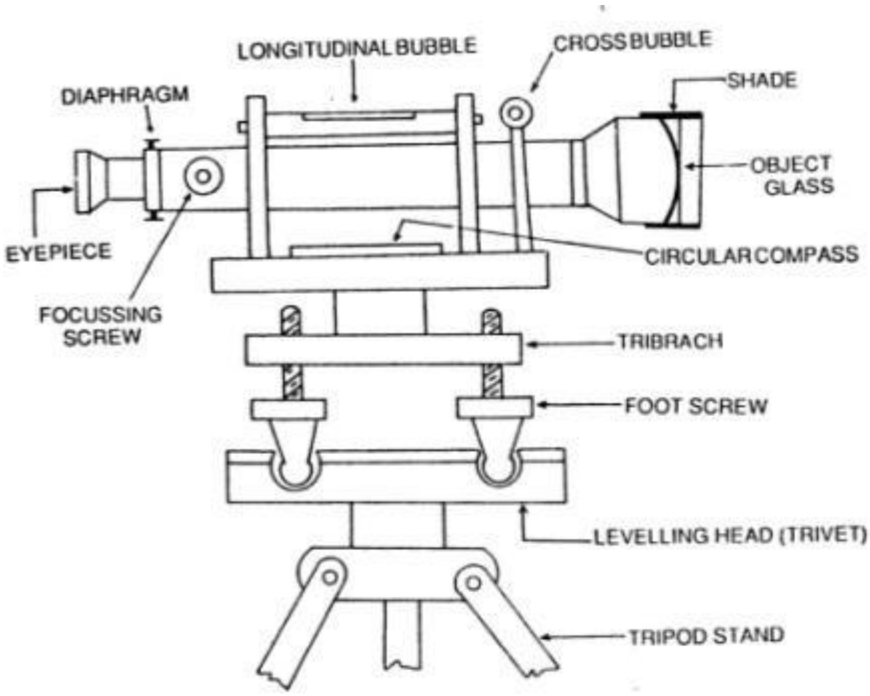
1) Dumpy level 2) Cooke's Reversible level
3) Cushing's Level 4) Wye (or, Y) level 5) Auto Level
4)

DUMPY LEVEL (Important)

1. Tripod stand The tripod stand consists of three legs which may be solid or framed. The legs are made of light and hard wood. The lower ends of the legs are fitted with steel shoes.

2. Levelling head The levelling head consists of two parallel triangular plates having three grooves to support the foot screws.

3. Foot screws Three foot screws are provided between the trivet and tribrach. By turning the foot screws the tribrach can be raised or lowered to bring the bubble to the centre of its run.



4. Telescope The telescope consists of two metal tubes, one moving within the other. It also consists of an object glass and an eye-piece on opposite ends. A diaphragm is fixed with the telescope just in front of the eye-piece. The diaphragm carries cross-hairs. The telescope is focussed by means of the focussing screw and may have either external focussing, or internal focussing.

In the external focussing telescope, the diaphragm is fixed to the outer tube and the objective to the inner tube. By turning the focussing screw the distance between the objective and diaphragm is altered to form a real image on the plane of cross-hairs.

In the internal focussing telescope, the objective and eye-piece do not move when the focussing screw is turned. Here, a double concave lens is fitted with rack and pinion arrangement between the eye-piece and the objective. This lens moves to and fro when the focussing screw is turned and a real image is formed on the plane of cross-hairs.

5. Bubble tubes Two bubble tubes, one called the longitudinal-bubble tube and other the cross-bubble tube, are placed at right angles to each other. These tubes contain spirit bubble. The bubble is brought to the centre with the help of foot screws. The bubble tubes are fixed on top of the telescope.

6. Compass A compass is provided just below the telescope for taking the magnetic bearing of a line when required.

The compass is graduated in such a way that a 'pointer', which is fixed to the body of compass, indicates a reading of 0° when the telescope is directed along the north line.

In some compasses, the pointer shows a reading of a few degrees when the telescope is directed towards the north. This reading should be taken as the initial reading. The bearing is obtained by deducting the initial reading from the final reading of the compass.

In short, above can be written as

(i) a telescope to provide horizontal line,
(ii) a level tube to make the line of sight horizontal,
(iii) a levelling head to bring the bubble to the centre,
(iv) a tripod to support the instrument,
(v) a focussing screw to focus at the staff,
(vi) eye piece to observe the staff readings,
(vii) foot screws for levelling purpose,
(viii) bubble tube adjusting screw,
(ix) tribrach-upper parallel plate,
(x) trivet-lower plate,
(xi) levelling head,
(xii) objective end and
(xiii) ray shade.

2. Levelling Staff

The levelling staff is a rectangular rod having graduations.
The staff is provided with a metal shoes at its bottom to resist wear and tear.
The foot of the shoe represents zero reading. Levelling staff may be divided into two groups :-

1. **Self reading staff:** This staff reading is directly read by the instrument man through telescope.
   (a) *Solid staff:* It is a single piece of 3 m.
   (b) *Folding staff :* A staff of two pieces each of 2 m which can be folded one over the other.
   (c) *Telescopic staff:* A staff of 3 pieces with upper one solid and lower two hollow. The upper part can slide into the central one and the central part can go into the lower part. Each length can be pulled up and held in position by means of brass spring. The total length may be 4 m or 5 m.

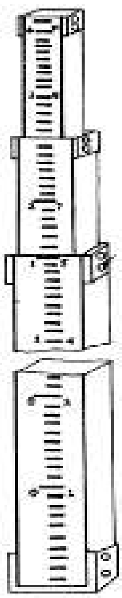


Fig. 5.6 Telescopic Metric Staff

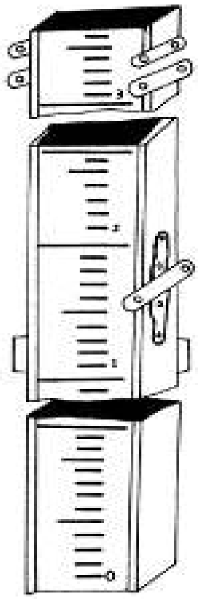
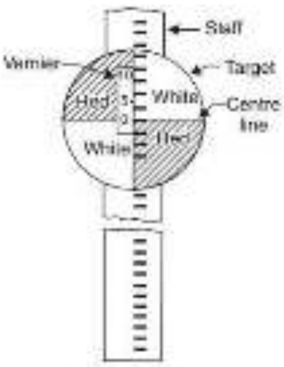


Fig. 5.7 Folding Metric Staff

2. **Target staff:** If the sighting distance is more, instrument man finds it difficult to read self reading staff. In such case a target staff shown in may be used. Target staff is similar to self reading staff, but provided with a movable target.



(c) Target staff

Temporary Adjustments of A Level (Important – 7 marks Question)

The adjustments to be made at every setting of the instrument are called temporary adjustments. The following three adjustments are required for the instrument whenever set over a new point before taking a reading:
(i) Setting (ii) Levelling and (iii) Focussing.

A. Setting

Tripod stand is set on the ground firmly so that its top is at a convenient height. Then the level is fixed on its top. By turning tripod legs radially or circumferentially, the instrument is approximately levelled.
Some instruments are provided with a less sensitive circular bubble on tribrach for this purpose.

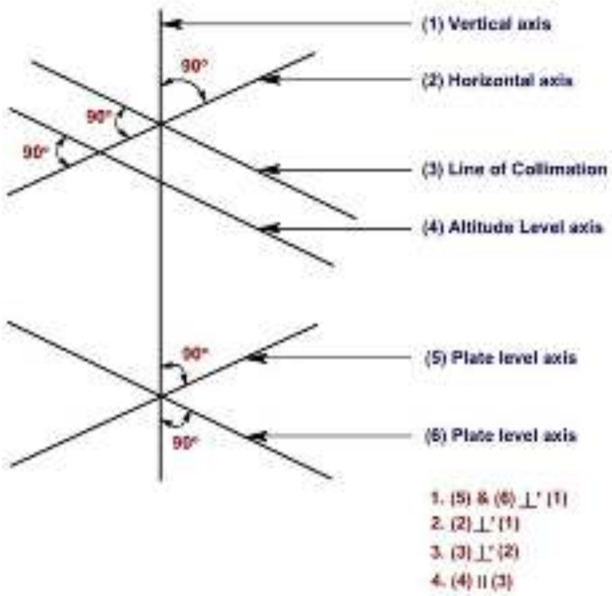
B. Levelling

The procedure of accurate levelling with three levelling screw is as given below:
(i) Loosen the clamp and turn the telescope until the bubble axis is parallel to the line joining any two screws .
(ii) Turn the two screws inward or outward equally and simultaneously till bubble is centred.
(iii) Turn the telescope by 90° so that it lies over the third screw [Fig. 15.4 (b)] and level the instrument by operating the third screw.
(iv) Turn back the telescope to its original position and check the bubble.
Repeat steps (ii) to (iv) till bubble is centred for both positions of the telescope.
(v) Rotate the instrument by 180°. Check the levelling.

C. Focussing

Focussing is necessary to eliminate parallax while taking reading on the staff. The following two steps are required in focussing:
(i) Focussing the eyepiece:For this, hold a sheet of white paper in front of telescope and rotate eyepiece in or out till the cross hairs are seen sharp and distinct.
(ii) Focussing the objective:For this telescope is directed towards the staff and the focussing screw is turned till the reading appears clear and sharp.

The Relation Between Bubble Tube Axis, Optical Axis And Vertical Axis With The Line Of Collimation (Important)



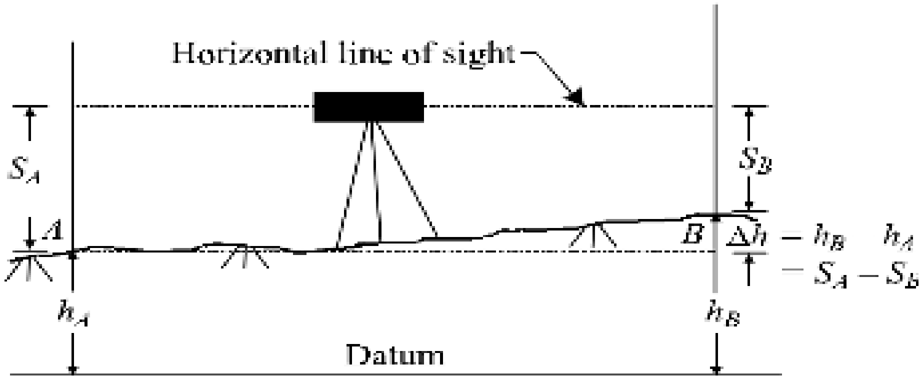
Vertical axis is <u>perpendicular</u> to Horizontal axis, Line of collimation(line of sight), bubble tube axis, optical axis.

Line of collimation(line of sight) is parallel to Bubble tube axis, optical axis
& perpendicular to Vertical axis.

Bubble tube Axis is parallel to Line of collimation, optical axis.
& perpendicular to vertical axis.

Technical Terms used in Levelling :

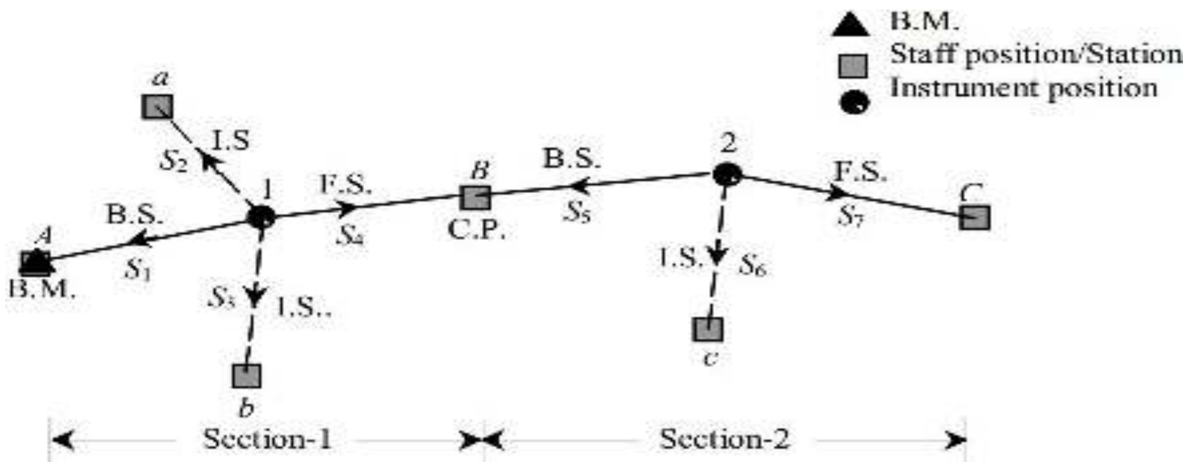
Height of instrument (H.I.) or height of collimation: For any set up of the level, the elevation of the line of sight is the height of instrument. (H.I. = hA+ SA in Fig.)



Station: A station is the point where the levelling staff is held. (Points A, a, b, B, c, and C in Fig.)

Back sight (B.S.): It is the first reading taken on the staff after setting up the level usually to determine the height of instrument.

It is usually made to some form of a bench mark (B.M.) or to the points whose elevations have already been determined.



When the instrument position has to be changed, the first sight taken in the next section is also a back sight. (Staff readings S1and S5 in Fig).

Fore sight (F.S.): It is the last reading from an instrument position on to a staff held at a point.It is thus the last reading taken within a section of levels before shifting the instrument to the next section, and also the last reading taken over the whole series of levels. (Staff readings S4 and S7in Fig.).

Change point (C.P.) or turning point: A change point or turning point is the point where both the fore sight and back sight are made on a staff held at that point. A change point is required before moving the level from one section to another section. By taking the fore sight the elevation of the change point is determined and by taking the back sight the height of instrument is determined.The change points relate the various sections by making fore sight and back sight at the same point.(Point B in Fig).

Intermediate sight (I.S.): The term 'intermediate sight' covers all sightings and consequent staff readings made between back sight and fore sight within each section.Thus, intermediate sight station is neither the change point nor the last point. (Points a, b, and c in Fig.).

Reduced level (R.L.): Reduced level of a point is its height or depth above or below the assumed datum.It is the elevation of the point.

Rise and fall: The difference of level between two consecutive points indicates a rise or a fall between the two points. In Fig. , if (SA– SB) is positive, it is a rise and if negative, it is a fall. Rise and fall are determined for the points lying within a section.

Section: A section comprises of one back sight, one fore sight and all the intermediate sights taken from one instrument set up within that section.

Parallax: is a displacement or difference in the apparent position of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines.

Focal length- The distance from the focal point of a lens or mirror to the reflecting surface of the mirror or the centre point of the lens. The focal length of an optical system is a measure of how strongly the system converges or diverges light.

Methods Of Levelling

Simple Levelling- It is the method used for finding difference between the levels of two nearby points.

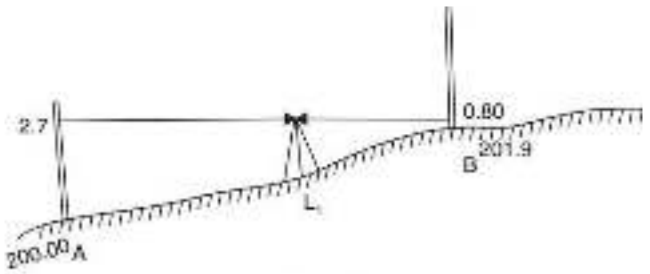
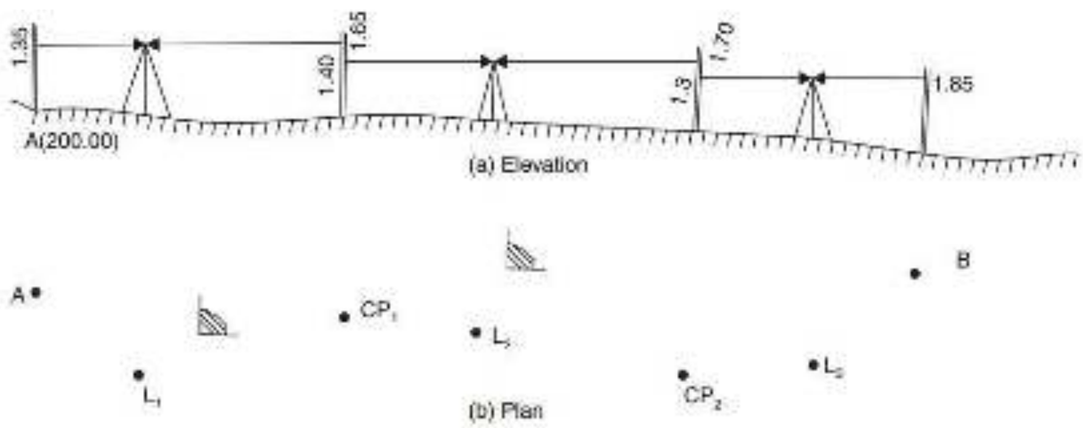


Fig. 15.6

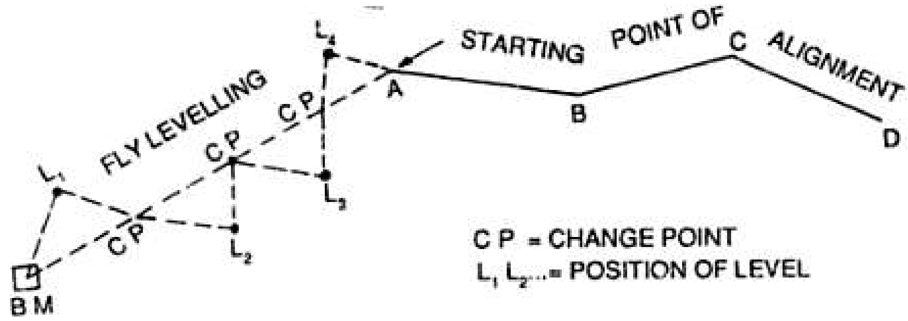
Differential Levelling

If the distance between two points A and B is large, it may not be possible to take the readings on A and B from a single setting. In such situation differential levelling is used. In differential levelling the instrument is set atmore than one position, each shifting facilitated by a change point. Figure shows a scheme of such setting.



Fly levelling

The levelling operation in which only BS and FS readings are taken and no intermediate sights are observed is known as fly levelling.
Fly levelling is done for connecting the benchmark to the starting point of any project. In such levelling, no horizontal distances are required to be measured.



Methods for Finding Reduced Levels of points

Height of Collimation method

1. The collimation system The reduced level of the line of collimation is said to be the height of the instrument. In this system, the height of the line of collimation is found out by adding the backsight reading to the RL of the BM on which the BS is taken. Then the RL of the intermediate points and the change point are obtained by subtracting the respective staff readings from the height of the instrument (HI).

The level is then shifted for the next se tup and again the height of the line of collimation is obtained by adding the backsight reading to the RL of the change point (which was calculated in the first set up).

So, the height of the instrument is different in different setups of the level. Two adjacent planes of collimation are correlated at the change point by an FS reading from one setting and a BS reading from the next setting.

It should be remembered that, in this system, the RLs of unknown points are to be found out by deducting the staff readings from the RL of the height of the instrument.

Station	Staff Reading			Ht of Instrument	R.L.	Remarks
	Back	Inter	Fore			

Check : Sum of Back Reading -Sum of Fore Reading= Last R.L. - First R.L.

Note- Ht. of instrument changes at every Change Point.

New Ht of Instument = RL of that point + Staff reading (Back Sight)
Staff Reading (IS /FS) = Ht of Instrument (will be same)– Staff reading(changes at every point)

Example. The following readings were taken with a level and 4 m staff.

Draw up a level book page and reduce the levels by the Ht of Collimation method. 0.578 B.M.(= 58.250 m), 0.933, 1.768, 2.450, (2.005 and 0.567) C.P., 1.888, 1.181, (3.679 and 0.612) C.P., 0.705, 1.810.

Station	Staff Reading			Ht of Instrument	R.L.	Remarks
	Back	Inter	Fore			
1	0.578			58.828	58.25	BM
2		0.933			57.895	
3		1.768			57.060	
4		2.450			56.378	
5	0.567		2.005	57.390	56.823	CP
6		1.888			55.502	
7		1.181			56.209	
8	0.612		3.679	54.323	53.711	CP
9		0.705			53.618	
10			1.810		52.513	
SUM	1.757		8.925			

Rise and Fall method

Compute all rises & falls
Start at a Benchmark (BM) with known Reduced Level (RL)
To get RL of next station:
add rise to previous RL, or subtract fall from previous RL
Repeat for all subsequent stations

Station	Staff Reading			Difference		R.L.	Remarks
	Back	Inter	Fore	Rise	Fall		
Sum							

Check : Sum of Back Reading-Sum of Fore Reading = Total Rise -Total Fall = Last R.L. -First R.L.

Solving above question by Rise and fall method.

Station	Staff Reading			Difference		R.L.	Remarks
	Back	Inter	Fore	Rise	Fall		
1	0.578					58.25	BM
2		0.933			0.355	57.895	
3		1.768			0.835	57.06	
4		2.450			0.682	57.378	
5	0.567		2.005	0.445		56.823	C.P.
6		1.888			1.321	55.502	
7		1.181		0.707		56.209	
8	0.612		3.679		2.498	53.711	C.P.
9		0.705			0.093	53.618	
10			1.810		1.105	52.513	
Sum	1.757		7.494	1.152	6.889		

Q. The following staff reading were observed successively with a level, the instrument having been moved after third, sixth and eighth reading 2.228, 1606, 0.988, 2.090, 2.864, 1.262, 0.602, 1.982, 1.044, 2.864 Enter the above readings in a page of level book and calculate the RL of points if the first reading was taken with staff hold on a bench mark of 432.384 m .

By rise and fall method

Station	B.S.	I.S.	F.S.	Rise	fall	R.L.	Remarks
1	2.228					432.384	B.M
2		1.606		0.622		433.006	
3	2.09		0.988	0.618		433.624	C.P.1
4		2.864			0.774	432.85	
5	0.602		1.262	1.602		434.452	C.P.2
6	1.044		1.982		1.38	433.072	C.P.3
7			2.684		1.64	431.432	
							Checked
Check	5.964		6.916	2.842	3.794		
			-0.952		-0.952	-0.952	

By height of instrument method

Station	B.S.	I.S.	F.S.	Ht of instrument	R.L.	Remarks
1	2.228			434.612	432.384	B.M
2		1.606			433.006	
3	2.09		0.988	435.714	433.624	C.P.1
4		2.864			432.85	
5	0.602		1.262	435.054	434.452	C.P.2
6	1.044		1.982	434.116	433.072	C.P.3
7			2.684		431.432	
Check						

Apply Check = 5.964-6.916 = 431.432 -432.384 = -0.952

Comparison of the two systems

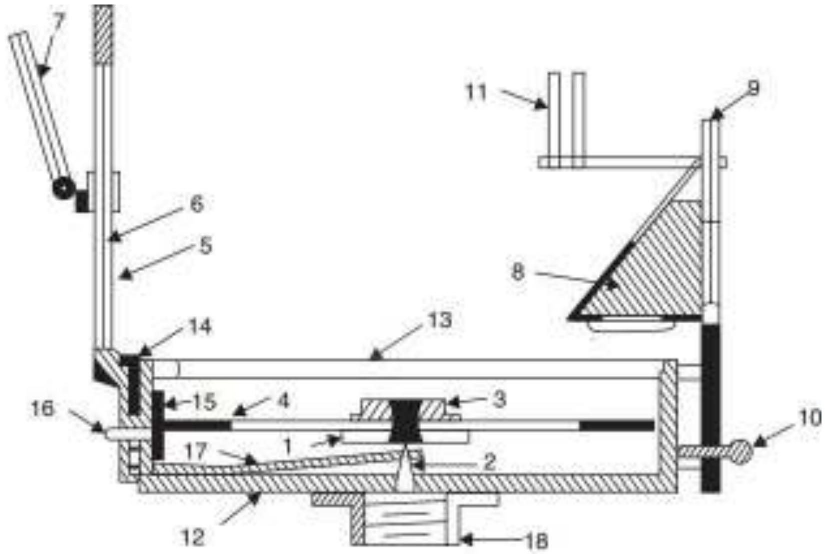
Collimation System	Rise-and-Fall System
1. It is rapid as it involves few calculation.	It is laborious, involving several calculations.
2. There is no check on the RL of intermediate points.	There is a check on the RL of intermediate points.
3. Errors in intermediate RLs cannot be detected.	Errors in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

Factors to be considered in selecting contour Interval

Scale of Map	Type of ground	Contour Interval (m)
Large	Flat	0.2 to 0.5
	Rolling	0.5 to 1
	Hilly	1, 1.5 or 2
Intermediate	Flat	0.5,1 or 1.5
	Rolling	1, 1.5 or 2
	Hilly	2, 2.5 or 3
Small	Flat	1,2 or 3
	Rolling	2 to 5
	Hilly	5 to 10
	Mountainous	10, 25 or 50

Purpose of Survey	Scale	Interval
Builing sites	1 cm = 10 m or less	0.2 to 0.5
Town planning schemes, reservoirs, etc.	1 cm = 50 m to 100 m	0.5 to 2
Location Surveys	1 cm = 50 m to 200m	2 to 3

Prismatic Compass



1. Needle
2. Pivot
3. Agate cap
4. Graduated disc
5. Slit metal frame
6. Horse hair
7. Mirror
8. Reflecting prism with cap
9. Eye vane
10. Focussing stud
11. Dark sunglasses
12. Box
13. Glass cover
14. Lifting pin
15. Light spring
16. Brake pin or knob
17. Lifting lever
18. Support to fit on tripod

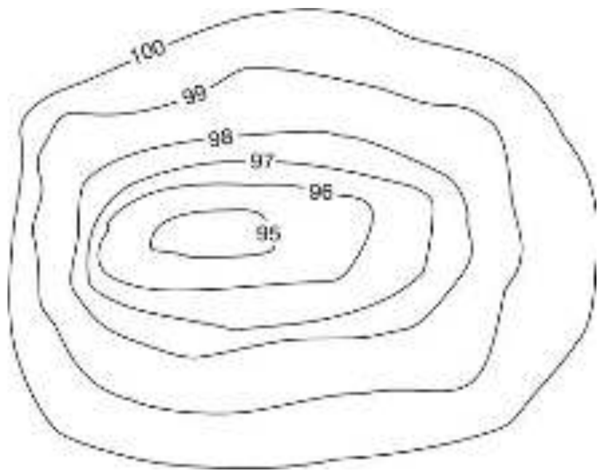
A magnetic needle of broad form (1) is balanced on a hard and pointed steel pivot (2). The top of the pointed pivot is protected with agate cap (3). An aluminium graduated disk (4) is fixed to the top of the needle. The graduations are from zero to 360° in clockwise direction when read from top. The direction of north is treated as zero degrees, east as 90°, south as 180° and west as 270°. However, while taking the readings observations are at the other end of line of sight. Hence, the readings are shifted by 180° and graduations are marked as shown in Fig.. The graduations are marked inverted because they are read through a prism.

The line of sight consists of object unit and the reading unit. Object unit consists of a slit metal frame (5) hinged to the box. In the centre the slit is provided with a horse hair or a fine wire or thread (6). The metal frame is provided with a hinged mirror (7), which can be placed upward or downward on the frame. It can be slided along the frame. The mirror can be adjusted to view objects too high or too low from the position of compass. Reading unit is provided at diametrically opposite edge. It consists of a prism (8) with a sighting eye vane (9). The prism magnifies the readings on the graduation disk just below it. For focussing, the prism is lowered or raised on the frame carrying it and then fixed with the stud (10). Dark sunglasses (11) provided near the line of sight can be interposed if the object to be sighted is bright (e.g.,sun).

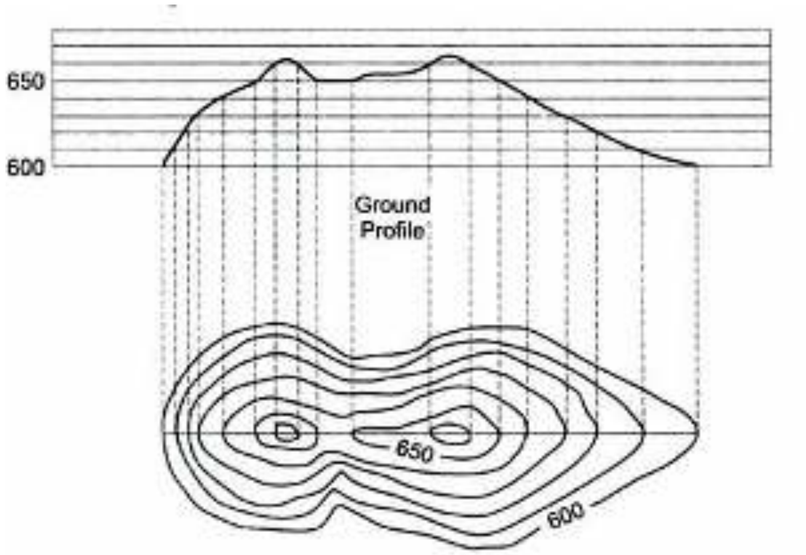
The bottom of the box (12) which is about 85 mm to 110 mm supports the pivot of needle firmly at its centre. The object vane and the prism are supported on the sides of the box. The box is provided with a glass (13) lid which protects the graduation disc at the same time permit the direct reading from the top. When the object vane is folded on the glass top it presses a lifting pin (14) which activates lifting lever (15) lifts the needle off the pivot. Thus, it prevents undue wear of pivot point. While taking reading, if graduation disc vibrates, it can be dampened with a spring (16). For pressing spring a knob or brake pin (17) is provided on the box. When not in use prism can be folded over the edge of the box. The box is provided with a lid to close it when the compass is not in use. The box is provided with a socket to fit it on the top of a tripod.

Contours

A **contour line** is a imaginary line which connects points of equal elevation.
Such lines are drawn on the plan of an area after establishing reduced levels of several points in the area.
A numerical value placed upon a contour line to denote its elevation relative to a given datum, usually mean sea level is called **Contour Value**
The contour lines in an area are drawn keeping difference in elevation of between two consecutive lines constant.
The **contour interval** of a contour map is the difference in elevation between successive contour lines. For example, Figure shows contours in an area with contour interval of 1 m.



On contour lines the level of lines is also written.



Characteristics of Contours

1. Contour lines must close, not necessarily in the limits of the plan.
2. Widely spaced contour indicates flat surface.
3. Closely spaced contour indicates steep ground.
4. Equally spaced contour indicates uniform slope.
5. Irregular contours indicate uneven surface.
6. Approximately concentric closed contours with decreasing values towards centre indicate a pond.

6. Approximately concentric closed contours with decreasing values towards centre indicate a pond

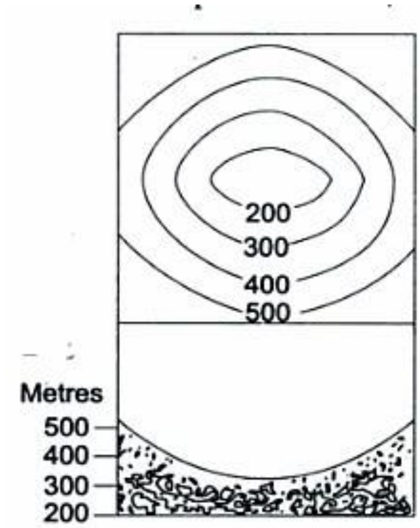


Fig. 9.6 (j) A depression

7. Approximately concentric closed contours with increasing values towards centre indicate hills.

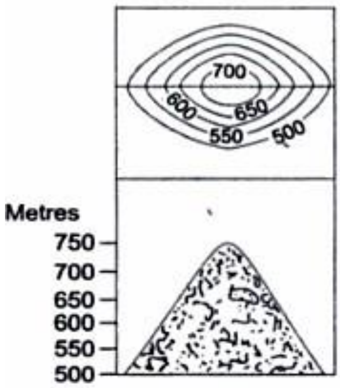


Fig. 9.6(e) A hill

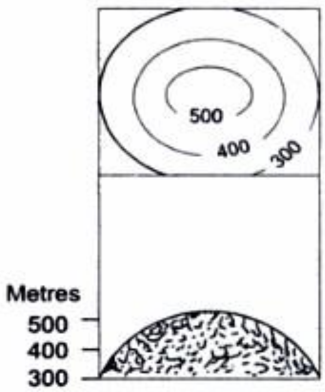


Fig. 9.6(f) A hillock

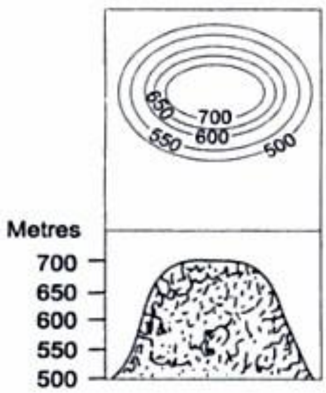
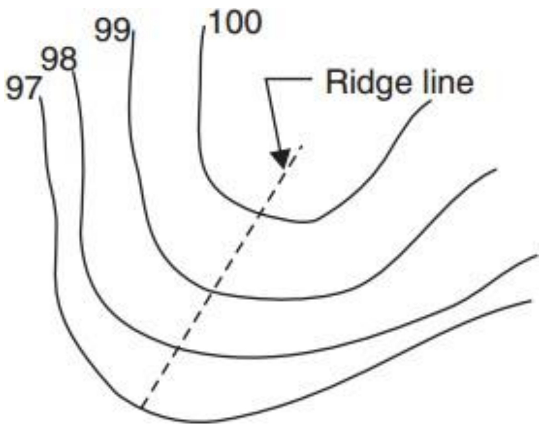
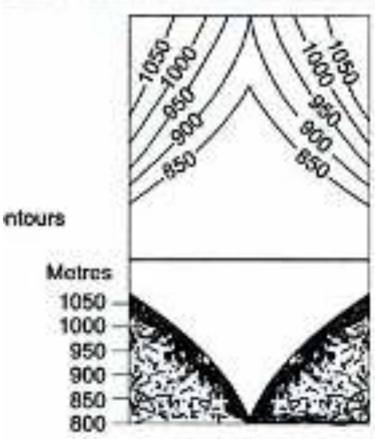


Fig. 9.6(g) A plateau

8. Contour lines with U-shape with convexity towards lower ground indicate ridge



9. Contour lines with V-shaped with convexity towards higher ground indicate valley



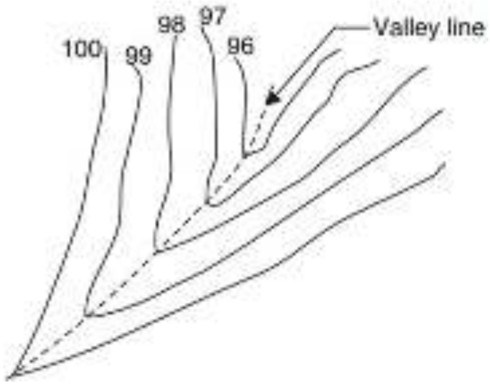
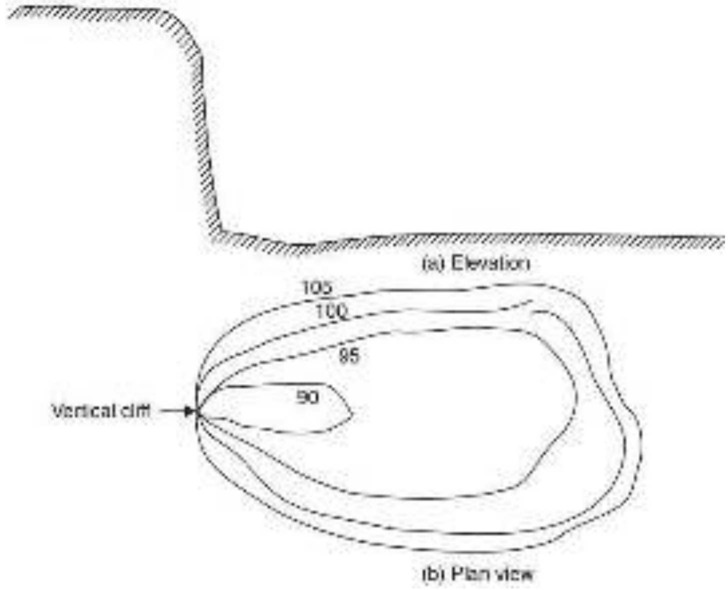


Fig. 9.6 (I) A V-shaped valley

10. Contour lines generally do not meet or intersect each other.

11. If contour lines are meeting in some portion, it shows existence of a vertical cliff



12. If contour lines cross each other, it shows existence of overhanging cliffs or a cave.