BCME

UNIT-II

SURVEYING

Unit-II Syllabus

Surveying: Objectives of Surveying- Horizontal Measurements- Angular Measurements- Introduction to Bearings Levelling instruments used for levelling -Simple problems on levelling and bearings-Contour mapping.

SURVEYING

- Objectives Of Surveying
- Horizontal Measurements
- Angular Measurements
- Introduction To Bearings
- Introduction To Levelling Instruments Used For Levelling
- Simple Problems On Levelling And Bearings
- Contour Mapping

SURVEYING

It is the art of determining or establishing the relative positions of points on, above or below the surface of the earth by means of direct or indirect measurements of distance, direction and elevation to prepare a map or plan to represent an area on a horizontal plan

OBJECTIVES OF SURVEYING

1. To take measurements to determine the relative positions of the existing features on or near the ground.
2. To layout or to mark the positions of the proposed structure on the ground.
3. To determine areas, volumes and other related quantities.

(2) Classification of Survey:

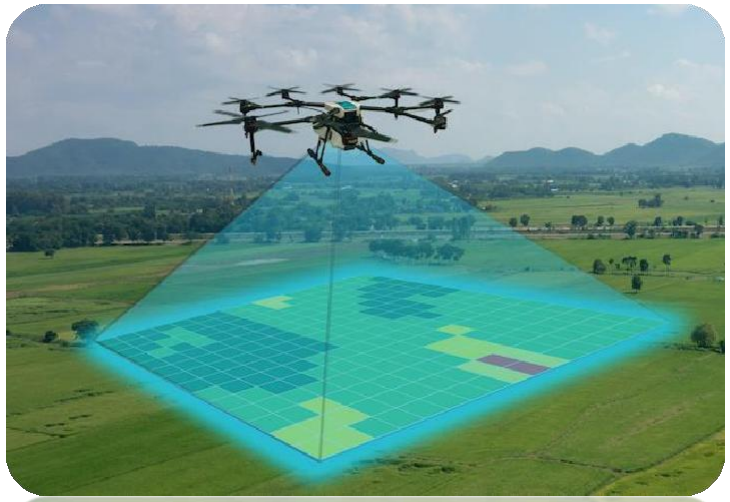
Engineering Survey	This is undertaken for the determination of quantities or to afford sufficient data for the designing of engineering works such as roads, railways and reservoirs
Military Survey	This is used for determining points of strategic importance
Mine Survey	This is used for the exploring mineral wealth
Geological Survey	This is used for determining different strata in the Earth's Crust
Archaeological Survey	This is used for unearthing relics of antiquity
Topographical Survey	To plot natural features such as rivers, valleys, lakes etc
Cadastral survey	To determine additional details such as boundaries of fields, houses and properties
Hydrographic survey	For survey of large water bodies

(3) Classification based on Instruments used:

An alternative classification may be based upon the Instruments or methods employed, the chief types being:

- Chain survey
- Compass Survey
- Theodolite survey
- Tachometric survey
- Plane table survey
- Photogrammetric survey
- Aerial survey
- EDM (Electronic Distance Measurement) Survey

EDM (Electronic Distance Measurement) Survey

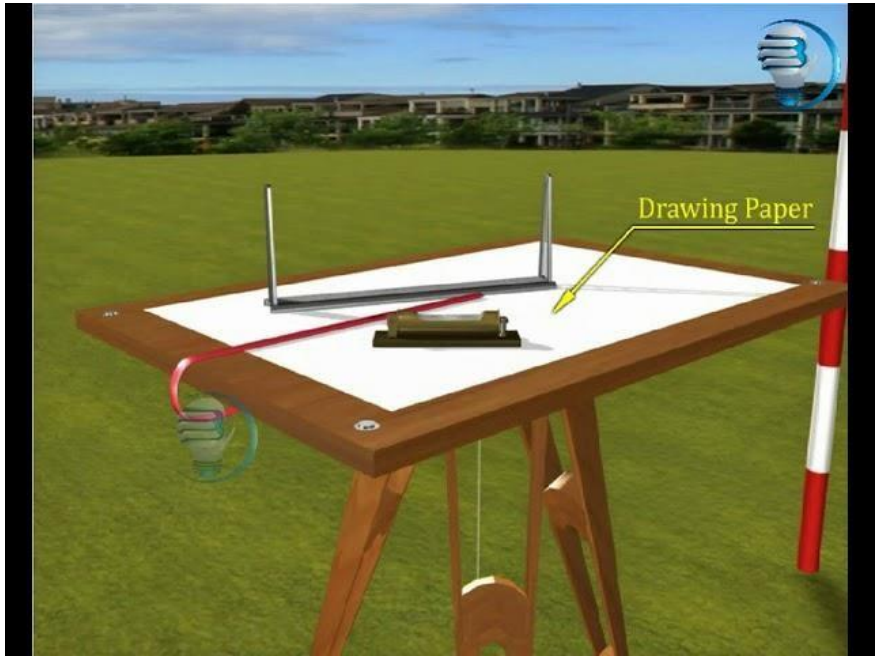


Aerial survey

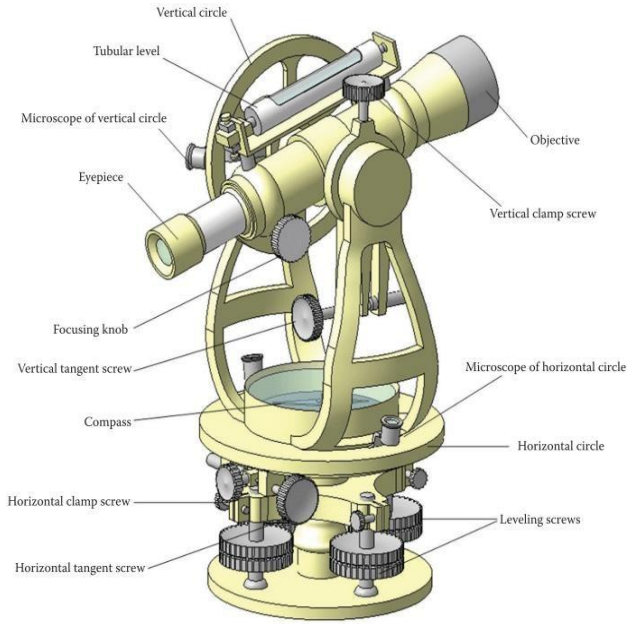
Compass Survey

Chain survey

Tachometric survey



Plane table survey



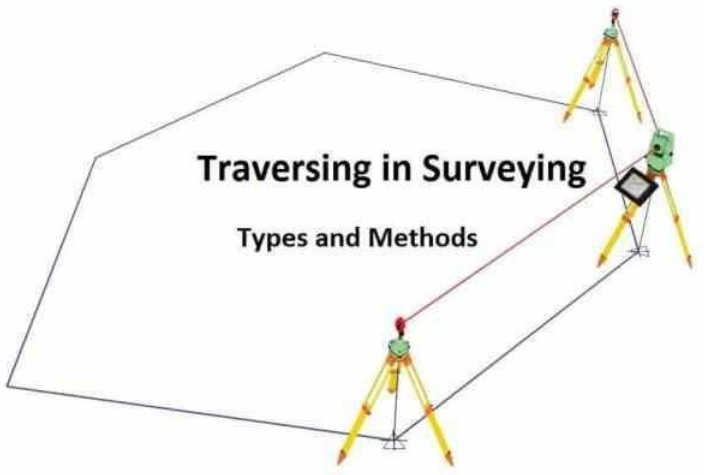
Theodolite survey

Methods of Surveying:

Traversing

- Traversing is of two types

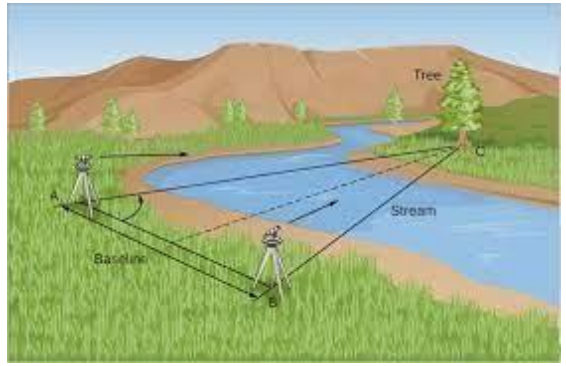
  1) Open traversing & 2) Closed traversing
- In traversing, the frame work consist of connected lines.
- The length are measured by a chain or a tape and the direction measured by angle measuring instruments.
- Hence in compass surveying direction of survey lines are determined with a compass and the length of the lines are measured with a tape or a chain. This process is known as compass traversing.



Traversing

Triangulation

- Triangulation surveying is a method for determining the location of a point by measuring the angles of a triangle formed by three survey control points. The process involves:
- **Measuring angles:** Using a theodolite, an instrument with a telescope and two rotating circles
- **Calculating distances:** Using trigonometry and the measured length of one side of the triangle

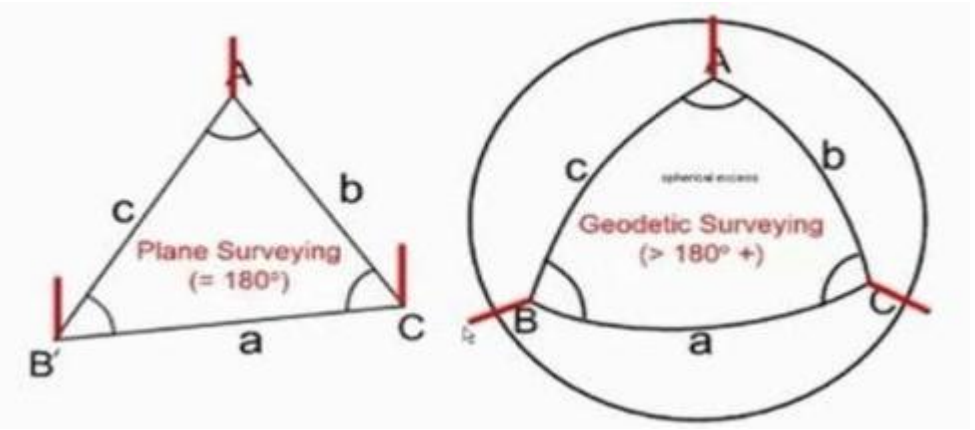


Triangulation

Surveying is primarily divided into two types:

Plane Surveying:

•It is the type of surveying in which the mean surface of the earth is considered as plane and the spherical shape is neglected. All triangles formed by survey lines are considered as plane triangles. The level line is considered as straight and all plumb lines are considered parallel.



Geodetic Surveying:

•It is the type of surveying in which the shape of the earth is taken into account. All lines lying on the surface are curved lines and the triangles are spherical triangles. It, therefore, involves spherical trigonometry. All geodetic surveys include work of larger magnitude and high degree of precision.

PRINCIPLES OF SURVEYING:

The fundamental principles upon which the various methods of surveying are based are of very simple nature and can be stated as below

1. Working from whole to part
2. Always choose the method of survey that is most suitable for the purpose
3. Always make Provisions of Adequate checks
4. Always record Field Data Carefully.

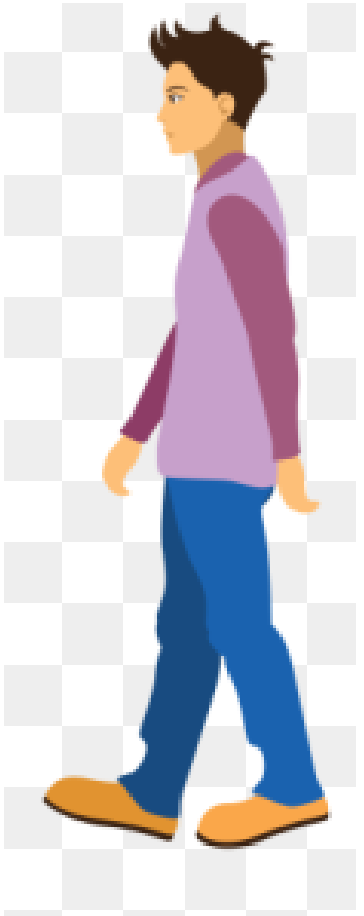
Horizontal Measurements - Angular Measurements

Direct Measurements:

The various methods of measuring the distances directly are as follows:

(1) Pacing :

Measuring linear distance by walking



(2) Measurement by Odometer and Speedometer :

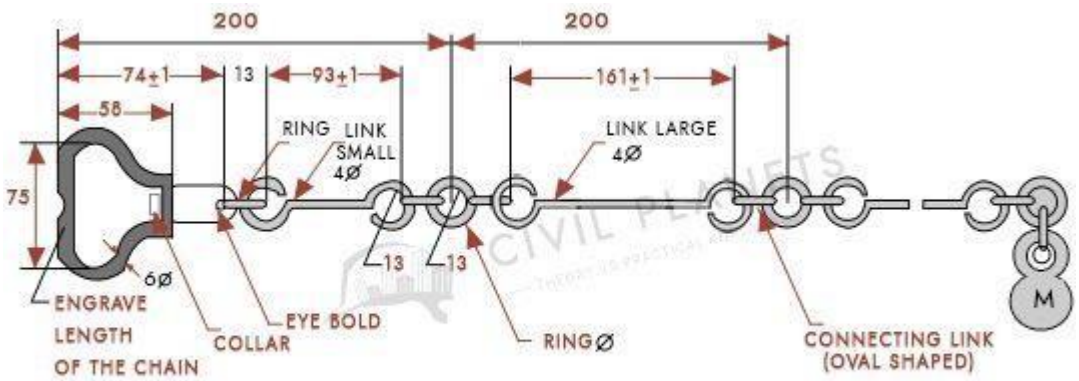
The odometer is an instrument used to measure the distance travelled by a vehicle whereas speedometer is used to measure the speed of a vehicle

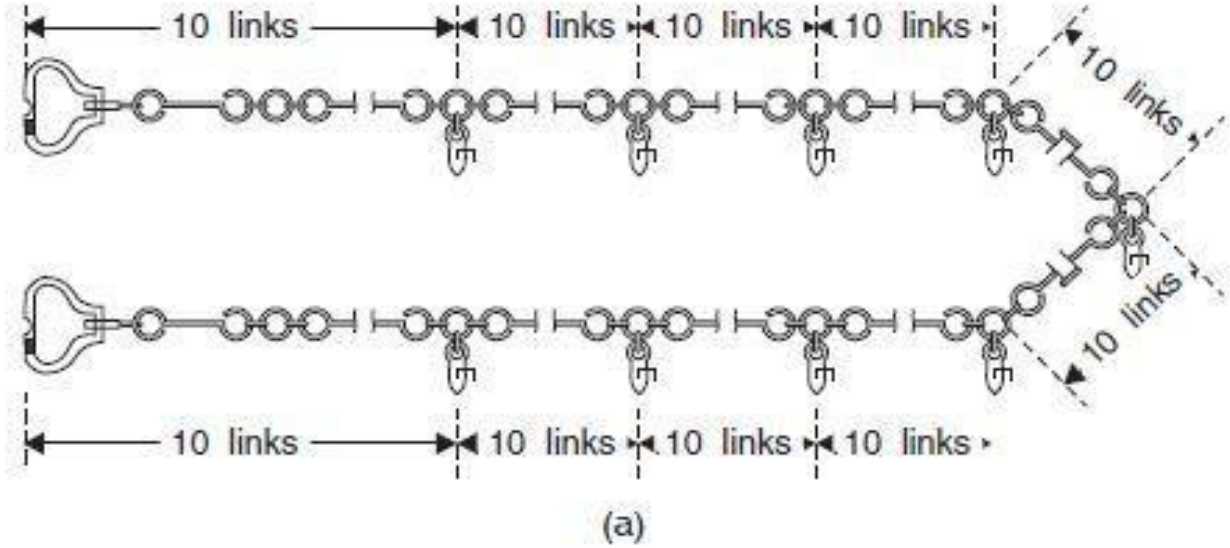
(3) Measurement with Passometer and Pedometer :

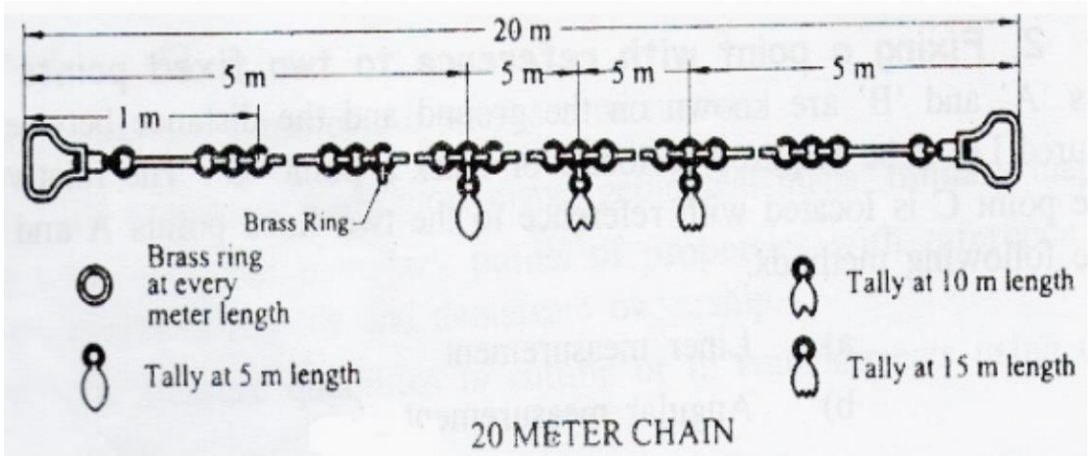
- Passometer monitors physical activity in more ways than just counting steps. It uses sensors to track other activities, such as distance covered.
- Pedometers are usually electronic or electromagnetic devices that detect the motion
- There are some units used in the Passometer and Pedometer to calculate.
- They are the km (Kilometer) scale or mile scale or ft (foot) scale or lap system or pace system or step length system.

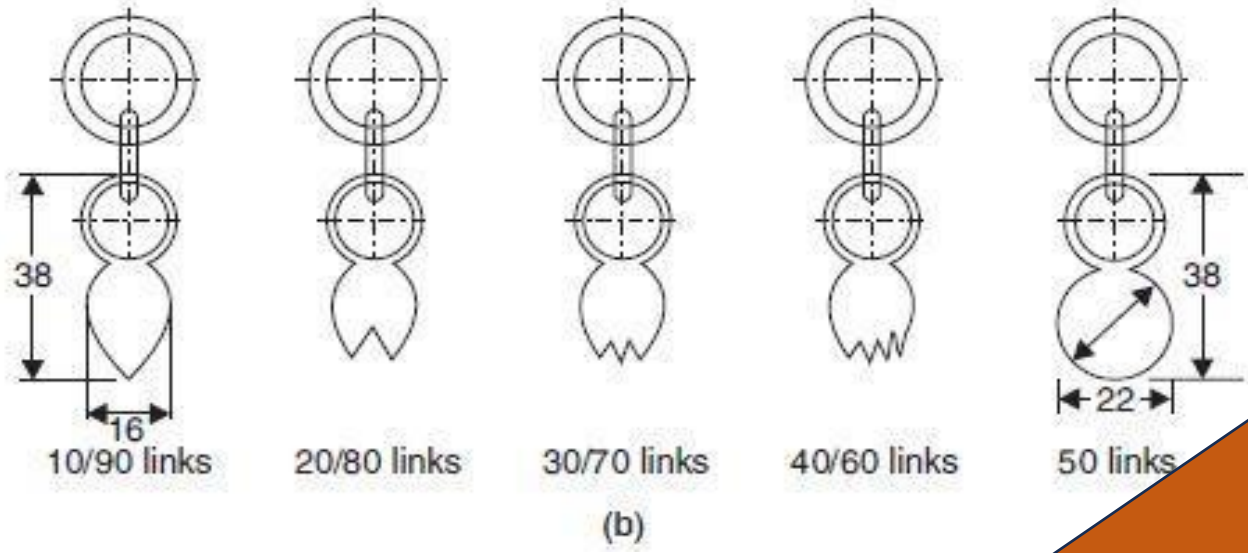
(4) Chaining:

- Chain is an instrument used to measure linear distance in surveying.









TYPES OF CHAINS

Type of Chain	Length	Number of Links	Link Length	Usage	Applications
Gunter's Chain	66 feet (20.12 meters)	100 links	0.66 feet (7.92 inches)	Used in the British Imperial system	Land surveying, measuring distances and acreage
Engineer's Chain	100 feet (30.48 meters)	100 links	1 foot	Used in engineering surveys	Road construction, railways, civil engineering
Metric Chain	20 meters or 30 meters	100 links (20 m) / 150 links (30 m)	0.2 meters	Used in countries following the metric system	General land surveying, construction projects
Revenue Chain	33 feet (10 meters)	16 links	2 feet	Used in revenue surveys, especially in India	Measuring agricultural land for revenue

Errors Due to Chaining

If a chain has been damaged and it may be too short or too long of the true length of the chian, and all the measurements taken will be too long or too short, conversely a contracted or stretched chain will give incorrect measurements of the true lengths.

The correct lengths of a measured distance is found from

$$\text{Correct Length} = \text{Measured Length} \times \frac{\text{Incorrect length of chain}}{\text{Correct length of chain}}$$

$$\text{Or Correct Length} = \text{Measured Length} \times \frac{L'}{L}$$

where L' = Incorrect length of chain or tape

L = Correct length of chain or tape

If an area has been calculated then,

$$\text{Correct area} = \text{Calculated area} \times \left[\frac{\text{Incorrect length of chain}}{\text{Correct length of chain}}\right]^2$$

If an volume has been calculated then,

$$\text{Correct volume} = \text{Calculated volume} \times \left[\frac{\text{Incorrect length of chain}}{\text{Correct length of chain}}\right]^3$$

Problems on Errors Due to Chaining

The length of the line measured with a chain having 100 links was found to be 2000 links if the chain was 0.5 link too short, find the true length of the line?

Explanation:

Let

True length of the Chain = L = 100 links

Incorrect length of the chain measured L' = 100 – 0.5 = 99.5 links

True length of the line l = ?

Wrong length of the line l' = 2000 links

$$l = l' * \frac{L'}{L}$$

$$l = 2000 * \frac{99.5}{100}$$

True length of the line is

$$\boldsymbol{l = 1990\ links}$$

The distance between two stations was measured with 20m chain and found to be 1500m. The same was measured with 30m chain and found to be 1476m. If the 20 m chain was 5cm too short, what was the true distance chained?

Explanation:

1) With 20 m chain : $L' = 20 - 0.05 = 19.95$ m

$l' = 1500\text{m}$

$$\boldsymbol{l = l' * \frac{L'}{L}}$$

$$l = 1500 * \frac{19.95}{20}$$

$$l = 1496.25m$$

2) With 30 m chain :$L' = ?$

$l' = 1476\text{m}$

$$\boldsymbol{l = l' * \frac{L'}{L}}$$

$$1496.25 = 1476 * \frac{L'}{30}$$

$$L' = 30.41158\text{m}$$

Were 30 m chain was **41.116 cm** or **0.4116 m** too long.

A chain was tested before the starting the survey and was found to be exactly 20m at the end of the survey, it was tested again and was found to be 20.12m area of plan of the field drawn to a scale of 1cm = 6m was 50.4sq cm. find the true area of the field in sq. meters.

To find the true area of the field, we need to adjust the area measured on the plan by considering the error in the length of the chain.

Given:

Initial length of chain L=20 m

Final length of chain L'=20.12 m

Area of the plan A'=50.4 sq.cm

Scale 1 cm = 6 m

Step 1: Calculate the measured area

The area of the plan is in square centimeters, but we need the measured area in square meters.

Using the scale 1 cm = 6 m

The scale of the plan = 1 cm = 6 m

So the measured area of the field $A' = 50.4 \times 6^2$

$$A' = 50.4 \times 36$$

$$A' = 1814.4\ m^2$$

Step 2: Apply the correction for chain length

The measured area was based on a chain length that changed from 20 m to 20.12 m during the survey. The true area is corrected by the ratio of the true length of the chain to the incorrect length.

$$\text{True Area} = A' * \left(\frac{L'}{L}\right)^2$$

$$\text{True Area (A)} = 1814.4 * \left(\frac{20.12}{20}\right)^2$$

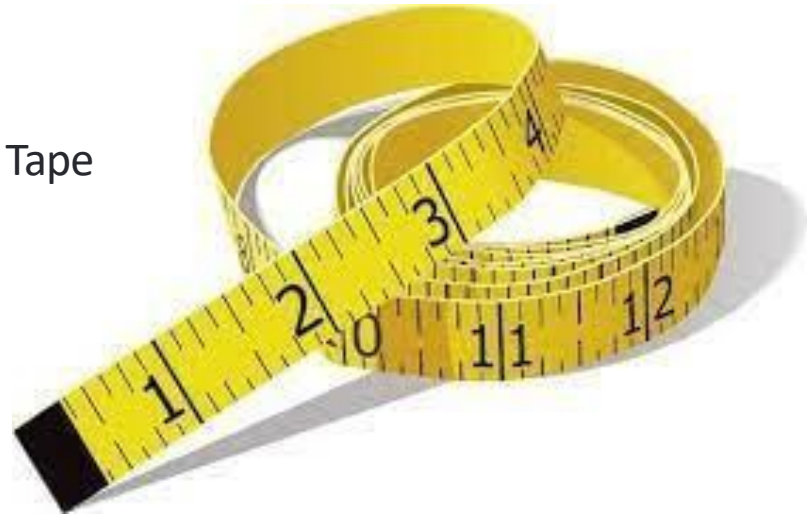
The true area of the field is approximately $1825.30\ m^2$

(5) Tape

Accurate measurements are carried out through tape in survey.

There are 5 types of tapes available in surveying for linear measurements and they

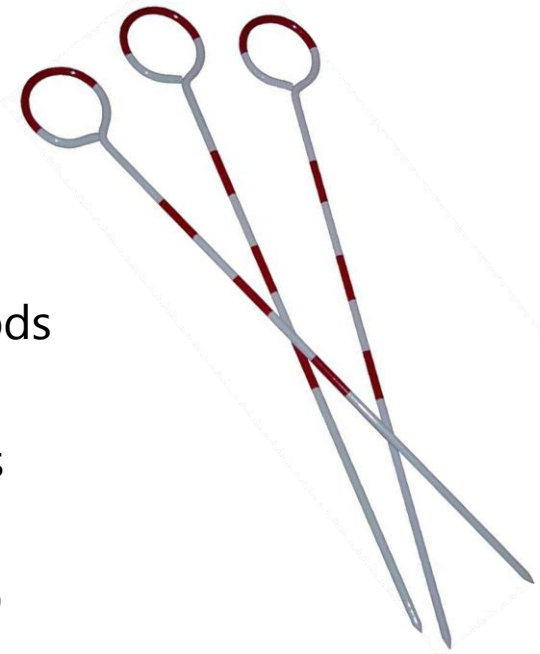
1. Linen Tape
2. Woven Metallic Tape
3. Steel Tape
4. Synthetic Tape
5. Invar Tape



Instruments for Surveying

The various instruments used for the determination of the length of line by chaining are as follows:

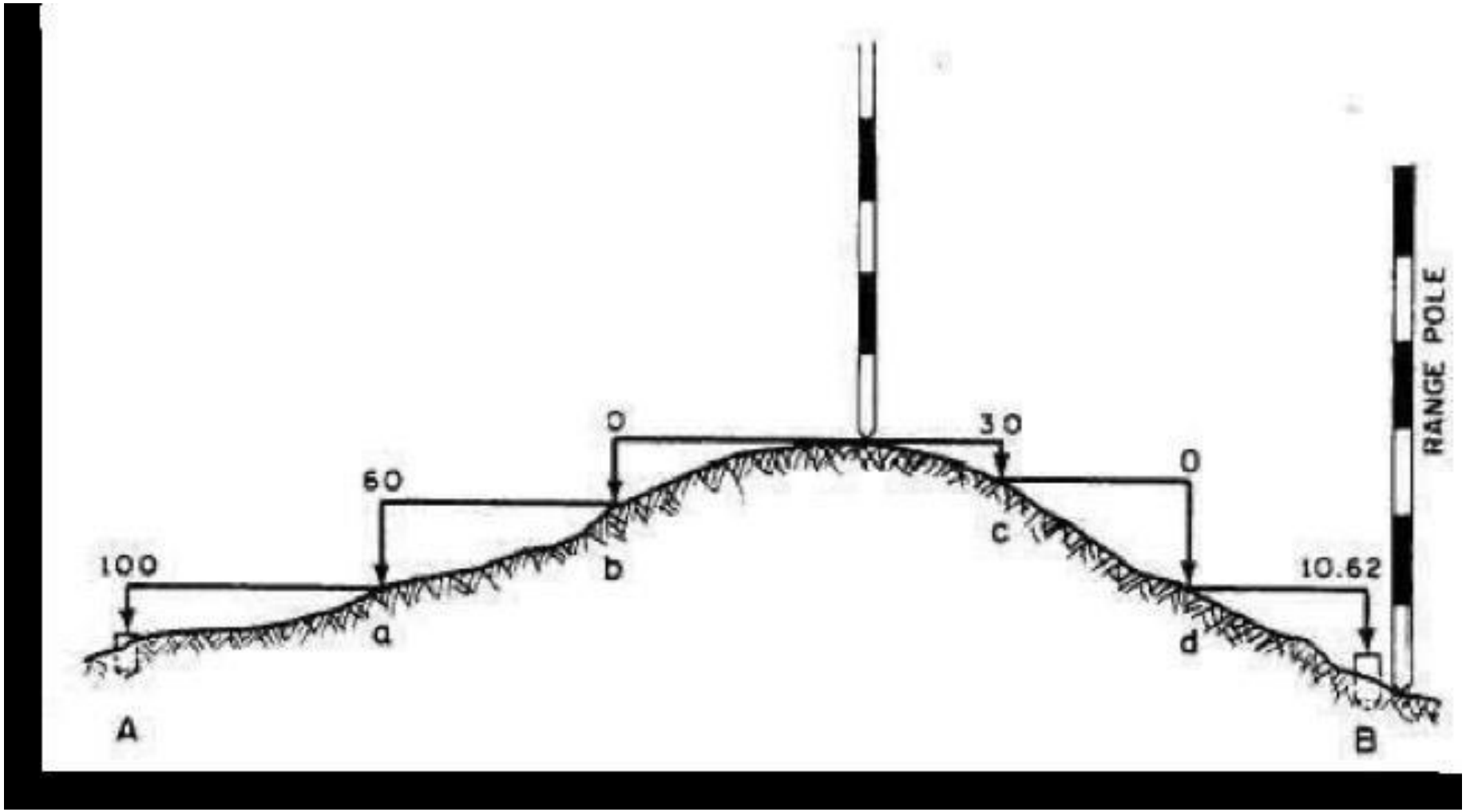
1) Chain or Tape
2) Arrows
3) Pegs
4) Ranging rods
5) Offset rods
6) Plumb bob



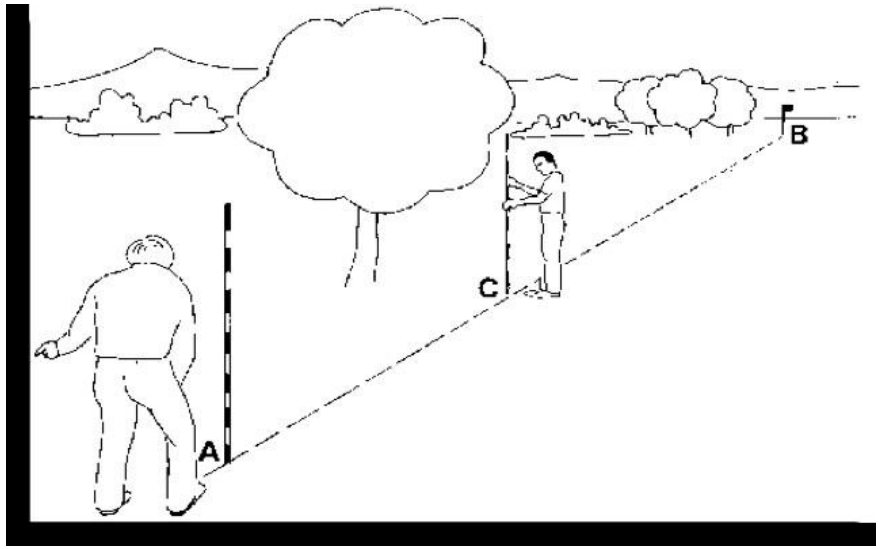
Linear Measurements

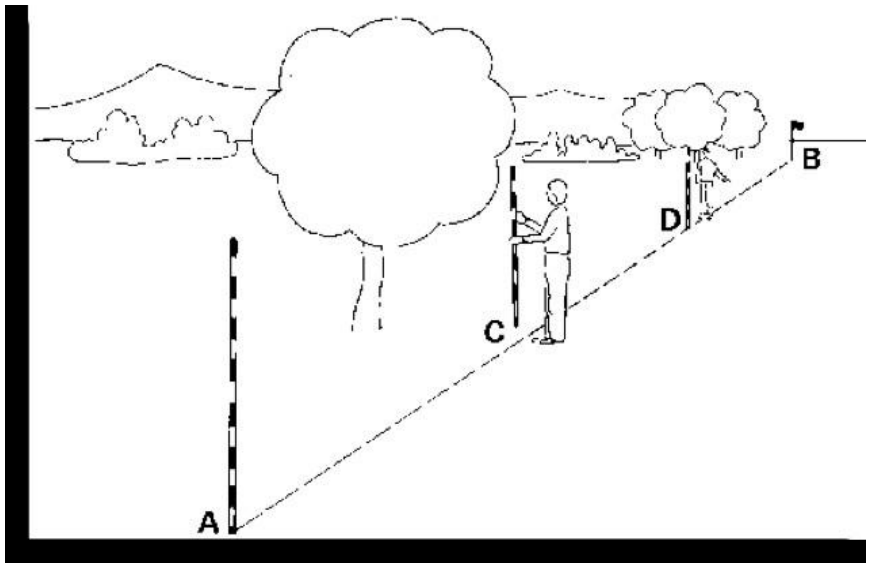
Different types of ranging, tapes, chains, linear measurements, approximate, direct methods

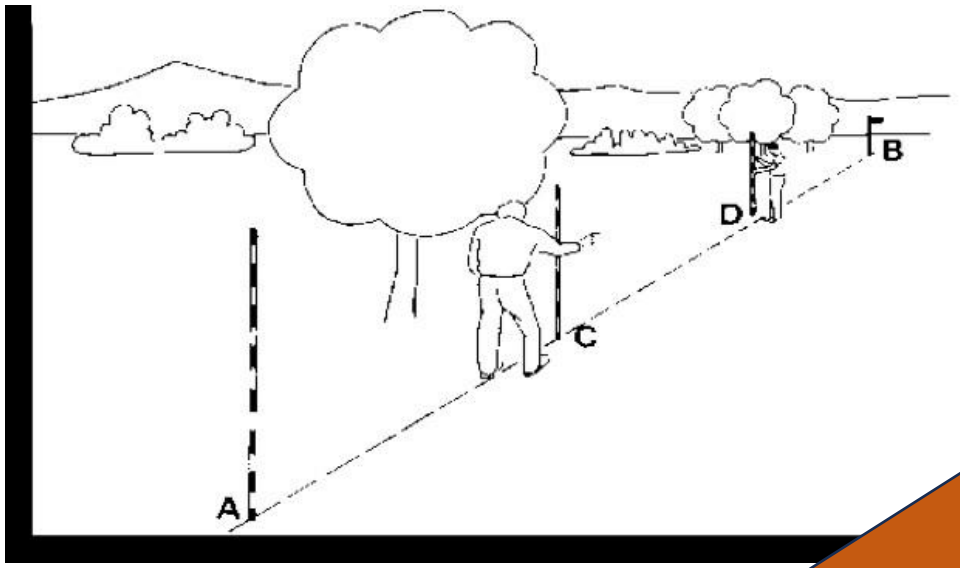
❖ Ranging



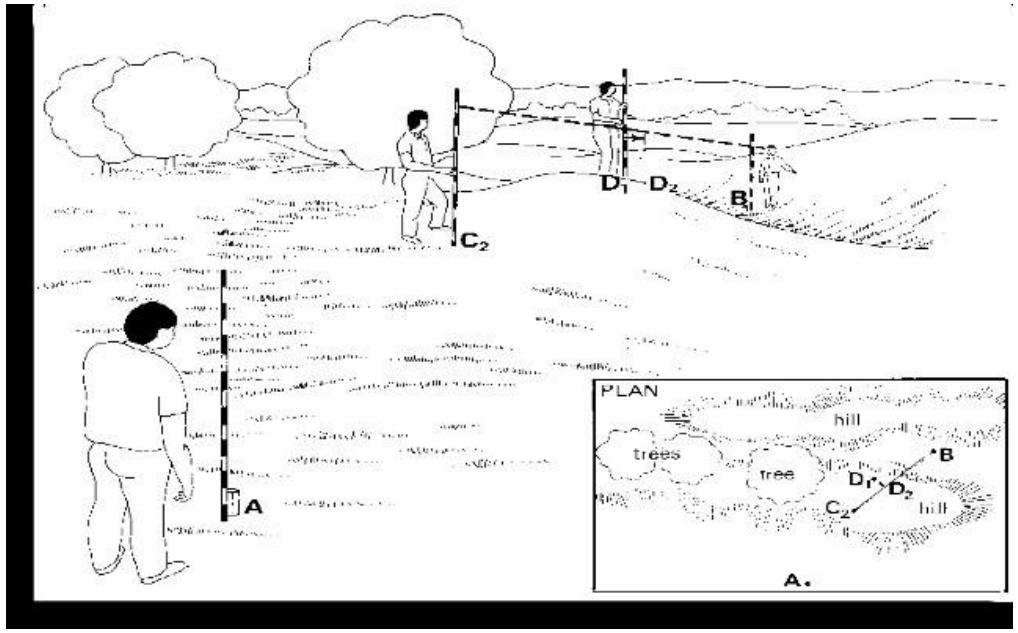
1. Direct Ranging

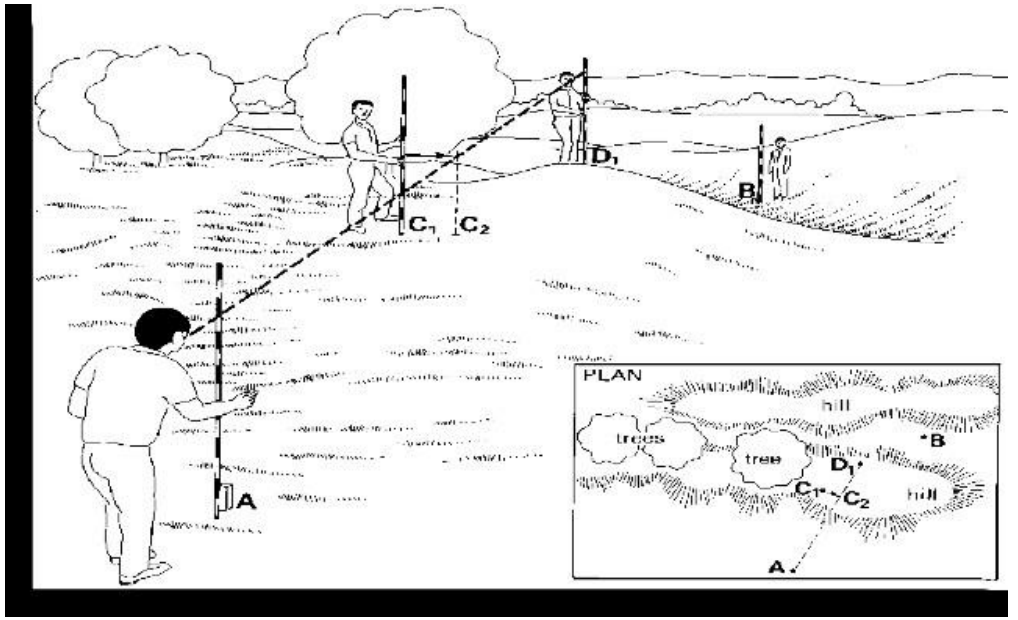






2. Indirect or Reciprocal Ranging





INTRODUCTION TO BEARINGS

Introduction to Compass Surveying

- Chain surveying can be used when the area to be surveyed is comparatively is small and is fairly flat.
- But when the area is large , undulating and crowded with many details triangulation

  (which is the principle of chain survey) is not possible.

- In such an area , this method of surveying is used.

Compass

- A compass is a small instrument essentially consisting of a graduated circle, and a line of sight.
- The compass can not measures angle between two lines directly but can measure angle of a line with

  reference to magnetic meridian at the instrument station point is called magnetic bearing of a line.

Types of compass

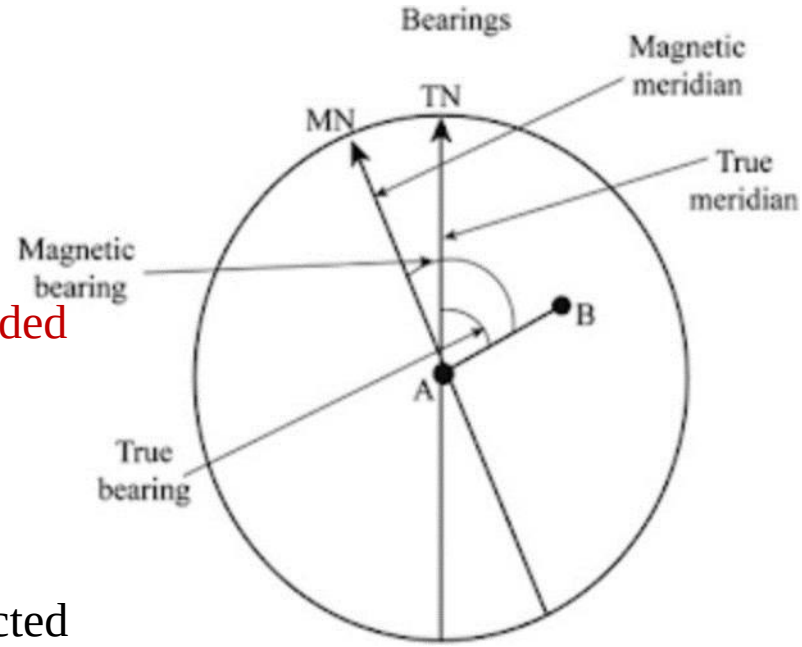
There are two types of compass they are as follows:

- The Prismatic Compass

- The Surveyor's Compass

Principle of compass surveying

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



Bearing

The bearing of a line is the horizontal angle which it makes with a reference line depending upon the meridian, there are four types of bearings.

True bearing

The true bearing line is horizontal angle between the true meridian and the survey line. The true bearing is measured from the true north in the clockwise direction.

Magnetic bearing

The magnetic bearing of a line is the horizontal angle which the line makes with the magnetic north.

Arbitrary bearing

The arbitrary bearing of a line is the horizontal angle which the line makes with the arbitrary meridian.

The bearings are of two systems.

1. Whole Circle Bearing system (W.C.B) or Azimuthal system
2. Quadrantal Bearing system (Q.B) or Reduced bearing (R.B)

Whole Circle Bearing (W.C.B)

It can be taken 0° to 360°. Quadrants are taken clock-wisely and angles are also determined in clockwise direction.

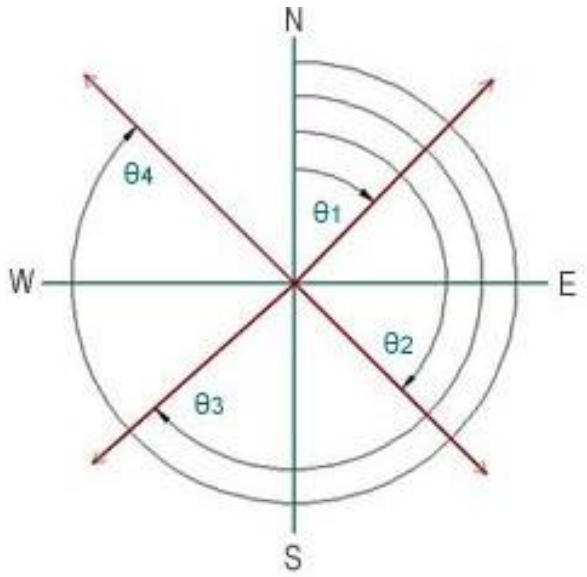


Fig: Whole Circle Bearing

Reduced Bearing (R.B)

Reduced bearing or Quadrantal bearing is the angle which a line makes from North or South Pole whichever may be near. It is value is from 0° to 90°.

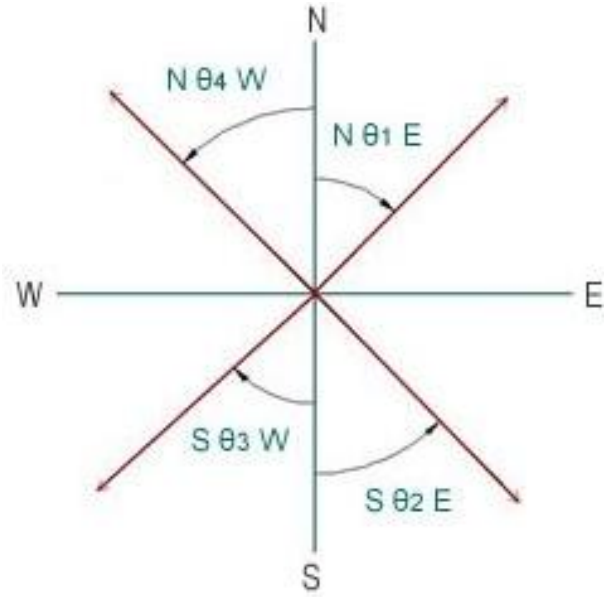


Fig: Reduced Bearing

The bearing of a line can be converted from Whole Circle Bearing (W.C.B.) system to Reduced Bearing (R.B.)

Line	W.C.B between	Quadrant	Rule of conversion from W.C.B to R.B	R.B
AB	0° - 90°	NE	R.B = W.C.B	N θ_1 E
BC	90°- 180°	SE	R.B = 180° - W.C.B	S θ_2 E
CD	180° - 270°	SW	R.B = W.C.B - 180°	S θ_3 W
DA	270° - 360°	NW	R.B = 360° - W.C.B	N θ_4 W

The bearing of a line can be converted from Reduced Bearing (R.B.) system to Whole Circle Bearing (W.C.B.) system

Line	R.B Quadrant	Rule of conversion from W.C.B to R.B	W.C.B between
AB	N θ_1 E	W.C.B = R.B	0° - 90°
BC	S θ_2 E	W.C.B = 180° - R.B	90°- 180°
CD	S θ_3 W	W.C.B = R.B + 180°	180° - 270°
DA	N $\theta\varphi_4$ W	W.C.B = 360° - R.B	270° - 360°

Simple problems on Bearings

The following are the bearing taken on a closed traverse

Line	Fore bearing	Back bearing
AB	80°10′	259°0′
BC	120°10′	301°50′
CD	170°50′	350°50′
DE	230°10′	49°30′
EA	310°20′	130°15′

Compute the interior angles and correct them for observational errors. Assuming the observed bearings of the line CD to be correct adjust the bearing of the remaining sides.

Check

- Sum of included angles = (2n-4) *90
- (50°05′+138°50′+131°00′+120°40′+99°10′) = (2*10-4) *90
- 539°45′=540°
- Difference = $\frac{0°15'}{5}$ = 0°03′

Therefore, add the difference in included angle

Correction of back bearing = Fore bearing ± 180°

Correction of fore bearing = Back bearing - Included angle

Included angle = Back bearing of previous line - Fore bearing of next line

Line	Fore bearing	Back bearing	Included angle	Corrected include angle	Corrected F.B	Corrected B.B
AB	80°10′	259°0′	130°15′ - 80°10′ = 50°05′	**50°08′**	**80°46′**	**260°46′**
BC	120°10′	301°50′	259°0′ - 120°10′ = 138°50′	**138°53′**	**121°53′**	**301°53′**
CD	**170°50′**	**350°50′**	301°50′ - 170°50′ =131°00′	**131°03′**	**170°50′**	**350°50′**
DE	**230°10′**	49°30′	350°50′ - 230°10′ =120°40′	**120°43′**	**230°07′**	**50°07′**
EA	310°20′	130°15′	49°30′ - 310°20′ = -260°50′ +360° = 99°10′	**99°13′**	**310°54′**	**130°54′**

The Following fore and back bearings were observed in traversing with a compass in place where local attraction was suspected. Find the corrected FB and BB lies using included angles.

Lines	Fore Bearing	Back Bearing
AB	158°30’	339°
BC	62°	242°
CD	342°	163°
DE	281°	101°30’
EA	210°30’	30°

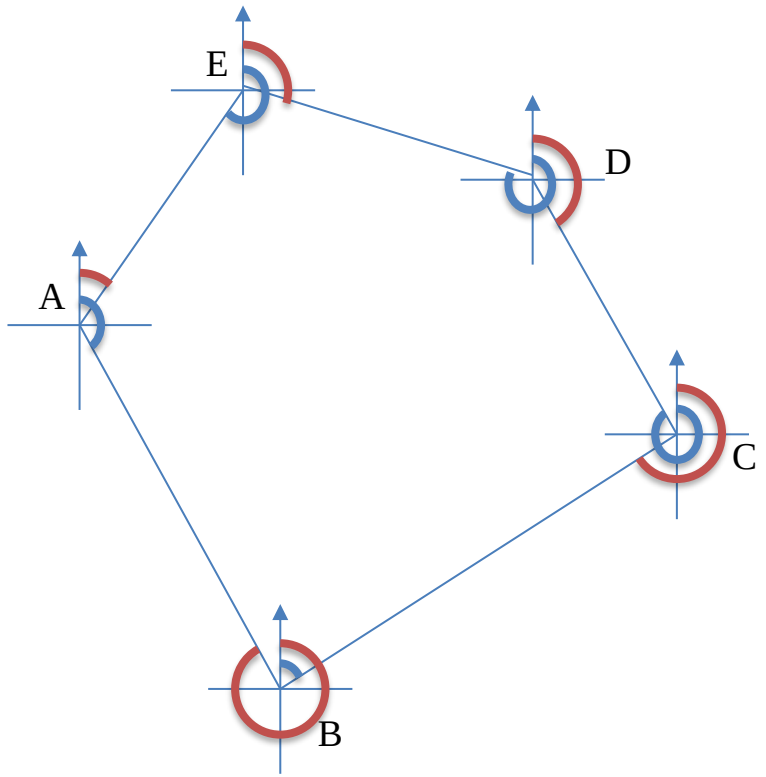
Formula:

- **Included angle** = Fore bearing of fore line - Back bearing of back line
- **Fore bearing** = Back bearing + Included angle
- **Back bearing** = Fore bearing ± 180°

Note

- Back bearing = (Fore bearing ≤ 180°)+180°
- Back bearing = (Fore bearing ≥ 180°) - 180°

Lines	Fore Bearing	Back Bearing	Included Angle	Corrected		
				Included Angle	Fore Bearing	Back Bearing
AB	158°30’	339°	128°30′	128°48′	158°42′	338°42′
BC	62°	242°	83°	83°18′	62°	242°
CD	342°	163°	100°	100°18′	342°18′	162°18′
DE	281°	101°30’	118°	118°18′	280°36′	100°36′
EA	210°30’	30°	109°	109°18′	209°54′	29°54′



Definition, Principle, & Object of Levelling

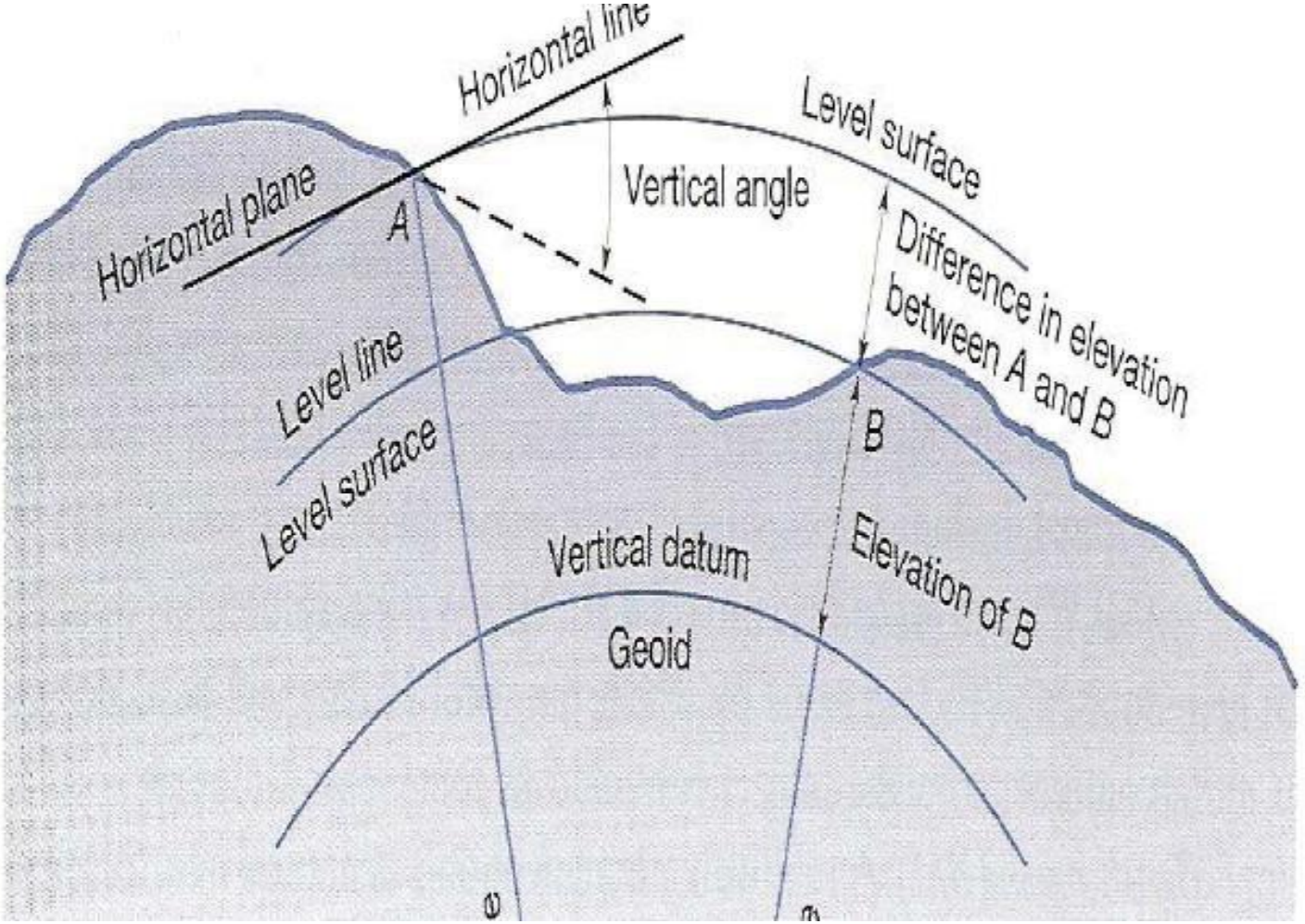
Definition:- Levelling is defined as “An art of determining the relative height of different points on, above or below the surface”

Principle:- The principle of levelling is to obtain horizontal line of sight with respect to which vertical distances of the points above or below this line of sight are found.

The objective of levelling is to

1) Find the elevation of given point with respect to some assumed reference line called datum.

2) To establish point at required elevation with respect to datum.


Horizontal line
Level surface
Horizontal plane
A
Vertical angle
Difference in elevation
between A and B
Level line
Level surface
B
Vertical datum
Elevation of B
Geoid

Definitions used in levelling

Level surface:- It is the surface parallel to the mean spheroidal surface of the earth

Level line:- Line lying on level surface.

Horizontal plane:- Horizontal plane through a point is a plane tangential to level surface.

Horizontal line:- It is a straight line tangential to level line.

Datum:- “It is an arbitrary level surface from which elevation of points may be referred”. In India mean sea level is considered as datum of zero elevation it is situated at Karachi.

Mean sea level:- It is the average height of sea for all stages of tides it is derived by averaging the hourly tide height over a period of 19 years.

Elevation or Reduced level:- It is height or depth of any point above or below any datum.

It is denoted as R.L.

Bench Mark (B.M.):- It is a fixed reference point of known elevation with respect to datum.

Line of collimation:- It is a line joining the intersection of cross hairs of diaphragm to the optical centre of object glass and its continuation. It is also known as line of sight.

Height of instrument:- It is the elevation of line of collimation with respect to datum

Back sight:- It is a staff reading taken at a known elevation. It is the first staff reading taken after setup of instrument.

Fore sight(F.S.):- It is the last staff reading taken denoting the shifting of the instrument.

Intermediate sight.(I.S.):-It is staff reading taken on a point whose elevation is to be determined. All staff reading between B.S. and F.S. are Intermediate sight.

Change Point:- It is a point on which both fore and back sight are taken

Level:- The instrument used to furnish horizontal line of sight for observing staff readings and determining R.L.s

Types of level (Levelling instruments)

1. Dumpy level
2. Tilting level
3. Wye level
4. Automatic level

Dumpy level

The Dumpy level is a simple, compact and stable instrument. The telescope is rigidly fixed to its supports. Hence it cannot be rotated about horizontal axis.

Tilting level

It is also known as I.O.P. level (Indian office Pattern). In this level the telescope tilts about its horizontal axis hence it is called tilting level

Wye level

The essential difference between wye level and other levels is that in wye level the telescope is carried by two vertical wye supports. The telescope can be rotated, moved or even raised in wyes.

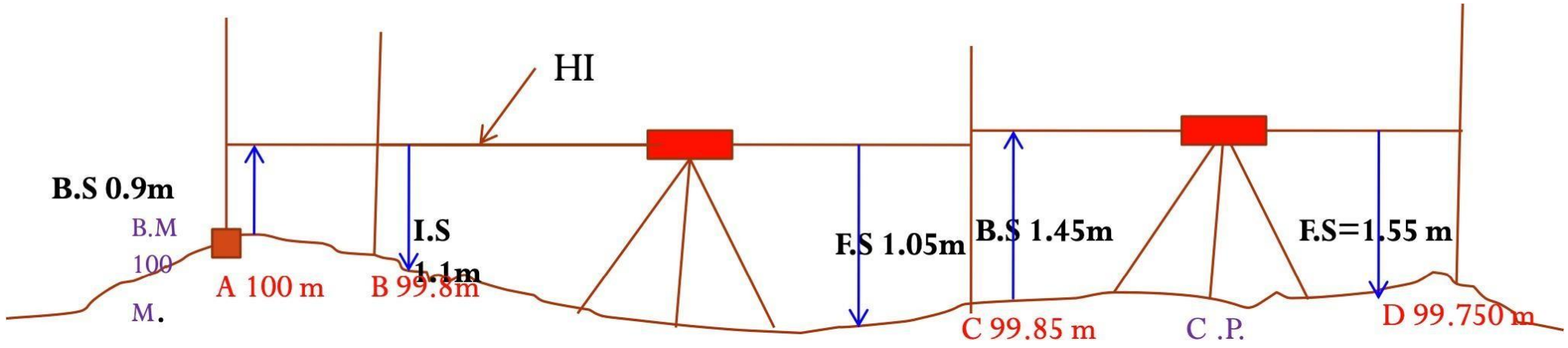
Automatic level

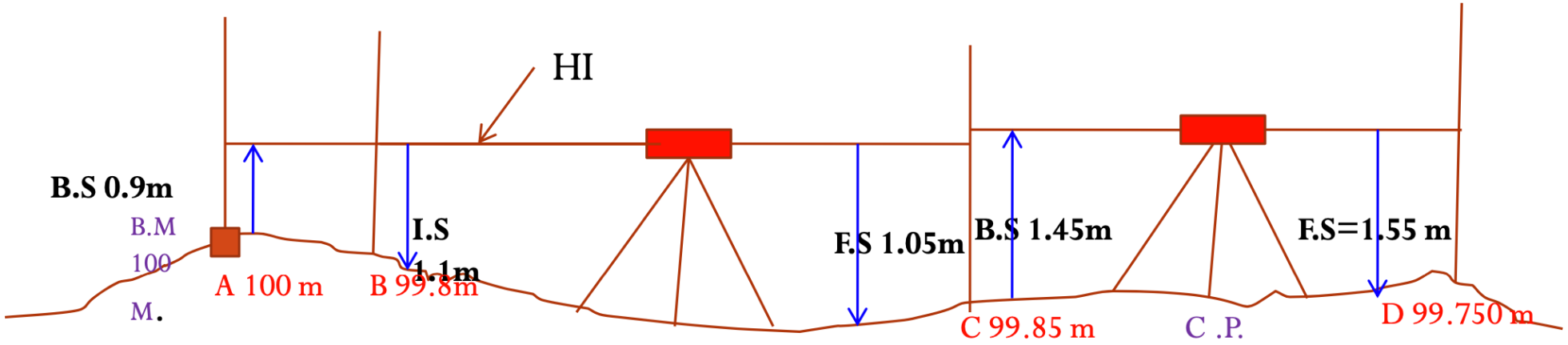
It is also known as self aligning level. It is a recent development. The fundamental difference between auto level and other levels is that the levelling is not manually but it is levelled automatically. It is achieved by inclination compensating device.

Methods of Reducing Levels (Reduction of Levels)

1. Height of Instrument Method (Collimation Method):-

This method consist of finding H.I. for every setup of instrument, and then obtaining the R.L. of point of reference with respect to H.I

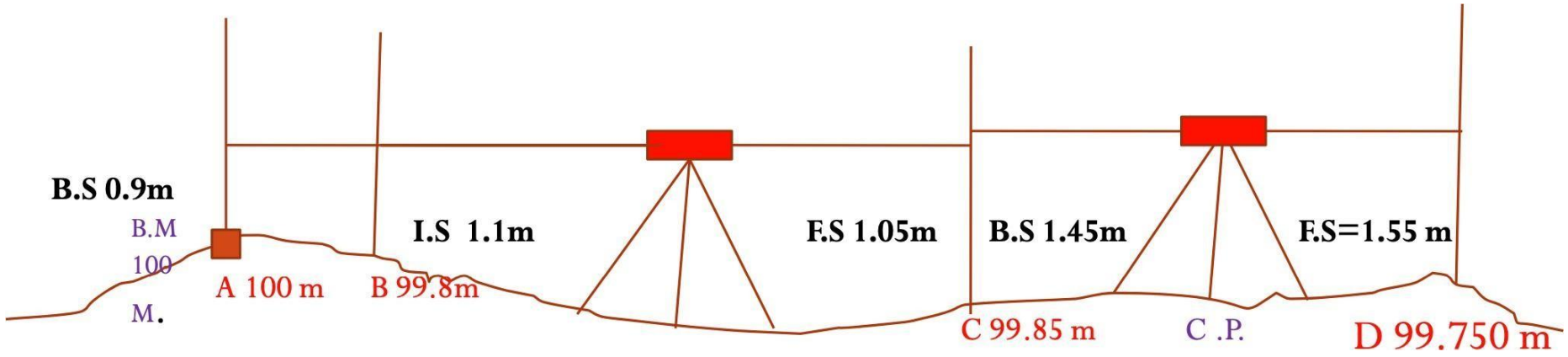


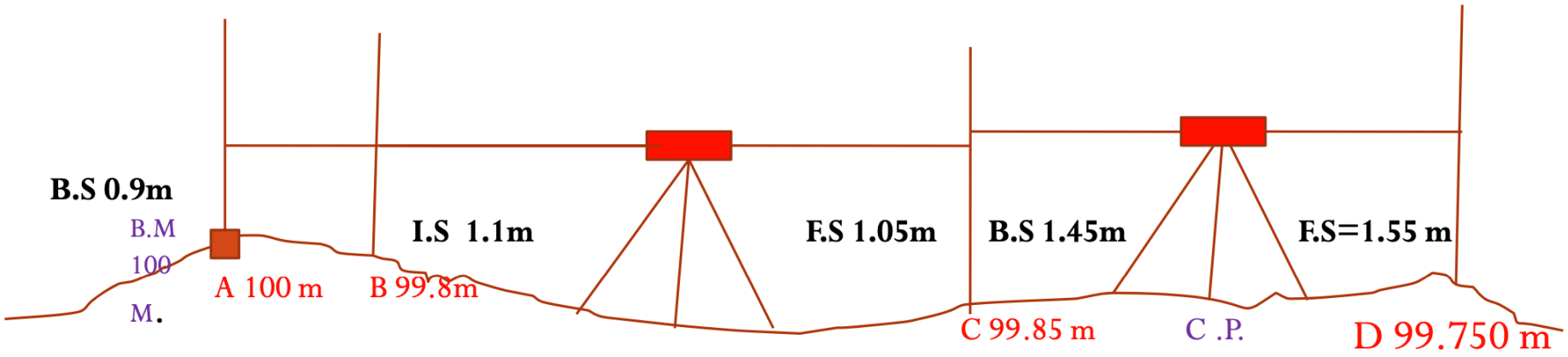


Station	B.S	I.S	F.S	H.I	R.L	Remark
A	0.9			100.9	100.00	B.M
B		1.1			99.800	
C	1.450		1.05	101.3	99.850	C.P.
D			1.550		99.750	

2. Rise and Fall Method:-

This method consist of determining the difference of level between consecutive points by comparing each point with immediate preceding point.





Station	B.S	I.S	F.S	Rise	Fall	R.L	Remark
A	0.9					100.00	B.M
B		1.1			0.2	99.800	
C	1.450		1.05	0.05		99.850	C.P.
D			1.550		0.1	99.750	

Example.1

The following staff readings were observed successively with a level the instrument is moved by third sixth and eighth readings. 2.228 :1.606 :0.988 :2.090 :2.864 :1.262 0.602 :1.982 :1.044 :2.684 m enter the reading in record book and calculate R.L.

if the first reading was taken at a B.M of 432.383m

1. Height of Instrument Method (Collimation Method):-

Station	B.S	I.S	F.S	HI	RL	REMARKS
1	2.228			434.612	432.384 M	B.M.
2		1.606			433.006	
3	2.090		0.988	435.714	433.624	3RD C.P.
4		2.864			432.850	
5	0.602		1.262	435.054	434.452	6TH C.P
6	1.044		1.982	434.116	433.072	8TH C.P
7			2.684		431.432	
	5.964 =∑B.S		6.916 =∑F.S			

CHECK $\sum$ B.S- $\sum$ F.S= 5.964-6.916= -0.952 = LAST R.L- FIRST R.L= 431.432-432.384=-0.952

2. Rise and Fall Method:-

Station	B.S	I.S	F.S	Rise	Fall	RL	REMARKS
1	2.228					432.384 M	B.M.
2		1.606		0.622		433.006	
3	2.090		0.988	0.618		433.624	3RD C.P.
4		2.864			0.774	432.850	
5	0.602		1.262	1.602		434.452	6TH C.P
6	1.044		1.982		1.38	433.072	8TH C.P
7			2.684		1.64	431.432	
	5.964 =∑B.S		6.916 =∑F.S				

CHECK ∑ B.S- ∑ F.S= 5.964-6.916= -0.952 =

LAST R.L- FIRST R.L= 431.432-432.384=-0.952

∑RISE- ∑ FALL= 2.842-3.794=-0.952

Example.2

The following readings were taken with a dumpy level and 4m leveling staff. The instrument was shifted after 3rd and 6th readings. The readings are 2.665, 3.225, 2.905, 1.85, 0.98, 2.62, 1.585, 0.96, 0.425. m Enter the above readings in a page of level book and calculate R.L. of points, if the first reading was taken with a staff held on B.M. of 240 m. use rise and fall method. Apply arithmetic checks

1. Rise and Fall Method:-

Station	B.S.	I.S.	F.S	Rise (+)	Fall (-)	RL	Remarks
A	2.665					240	BM
B		3.225			0.56	239.44	
C	1.85		2.905	0.32		239.76	3rd CP
D		0.98		0.87		240.63	
E	1.585		2.62		1.64	238.99	6th CP
F		0.96		0.625		239.615	
G			0.425	0.535		240.15	
CHECK	∑ BS- ∑ FS			∑RISE- ∑ FALL		L.RL –F. RL	
	6.1		5.95	2.35	2.2		
	∑ BS- ∑ FS= 0.15			∑RISE- ∑ FALL =0.15		L.RL –F. RL= 0.15	

2. Height of Instrument Method (Collimation Method):-

Station	B.S.	I.S.	F.S	HI	RL	Remarks
A	2.665			242.665	240 .00	BM
B		3.225			239.44	
C	1.85		2.905	241.61	239.76	3rd CP
D		0.98			240.63	
E	1.585		2.62	240.575	238.99	6th CP
F		0.96			239.615	
G			0.425		240.15	
CHECK	∑ BS- ∑ FS				L.RL –F. RL	
	6.1		5.95			
	∑ BS- ∑ FS= 0.15				L.RL –F. RL= 0.15	

Example.3

The Following observations were taken with dumpy level and 4 m leveling staff. The instrument were shifted after the 4th and 7th reading. The first reading was taken on a bench mark whose R.L. was 15.575 m. prepare a page of level book and calculate RL of all the points. The observations were taken at every 30 m interval. Also find out the gradient between first and last point. Also draw the profile of ground. Use H.I. Method. Observations are: 0.565, 1.250, 1.675, 3.695,0.125, 2.345, 0.500, 1.785, 2.535.

1. Height of Instrument Method (Collimation Method):-

Station	B.S.	I.S.	F.S	HI	RL	Remarks
A	0.565			16.14	15.575	BM
B		1.250			14.89	
C		1.675			14.46	
D	0.125		3.695	12.565	12.44	CP
E		2.345			10.22	
F	1.785		0.500	13.85	12.065	CP
G			2.535		11.315	
CHECK	$\sum$ BS- $\sum$ FS				L.RL –F. RL	
	2.47		6.73			
	$\sum$ BS- $\sum$ FS= -4.26				L.RL –F. RL= -4.255	

2. Rise and Fall Method:-

Station	B.S.	I.S.	F.S	RISE	FALL	RL	Remarks
A	0.565					15.575	BM
B		1.250			0.685	14.89	
C		1.675			0.425	14.46	
D	0.125		3.695		2.02	12.44	CP
E		2.345			2.22	10.22	
F	1.785		0.500	1.845		12.065	CP
G			2.535		0.75	11.315	
CHECK		∑ BS- ∑ FS				L.RL –F. RL	
	2.47		6.73				
	∑ BS- ∑ FS= -4.26			∑RISE- ∑ FALL =-4.26		L.RL –F. RL= -4.26	

GRADIENT

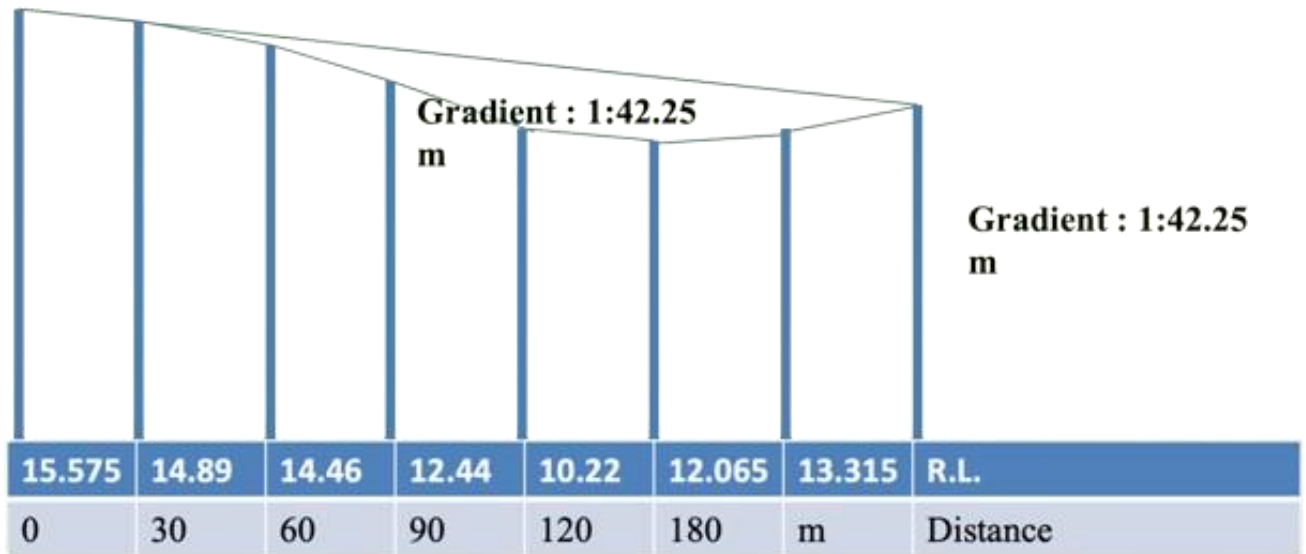
- Gradient of line AG = $\frac{\text{Diff of RLs}}{\text{Length}}$

- Gradient of line AG = $\frac{4.260}{180}$

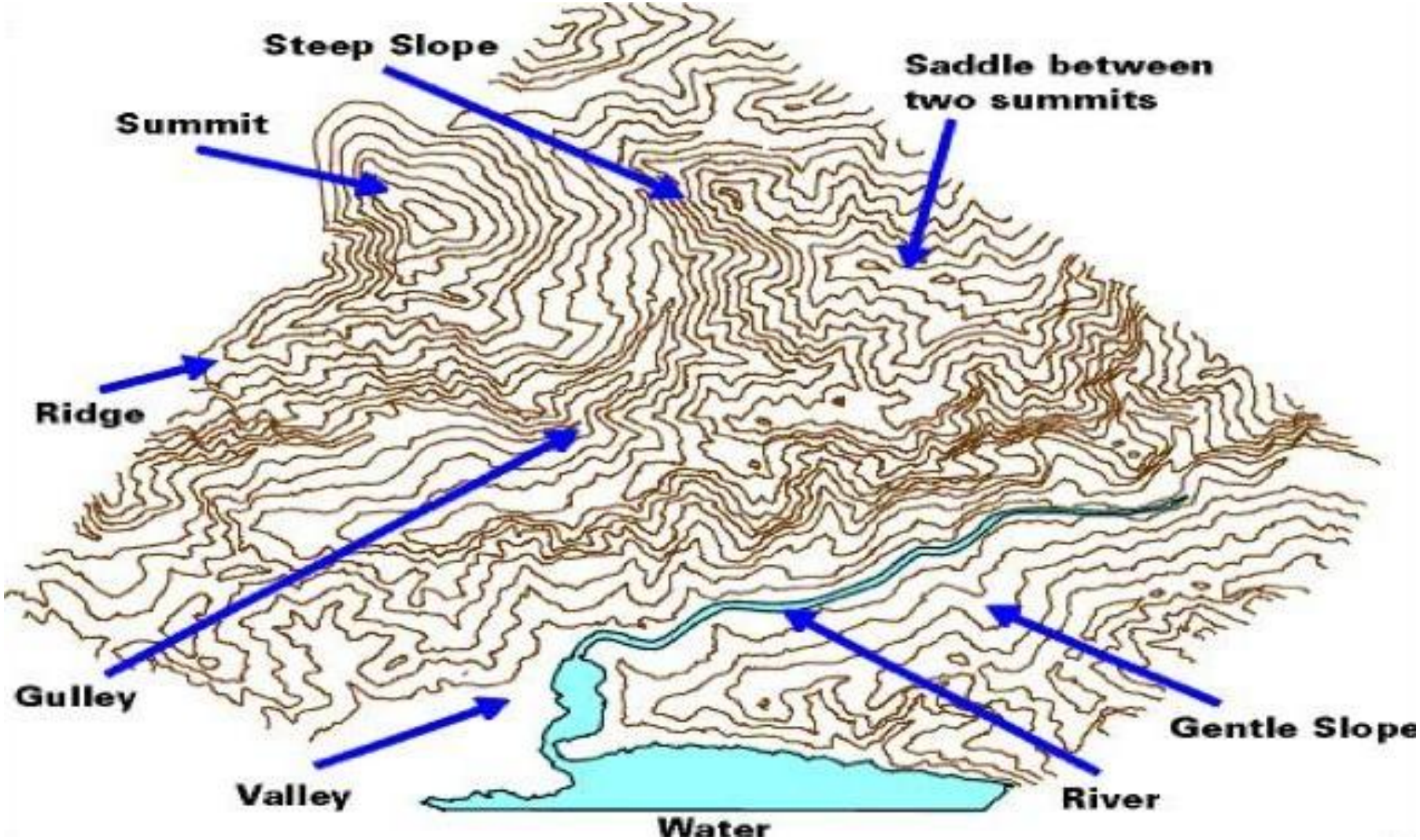
$= \frac{1}{42.25}$

= 1 in 42.25 Gradient.

Profile



Contour mapping A contour is an imaginary line joining points of equal elevation



The vertical distance between any two consecutive contours is known as contour interval