CE 103

Surveying

Levelling

Contents

❑Definition

❖ Levelling is defined as an art of determining the relative height of different points on, above or below the surface.

Principle of Levelling

- 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.

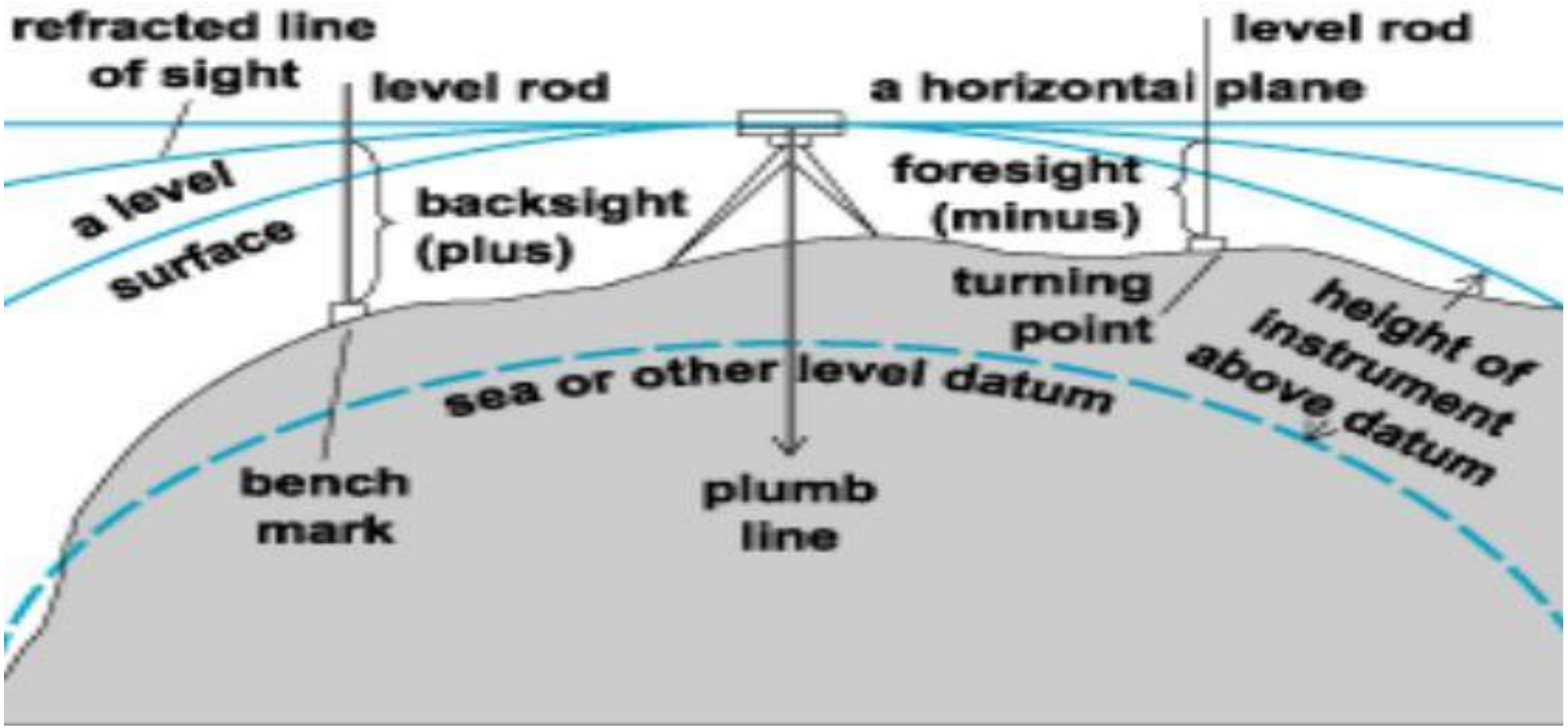
Object of levelling

- To Find the elevation of given point with respect to some assumed reference line called datum.
- To establish point at required elevation respect to datum.

Terms 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.

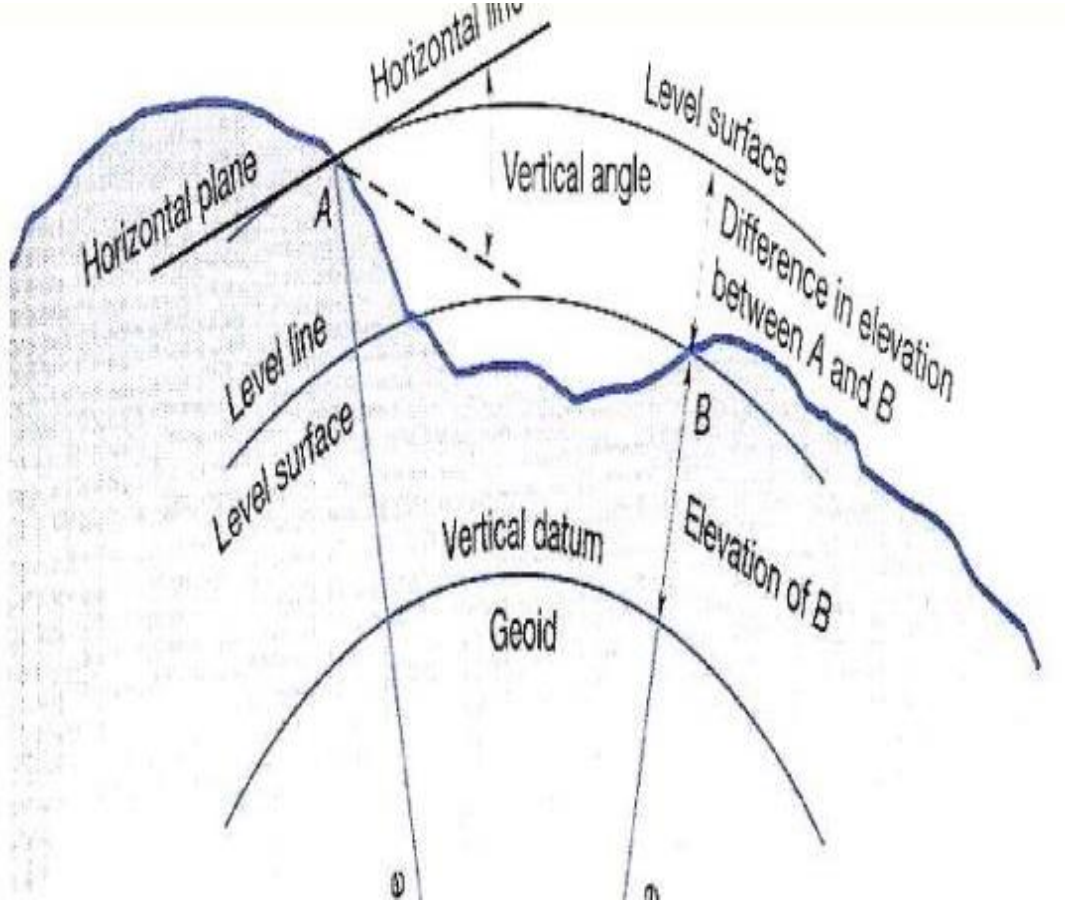
Terms used in Levelling



Terms used in Levelling

- **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.
- **Reduced level:** It is height or depth of any point above or below any datum. It is denoted as R.L.

Terms used in levelling



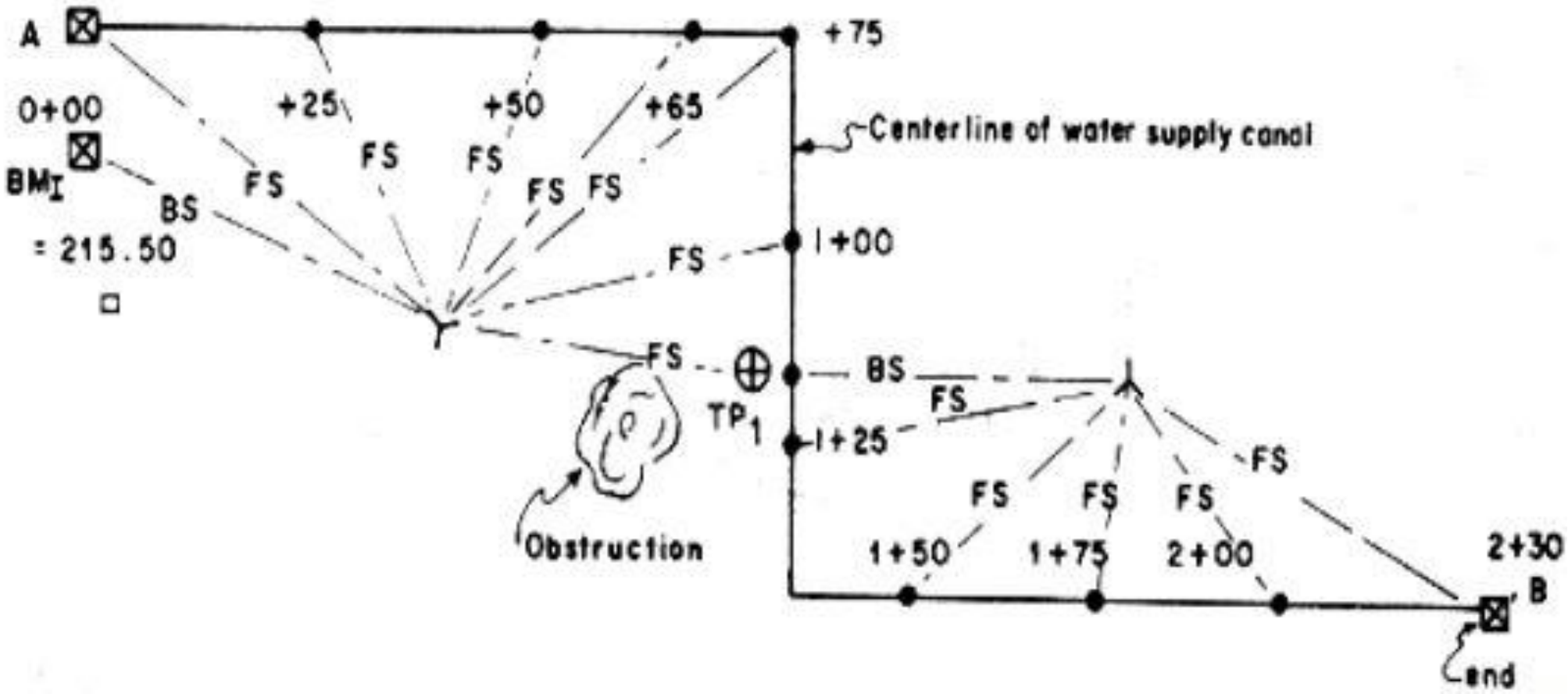
Terms used in Levelling

- **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.

Terms used in Levelling

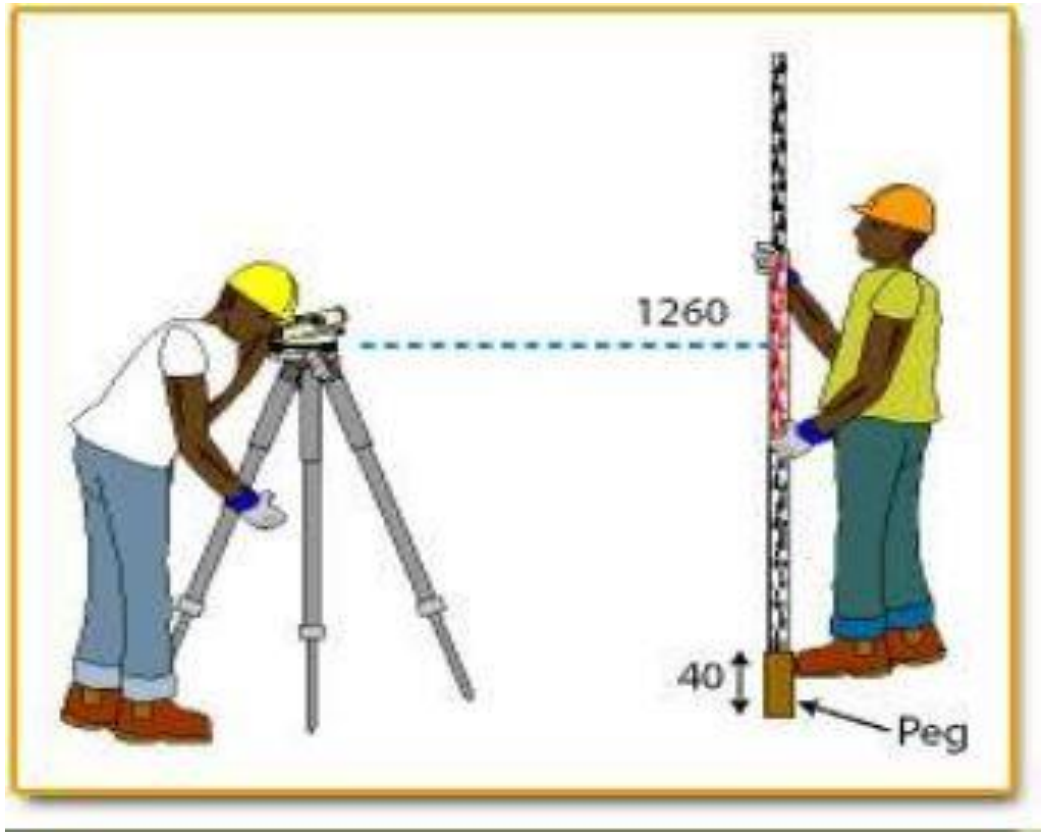
- **Fore sight(F.S.):** It is the last staff reading taken denoting the shifting of the instrument.
- **Intermediate sight.(I.S.):** It is staff reading taken on a point whose elevation is to be determined. All staff reading between B.S. and F.S. are Intermediate sight.
- **Change Point (C.P):** It is a point on which both fore and back sight are taken.

Terms used in Levelling



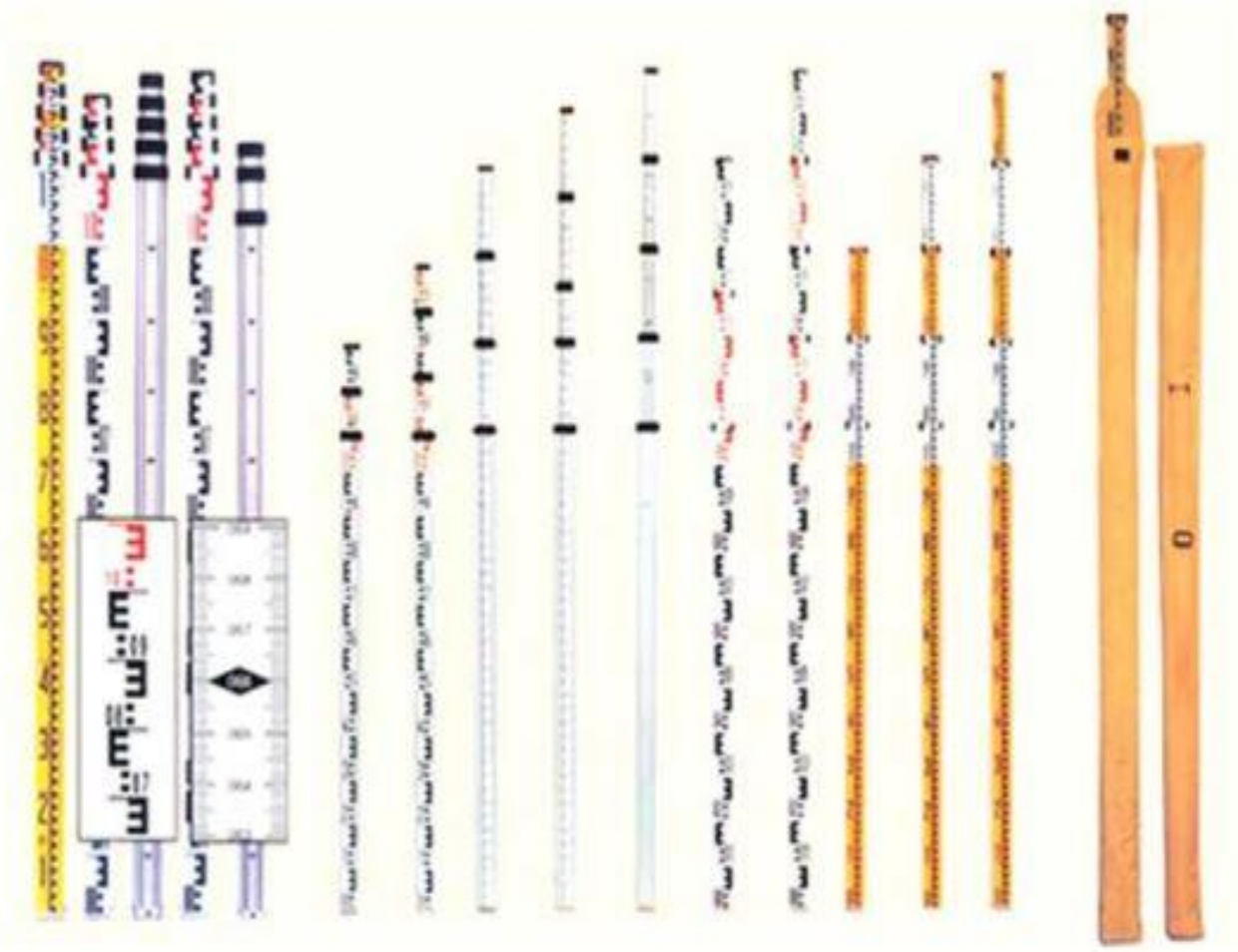
Instruments for levelling

- The following instruments are essentially required for levelling
  - Level
  - Levelling Staff



Levelling Staffs

- Levelling staffs are scales on which these distances are measured.
- Levelling staffs are of two types
  - Self Reading staff
  - Target staff



Bench Marks

- Bench mark is a point of known elevation

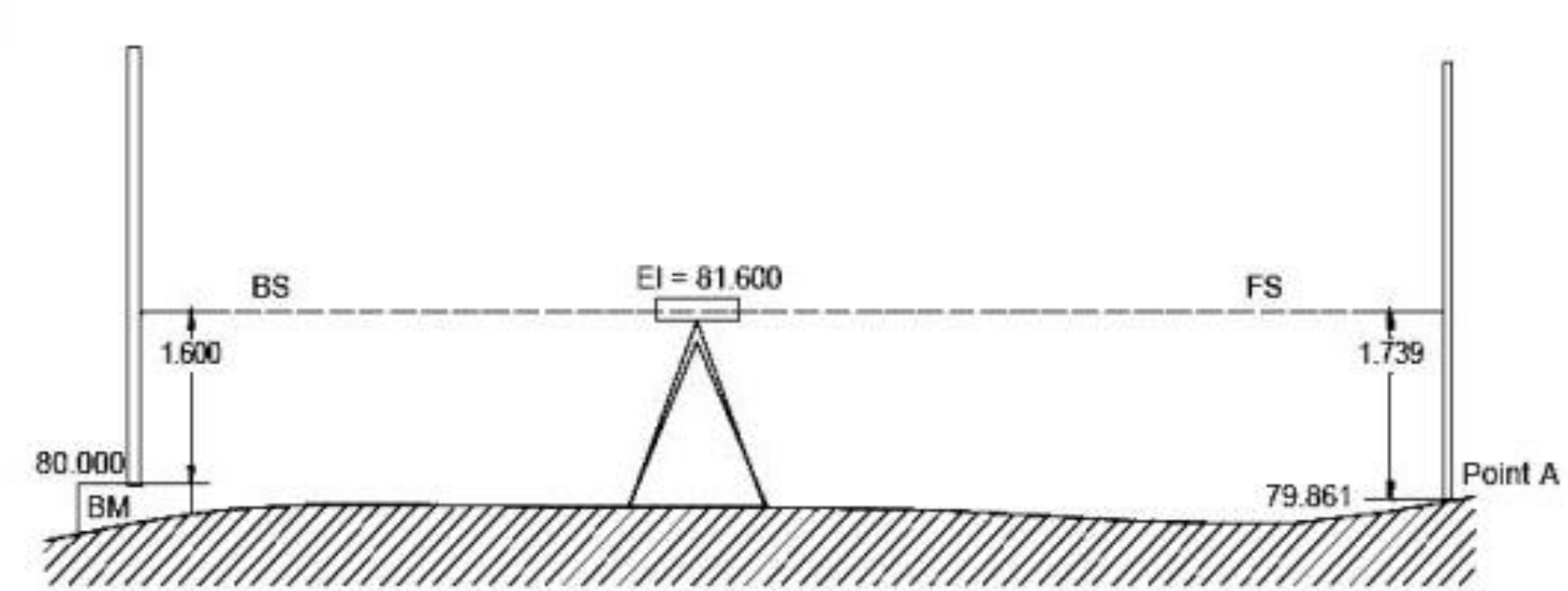
- There are 4 kinds of bench marks
- ✓ GTS (Great trigonometrically survey bench mark)
- ✓ Permanent bench mark
- ✓ Arbitrary bench mark
- ✓ Temporary bench mark

Classification of Levelling

- Simple Levelling
- Differential Levelling
- Fly Levelling
- Check Levelling
- Profile Levelling
- Cross Levelling
- Reciprocal Levelling
- Precise Levelling
- Trigonometric Levelling
- Barometric Levelling
- Hypersometric Levelling

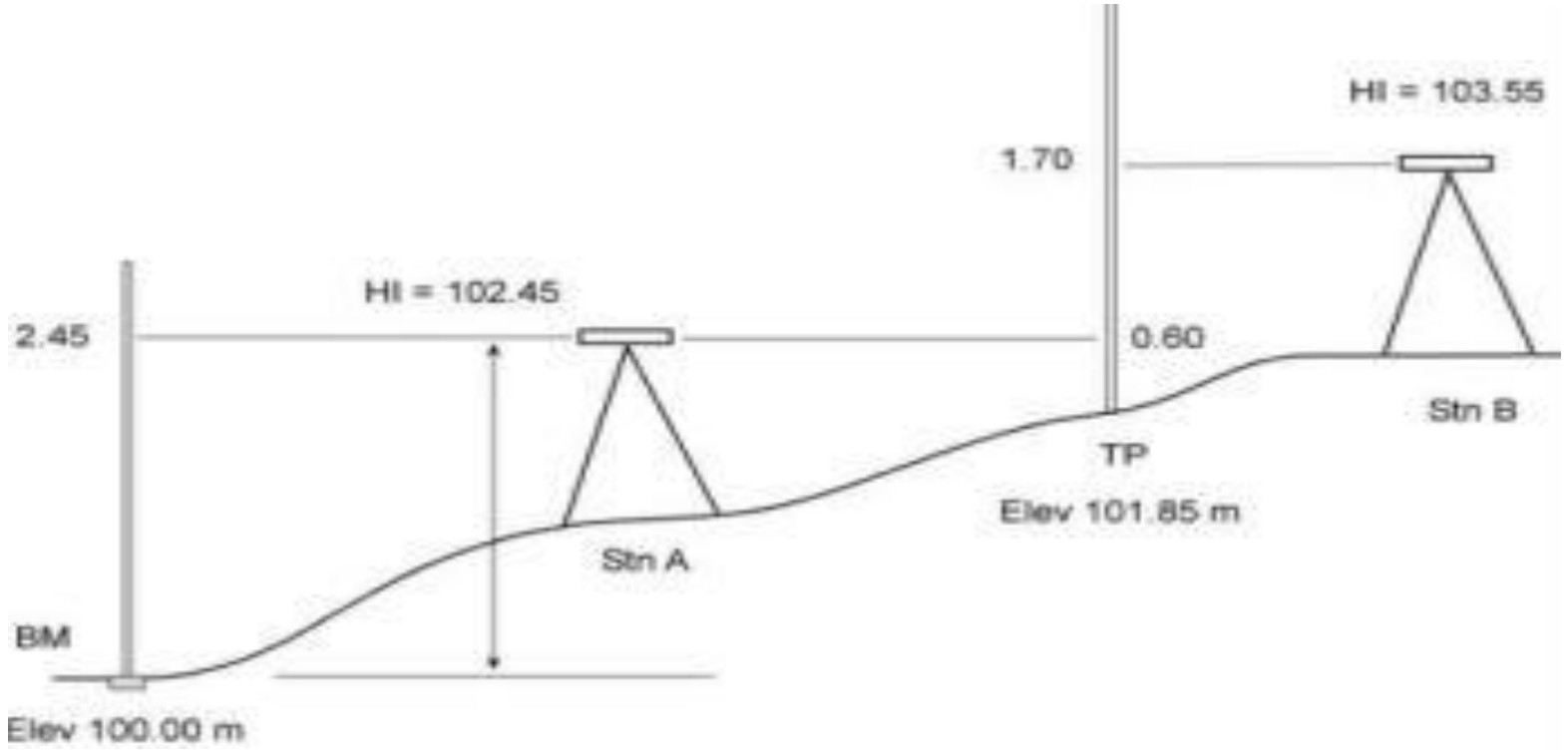
Simple Levelling

- It is the simplest method used, when it is required to find the difference in elevation between 2 points.



Differential Levelling

- This method is used to find the difference in the elevation between points if they are too far apart or the difference in elevation between them is too much.



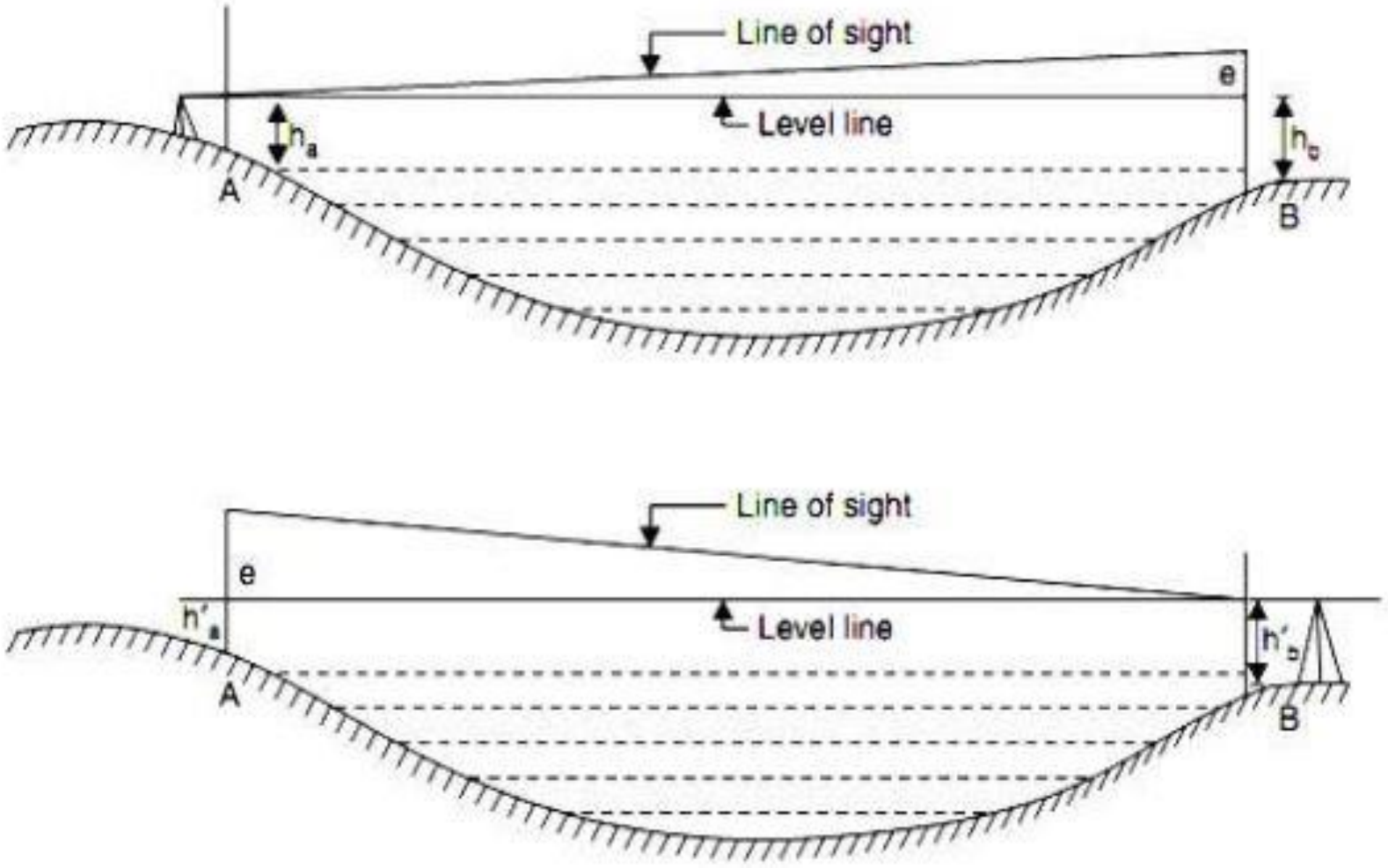
Reciprocal levelling

- This method is adopted to accurately determine the difference of level between two points which are far apart. It is also used when it is not possible to setup level in midway between two points.

Procedure:

- Let A and B be the two points on opposite banks of a river. It is required to find out the level difference between A&B.
- Setup the level very near to A and take the reading at A and B let the reading be a1 and b1
- Shift the level and setup very near to B and observe A and B to get reading a2 and b2
- Let d is the true difference of level between A and B, and e=error due to curvature, refraction and imperfect adjustment.

Reciprocal levelling



Reciprocal Levelling

- Thus to eliminate the error take an average of the difference in elevation taken from 2 points

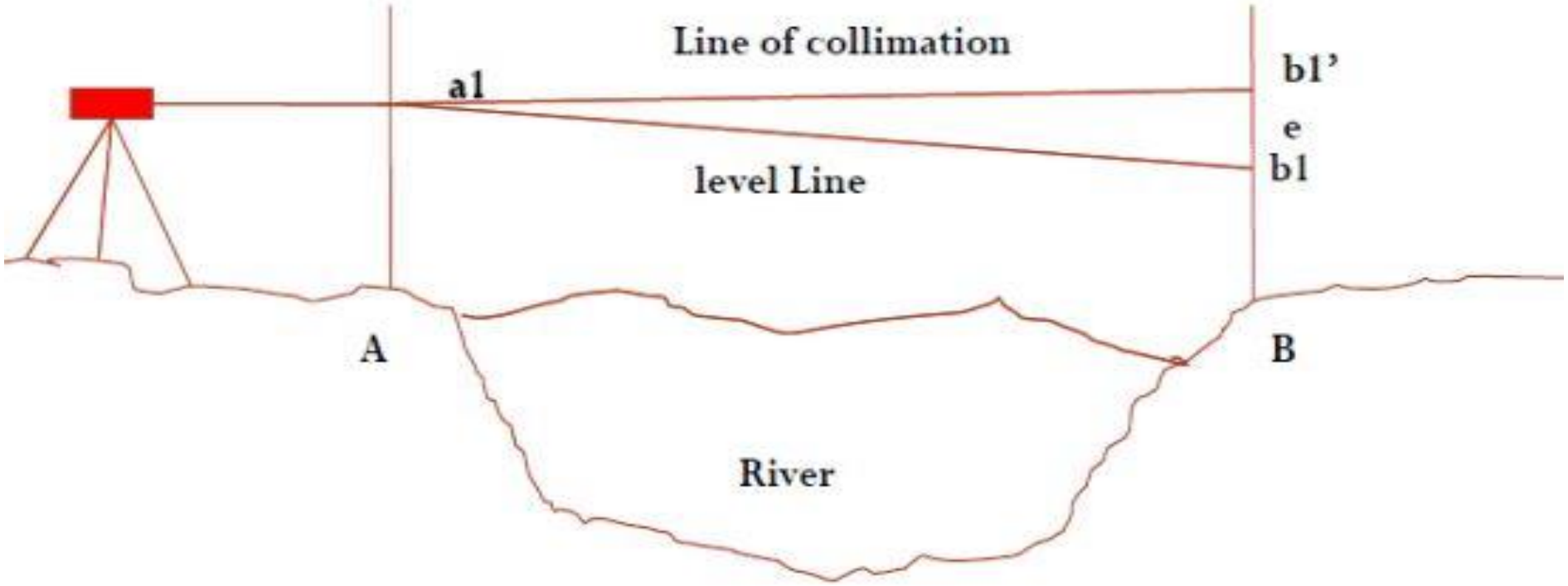
  From A the true difference will be =(b1-e)-a1 **Or d= (b 1- a1)-e**

  From B the difference will be = b 2-(a2-e) **Or d= (b2-a2)+ e**

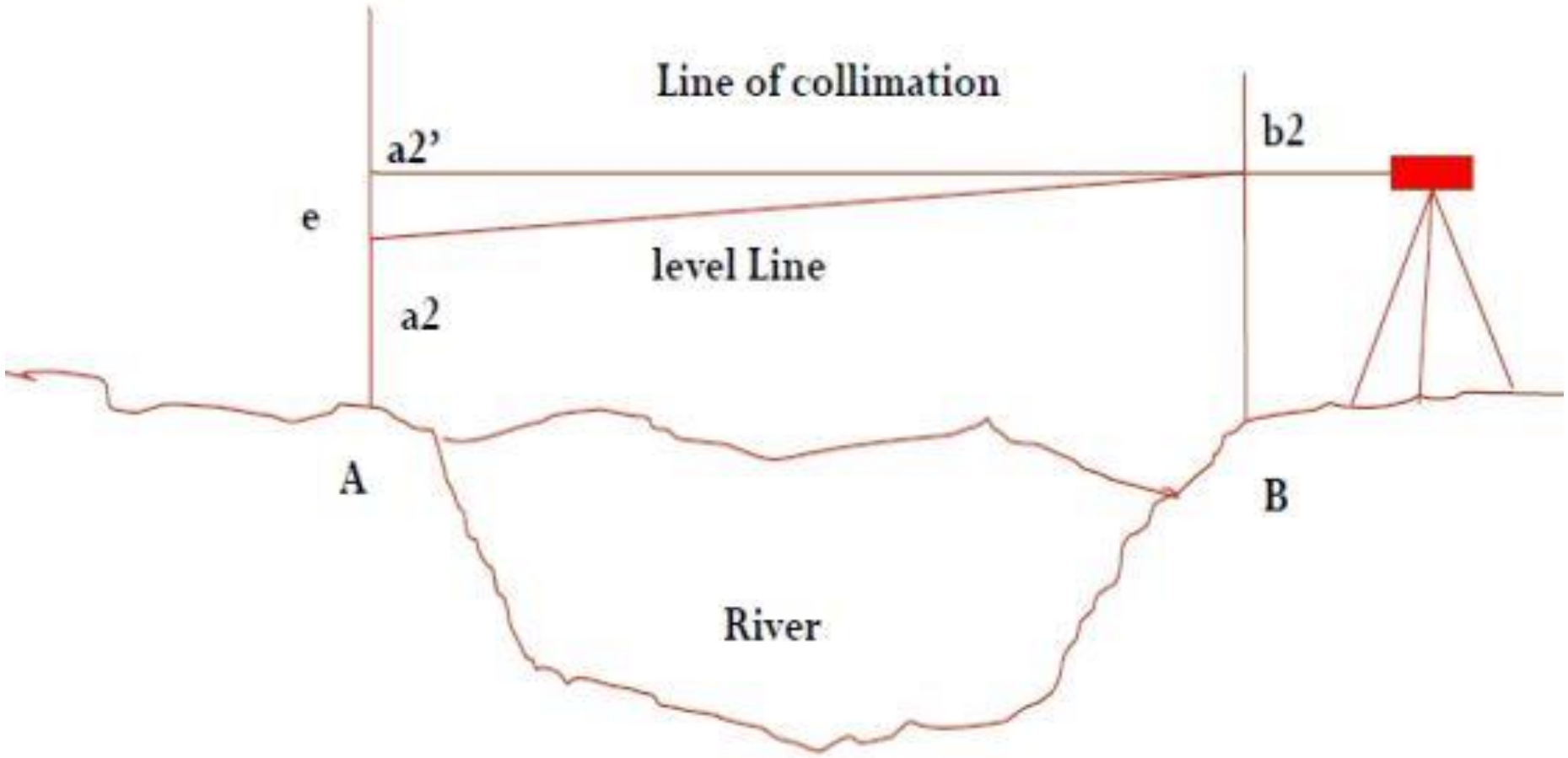
  Adding these two equation to eliminate e, we get

- Therefore **d={(b1-a1)+ (b2-a2)}/2**

Reciprocal Levelling



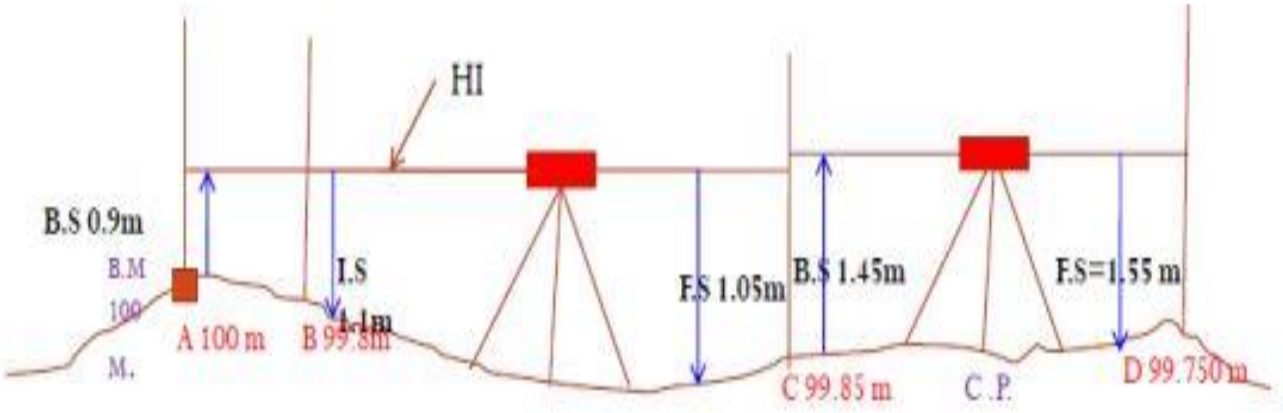
Reciprocal Levelling



Methods of Reducing Levels

- **Height of Instrument Method**

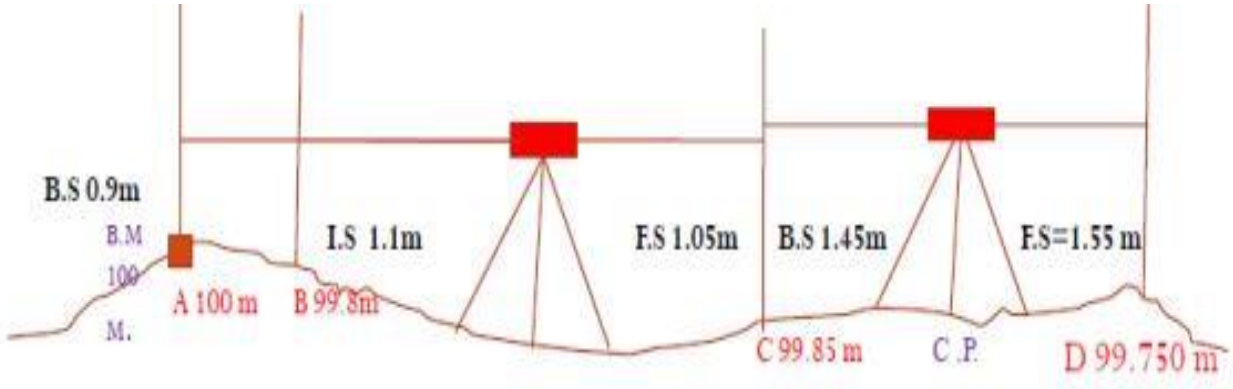
✓ This method consist of finding H.I. for every setup of instrument, and then obtaining the R.L. of point of reference with respect to H.I



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	

Methods of Reducing Levels

- **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	

Errors in Levelling

➢ The following are the different sources of Errors

❑ **Personal Error**

- The Instruments may not be levelled
- The focusing of eye piece and objective glass may not be perfect
- The parallax may not be eliminated
- The position of staff may have changed
- Entry and recording in the field book may not be correct
- The staff may not be fully extended, may not be held vertical.

Errors in Levelling

- **Instrumental Error**

  • The Permanent adjustment of the instrument may not be perfect. That is the line of collimation may not be horizontal line.

  • The internal arrangement of focusing tube may not be correct

  • The graduation of the staff may not be perfect

  • Defective bubble tube, if the bubble tube is sluggish, it may apparently be in the mid-position even though the bubble line is not horizontal.

Errors in Levelling

- **Errors due to Natural Causes**
  - The Curvature of the Earth may affect the staff readings when the distance of sight is long.
  - The effect of refraction may cause a wrong staff reading
  - There are some errors in staff readings due to high velocity wind

Common errors in Leveling

- Foresight and back sight not being taken on exactly the same point
- Reading the staff upward instead of downward
- Reading of stadia hair
- Reading of wrong number of metre and decimeter
- Entering backsight in F.S and vice versa
- Transposing the figures
- Omitting an entry
- The leveling staff not being fully extended.

Practical Problems

Problem-01:

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**.

Rise and Fall Method

Solution:

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		6.916				

CHECK : Σ B.S-Σ F.S= 5.964-6.916= -0.952 = LAST R.L-FIRST R.L= 431.432-432.384=-0.952 ΣRISE-Σ FALL= 2.842-3.794=-0.952

Problem 2: A man at a position 10m above sea level observes the peak of a hill. The distance between the man and the hill 80 km, find the height of the hill.

Solution:

From the relation

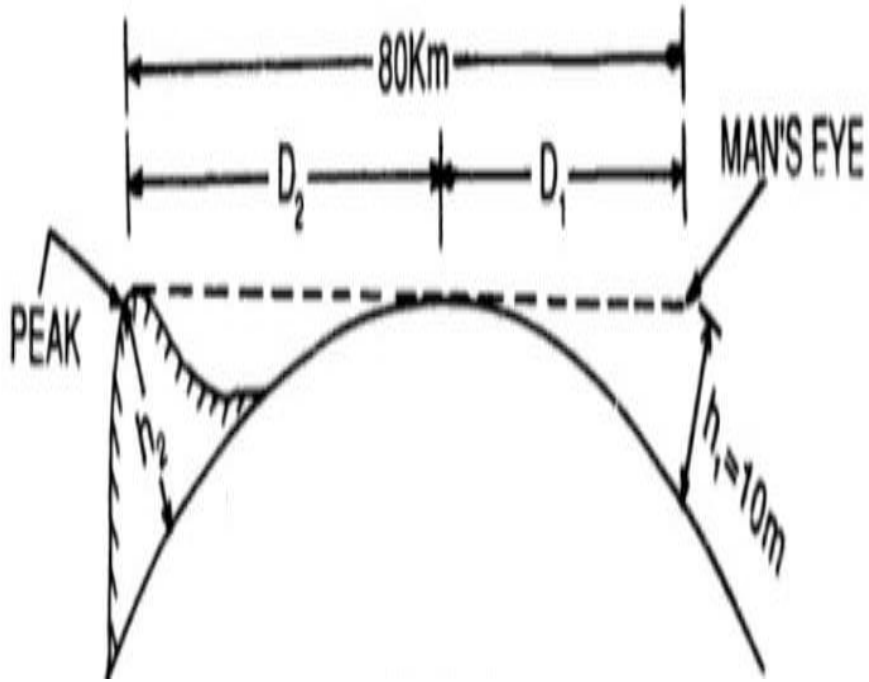
So $h_1 = 0.0673\ D_1^2$ Here, $D_1 + D_2 = 80$ km

$D_1 = \sqrt{\frac{100}{0.0673}} = 12.19$ Km $h_1 = 10$m , height of man's eye

And $D_2 = 80\text{-}12.19 = 67.81$ km =height of the hill

$h_2 = 0.0673 * D_1^2 = 0.0673 * (67.81)^2$

Here the height of the hill is 309.46 m



Problem 3: The line of sight from two stations A and B just grazes the sea level. If the height of A and B above sea level are 100 and 150 m respectively, find the distance AB (diameter of earth 12,880 km).

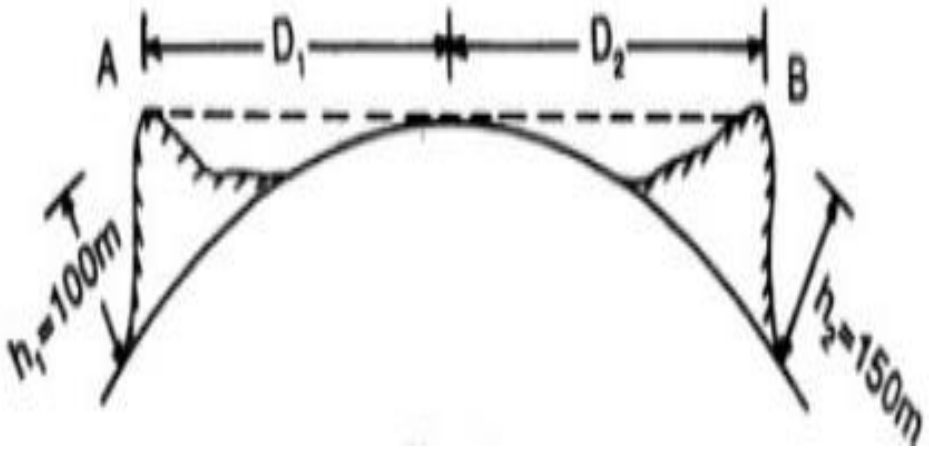
Solution:

we that combined correction

$$= \frac{6}{7} * \frac{1{,}000D^2}{2R}$$

$$= \frac{6}{7} * \frac{1{,}000D^2}{12{,}880}$$ (R= radius of the earth)

$$= 0.0665\ D^2$$ (2R = diameter= 12,880km)



Surveying and levelling

So $h_1 = 0.0665\ D_1^2$

$$D_1 = \sqrt{\frac{h_1}{0.0665}} = \sqrt{\frac{100}{0.0665}} = 38.78 \text{ Km} \quad (h_1 = 100\text{m})$$

And $h_2 = 0.0665\, D_1^2$

$$D_2 = \sqrt{\frac{150}{0.0665}} = 47.49\text{km}$$

$(h_2 = 150\, m)$

Distance AB = D_1 +D_2 = 38.78 + 47.49 = 86.27 km


Thank you!