

(a) Graphical or Bessel's Method.

(b) Mechanical Method.

(c) Trial & Error Method.

Class - 19

LEVELLING :-

The art of determining the relative height of different points on or below the surface of earth is known as levelling.

→ Levelling deals with measurements in the vertical plane.

Level surface :-

Any surface parallel to the mean spheroidal surface of earth is said to be level surface.

Level line :-

Any line laying on the level surface is called level line.

Horizontal plane :-

Any plane tangential to the level surface at any point is known as ~~horizontal~~ Horizontal plane.

Vertical line :- The direction indicated by a plumb line (the direction of gravity) is called vertical line.

Vertical plane :- Any plane passing through vertical line is called ~~vertical~~ as vertical plane.

Datum surface or datum line :- (Mean sea level)

This is an imaginary level surface (MSL) or level line from which the vertical distances of different points (above or below this line) are measured.

→ Initially datum surface is adopted mean sea level (MSL) at Karachi (Before Independence)

→ But present Arabian sea level - Mumbai

Reduced level :-

The vertical distance of a point above or below the datum line is known as reduced level of that point.

Bench Mark :- (BM)

These are fixed points or marks of known reduced level determined with reference to the datum line.

⇒ 4 type of BM

① L.T.S (Least Trigonometrical Survey)

② permanent BM

③ Temporary BM.

④ Arbitrary BM

L.T.S BM :- (Least trigonometric survey).

These BMs are established by survey of India department at large intervals all over the country.

→ The values of RLs, relative positions & the numbers of BMs are given in a catalogue published by this department.

Permanent BM :-

These are fixed points established by different Govt. department like PWD, Railway, Irrigation etc. → RLs of these points are determined with reference to the LHS BM.

Temporary BM :-

When the BM are established temporarily at the end of day's work.

Arbitrary BM :-

When RLs of some fixed points are assumed they are termed as Arbitrary BM.

→ These are adopted in small survey operations when any undulation of the ground surface is required to be determined.

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Backsight Reading (BS) :-

1st staff reading taken in any set up of the instrument.

Fore sight Reading (FS) :-

Last staff reading in any set up at the instrument.

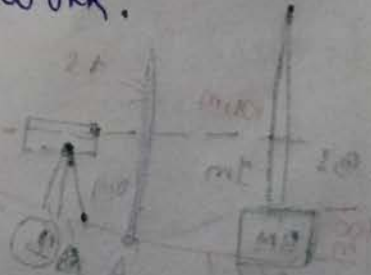
Levelling operation :-

1. Levelling Instrument :-

- Dumpy level.
- Auto Level.
- Theodolite - Manually
- Total station ← advance version of theodolite. Digitally work.

2. Tripod Stand

3. Levelling staff



Intermediate sight Reading (IS) :-

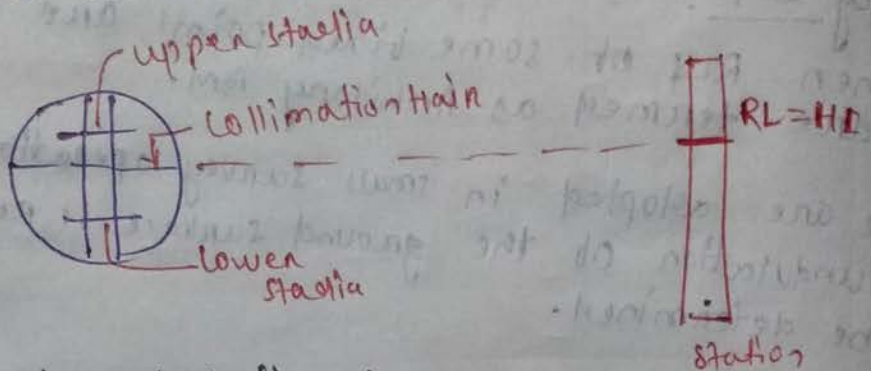
Any other staff reading between BS & FS in same setup of instrument.

change point (CP) :-

The point indicates the shifting of the Instrument.

Height of Instrument :- (HI)

The RL of line of collimation is known as HI.



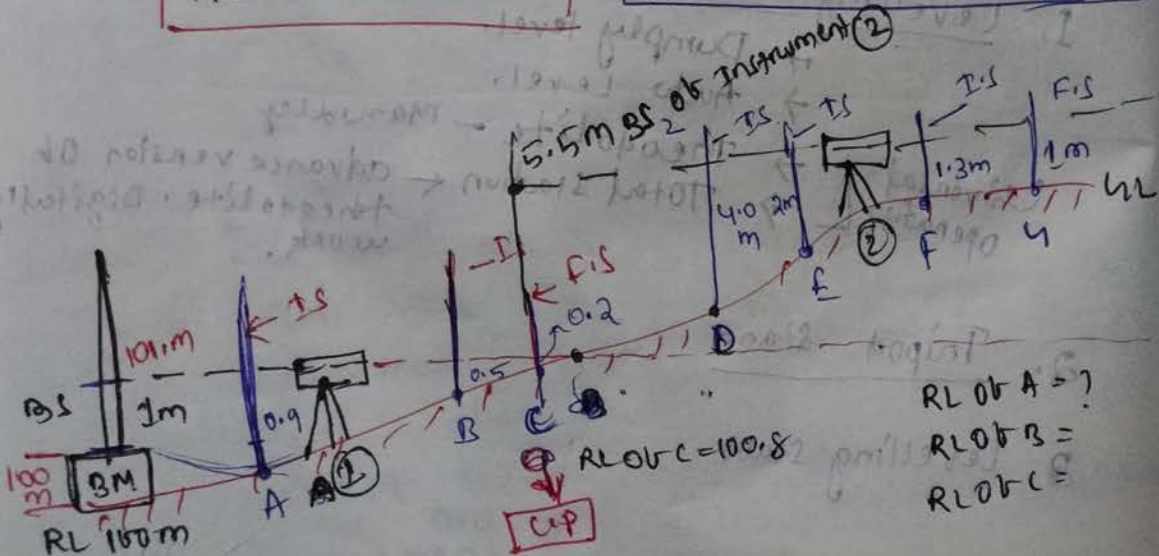
Methods of calculation of Reduced Level :-

- ① The collimation system or HI method.
- ② Rise and Fall system.

Collimation system or HI method :-

$$HI = BM\ RL + BS$$

$$HI = RL\ of\ collimation\ line$$



HI₁ = RL of collimation line = BM + BS

RL of 'A' = HI - BS = 100 + 1.0m = 101m = HI
= 101 - 0.9 = 100.1m

RL of 'B' = 101 - 0.5 = 100.5m

RL of 'C' = ~~100.5~~ 101 - 0.2 = 100.8m

HI₂ = RL of C + BS₂ = 100.8 + 5.5 = 106.3m

RL of 'D' = HI₂ - BS = 106.3 - 0.4 = 102.3m

RL of 'E' = 102.3 - 2.0m = 100.3m

RL of 'F' = 100.3 - 1.3 = 99.0m

RL of 'G' = 99.0 - 1m = 98.0m

29.01.24

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Method of calculation of Reduced level or Height of

- 1) The collimation system or Instrument system.
- 2) Rise & fall method.

Collimation system or HI instrument system:

Arithmetic check :- $\sum BS - \sum FS = \text{Last RL} - \text{1st RL}$

Rise & Fall method

$\sum BS - \sum FS = \sum \text{Rise} - \sum \text{Fall} = \text{Last RL} - \text{1st RL}$

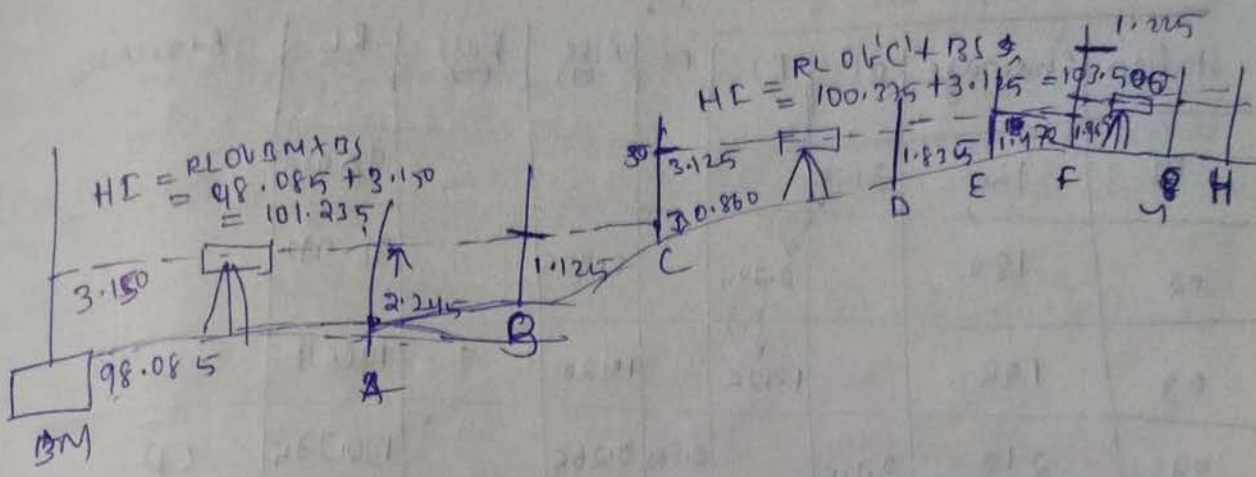
The following consecutive readings were taken with a dumpy level along a chain line at a common interval of 15m. The first reading was at a height of 165m where the RL is 98.085m. The instrument was shifted after the sixth and ninth readings.

3.150, 2.245, 1.125, 0.860, 3.125, 2.760, 1.835, 1.470, 1.965, 1.225, 2.390 & 3.035m.

Find the RL of all points?

Station point	Chainage	BS	IS	FS	HT R.O.V. HI RLOV BM+BS	RL	Remarks
01	165	3.150			101.235	98.085	1st RL
02	180		2.245		100.28	98.95	101.235 - 2
03	195		1.125			100.11	
04	210	3.125		0.860	103.50	100.275	CP
05	225		2.760			100.740	
06	240		1.835			101.665	
07	255		1.470			102.030	
08	270	1.225		1.965	102.76	101.353	CP
09	285		2.390			100.370	
10	300			3.035		99.725	Last RL
		$\Sigma BS = 7.5$		$\Sigma FS = 5.86$			

Arithmetic check = $\Sigma BS - \Sigma FS = \text{Last RL} - 1^{\text{st}} \text{RL}$
 $= 7.5 - 5.86 = 99.725 - 98.085$
 $\Rightarrow 1.64 = 1.64$ proved.



$HI_3 = RLOV F + BS$
 $= 101.553 + 1.225$
 $= 101.353 + 1.225$

class-18

2.375, 1.730, 0.615, 3.450
 Find the RL of change point 60m when the survey started from the chainage 0m at 20m intervals

Station	Chainage	BS	IS	FS	RL	Remarks
01	0	2.375			62.375	60
02	20		1.730		60.645	
03	40		0.615	3.450	61.780	
04	60			3.450	58.925	

Arithmetic check = $\sum BS - \sum FS = \text{Last RL} - \text{1st RL}$
 $= 2.375 - 3.450 = 58.92 - 60$
 $= -1.075 = -1.075 \text{ Am}$

Rise and Fall method :-

Station	Chainage	BS	IS	FS	Rise (+)	Fall (-)	RL	Remark
01	165	3.150					98.085	
02	180		2.245		0.905		98.990	
03	195		1.125		1.120		100.11	
04	210	3.125		0.860	0.265		100.375	CP
05	225		2.760		0.365		100.74	
06	240		1.835		0.925		101.665	
07	255		1.470		0.365		102.03	
08	270	1.225		1.965	0.495		101.535	CP
09	285		2.390		1.165		100.37	
10	300		3.035		0.645		99.725	
		7.5	5.86	3.945	2.305			

Arithmetical check = $\sum BS - \sum FS = 7.5 - 5.86 = 1.64$
 $= \sum Rise - \sum Fall = 3.945 - 2.30 = 1.64$
 $= Last RL - 1st RL = 99.725 - 98.085 = 1.64$

Survey - 19

Dumpy Level :-

Temporary adjustment or level :-

1. Selection of suitable position.
2. Fixing the level with tripod stand.
3. Approximate levelling by legs or foot screws.
[bubble is approximately in the central area]
4. perfect levelling by foot screws → bubble exactly at in central position.
5. Focussing the Eye - piece.
6. Focussing the object - glass.
7. Taking the staff Reading.

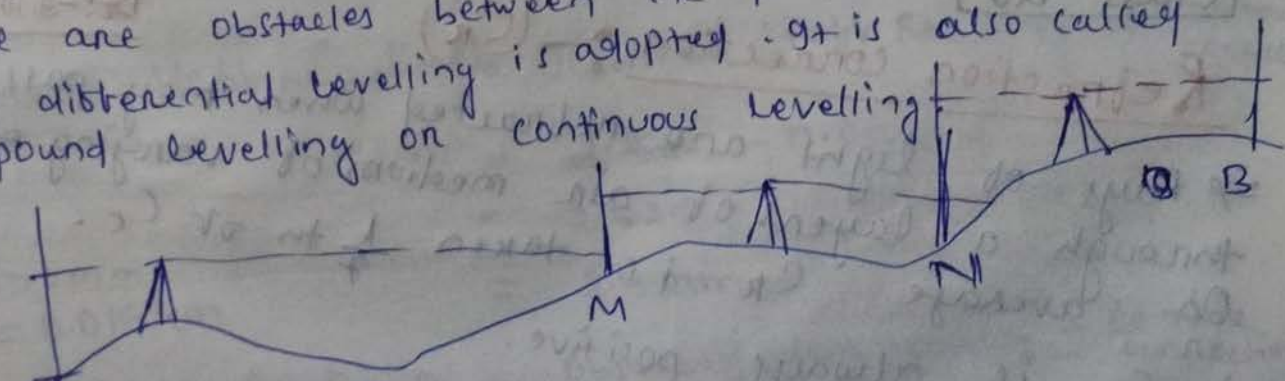
Simple levelling :-

When the difference or level between two points is determined by setting the levelling instrument midway between the points, the process is called Simple levelling.

⇒ Two stations are in small distance & visible.

ⓐ Differential levelling :-

- When the points are a great distance apart.
- Difference of elevation between the point is large.
- There are obstacles between the points.
- So, differential levelling is adopted. It is also called compound levelling or continuous levelling.



$$C_n = C_c \times \frac{1}{2}$$

$$= \frac{0.0785}{2} = 0.0112 D^2$$

$$C_n = +0.0112 D^2$$

combine correction (C) :-

$$\text{combined correction} = C_c + C_n$$

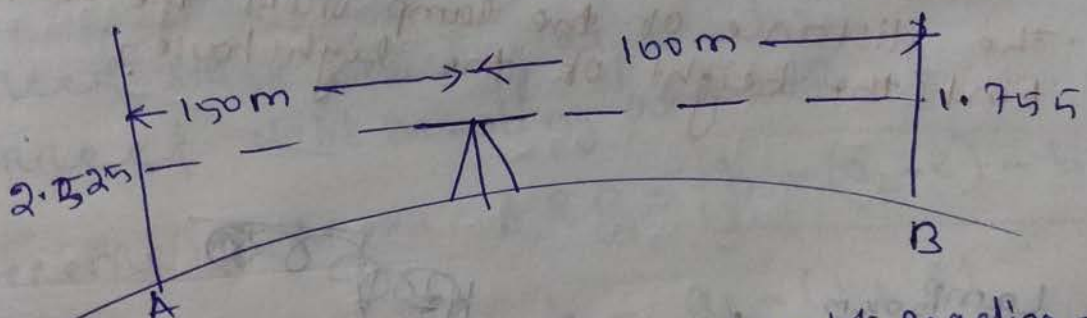
$$= -0.0785 D^2 + 0.0112 D^2$$

$$C = -0.0673 D^2 \text{ in m}$$

⇒ Combine correction is always negative.

D = Horizontal distance in km.

Ex:- A level is set up at a point 150m from A & 100m from B. The observed staff readings at A & B are 2.525 and 1.755 respectively. Find the true difference of level between A & B?



Fall from B to A

Observed staff Reading = 2.525

$$\text{True staff reading 'A'} = \text{Observed staff Reading} - \text{comb. corr.}$$

$$= 2.525 - 0.0673 D^2$$

$$= 2.525 - 0.0673 \times (0.015)^2$$

$$= 2.523 \text{ m}$$

$$D = 150 \text{ m}$$

$$= 0.015 \text{ km}$$

$$\text{True staff reading 'B'} = \text{Observed staff reading} - \text{combine correct}$$

$$= 1.755 - 0.0673 \times (0.1)^2$$

Instrument at	Staff Reading		Remarks
	A	B	
A	1.155	2.595	RL of A = 100m
B	0.985	2.415	

Find the true difference of level between A & B

Find true RL of B?

Soln fall B to A

$$h = \frac{(b_1 - a_1) + (b_2 - a_2)}{2} = \frac{(2.595 - 1.155) + (2.415 - 0.985)}{2}$$

$$= \frac{1.340 + 1.530}{2} = \frac{2.870}{2} = 1.435 \text{ m}$$

$$\text{RL of B} = \text{RL of A} - h$$

$$= 100 - 1.435$$

$$= 98.565 \text{ m}$$

Sensitiveness of bubble tube:-

Instrument at	Staff Reading		Remarks
	A	B	
A	3.204	2.125	RL of B = 210m
B	3.153	1.986	

And the true difference of level set up
Find the RL of A.

solⁿ
Fall from (A to B)

$$h = \frac{(a_1 - b_1) + (a_2 - b_2)}{2}$$

$$= \frac{(3.264 - 2.125) + (3.135 - 1.986)}{2}$$

$$= \frac{1.139 + 1.149}{2} = \frac{2.288}{2} = 1.144 \text{ m}$$

3.135
1.986

1.149

3.264
2.125

1.139

RL of A = RL of B - h

$$= 210 - 1.144 = 208.856 \text{ m}$$

210.00
1.144

208.856

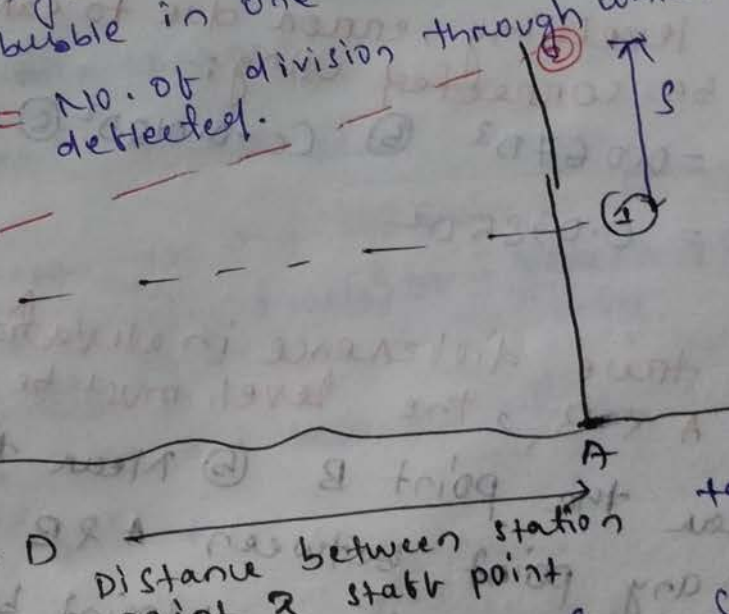
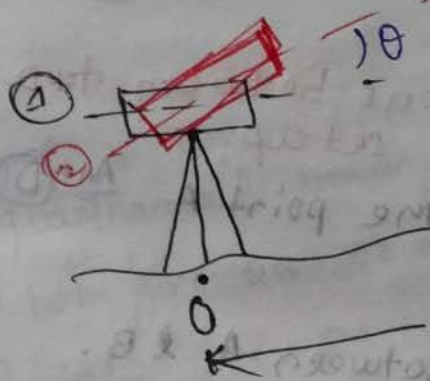
Sensitivity of bubble tube :- Dumpy level
Bubble is at centre
Cross bubble longitudinal bubble

∴ If bubble is perfect level → Bubble is at centre

∴ 'α' symbol

$$\alpha = \frac{\theta}{n}$$

α = Angle of Rotation required to move the bubble in one direction division.
n = No. of division through which bubble is detected.



$$\tan \theta = \frac{S}{D}$$

Distance between station point & staff point

$$\alpha = \frac{\theta}{n} = \frac{S}{Dn} = \frac{S}{Dn} \text{ radian}$$

$$\alpha = \frac{S}{Dn} \text{ Radian}$$

1 radian = 206265 sec

$$\alpha = \frac{S}{Dn} \times 206265''$$

$$RO = dn$$

$$\theta = \frac{nd}{R}$$

$$\alpha = \frac{\theta}{n} = \frac{nd}{Rn} = \frac{d}{R}$$

$$\alpha = \frac{d}{R} \text{ Radian}$$



R = Radius of curvature of bubble tube
d = length of one division.

$$\alpha = \frac{d}{R} \text{ } 206265'' \text{ sec}^{-1}$$

Radius of curvature of bubble tube

$$R = \frac{nd \times d}{\theta}$$

Class-22

Dt: - 31/02/23

- ① In levelling, error due to earth's curvature is to be corrected using:-
- (a) $C_c = 0.067D^2$ (b) $C_c = 0.012D^2$ (c) $C_c = 0.0136D^2$ (d) $C_c = 0.0785D^2$
- Ans: (d)
- ② For true difference in elevations between two point A & B, the level must be setup.
- (a) Near the point B (b) Near the point A (c) At any point between A & B (d) Exactly at the midpoint between A & B.
- Ans: (d)
- ③ The slope correction for a length of 30m along a gradient of 1 in 20 is
- (a) 0.375 cm (b) 37.5 cm (c) 3.75 cm (d) 1.75 cm