Q1/

## HI method of RL calculation

| Stn | Reading | | | HI | RL | Remarks |
|---|---|---|---|---|---|---|
| | BS | IS | FS | | | |
| TBM | 1.265 | | | 101.265 | 100.000 | TBM no 1 on parapet of well near Ch. 1000m |
| P1 | | 1.390 | | | 99.875 | |
| P2 | | 0.850 | | | 100.415 | |
| P3 | | 2.255 | | | 99.010 | |
| P4 | | 1.640 | | | 99.625 | |
| CP1 | 1.220 | | 1.350 | 101.135 | 99.915 | Change point on found. Of El pole |
| | | 1.350 | | | 99.785 | |
| | | 1.275 | | | 99.860 | |
| | | | 1.135 | | 100.000 | Closed on same TBM1 |

## Rise -Fall method of RL calculation

| Stn | Reading | | | Rise | Fall | RL | Remarks |
|---|---|---|---|---|---|---|---|
| | BS | IS | FS | | | | |
| TBM | 1.265 | | | | | 100.000 | TBM no 1 …. |
| P1 | | 1.390 | | | 0.125 | 99.875 | |
| P2 | | 0.850 | | 0.540 | | 100.415 | |
| P3 | | 2.255 | | | 1.405 | 99.010 | |
| P4 | | 1.640 | | 0.615 | | 99.625 | |
| CP1 | 1.220 | | 1.350 | 0.290 | | 99.915 | Change point …. |
| | | 1.350 | | | 0.130 | 99.785 | |
| | | 1.275 | | 0.075 | | 99.860 | |
| | | | 1.135 | 0.140 | | 100.000 | Closed on same TBM1 |

+

Q2/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. Calculate the RL of all points and apply usual checks. (I) Apply HI method (II) Apply RF method

## H.I. Method

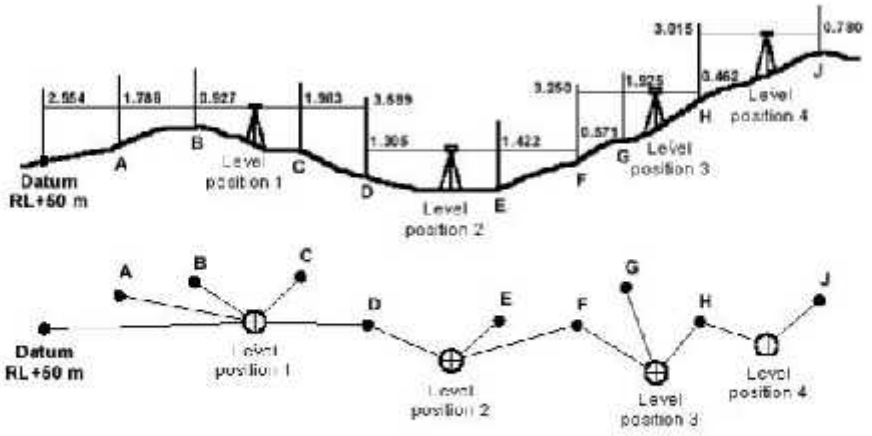
| Station | B.S | I.S | F.S | HI | RL | REMARKS |
|---|---|---|---|---|---|---|
| 1 | 2.228 | | | 434.612 | 432.384 M | B.M. |
| 2 | | 1.606 | | | 433.006 | |
| 3 | 2.090 | | 0.988 | 435.714 | 433.624 | 3RD C.P. |
| 4 | | 2.864 | | | 432.850 | |
| 5 | 0.602 | | 1.262 | 435.054 | 434.452 | 6TH C.P |
|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

CHECK $\sum$ B.S- $\sum$ F.S = 5.961-6.916 = -0.952 LAST R.L- FIRST R.L = 431.432-432.384 = -0.952

## 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 | | 6.916 | | | | |

CHECK $\sum$ B.S- $\sum$ F.S= 5.961-6.916= -0.952 =
LAST R.L- FIRST R.L= 431.432-432.384=-0.952
$\sum$RISE- $\sum$ FALL= 2.842-3.794=-0.952




Q3/

**Table 1 Rise & Fall Method**

| Back-sight | Inter-mediate | Fore-sight | Rise | Fall | Reduced level | Distance | Remarks |
|---|---|---|---|---|---|---|---|
| 2.554 | | | | | 50.00 | 0 | Datum RL+50 m |
| | 1.788 | | 0.771 | | 50.771 | 14.990 | **A** |
| | 0.926 | | 0.857 | | 51.628 | 29.105 | **B** |
| | 1.963 | | | 1.037 | 50.591 | 48.490 | **C** |
| 1.305 | | 3.587 | | 1.624 | 48.967 | 63.540 | **D** / change point **1** |
| | 1.132 | | | 0.127 | 48.840 | 87.665 | **E** |
| 3.250 | | 0.573 | 0.859 | | 49.699 | 102.050 | **F** / change point **2** |
| | 1.925 | | 1.325 | | 51.024 | 113.285 | **G** |
| 3.015 | | 0.496 | 1.429 | | 52.453 | 128.345 | **H** / change point **3** |
| | | 0.780 | 2.235 | | 54.688 | 150.460 | **J** |
| **10.124** | | **5.436** | **7.476** | **2.788** | **54.688** | | Sum of B-sight & F-sight, Sum of Rise & Fall |
| -5.436 | | | -2.788 | | -50.000 | | Take smaller from greater |
| **4.688** | | | **4.688** | | **4.688** | | Difference should be equal |

**Table 2 Height of collimation method** (height of instrument)

| Back-sight | Inter-mediate | Fore-sight | Height of collimation | Reduced level | Distance | Remarks |
|---|---|---|---|---|---|---|
| 2.554 | | | 52.554 | 50.00 | 0 | **Datum RL+50 m** |
| | 1.783 | | | 50.771 | 14.990 | **A** |
| | 0.926 | | | 51.628 | 29.105 | **B** |
| | 1.963 | | | 50591 | 48.490 | **C** |
| 1.305 | | 3.587 | 50.272 | 48.967 | 63.540 | **D** / change point 1 |
| | 1.432 | | | 48.840 | 87.665 | **E** |
| 3.250 | | 0.573 | 52.949 | 49.699 | 102.050 | **F** / change point 2 |
| | 1.925 | | | 51.024 | 113.285 | **G** |
| 3.015 | | 0.496 | 55.168 | 52.153 | 128.345 | **H** / change point 3 |
| | | 0.780 | | 54.688 | 150.160 | **J** |
| **10.124** | | **5.436** | | **54.688** | | Sum of B-sight & F-sight, Difference between RL's |
| -5.436 | | | | -50.000 | | Take smaller from greater |
| **4.688** | | | | **4.688** | | Difference should be equal |

**Q4/ Define the following : Back shot, Turning Point, Intermediate Shot, Closure Error, Balancing Shot, HPC, Rise and Fall Method.**

- **Backshot (BS)** · A sighting with a level back to a point of known elevation
- **Foreshot (FS)** · A sighting with a level to determine the elevation of a point
- **Turning Point** · A point at which you have established an elevation with FS and on which you will subsequently take a BS
- **Intermediate Shot** · A foreshot to a point at which you want to know the elevation but which will not be used as a turning point

- **Balancing shots** · Attempt when doing a levelling survey to keep the lengths of FS and BS at any given instrument setup as close as possible.
- **Closure Error** · Difference in elevation determined from the levelling survey and the known elevation of a benchmark.

## HPC Method

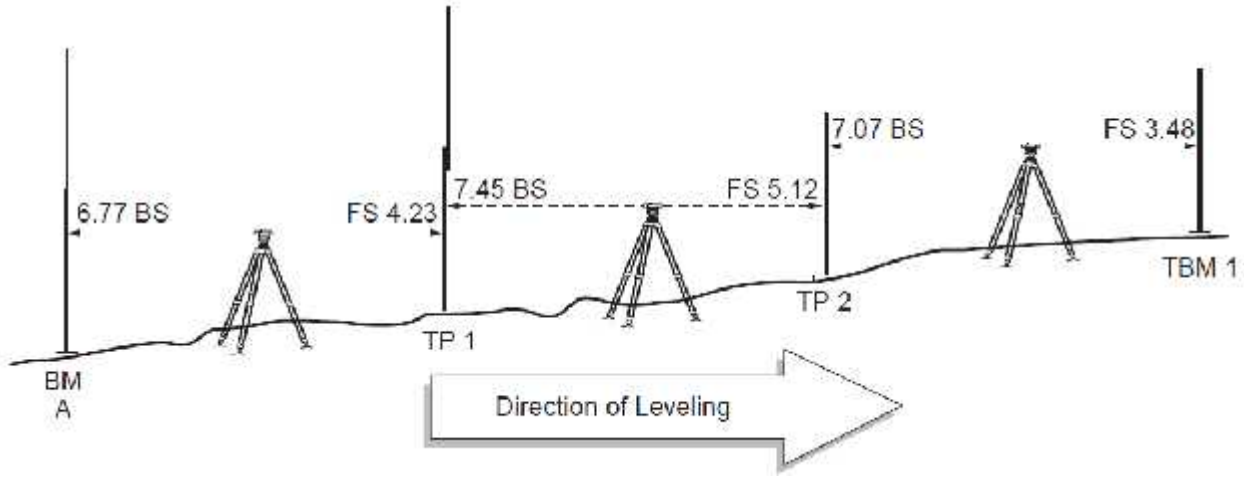
### Height of the Plane of Collimation Method

- It consists in finding the elevation of the plane of collimation for every set up of the instrument and then obtaining the reduced levels (RL) of point with reference to the respective plane of collimation.

# Rise and Fall Method

- It consist in determining the difference of level between consecutive points by comparing each point after the first with that immediately preceding it.
- The difference between their staff reading indicates a rise or a fall according as the staff reading at the point is smaller or greater than that preceding point.

**Q5/ Use the data in the following figure, Calculate the RL of the point using HI method. RL for BM= 100 m.**




| Station | Reading | | RL | HI |
|---|---|---|---|---|
| | BS | FS | | |
| A | 6.77 | | 100 | 106.77 |
| | | 4.23 | 102.54 | |
| TP1 | 7.45 | | | 109.99 |
| TP1 | | 5.12 | 104.87 | |
| TP2 | 7.07 | | | 111.94 |
| TP2 | | 3.48 | 108.46 | |

**Q6/ Use the data in the following table, Calculate the RL of the points using Rise and Fall method. Draw the points at the final.**

| Station | Reading | | | RL |
|---|---|---|---|---|
| | BS | IS | FS | |
| A | 0.865 | | | 560.500 |
| B | 1.025 | | 2.105 | |
| C | | 1.580 | | |
| D | 2.230 | | 1.865 | |
| E | 2.355 | | 2.835 | |
| F | | | 1.760 | |

| Station | B.S.(m) | I.S.(m) | F.S.(m) | Rise | Fall | R.L.(m) |
|---|---|---|---|---|---|---|
| A | 0.865 | | | | | 560.500 |
| B | 1.025 | | 2.105 | | 1.240 | 559.260 |
| C | | 1.580 | | | 0.555 | 558.705 |
| D | 2.230 | | 1.865 | | 0.285 | 558.420 |
| E | 2.355 | | 2.835 | | 0.605 | 557.815 |
| F | | | 1.760 | 0.595 | | 558.410 |
| | ∑B.S. = 6.475 | | ∑F.S. = 8.565 | | | |
| | | | 6.475<br>-8.565 | | 2.685<br>-0.595 | 558.410<br>-560.500 |
| ∑B.S. - ∑F.S = | | | -2.090 | Fall | 2.090 | -2.090 |

**Q7/**

Q.1(c)

missing reading = 10 marks

Rise-Fall = 5 marks
H.I = 5 marks

| | Station | Reading BS | Reading IS | Reading FS | Rise | Fall | R.L | H.I |
|---|---|---|---|---|---|---|---|---|
| BM1 | 1 | 2.150 | | | | | 450.000 | 452.150 |
| | 2 | 1.640 | | 1.65 | 0.500 | | 450.500 | 452.140 |
| | 3 | | 2.345 | | | 0.705 | 449.795 | |
| | 4 | 1.425 | | 1.965 | 0.380 | | 450.175 | 451.600 |
| | 5 | 2.050 | | 1.825 | | 0.400 | 449.775 | 451.825 |
| BM2 | 6 | | 0.325 | | 1.725 | | 451.500 | |
| | 7 | 1.690 | | 0.205 | 0.120 | | 451.620 | 453.310 |
| | 8 | 2.865 | | 2.100 | | 0.410 | 451.210 | 454.075 |
| BM3 | 9 | | | 1.825 | 1.040 | | 452.250 | |
| Σ | | 11.82 | | 9.57 | | | | |

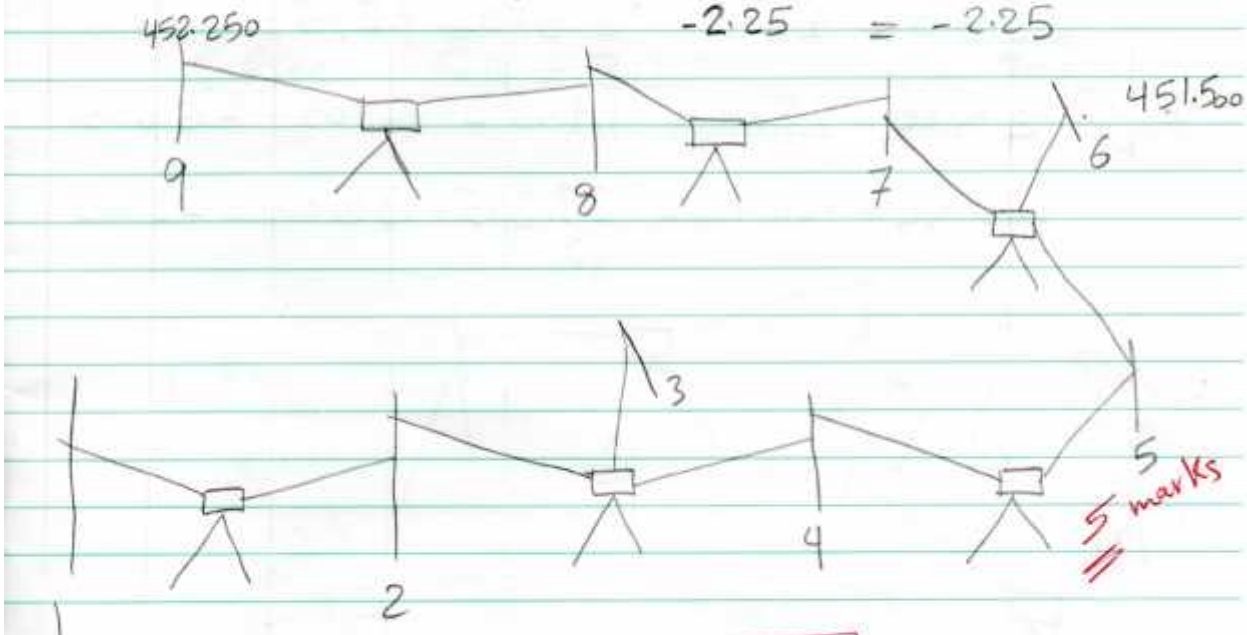
B.S - F.S = + Rise ; RL = Previous RL + Rise

= - Fall ; RL = Previous RL - Fall

5 marks

Calculation checks ⟹ ΣF.S - ΣB.S = 1st RL - Last RL

-2.25 = -2.25




5 marks

30 marks

**Q8/**

Q.2

Table (10 marks)

| Station | B.S | I.S | F.S | Rise | Fall | R.L |
|---|---|---|---|---|---|---|
| A | 0.585 | | | | | 135.000 m |
| 1 | | 1.010 | | | 0.425 | 134.575 |
| 2 | | 1.735 | | | 0.725 | 133.850 |
| 3 | | 3.295 | | | 1.560 | 132.290 |
| B | 0.350 | | 3.775 | | 0.480 | 131.810 |
| 4 | | 1.300 | | | 0.950 | 130.860 |
| 5 | | 1.795 | | | 0.495 | 130.365 |
| 6 | | 2.575 | | | 0.780 | 129.585 |
| 7 | | 3.375 | | | 0.800 | 128.785 |
| C | 1.735 | | 3.895 | | 0.520 | 128.265 |
| 8 | | 0.635 | | 1.1 | | 129.365 |
| 9 | | | 1.605 | | 0.970 | 128.395 |
| Σ | 2.670 | | 9.275 | 1.100 | 7.705 | |

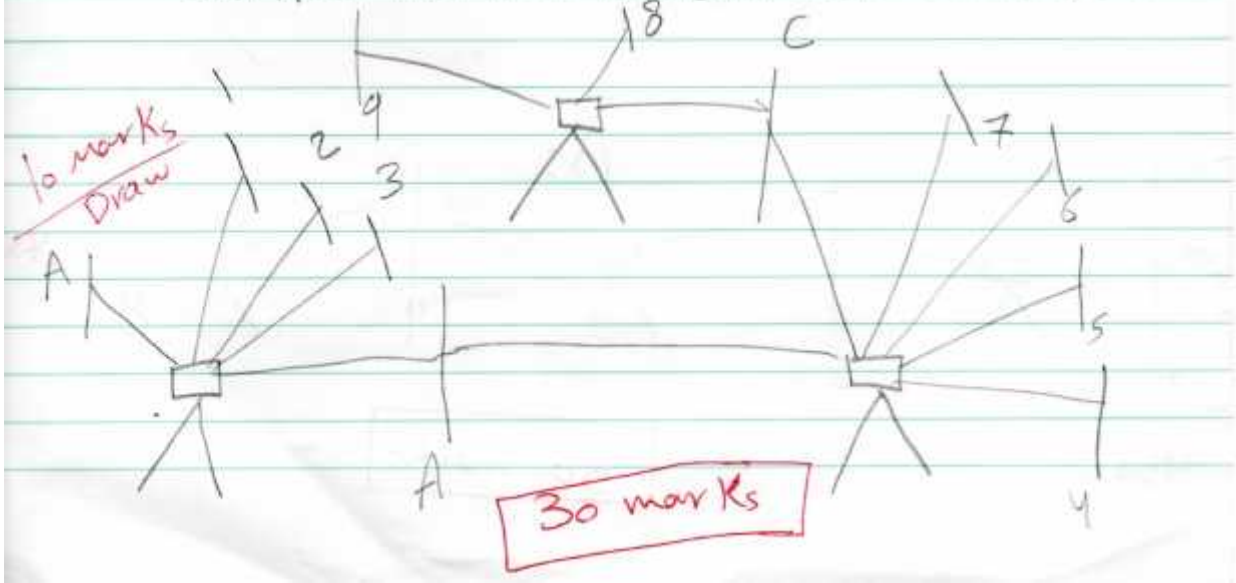
10 marks check

$\Sigma B.S - \Sigma F.S = 2.670 - 9.275 = -6.605$

$\Sigma Rise - \Sigma Fall = 1.100 - 7.705 = -6.605$

$Last\ RL - First\ RL = 128.395 - 135.000 = -6.605$

10 marks Draw




30 marks

**Q9/**

Q.3 — 10 marks — 10 Marks

| Station | B.S | I.S | F.S | H.I | Rise | Fall | R.L |
|---|---|---|---|---|---|---|---|
| 1 | 0.756 | | | 20.756 | | | 20.000 |
| 2 | | 1.321 | | | | 0.565 | 19.435 |
| 3 | | 1.782 | | | | 0.461 | 18.974 |
| 4 | 1.231 | | 1.671 | 20.316 | 0.111 | | 19.085 |
| 5 | | 1.012 | | | 0.219 | | 19.304 |
| 6 | | (-2.045) | | | 3.057 | | 22.361 |
| 7 | 1.125 | | 0.991 | 20.450 | | 3.036 | 19.325 |
| 8 | | 1.321 | | | | 0.196 | 19.129 |
| 9 | | | 1.524 | | | 0.203 | 18.926 |
| Σ | 3.112 | | 4.186 | | 3.387 | 4.461 | |

$\Sigma B.S - \Sigma F.S = 3.112 - 4.186 = -1.074$

10 Marks Check

Last RL - First RL = 18.926 - 20.000 = -1.074

$\Sigma Rise - \Sigma Fall = 3.387 - 4.461 = -1.074$

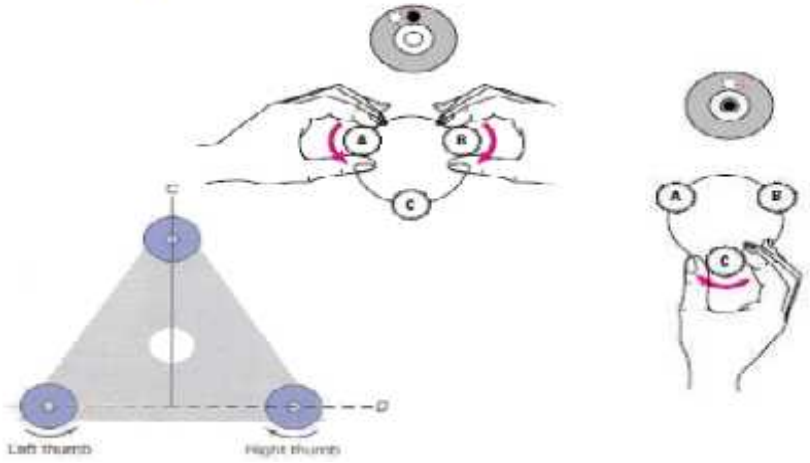
30 Marks

**Q10/ Write a step by step procedure for setting up and leveling instrument. Use surveying equipment that you need. (5 marks)**

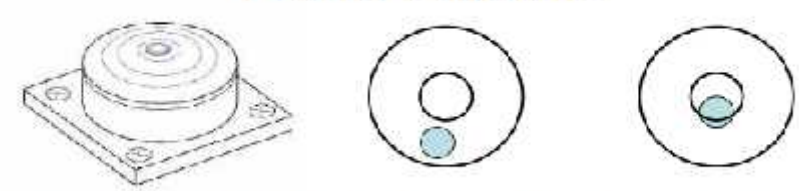
## Carrying and Setting Up a Level

- Always carry it in the container.
- Screw the head snugly on the tripod.
- For bull eye's bubble, alternately turn one screw and then the other two.
- On side-hill setups, place one leg on the uphill side and other two on the down hill side.
- Use hand level to check for proper height of the setup before precisely levelling the instrument. vial

## Carrying and Setting Up a Level



## Pond Bubble



- When pond bubble is centred the instrument's standing axis is approximately vertical.
- The compensators in the instrument take over and adjust the optical Line of Collimation so that it is horizontal.
- When the instrument is rotated the compensators ensure that a horizontal plane of collimation is swept out.

**Q11/ Define the following : Back shot, Turning Point, Intermediate Shot, Closure Error, Balancing Shot, HPC, Rise and Fall Method.**

- **Backshot (BS)** · A sighting with a level back to a point of known elevation
- **Foreshot (FS)** · A sighting with a level to determine the elevation of a point
- **Turning Point** · A point at which you have established an elevation with FS and on which you will subsequently take a BS
- **Intermediate Shot** · A foreshot to a point at which you want to know the elevation but which will not be used as a turning point

- **Balancing shots** · Attempt when doing a levelling survey to keep the lengths of FS and BS at any given instrument setup as close as possible.
- **Closure Error** · Difference in elevation determined from the levelling survey and the known elevation of a benchmark.

## HPC Method

### Height of the Plane of Collimation Method

- It consists in finding the elevation of the plane of collimation for every set up of the instrument and then obtaining the reduced levels (RL) of point with reference to the respective plane of collimation.

# Rise and Fall Method

- It consist in determining the difference of level between consecutive points by comparing each point after the first with that immediately preceding it.
- The difference between their staff reading indicates a rise or a fall according as the staff reading at the point is smaller or greater than that preceding point.

**Q12/ The following is an incomplete page of level book in which X indicates missing Entry .Calculate all the missing entries and complete the page of level book .also give the usual arithmetical checks.**

| Station | Reading | | | Rise | Fall | R.L | Remarks |
|---|---|---|---|---|---|---|---|
| | BS | IS | FS | | | | |
| A | 2.560 | | | | | 100.000 | BM |
| B | | 3.540 | | | X | X | |
| C | | 3.200 | | X | | X | |
| D | | 2.340 | | X | | X | |
| E | 1.950 | | X | 1.08 | | X | CP1 |
| F | | 2.440 | | | X | X | |
| G | | | 3.465 | | X | X | |

| Station | BS | IS | FS | Rise | Fall | RL | Remark |
|---|---|---|---|---|---|---|---|
| A | 2.560 | | | | | 100.000 | BM |
| B | | 3.540 | | | X | X | |
| C | | 3.200 | | X | | X | |
| D | | 2.340 | | X | | X | |
| E | 1.950 | | X | 1.08 | | X | CP1 |
| F | | 2.440 | | | X | X | |
| G | | | 3.465 | | X | X | |

Solution :

Rise and Fall Method

| Station | BS | IS | FS | Rise | Fall | RL | Remark |
|---|---|---|---|---|---|---|---|
| A | 2.560 | - | - | - | - | 100.000 | BM |
| B | - | 3.540 | - | - | 0.98 | 99.020 | |
| C | - | 3.200 | - | 0.34 | | 99.360 | |
| D | - | 2.340 | - | 0.86 | - | 100.220 | |
| E | 1.950 | - | 1.28 | 1.08 | - | 101.300 | CP1 |
| F | - | 2.440 | - | - | 0.49 | 100.810 | |
| G | - | - | 3.465 | - | 1.025 | 99.785 | |

ΣBS = 4.51 ΣFS = 4.725 ΣRise ΣFall

= 2.28 = 2.495

Arithmatic Check :

ΣBS - ΣFS ΣRise - ΣFall Last RL - First RL

= 4.51 - 4.725 = 2.28 - 2.495 = 99.785 - 100.00

**Q13/ The following consecutive readings were taken with a level and a 4m staff at a common interval of 30m; The first reading was taken at B.M. having R.L. =100m.The instrument were shifted after the fourth and ninth readings. Rule out a page of a level book, enter the readings given and also calculate the reduced levels of the points by the collimation method and RF method. Also apply arithmetic checks. Consecutive readings are: 2.650, 1.745, 0.625, 0.260, 2.525, 2.160, 1.235, 0.870, 1.365, 0.625, 1.790, and 2.535. Draw the points at the final.**

| Station | B.S. | I.S. | F.S. | H.I. | R.L. | Remarks |
|---|---|---|---|---|---|---|
| 1 | 2.650 | - | | 102.650 | 100.000 | B.M. |
| 2 | - | 1.745 | - | | 100.905 | |
| 3. | - | 0.625 | - | | 102.025 | |
| 4. | 2.525 | - | 0.260 | 104.915 | 102.39 | C.P. |
| 5. | - | 2.160 | | | 103.060 | |
| 6. | - | 1.235 | - | | 101.345 | |
| 7. | - | 0.870 | - | | 104.045 | |
| 8. | 0.625 | - | 1.365 | 104.175 | 103.550 | C.P. |
| 9. | | 1.790 | 2.535 | | 101.640 | |
| Sum | 5.800 | | 4.160 | | | |
| Check | 1.640 | | | 1.640 | | |

- Arithmetic Check :

ΣB.S. - ΣF.S.

= 5.8 - 4.16

= 1.640

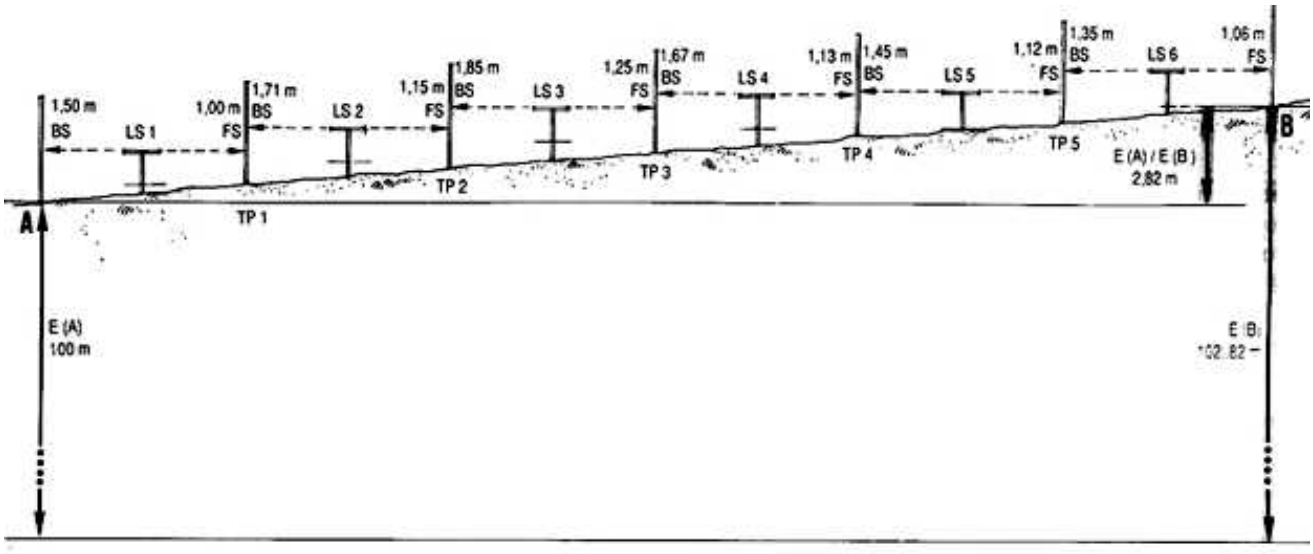
Last R.L. - First R.L.

= 101.640 - 100.000

= 1.640

**Q14/ Use the data in the following figure, Calculate the RL of the point using HI method and RF method. Apply usual checks.**

**(30 marks)**




Example

**Differential levelling with several turning points**

| Points | BS (+) | FS (−) | (BS − FS) + | (BS − FS) − | Elevations (m) | Remarks |
|---|---|---|---|---|---|---|
| A | 1.50 | – | – | – | 100.00 | Assumed elevation |
| TP1 | 1.71 | 1.00 | 0.50 | | 100.50 | Gate to farm |
| TP2 | 1.85 | 1.15 | 0.56 | – | 101.06 | Paths' junction |
| TP3 | 1.67 | 1.25 | 0.60 | – | 101.66 | Corner of maize field |
| TP4 | 1.45 | 1.13 | 0.54 | – | 102.20 | Centre of path |
| TP5 | 1.35 | 1.12 | 0.33 | – | 102.53 | Foot of large tree |
| B | – | 1.06 | 0.29 | – | 102.82 | Rock along path |
| Sums | 9.53 | 6.71 | 2.82 | | | |
| FS(−) | −6.71 | | | | | |
| D(E) | +2.82 | | | | | These two values should be the same |

**Q15/ The following is an incomplete page of level book in which X indicates missing Entry .Calculate all the missing entries and complete the page of level book .also give the usual arithmetical checks. (30 marks)**

| Station | Reading | | | Rise | Fall | R.L | Remarks |
|---|---|---|---|---|---|---|---|
| | BS | IS | FS | | | | |
| A | 3.125 | | | | | | BM |
| B | X | | X | 1.325 | | 125.505 | TP |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **C** | | **2.32** | | | **0.055** | | |
| **D** | | **X** | | | | **125.850** | |
| **E** | **X** | | **2.655** | | | | **TP** |
| **F** | **1.62** | | **3.205** | | **2.165** | | **TP** |
| **G** | | **3.625** | | | | | |
| **H** | | | **X** | | | **123.090** | **BM** |

The steps in the solution are as follows:

FS of station B= 3.125-1.325=1.800

BS of station B= 2.320-0.055=2.265

RL of BM 125.505 1.325 124.180M

Fall of station E 125.850 125.115 0.735

IS of station D = 2.655-0.735=1.920

BS of station F= 3.205-2.165=1.040

Rise of station H=123.090-120.945=2.145

FS of station H 3.625 2.145 1.480

The missing entries are filled and presented in the following table:

| Station | BS | IS | FS | Rise | Fall | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 3.125 | | | | | 124.180 | BM |
| B | 2.265 | | 1.800 | 1.325 | | 125.505 | TP |
| C | | 2.320 | | | 0.055 | 125.450 | |
| D | | 1.920 | | 0.400 | | 125.850 | |
| E | 1.040 | | 2.655 | | 0.735 | 125.115 | TP |
| F | 1.620 | | 3.205 | | 2.165 | 122.950 | TP |
| G | | 3.625 | | | 2.005 | 120.945 | |
| H | | | 1.480 | 2.145 | | 123.090 | BM |
| SUM | 8.050 | | 9.140 | 3.870 | 4.960 | | |

Arithmetic checks:

ΣBS-ΣFS=8.050-9.140= -1.09

ΣRise-ΣFall=9.87-10.96=-1.09

LRL-FRL=123.09-124.180=-1.09

Since, ΣBS-ΣFS=LRL – FRL=ΣRise-ΣFall

Therefore, the calculations are correct.

**Q16: The following consecutive readings were taken with a level and a 4m leveling staff on a continuously sloping ground at a common interval of 30m. The reading are: 0.855 (on A), 1.545, 2.335, 3.115, 3.825, 0.455 (change point), 1.380, 2.055, 2.855, 0.585 (change point), 1.015, 1.850, 2.755, 3.845. The R.L. of A was 380.500m. Determine the reduced level at all points using the collimation method and rise, fall method. Also apply arithmetic checks. Draw the points at the final.**

**Q17: Use the data in the following figure, Calculate the RL of the point using HI method and RF method. Apply usual checks.**