GEE 4812:
Principles of Geomatics

Leveling

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Introduction

- Leveling is the operation performed in surveying to determine and establish elevations of points, to determine differences in elevation between points, and for control in construction works.

Applications

- Highway Profiling
- Railways
- Canals
- sewer lines, pipelines
- Catchment area
- Volume of the reservoir
- Dam Capacity Determination
- Earthwork quantities for various projects
- Contouring
- Setting out, etc

Definition of Terms

I. A mean sea level at a location is obtained by averaging the height of the surface of the sea for all stages of tides for a long period (usually 19yrs).

- It is used as a reference datum.

II. The elevation of a particular point is the vertical distance above or below a reference datum.

III. A level surface is a surface of constant elevation that is perpendicular to the plumb line (vertical line) at every point.

- It is best represented by the surface of a still body of a sea or an ocean if it were unaffected by tides.

Definition of Terms

IV. A level line is a curved line on a level surface all points of which are at equal elevation.

- Every element of the level line is perpendicular to the plumb line.

V. A horizontal line is tangential to the level line at one point. For short distances, the level line and the horizontal line are assumed the same.

VI. The difference in elevation between two points is the vertical distance between the levels surfaces in which the points lie.

Definition of Terms

VII. Benchmark (BM) is a fixed point of known elevation above the datum.

- It is set as a survey marker to provide a starting point for the determination of the elevation of other points.
- A permanent object is used as a marker.

VIII. The reduced level (RL) of a point is its height with respect to a datum.

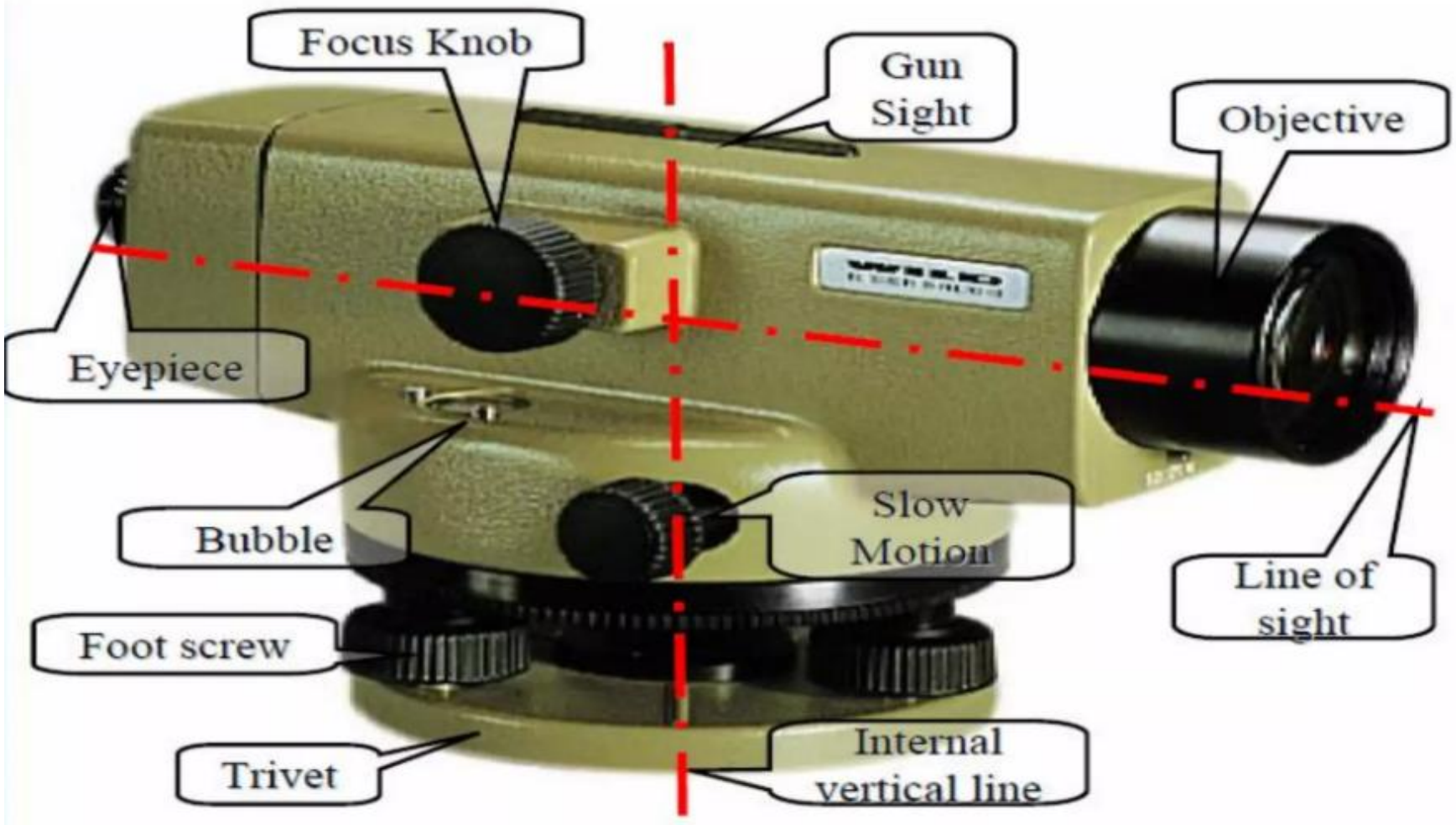
- The term elevation or altitude is synonymously used depending on the datum used.

IX. Temporal benchmark (TBM) is any mark fixed by the observer for reference purposes.

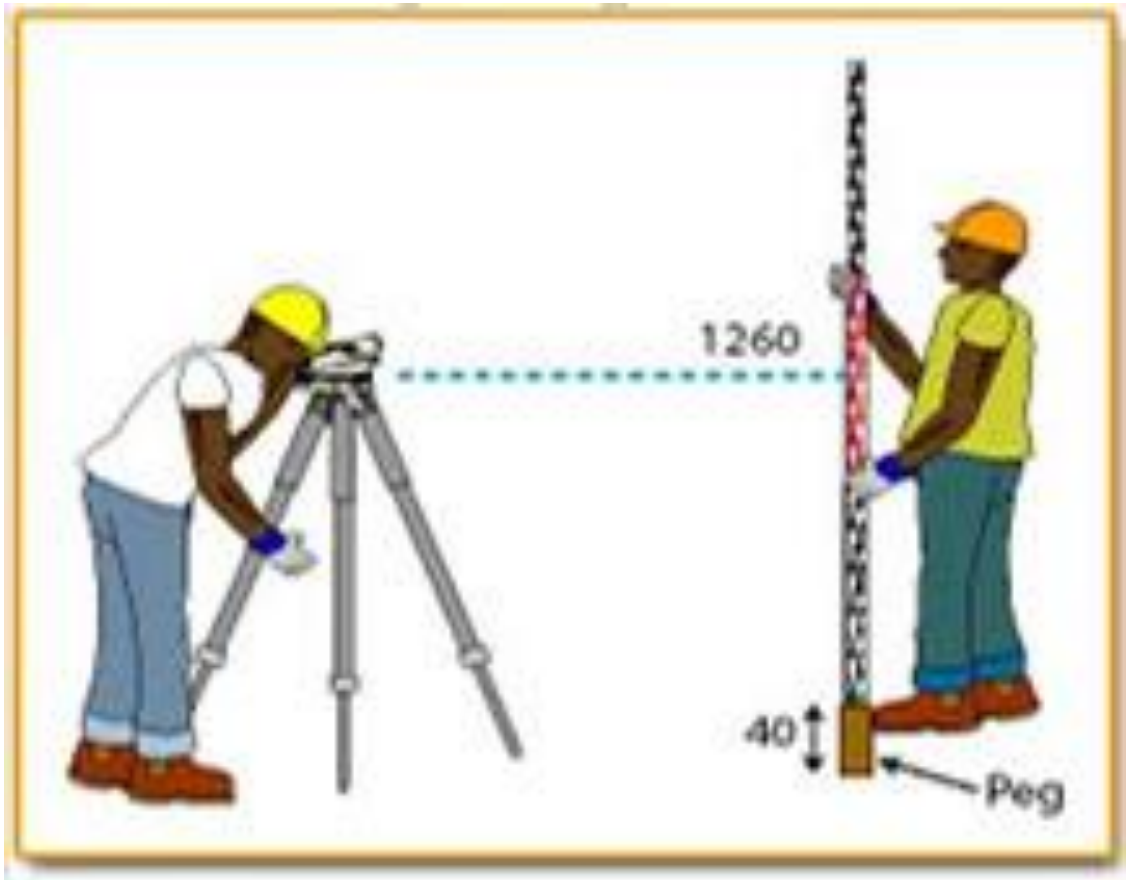
Leveling Instruments

- To carry out a leveling exercise, you will need a level and a leveling rod (staff).
- A level is a high-powered telescope with a spirit level connected so that the line of sight is horizontal when the bubble is centered.
- The line of sight, also known as the line of collimation, is an imaginary line traced through the center of the objective from the junction point of the crosshairs.

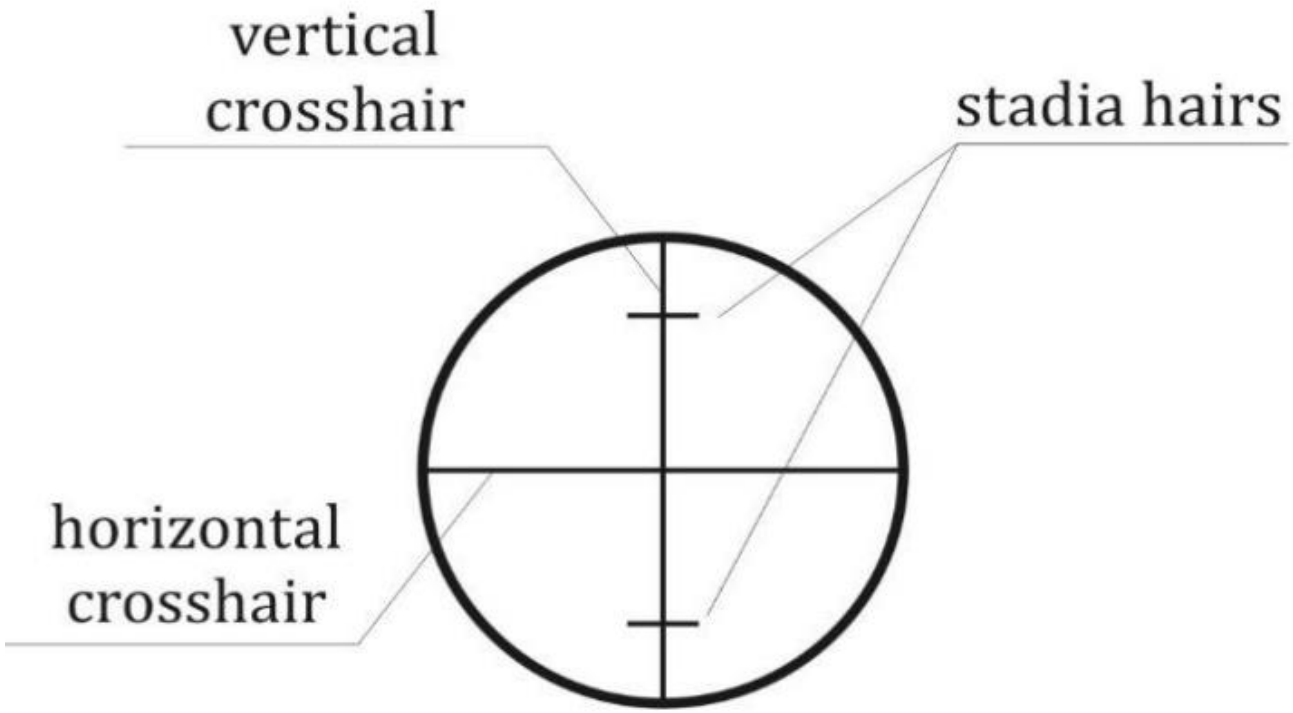
Leveling Instruments



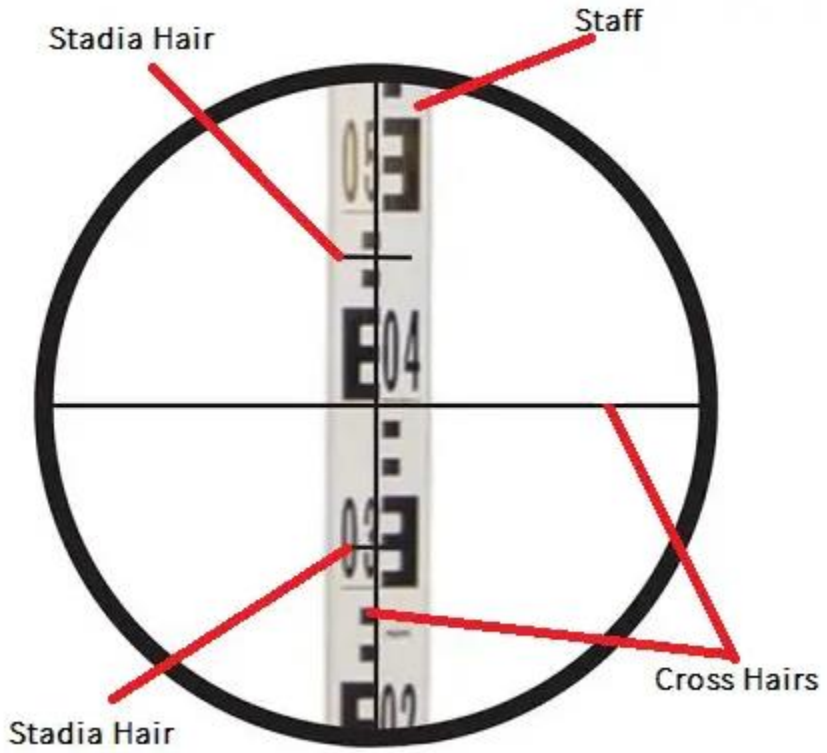
Leveling Instruments: Level & Staff



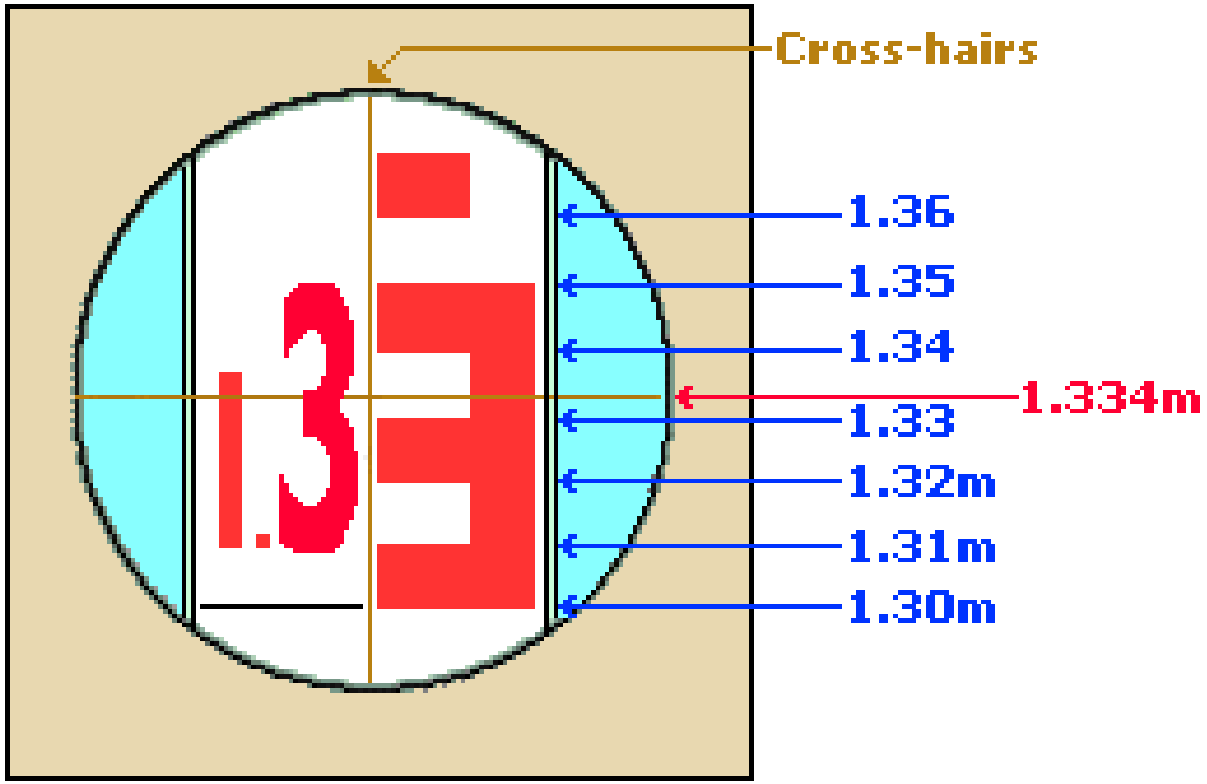
Telescope of Level

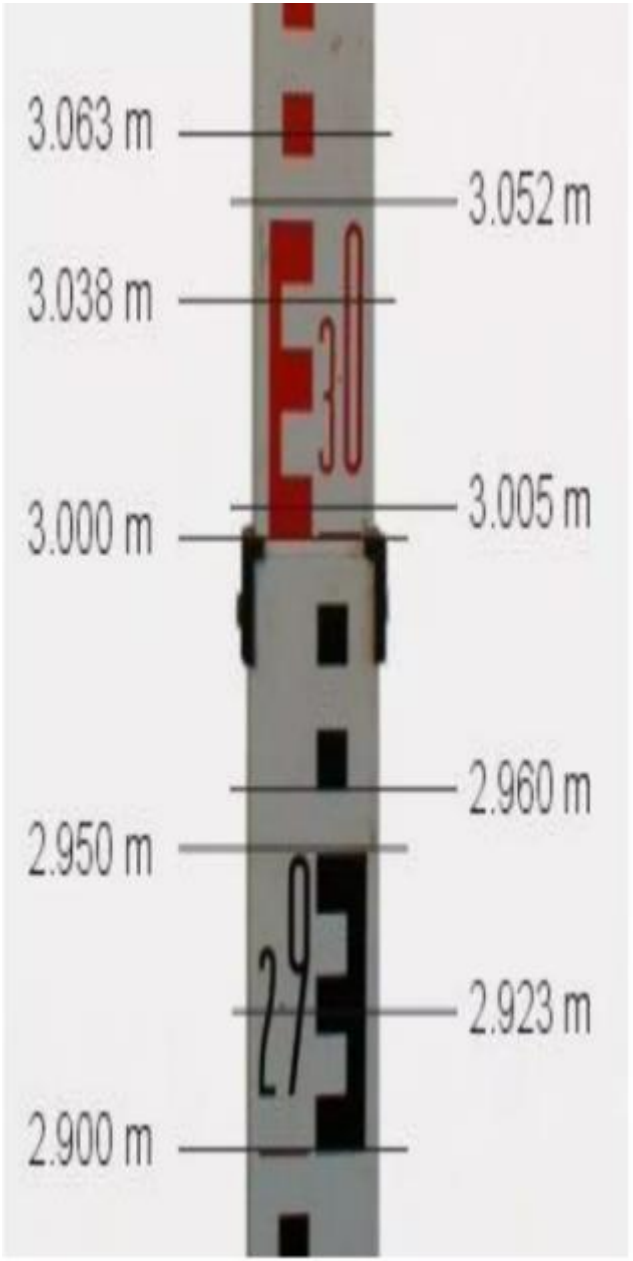


The view inside the scope of the level



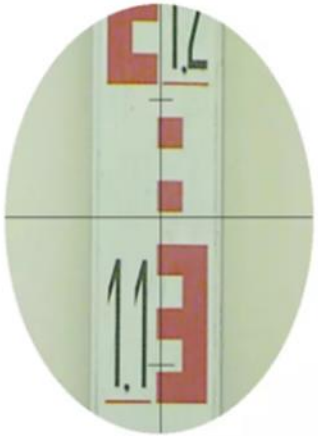
Staff Readings





Staff Readings

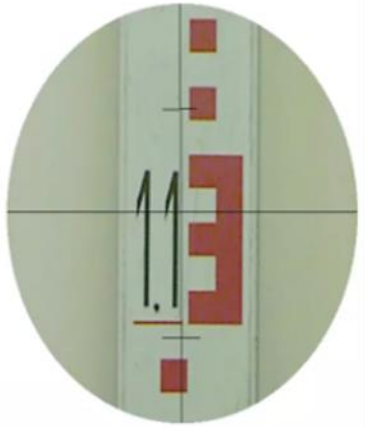
1.



Levelling staves:-

1st	1.158
2nd	1.133
3rd	1.932
4th	1.188

2.



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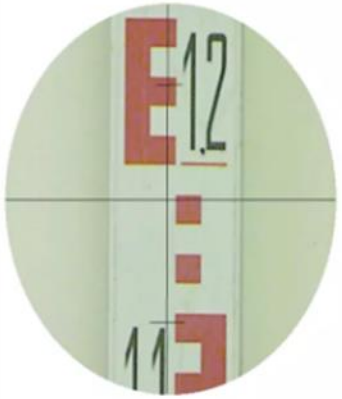

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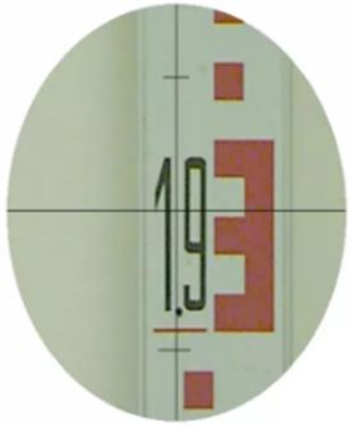
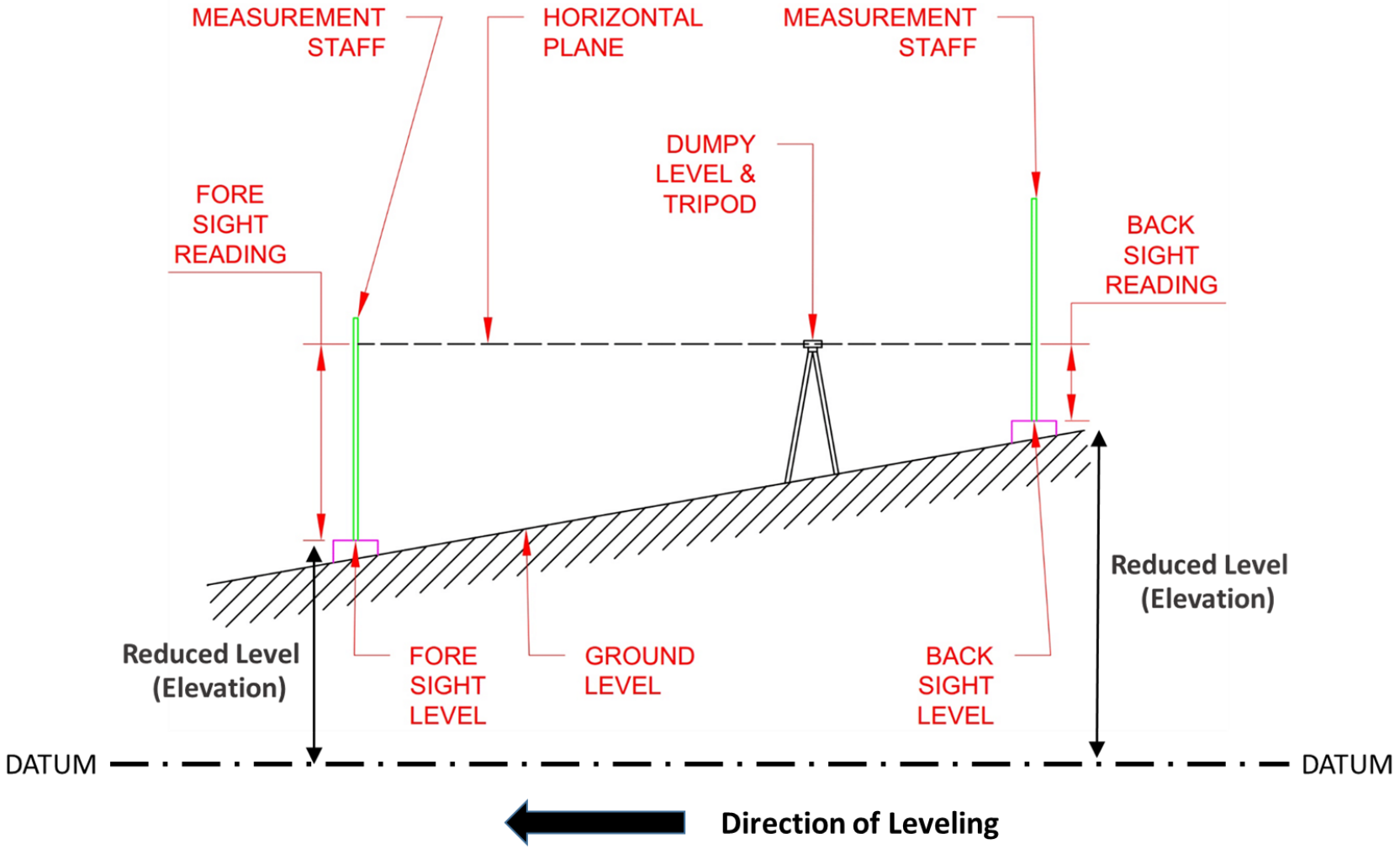


Principle of Leveling



More Definition of Terms

Datum: Datum is any arbitrarily assumed level surface to which elevations are referred.

Reduced level (RL): The reduced level of a place is its elevation or vertical distance above or below the datum or any fixed point.

Line of sight: It is the imaginary line joining the intersection of the crosshairs of the diaphragm to the optical centre of the object glass and its continuation.

Back Sight (BS)

- A backsight is the first staff reading taken after setting up the instrument at any position.
- This will always be reading on a point of known elevation.
- It ascertains the amount by which the line of sight is above or below the elevation of the point.
- Backsight enables the surveyor to obtain the height of the instrument.

Fore Sight (FS)

- A foresight is the last staff reading taken before shifting the instrument.
- This will always be reading on a point whose elevation is to be determined. This reading indicates the shifting of the instrument.
- It is also generally known as minus sight as the fore sight-reading is always subtracted from the height of the instrument (except when the staff is held inverted) to obtain the elevation.

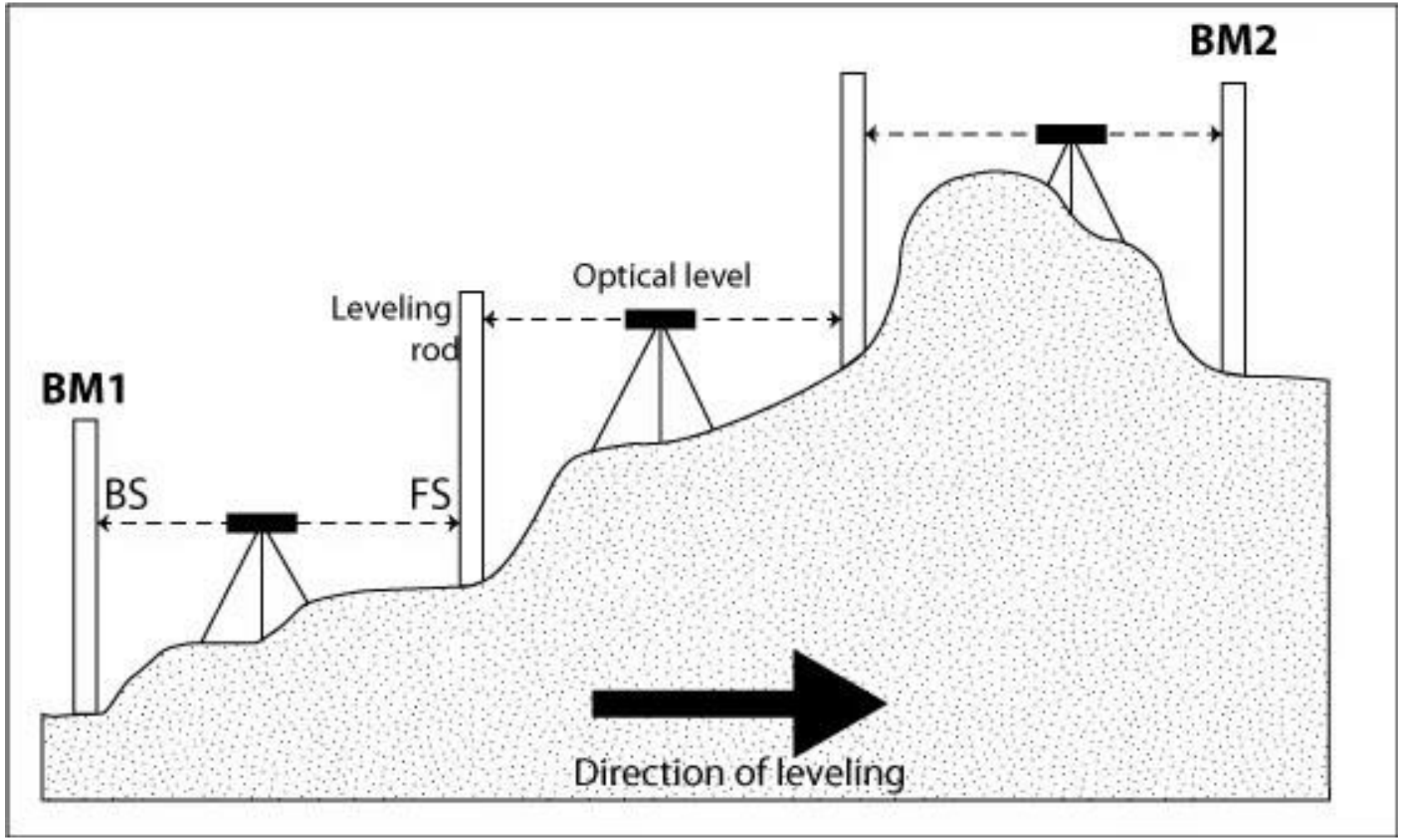
Intermediate Sight (IS)

- An intermediate sight is any staff reading, taken on a point of unknown elevation, after the back sight and before the foresight.
- This is necessary when more than two staff readings are to be taken from the same position of the instrument.
- It may be noted that for one set of a level there will be only a backsight and foresight but there can be any number of intermediate sights.

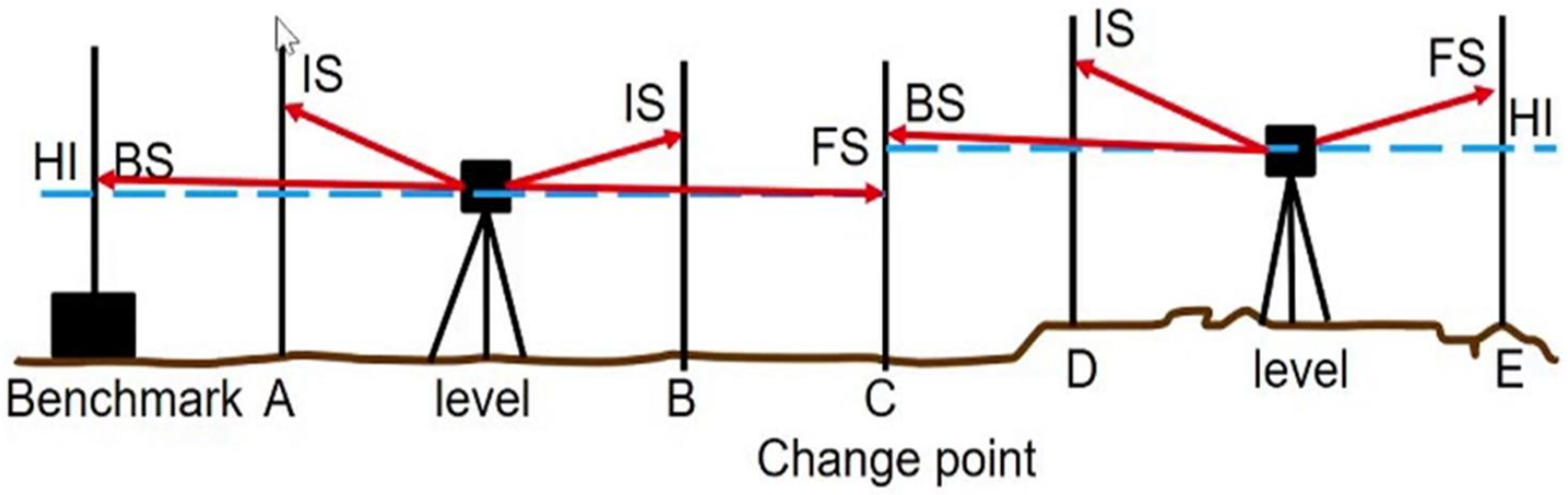
Change Point (CP)

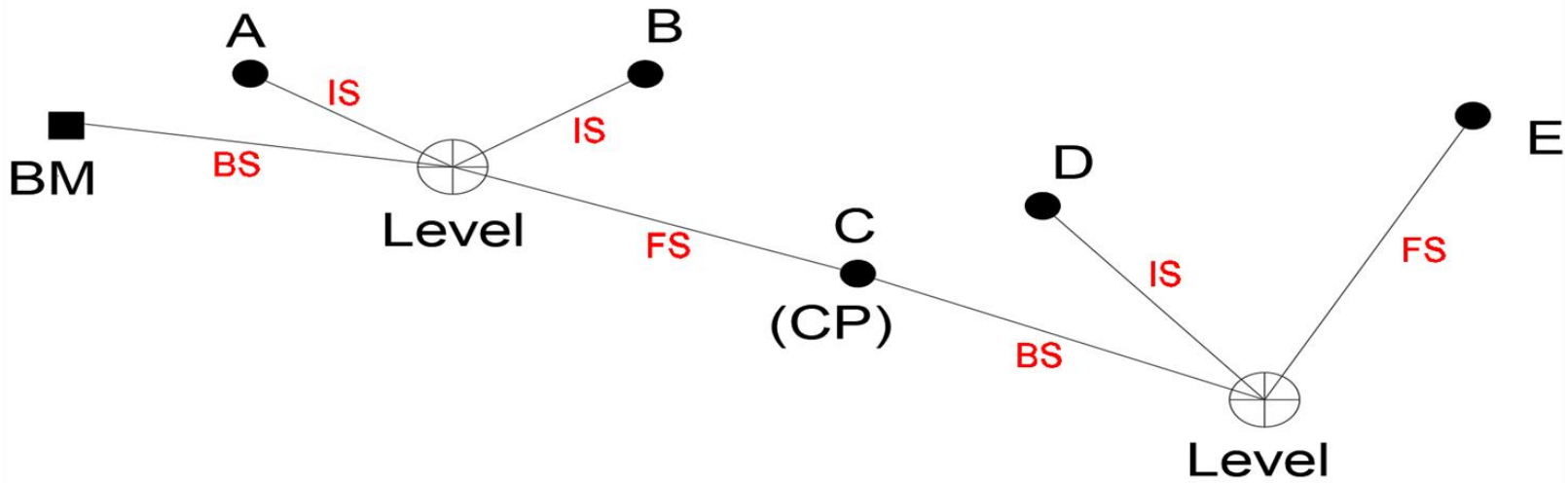
- This is an intermediate staff position and it is used for the purpose of shifting of the instrument.
- Both backsight and foresight are taken from this intermediate staff position.
- Great care is necessary for taking readings at the change point since an error in reading affects every succeeding point of observation (elevation).
- Any firm point, which can be easily found, may serve as a change point

Principle of Leveling



Principle of Leveling





Booking Forms

Station	BS	IS	FS	Height of Instrument	Reduced Level	Remark

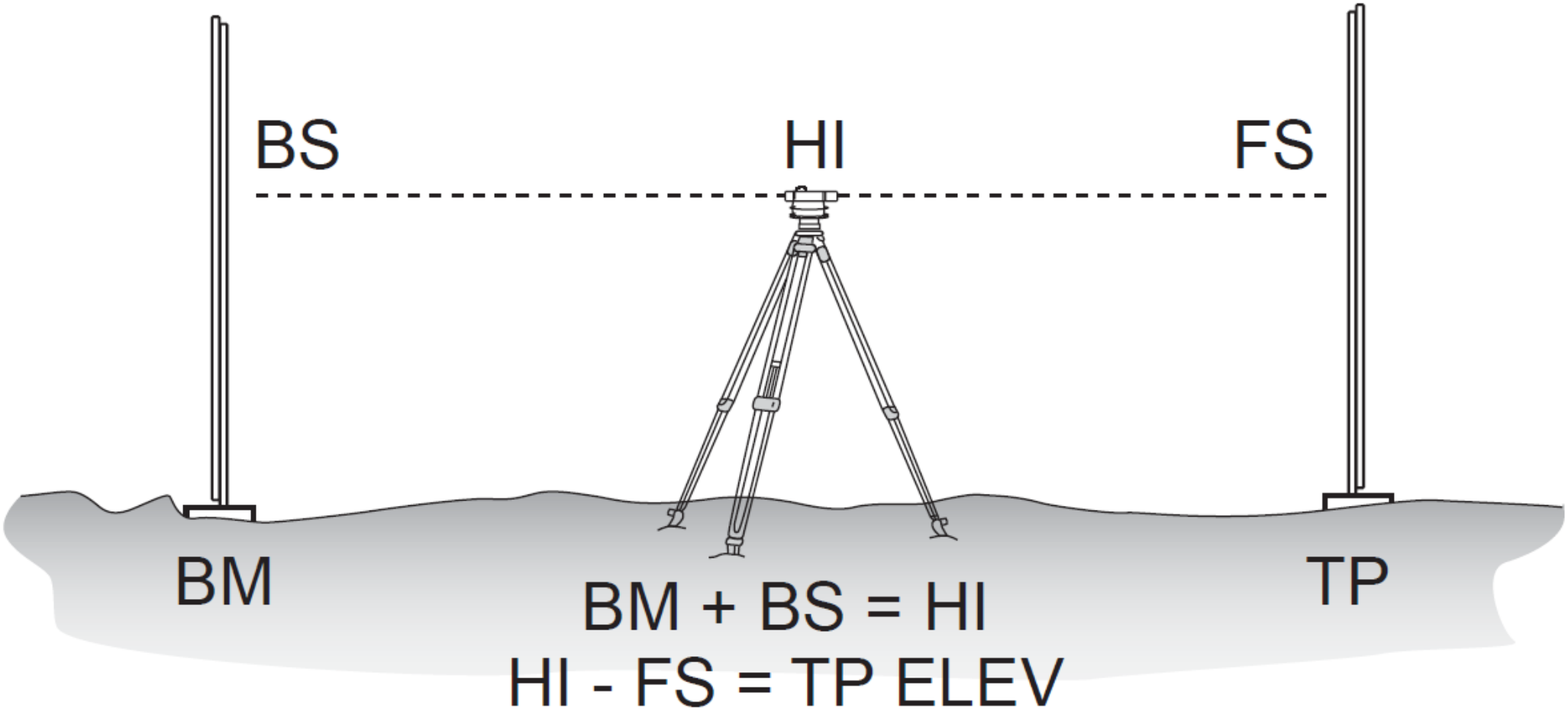
Station	BS	IS	FS	Rise	Fall	Reduced Level	Remark

Methods of Booking & Reduction of Levels

- There are two common types of booking methods used.
- These are:

1. Height of Instrument (HI) method
2. Rise and Fall (RF) method

1. Height of Instrument (HI) method



1. Height of Instrument (HI) method

- In this method the Reduced level of the line of sight is calculated in each step by adding the staff reading to a point with the known Reduced level.
- The RLs of the remaining points in that step are obtained by subtracting their respective readings from the RL of the line of sight (usually indicated by H.I., the height of Instrument).

1. Height of Instrument (HI) method

RL of a point = HI - FS = (RLBM +BS) - FS

Station	BS	IS	FS	HI	RL	Remark
A	0.628			100.000+0.628 (100.628)	100.000	BM (top of a spike)
B		1.564			99.064	
C		1.000			99.628	
D	2.259		1.210	99.418+2.259	99.418	HI= 101.677 (CP)
E			0.991		100.686	
Σ	2.887	2.564	2.201		100.686	
	- 2.201				-100.000	
	0.686				0.686	Ok!

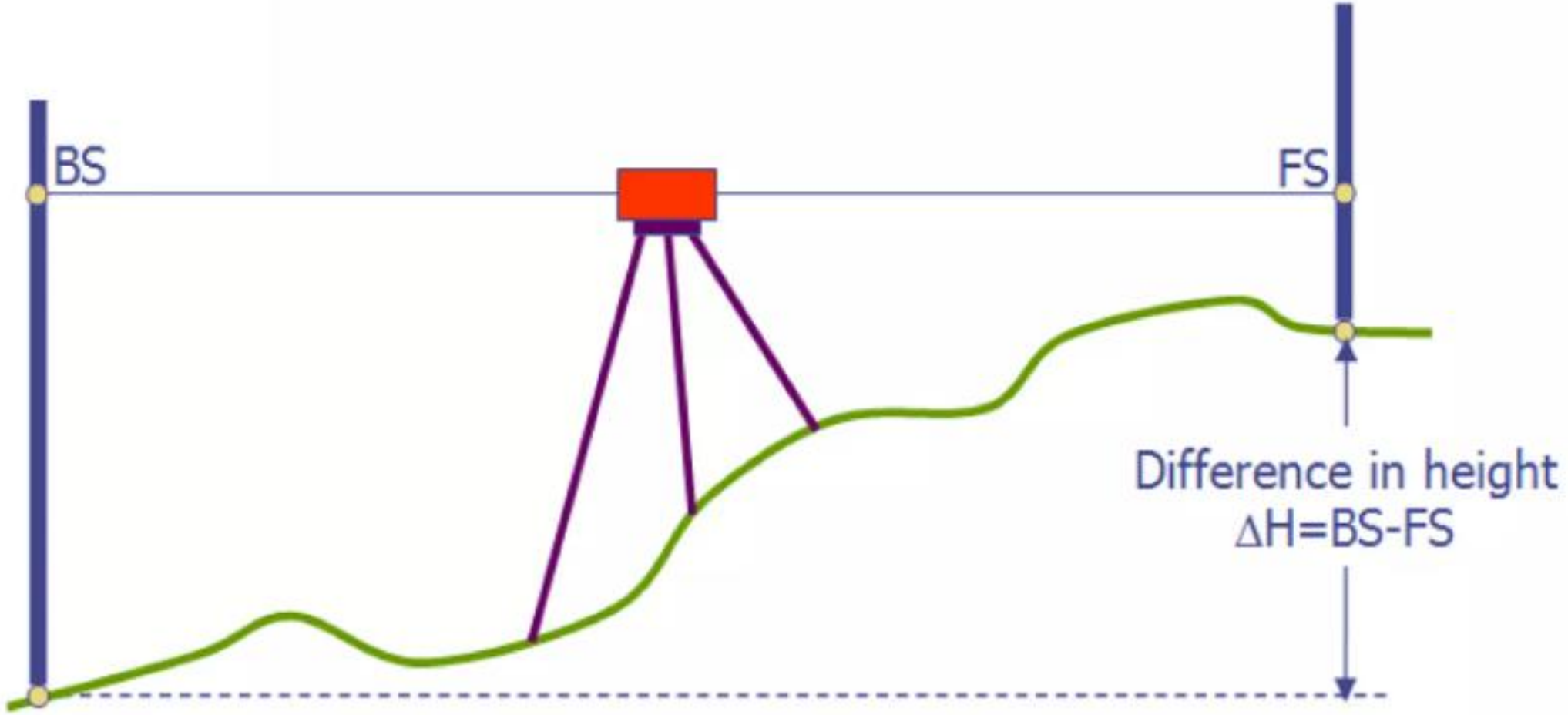
Arithmetic check: ΣBS - ΣFS= Last RL - first RL (short but not complete)

The complete check for HI method is ∑ RL less the first + ∑IS + ∑FS = ∑(HI * no of applications)

1. Height of Instrument (HI) method

- The No. of application is the number of points whose elevations are established using the given HI.
- In this example elevation of A is already known, the elevation of B, C & D is determined using the 1st HI (100.625) hence for this No. of appl=3, and elevation of E is established from the 2nd HI (101.677) hence for this no of appl=1

2. Rise and Fall (RF) method



2. Rise and Fall (RF) method

- The rise or fall of the ground between successive rod stations is considered.
- For the same instrument set up, If 2nd red reading > first-rod reading ⇒ fall If 2nd-rod reading < first-rod reading ⇒ rise Then,

RL of 2nd station = RL of first station - fall or RL of first station + rise

2. Rise and Fall (RF) method

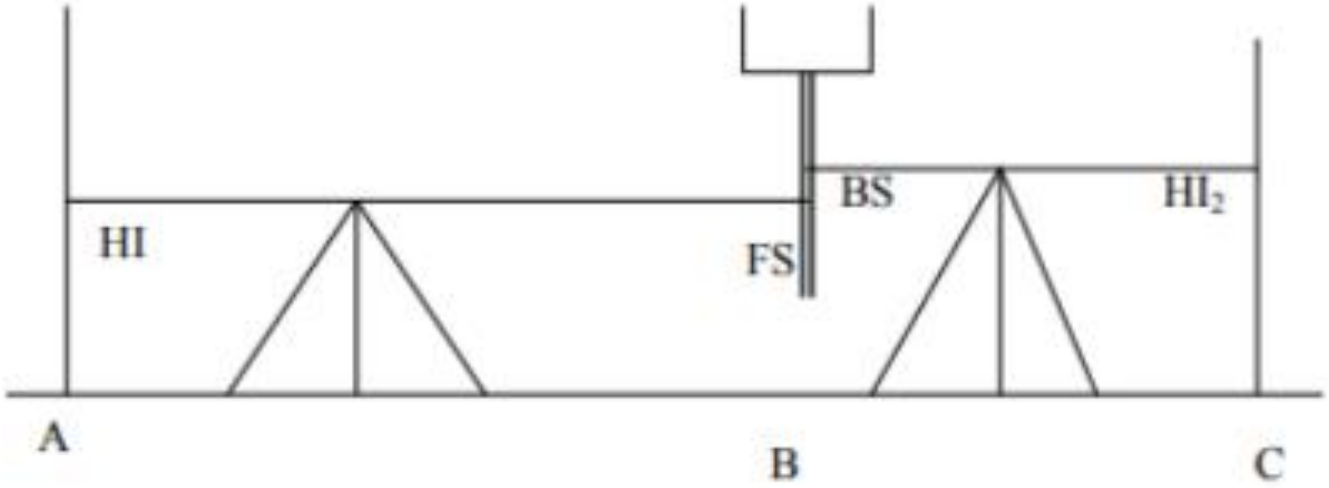
Station	BS	IS	FS	Rise	Fall	RL	Remark
A	0.628					100.000	BM (top of a spire)
B		1.564			0.936	99.064	RL = 100-0.936
C		1.000		0.564		99.628	RL= 99.0.64+0.564
D	2.259		1.210		0.210	99.418	RL= 99.628-0.210 **(CP)**
E			0.991	1.268		100.686	RL= 99.418+1.268
Σ	2.887		2.201	1.832	1.146	100.686	OK!
	- 2.201			-1.146		-100.000	
	0.686			0.686		0.686	

Arithmetic check: ΣBS - ΣFS = ΣRise - Σfall = Last RL - First RL

Inverted Sights

- Occasionally successive FS and BS readings are taken on an overhead point such as a point in the roof of a tunnel or the girder of a bridge or a crossway road.
- The FS taken at such a point is added to the HI to obtain the elevation of the overhead point.
- The BS taken on that point is subtracted from the elevation of the overhead point to obtain the HI for the next instrument set up.
- To follow the conventional reduction methods, these data are recorded as negative values in the field book.

Inverted Sights



At B the rode id held inverted upside down.

$$El.\ B = HI_1 + FS$$

$$HI_2 = El.\ B - BS$$

END