Surveying (Leveling Survey)

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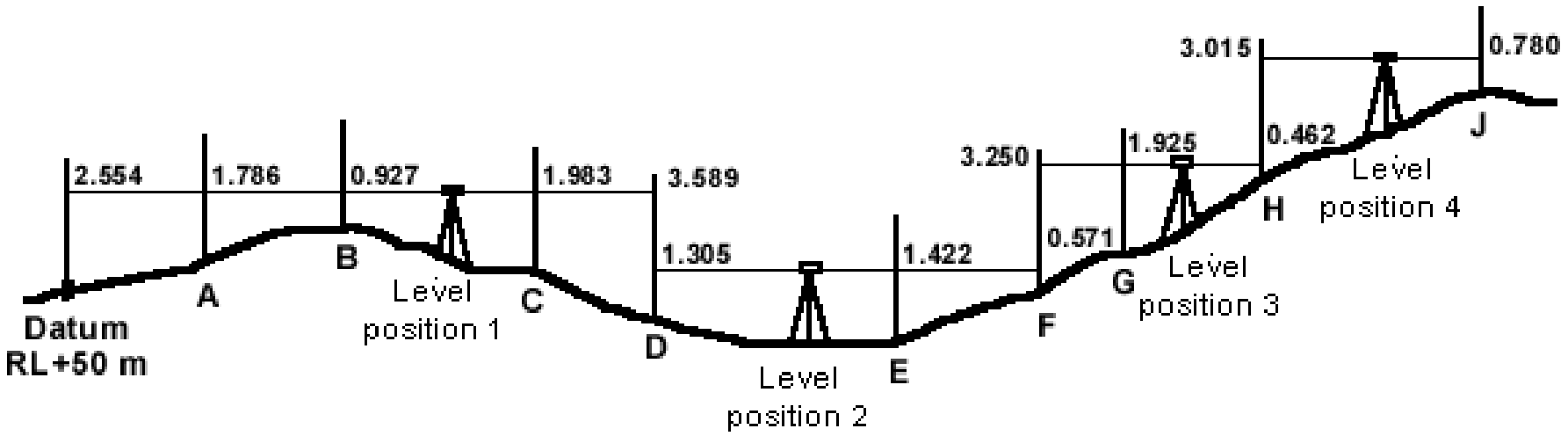
Leveling Survey

Leveling is a process of determining the height of one level relative to another.

Leveling survey is a branch of surveying to measure levels of different points with respect to a fixed point (Base Station/Point), such as elevation of building, height of one point from the ground (datum) etc.



Leveling Instruments

Levels are different instruments used for leveling in surveying and the process of measuring vertical distances in surveying is called leveling.

There are various types of levels, such as:-

- Dumpy level
- Y level
- Cushing’s level
- Tilting level
- Cooke’s Reversible level
- Automatic level

Y level

Tilting level

Dumpy level

Cooke’s Reversible level

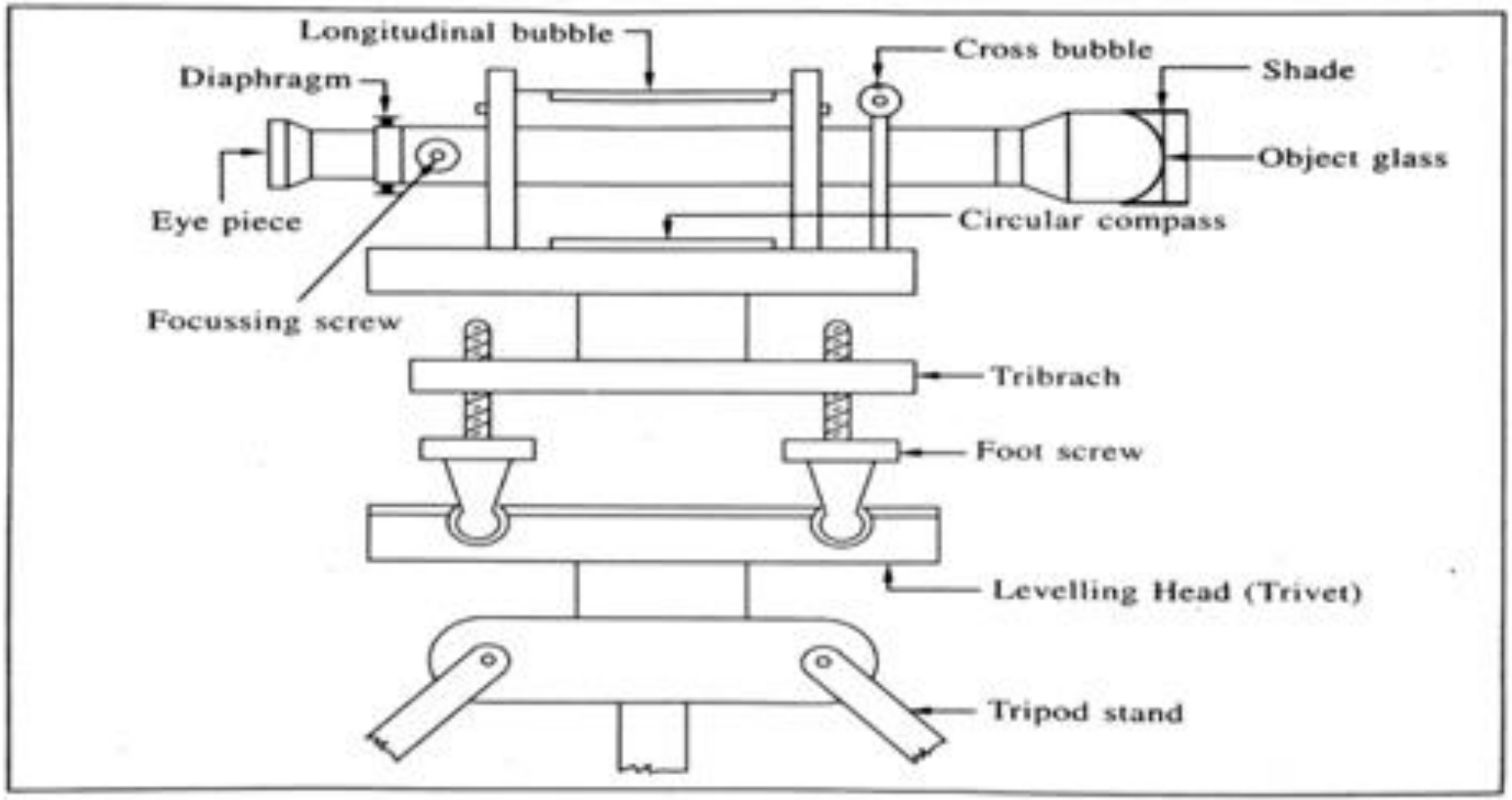
Automatic level

Dumpy Level

Dumpy level is the most commonly used instrument in leveling. In this level the telescope is restricted against movement in its horizontal plane and telescope is fixed to its support. A bubble tube is provided on the top of the telescope.

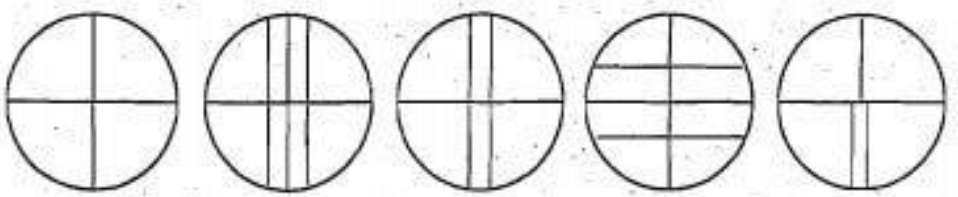
But the leveling head can be rotated in horizontal plane with telescope. Actually it’s a generic term for an optical level.

Dumpy Level


Longitudinal bubble
Cross bubble
Shade
Diaphragm
Object glass
Eye piece
Circular compass
Focussing screw
Tribrach
Foot screw
Levelling Head (Trivet)
Tripod stand

The telescope has a metal tube contains four main parts as given below:-

- ✓ **Objective lens:** It is made as a combination of crown and flint glasses. A thin layer coating which has smaller refractive index than glass is provided to reduce the loss due to reflection.
- ✓ **Negative lens:** Negative lens located co axial to the objective lens. So, the optical axis for both lenses is same.
- ✓ **Diaphragm:** It is fitted inside main tube that contains cross hairs (V & H), adjusted by capstan headed screws.
- ✓ **Eye-piece:** Its enable the ability to sight the object together with cross hairs. The image seen through eye piece is magnified and inverted. Some are erect image into normal view, called erecting eyepieces.



different types of cross-hairs

Y Level

Y level or Wye-level consists y-shaped frames which supports the telescope. Telescope can be removed from y-shaped supports releasing clamp screws.

These y-shaped frames are arranged to vertical spindle which helps to rotate the telescope.

Compared to dumpy level, adjustments can be rapidly tested in y-level. But there may be a chance of frictional wear of open parts of level.

Cushing's Level

In case of Cushing's level, the telescope is restricted against rotation in its longitudinal axis and it is non-removable. But the object and eye piece end can be interchangeable and reversible.

Tilting Level

Tilting level consist a telescope which enabled for the horizontal rotation as well as rotation about 4 degree in its vertical plane.

Centering of bubble can be easily done. But for every setup bubble is to be centered by tilting screw.

The main advantage of tilting level is to take few observations with one setup of level.

Cooke’s Reversible Level

It is a combination of dumpy and y-level. In this instrument, the telescope can be reversed without rotation.

Collimation error can be eliminated in this case because of bubble left and bubble right reading of telescope.

Automatic Level

This is also known as self-aligning level. This instrument leveled automatically within a certain tilt range by means of a compensating device (the tilt compensator, is also called stabilizer).

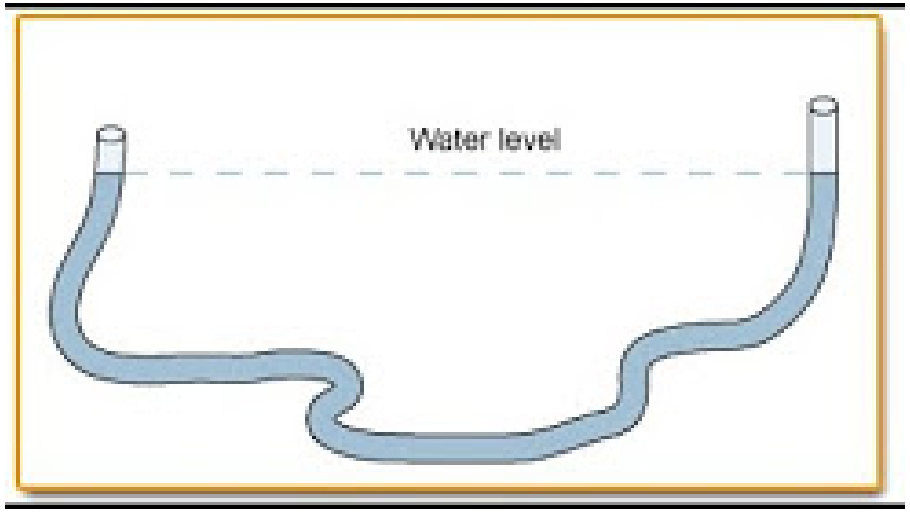
The stabilizer consists two fixed prisms and creates an optical path between eye piece and objective.

Note: Laser level, Digital level (Total Station) and Water level.


JOGGER 32


Nikon
AC-2E


Integrated Collimator
for rough targeting
Focusing knob
to get a sharp image
Telescope
with objective
BOSCH
Compensator
(inside the instrument)
Lens
for adjustment
of the crosshair
to your eye
Horizontal drive
screw
Horizontal circle
Gon or Degree
Spirit level
for checking
the level
Levelling
screws


Water level


HiLDA
LASER LEVEL


Carrying handle
Optical sight (finder)
Telescope focusing ring
Telescope eyepiece
Diopter ring
Rectical plate cover
Plate level
Face-1 display and keyboard
Tribrach clamp knob
Battery mounting button
Battery pack BC-65
Vertical tangent screw
Vertical clamp
Horizontal clamp
Horizontal tangent screw
The laser safety label shown is attached to the underside of the keyboard


LS15
Swiss Technology
Bluetooth
Leica Digital Level
Q-Level
Programs
Manage
Transfer
Settings
Tools
F1
F2
F3
F4
Leica

Objective of Leveling

The objectives are:-

- ✓ To have a hands on experience in setting and working with the instrument and collect the data of the relevant field work.
- ✓ To increase knowledge in the leveling procedure.
- ✓ To calculate reduced level of each station.

Importance of leveling

- ✓ It help the surveyor to make counter map of land surface or sea surface.
- ✓ It help surveyor to lay a ground level on which they can built a building.
- ✓ It help pipe transport engineer to ensure appropriate slope of land that will allow smooth movement of liquid.

Terminologies in leveling

- **Leveling**

  Determination of height differences for 2 or more points above the geoid.

- **Datum (Datum Surface/Geoid)**

  A particular level surface chosen on the basis of all elevations in the leveling work.

- **Mean Sea Level (MSL) Surface**

  Most commonly adopted datum, makes international comparison of heights possible.

➢ Reduced Level (RL)

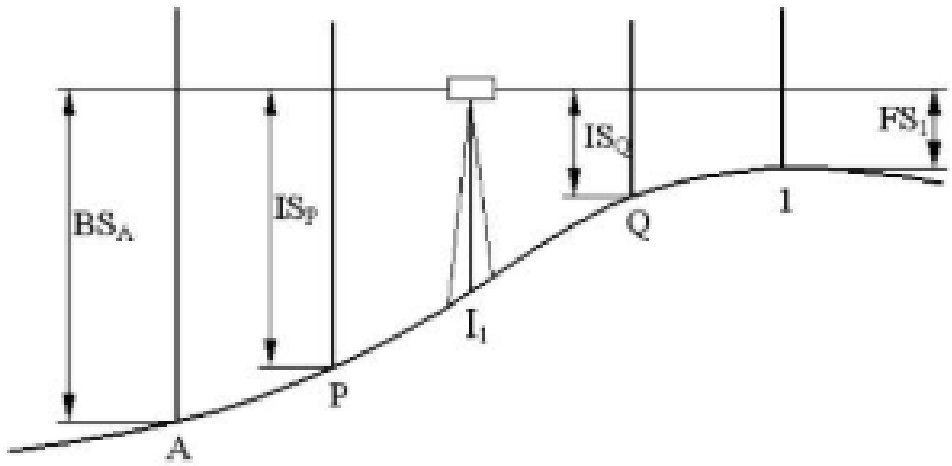
Height of a point above the particular used.

➢ Bench Mark (BM)

The point whose elevation is known called bench mark. Point with previously determined RL. Often constructed as permanent markers.

➢ Back Sight (B.S)

The first reading which we take after set a instrument or at bench mark on the field.



➢ Fore Sight (F.S)

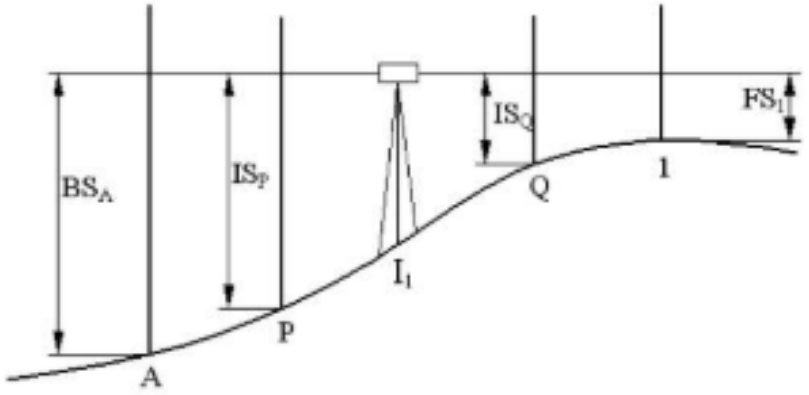
The last reading which we take before shifting our instrument or at change point or turning point.

➢ Intermediate Sight(I.S)

The reading between B.S and F.S called intermediate sight.

➢ Staff Reading

The reading takes on the field through instrument.



➢ Height of Instrument

It is the sum of staff reading which we take on the ground and bench mark (known elevation).

Measurement in Leveling

- **Back Sight (BS) Reading**

  First reading taken by the instrument after setting at any location known as BS Reading.

- **Fore Sight (FS) Reading**

  All last reading taken by the instrument location known as FS Reading.

- **Intermediate Sight (IS) Reading**

  All other reading except BS and FS are known as IS Reading.

Methods to Find RL

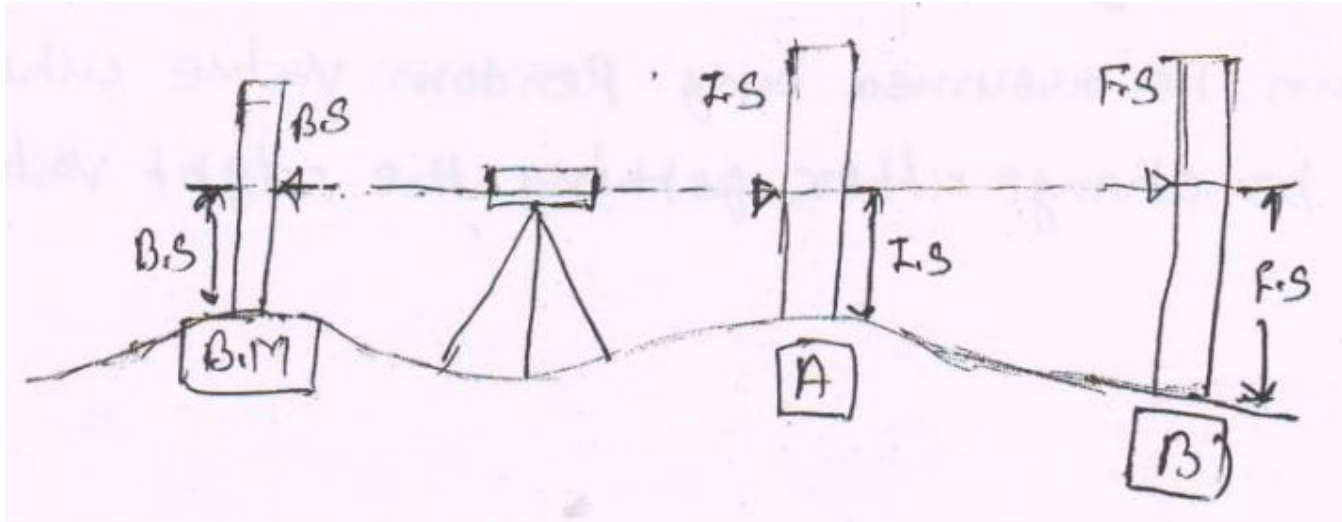
A. Height of Instrument Method

H.I= R.L of BM + B.S

R.L of any Point

R.L= H.I – IS/FS

Arithmetic Check

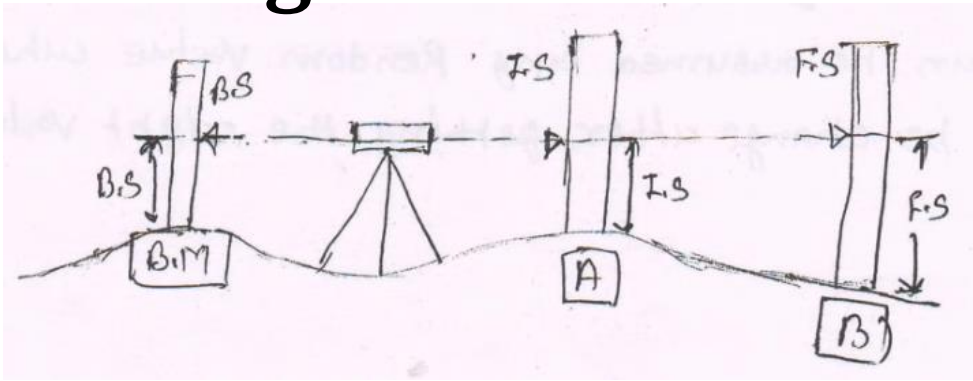


$\sum$ B.S. - $\sum$ F.S = Last R.L – First R.L

Methods to Find RL

B. Rise and Fall Method

= Previous reading - This reading



+ve or –ve

R.L of any point

R.L of Pre. Point + Rise (or Fall)

Arithmetic Check

$\sum$ Rise - $\sum$ Fall = Last R.L – First R.L

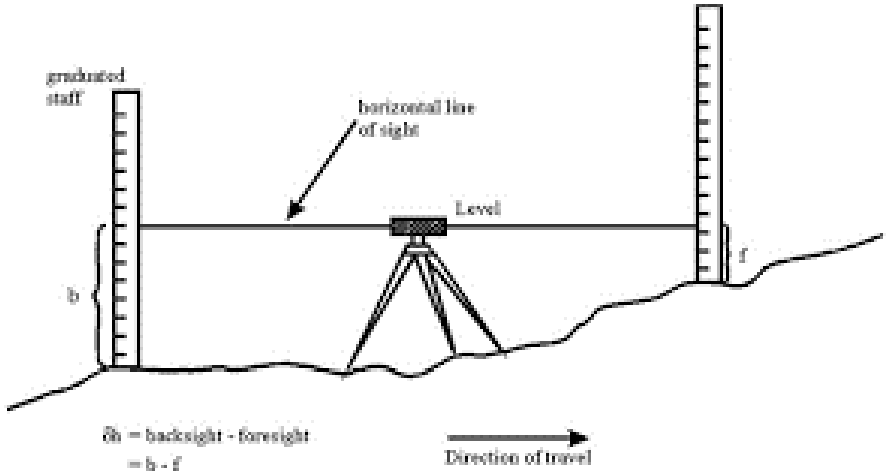
Leveling Procedures

➢ Setting Up

a) Back sight and foresight distances should be approximately equal to avoid any errors due to collimation, refraction or earth curvature.

b) Distances must not be so great as to not be able to read the graduations accurately.

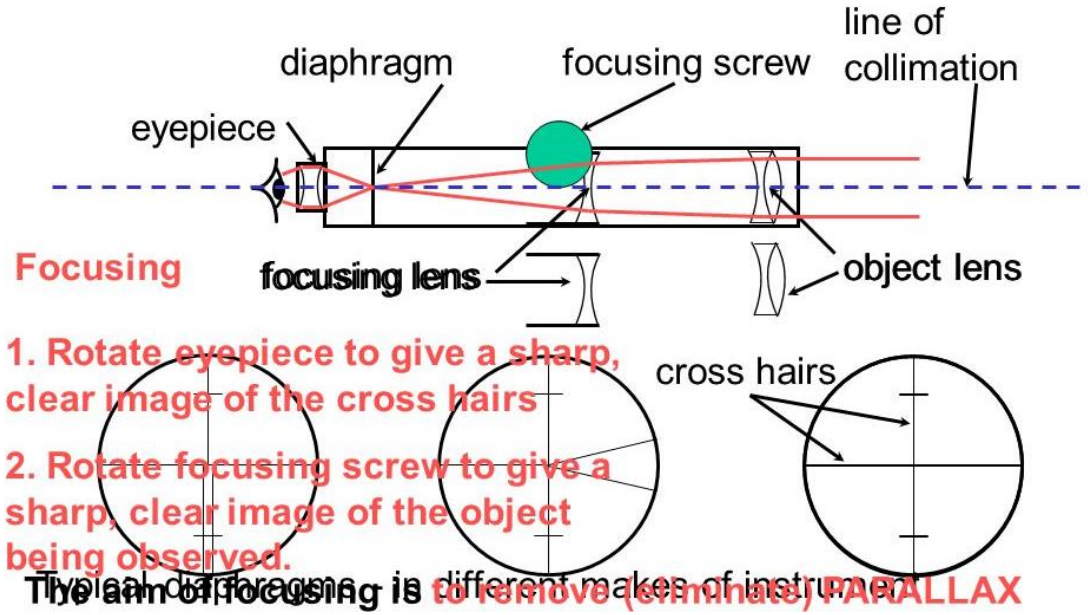
c) The point to be observed must be below the level of the instrument, but not lower than the height of the staff.

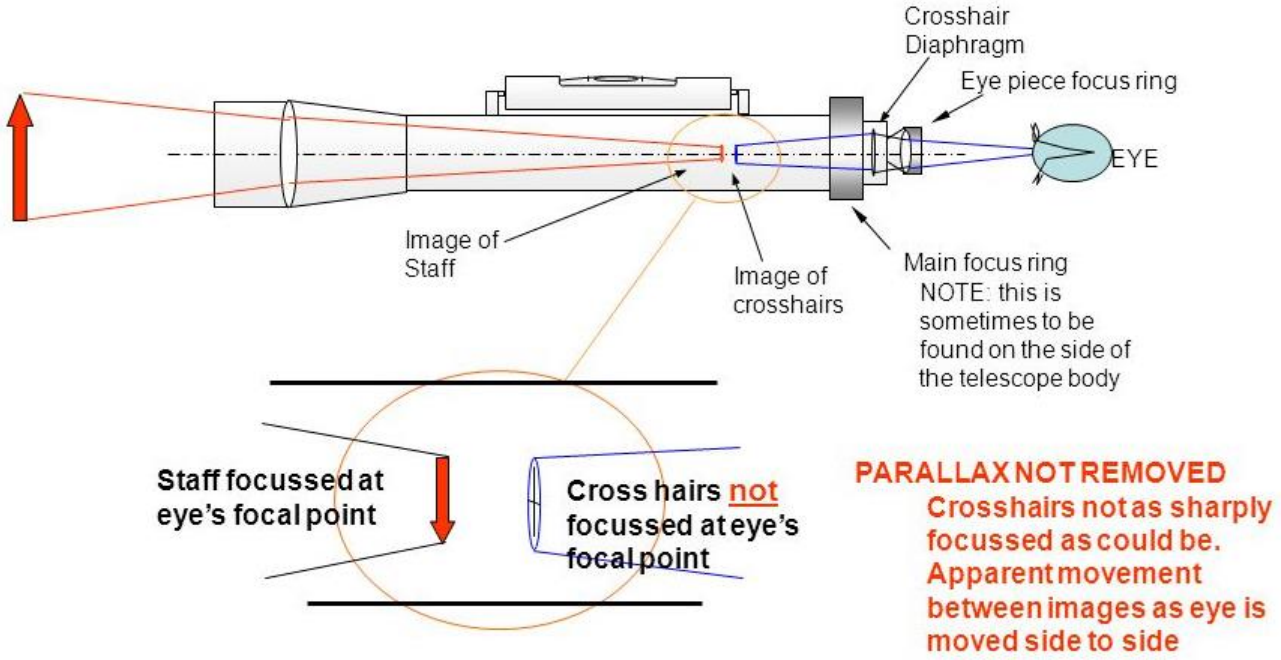


➢ Elimination of Parallax

Parallax is the apparent movement of the image produced by the movement of observer's eye at the eyepiece.

It is eliminated by focusing the telescope on infinity and then adjusting the eyepiece until the cross-hairs appear in sharp focus.





➢ Booking

Level books or leveling sheets shall be numbered & indexed in a register.

Details of the site, work, date, observer, chainman, booker, **weather**, instrument & any **relevant items** shall be entered.

Enter **first** observation (i.e. a known point) in backsight column, and sufficient detail in **remarks** column to identify it.

Enter all other points on subsequent lines as intermediates except foresight.

Change instrument to the next setup. Enter the following backsight on same line as the previous foresight but in backsight column.

Repeat above procedure at each setup.

Completed booking sheet example
Rise & Fall method

BS	IS	FS	RISE	FALL	RL	REMARK
2250					47.195	BM
	2825			575	46.620	A
2120		1976	849		47.469	B
1880		2400		280	47.189	C
		486	1394		48.583	D
6250		4862	2243	855	1388	
4862			855			
1388			1388			

Methods of Leveling Survey

The methods of leveling may be **Direct** or **Indirect**.

Direct methods of leveling are included:-

- ✓ **Profile Leveling** - *Rise & Fall*
  - *Line of Collimation*
- ✓ **Simple Leveling**
- ✓ **Differential Leveling**
- ✓ **Fly Leveling**
- ✓ **Precise Leveling**
- ✓ **Reciprocal Leveling**

Indirect methods of leveling are included:-

- ✓ **Trigonometric Leveling**
- ✓ **Barometric Leveling**
- ✓ **Stadia Leveling**

Direct Leveling Survey

The most commonly used method of leveling. In this method, measurements are observed directly from leveling instrument. It is divided into different types based on observation points and instrument positions.

Profile Leveling Survey

Profile leveling is a process of determining the elevations of points along the center line of a track on land.

Profile leveling is generally adopted to find elevation of points along a line such as road, rail, transmission lines, sewers or rivers etc.

In this case, readings of intermediate stations are taken and reduced level of each station is found.

It’s calculated by two methods- a) Rise & Fall

b) Line of Collimation

Rise and Fall Method of Leveling

Link: https://www.youtube.com/watch?time_continue=477&v=QvSr8jQ8UYQ&feature=emb_logo

Problem:

Station	B.S	I.S	F.S	Rise	Fall	R.L	Remarks
B.M	2.11					22.13	Bench Mark
10		1.14					
20		0.95					
30		0.84					
40		1.55					
50			1.88				Last Reading

Solution:

Station	B.S	I.S	F.S	Rise	Fall	R.L	Remarks
B.M	2.11					22.13	Bench Mark
10		1.14		0.97		23.1	
20		0.95		0.19		23.29	
30		0.84		0.11		23.4	
40		1.55			0.71	22.69	
50			1.88		0.33	22.36	Last Reading

Arithmetic Check:

$\sum$B.S – $\sum$F.S = $\sum$ Rise - $\sum$ Fall = Last R.L – First R.L

2.11 – 1.88 = (0.97+0.19+0.11) – (0.71+0.33) = 22.36 - 22.13

0.23 = 0.23 = 0.23

Line of Collimation Method of Leveling

Link: https://youtu.be/6ujrkL59uFU

Problem:

Station	B.S	I.S	F.S	H.I	R.L	Remarks
B.M	2.11				22.13	Bench Mark
10		1.14				
20		0.95				
30		0.84				
40		1.55				
50			1.88			Last Reading

Solution:

Station	B.S	I.S	F.S	H.I	R.L	Remarks
B.M	2.11			24.24	22.13	Bench Mark
10		1.14			23.1	H.I=R.L+B.S
20		0.95			23.29	R.L=H.I-I.S/F.S
30		0.84			23.4	
40		1.55			22.69	
50			1.88		22.36	Last Reading

Arithmetic Check:

$\sum$B.S – $\sum$F.S = Last R.L – First R.L

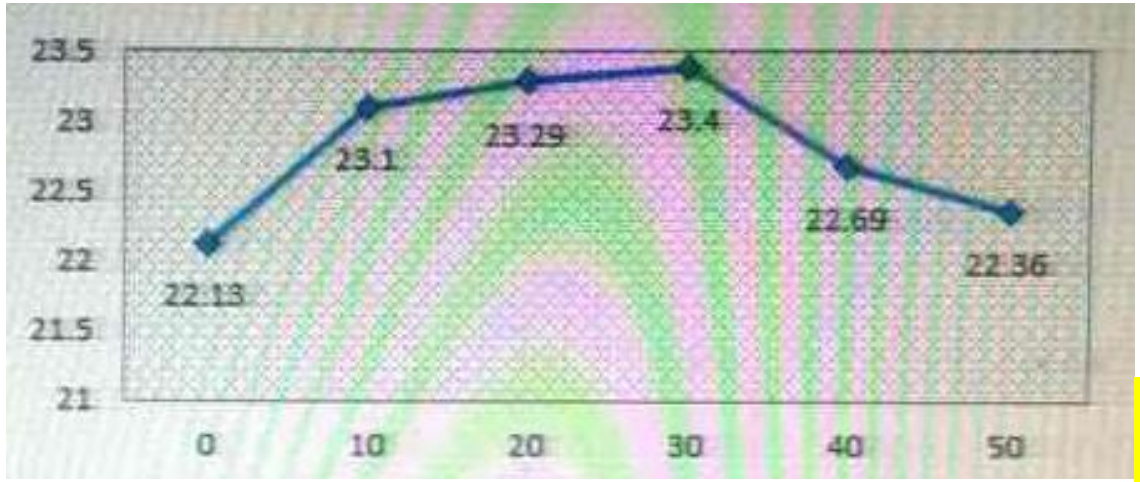
2.11 – 1.88 = 22.36 - 22.13

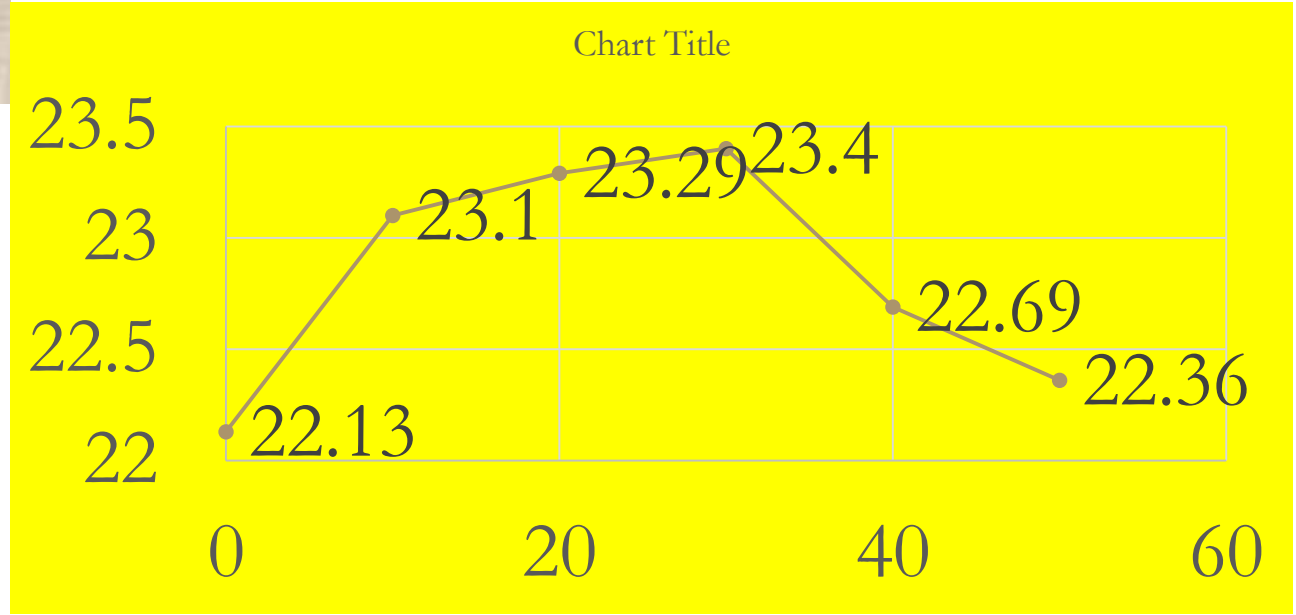
0.23 = 0.23

Note: If any change point/turning point occur then we calculate new height of instrument by formula (H.I- F.S + B.S= New H.I).Remaining procedure remain same and in remarks we write change point (C.P).

GRAPH:

It will be plotted between r.l (along y-axis) and horizontal distance (along x-axis).





Simple Leveling Survey

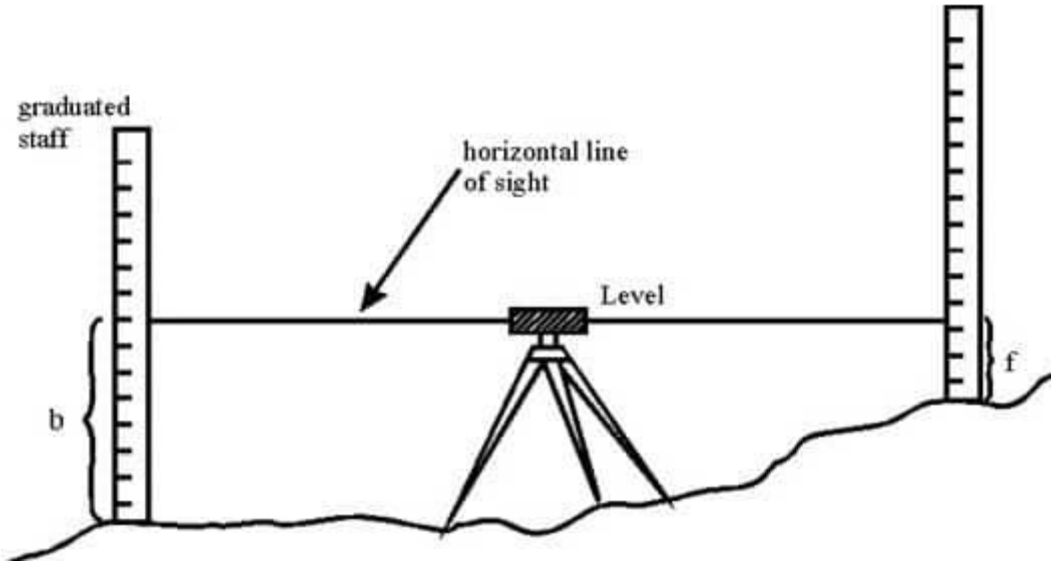
It is a simple and basic form of leveling in which the leveling instrument is placed between the points that find station's elevation.

Leveling rods placed at the points and sight them through leveling instrument.

It is performed only when the points

Are nearer to each other without any

Obstacles.

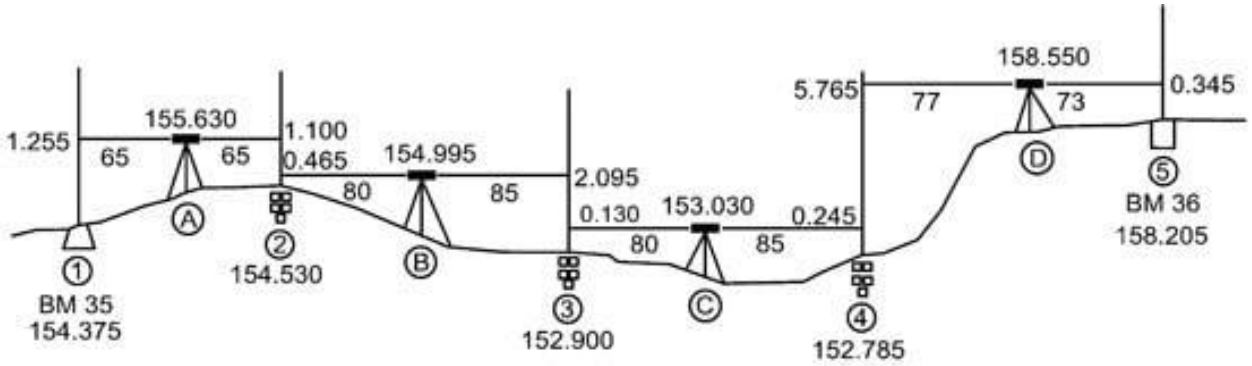


Differential Leveling Survey

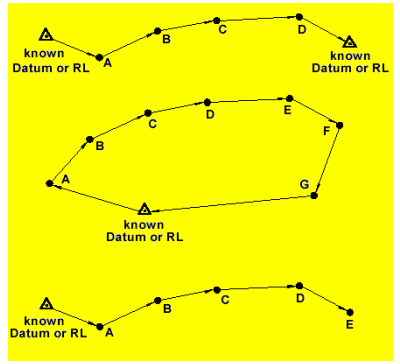
Differential leveling is performed when the distance between two points is more. In this process, number of inter stations are located.

Finally difference between original two points is determined.

Elev+BS=HI		HI-FS=Elev			
	Station	BS (+)	HI	FS (-)	Elev.
	BM	1.255	155.63		154.375
	A	0.465	154.995	1.1	154.53
	B	0.13	153.03	2.095	152.9
	C	5.765	158.55	0.245	152.785
	D			0.345	158.205



Fly Leveling Survey



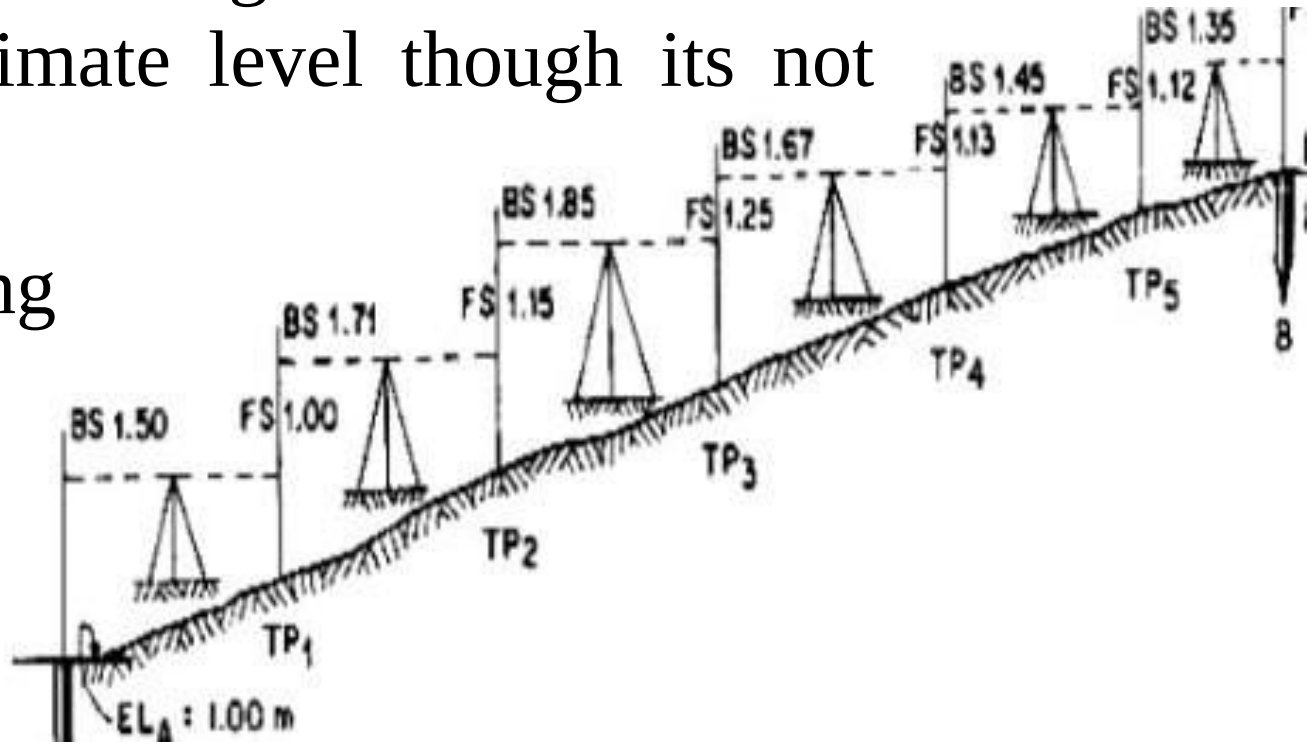
This leveling method is conducted when the benchmark is very far from the work station.

In such case, a temporary bench mark is located at the work station which is located based on the original bench mark. It is used for determining approximate level though its not highly precise.

In short, when differential leveling

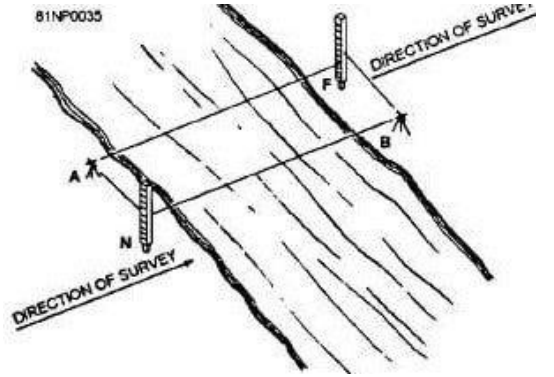
is done to connect a bench mark

as starting point of any project.



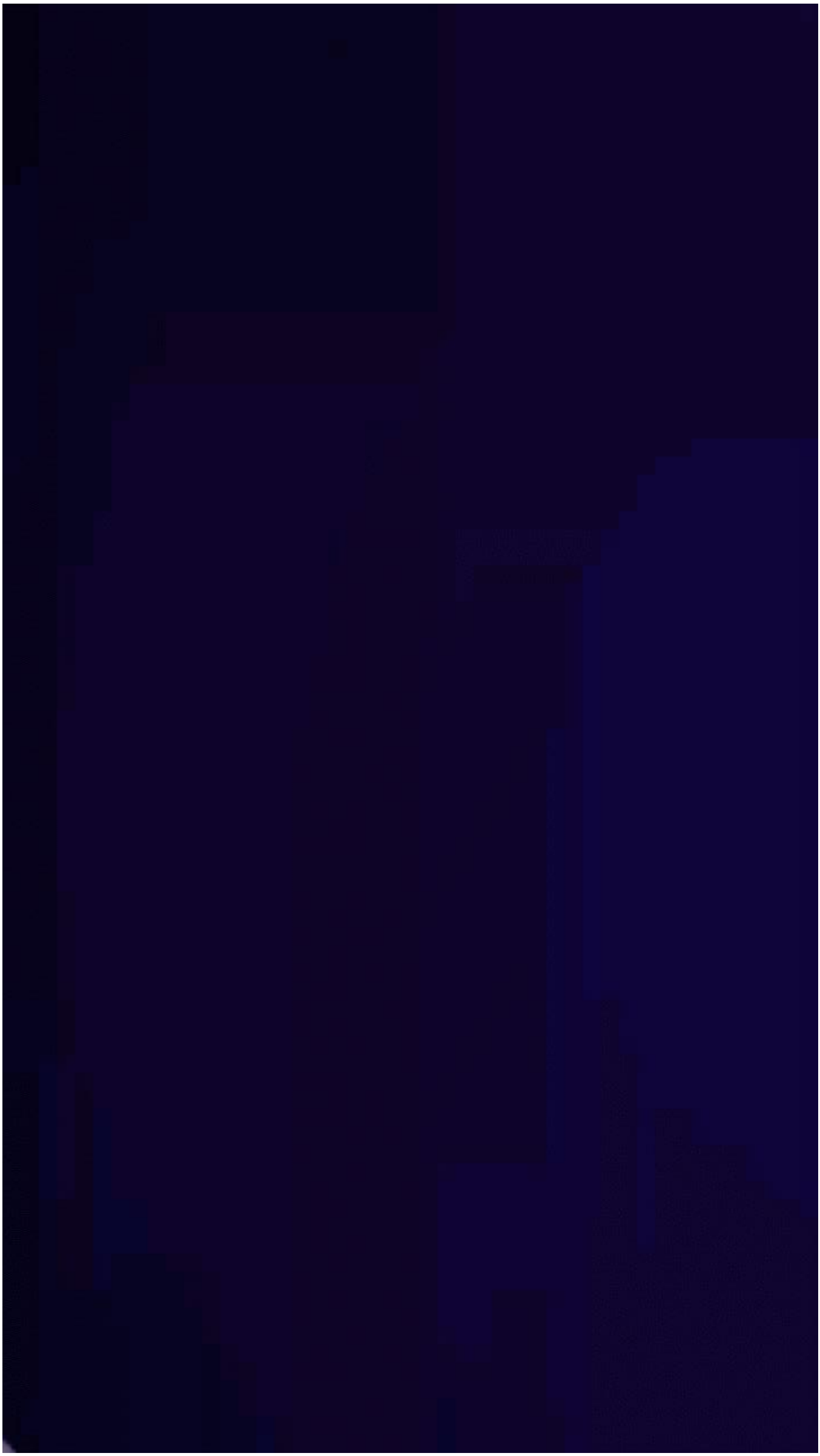
Precise Leveling Survey

Precise leveling is similar to differential leveling but need higher precise. To achieve high precise, serious observation procedure is performed. The accuracy of 1mm per Km is achieved.



Reciprocal Leveling Survey

When it is not possible to locate leveling instrument in between the inter visible points (ponds, rivers etc.), reciprocal leveling is performed. In this case, instrument is set nearer to 1st station and sighted towards 2nd station.



https://www.youtube.com/watch?v=bru-lpQtodg

Indirect methods of leveling are included:-

- ✓ **Trigonometric Leveling**
- ✓ **Barometric Leveling**
- ✓ **Stadia Leveling**

Indirect Leveling Survey

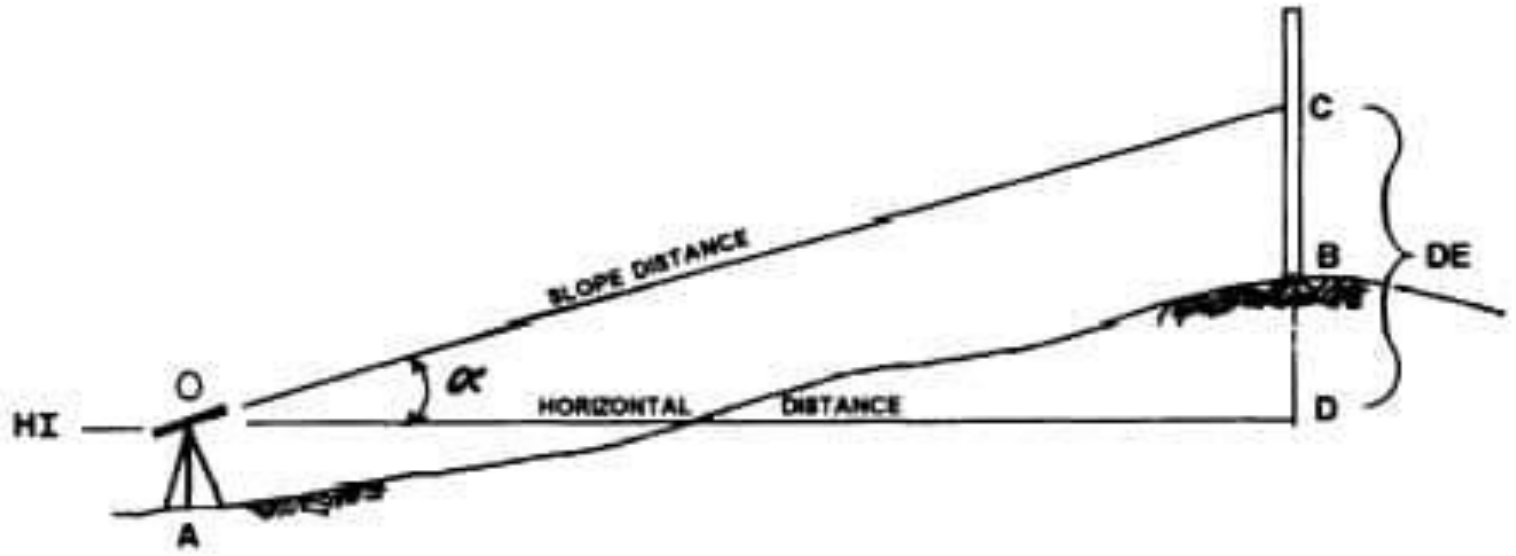
The rarely used method of leveling. The methods are applied based on mathematical equation. In this method, data are called from leveling instrument and measured using various equations. It is also divided into different types based on observation points and instrument positions.

Trigonometric Leveling Survey

The process of leveling in which the elevation of point or the difference between points is measured from the observed horizontal distances and vertical angles in the field is called trigonometric leveling.

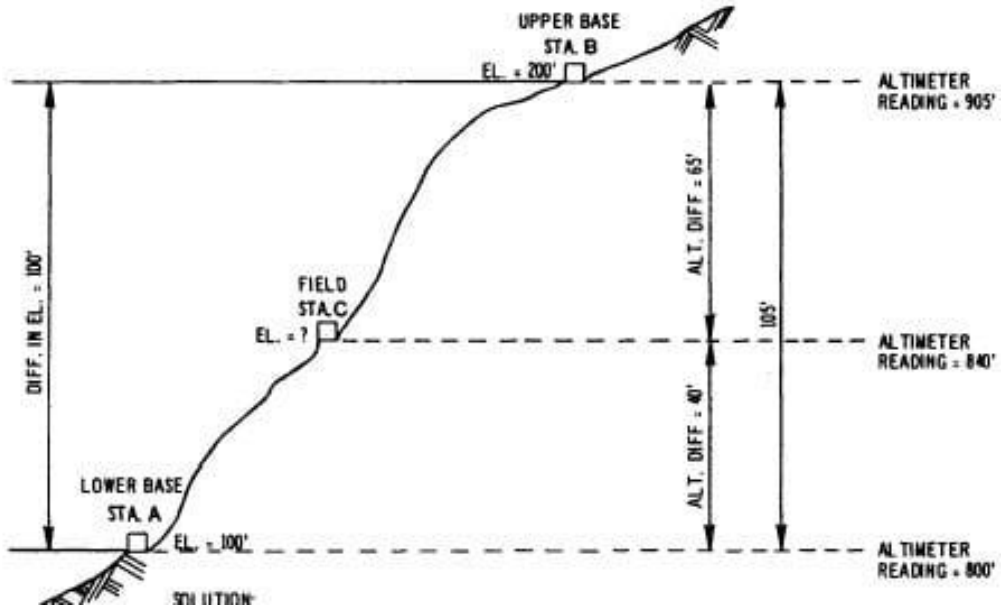
Trigonometric relations are used to find the elevation.

$CD = OC \times \sin\alpha$



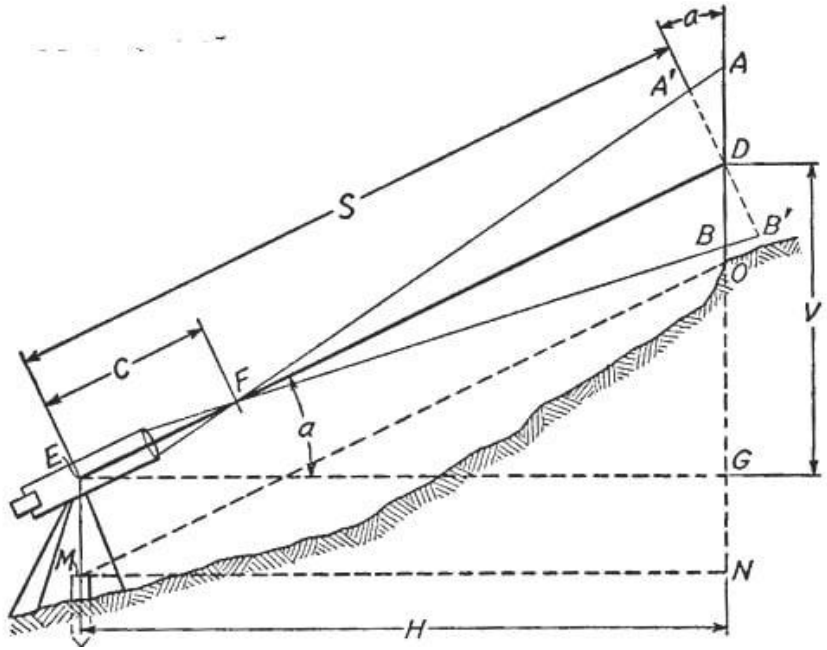
Barometric Leveling Survey

Barometer is an instrument used to measure atmosphere at any altitude. So, in this method, atmospheric pressure at two different points are observed and depending on the observation vertical difference is determined. It is a rough estimation and used rarely.



Stadia Leveling Survey

It is a modified form of trigonometric leveling in which Tacheometer principle is used to determine the elevation of point. In this case, the line of sight is inclined from the horizontal. It is useful in hilly terrains.



Difference between Dumpy and Auto level:

DUMPY LEVEL	AUTO LEVEL
In the dumpy level survey, staff reading need to be adjusted as inverted level staff reading is seen in the eyepiece.	In the auto level, no adjustment for staff reading is required as the actual reading is seen from the eyepiece.
In the dumpy level, to level the bubble, one has to keep bubble parallel to two leveling screws and then right angle to the third screw.	In the auto level, the bubble can be adjusted from any side and any angle with any 3 screws available.
Line of sight is manually adjusted in dumpy level.	The auto level has an internal compensatory machine which automatically adjusts the line of sight.
It difficult to make an accurate measurement with dumpy level.	The measurement accuracy of the auto level is higher than the dumpy level.