General basic of surveying

Surveying

Surveying has been defined as the science, art, and technology of measuring distances, angles, and positions on or near the surface of the earth.

Measurements and Errors القياسات والاخطاء

units of measurement

1. linear measurement units وحدات القياس الخطية

2. angular units of measurement وحدات القياس الزاوية

1- linear measurement units

Two different systems are in use for specifying units of observed

quantities, the metric and English systems.

1.1. Metric system

Because of its widespread adoption, the metric system is called the International System of Units, abbreviated SI.

<u>Length measurements</u>

- The basic unit employed for length measurements in the metric or SI system is the meter.

- Subdivisions of the meter (m) are the millimeter (mm), centimeter cm), and decimeter (dm).

1 meter (m)= 1000 millimeter (mm)=100 centimeter (cm)
1 meter (m)= 10 decimeter (dm)= 10^{-3} kilometer (km)

kilometer (km) = 1000 m.

Area measurements

- Areas in the metric system are specified using the square meter (m^2).
- Large areas are given in hectares (ha)

1 ha = 10,000 m^2

Dunam = 2500 m^2 = 0.25 ha

Volume measurements

The cubic meter (m3) is used for volumes in the SI system.

1.2English system

- The basic unit employed for length measurements in the English system is the foot.
- (mile, ft, inch)

1 foot (ft)(′)= 12 inch(in)(″) = 1/3 yard(yd)
1 mile (mil)= 5280 ft
1 inch = 2.54 centimeters (basis of international foot)
1 foot = 0.3048 m (basis of international foot)

Example

1- Convert the following distances (4129.574 m) given in meters to feet
2- Convert the following distances (537.52 ft) given in feet to meters:

Sol/ 1-13548.47 ft 2-163.836 m

- In the English system, areas are given in square feet or square yards. Large areas are given in acre.

Acre = 4840 yd^2 = 43560 ft^2

- Volumes in the English system can be given in cubic feet or cubic yards.

2- Angular units of measurement وحدات القياس الزاوية

There are three systems used for angles, namely the sexagesimal, the centesimal and radians.

2.1 Sexagesimal system (degree (°))

- subdivide a circle into 360°(degree). One degree (1°) equals 60' (min), and one min (1') equals 60" (sec).
- 1°=60'
- 1'=60"

For example

45°30'20"

2.2Centesimal system (grad (g))

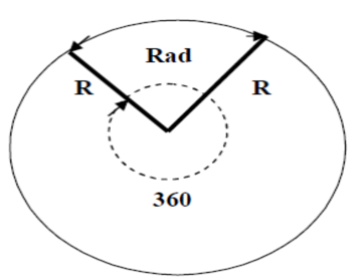
- subdivide a circle into 400 grads
- 1g=100 centigrade (cg)
- 1cg=100 cent centigrade (ccg)

For example

$82^{g}46^{cg}91^{ccg}$

2.3 Radians system (rad)

the angle subtended at the center of a circle by an arc of a length equal to the radius of the circle



Note

1- Degrees, minutes, and seconds, or the radian, are accepted for angles.

2- 2π rad=360° = 400 g

Relation between sexagesimal and radians system

1 rad= 180°/π

- To transform radians to degrees, multiply by 180°/ π

$$\text{angle (degree)}= \frac{180^{\circ}}{\pi} * \text{angle (rad)}$$

- To transform degrees to radians, multiply by π/180°

$$\text{angle (rad)}= \frac{\pi}{180^{\circ}} * \text{angle (degree)}$$

Relation between Centesimal and radians system

- To transform degrees to grad, multiply by 400/360

$$\text{angle (grad)}= \frac{400}{360} * \text{angle (degree)}$$

- To transform grad to degrees, multiply by 360/400

$$\text{angle (degree)}= \frac{360}{400} * \text{angle (grad)}$$

Example 1

1- An angle of 2.053 rad. Convert this angle to degree

$$\text{angle (degree)}= \frac{180^{\circ}}{\pi} * \text{angle (rad)}$$

$$\text{angle (degree)}= \frac{180^{\circ}}{\pi} * 2.053 = 117.628^{\circ} = 117^{\circ}37'41''$$

0.628*60=37.68'

0.68*60=40.8"=41"

2- An angle of $12^{\circ}15'26''$. Convert this angle to radian.

$$\text{angle (rad)}= \frac{\pi}{180^{\circ}} * \text{angle (degree)}$$

$$rad = \frac{\pi}{180}(12 + \frac{15}{60} + \frac{26}{3600})$$

3- An angle of 142°22′15". Convert this angle to centesimal and radians system

$$\left(\frac{15}{60} + 22\right) = 22.25'$$

$$\left(\frac{22.25'}{60} + 142\right) = 142.3708°$$

$$\text{angle (rad)} = \frac{\pi}{180^\circ} * \text{angle (degree)}$$

$$\text{angle (rad)} = \frac{\pi}{180^\circ} * 142.3708° = 2.48584\, rad$$

$$\text{angle (grad)} = \frac{400}{360} * \text{angle (degree)}$$

$$\text{angle (grad)} = \frac{400}{360} * 142.3708° = 158.18977\, grad$$

Example 2

1- An angle of 324.4625 grad. Convert this angle to Sexagesimal system (degree,minute, second)

$$\text{angle (degree)} = \frac{360}{400} * \text{angle (grad)}$$

$$\text{angle (degree)} = \frac{360}{400} * 324.4625 = 292.01625°$$

$$0.01625 * 60 = 0.975\, min$$

$$0.975 * 60 = 58.5\, sec$$

$$292°00'58.5''$$

Scale

the ratio of the length of a feature on a map to the true length of the feature. Choice of scale depends on the purpose, size, and required precision of the finished map.

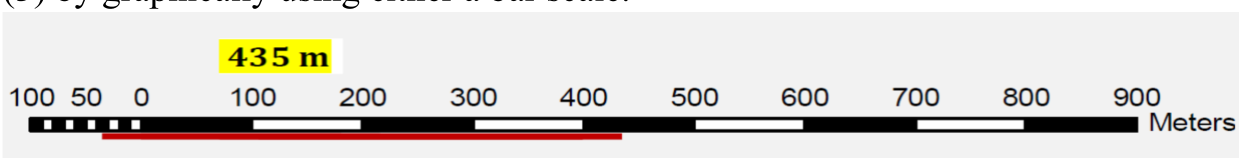
$$\text{Scale} = \frac{\text{Distance on map}}{\text{Distance on ground}}$$

Map scales are given in three ways:

(1) by ratio or representative fraction, such as 1:2000 or 1>2000;

(2) by an equivalence scale, for example, 1 in. = 200 ft; and

(3) by graphically using either a bar scale.



Example 1

if the distance between points a and b on map =25 cm and the distance between points a and b on ground =500 m. what is the map scale?

Solution

$$\text{Scale} = \frac{\text{distance on map}}{\text{distance on ground}} = \frac{25}{500*100} = \frac{1}{\frac{50000}{25}} = \frac{1}{2000}$$

Example 2

A 2500 m^2 land area is drawn with a scale of $\frac{1}{1000}$ what is the area of the land on the map?

بما ان المقياس $\frac{1}{1000}$, فأن 1 سنتيمترا على الخارطة يقابل 10 امتار على الطبيعة و كذلك 1 سم^2

على الخارطة 10X10 100 م^2 على الطبيعة.

area of the land on the map= $\frac{2500}{10*10} = 25\ cm^2$

baneen.mohammed.hilal@uomus.edu.iq

Example 3

The measured distance between two point on the ground is 258 m. what is the distance if want to be drawn on the map with scale of $\frac{1}{2500}$

$$\text{Scale} = \frac{\text{distance on map}}{\text{distance on ground}}$$

$$\frac{1}{2500} = \frac{\text{distance on map}}{258}$$

$$\text{distance on map} = \frac{258}{2500} = 0.1032\ m = 10.32\ cm$$

Errors

Error: is the difference between an observed value for a quantity and its true value:

Error = Measured Value - True Value

E=Xm –Xt

Where

E is the Error in an observation,

Xm the observed value

Xt the true value.

Types of Errors

1- Systematic Errors

2- Random Errors

Sources of Errors

1- Natural Errors

Natural errors are caused by variations in wind, temperature, humidity,atmospheric pressure, atmospheric refraction, gravity, and magnetic declination. An example is a steel tape whose length varies with changes in temperature.

baneen.mohammed.hilal@uomus.edu.iq

2- Instrumental Errors

Instrumental errors result from any imperfection in the construction or adjustment of instruments and from the movement of individual parts.

3- Personal Errors

Personal errors arise principally from limitations of the human senses of sight and touch.

Measurements of Horizontal Distances

Type of measurements

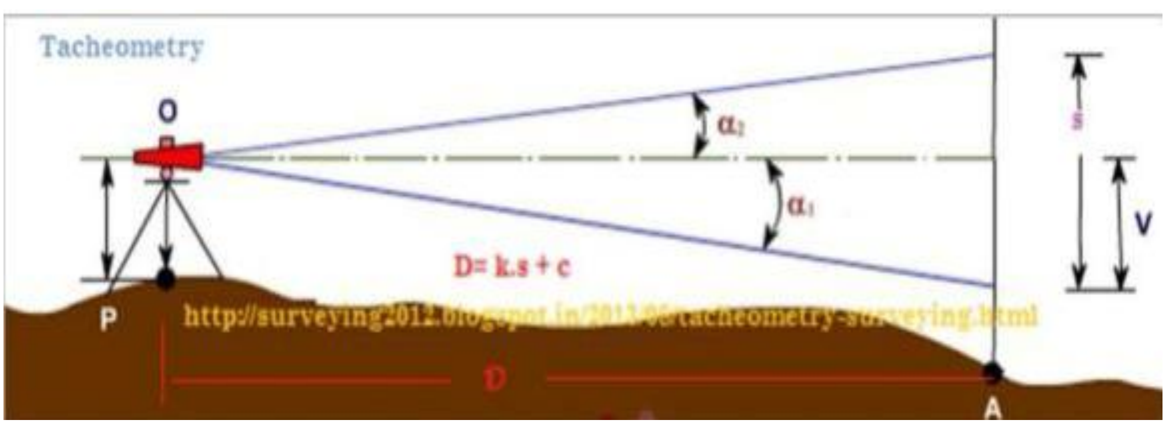
There are two main methods of determining the distance between points

1-Direct Measurements

In this method, distances are actually measured on the surface using measurement instruments. These measurements are used for plane terrain.

2-Indirect Measurements

Calculations are made to measure distances as in tacheometry and triangulation (or chain) surveying. These measurements are used for slope terrain.



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Distance Measurements by Measuring Tape

Types of measuring tape

Depending on materials used, tapes are classified as:

1- Cloth tapes	2- Metallic tape	3- Steel tape
		

Errors in Taping

1- Incorrect tape length

$$\text{total correction } C_d = C_a * \frac{\text{Measured distance (D)}}{\text{nominal tape length } (\text{L}_n)}$$

where

C_a: correction per tape length, m,

C_a =actual tape length (L') -nominal tape length (L_n)

$$\text{Corrected distance } (\bar{D}) = D + C_d$$

baneen.mohammed.hilal@uomus.edu.iq

Example A distance of 220.450 m was measured with a steel band of nominal length 30 m. On standardization the tape was found to be 30.003 m. Calculate the correct measured distance, assuming the error is evenly distributed throughout the tape.

$$C_a = \text{actual tape length } (L') - \text{nominal tape length } (L_n)$$

$$= 30.003 - 30 = 0.003 \text{ m}$$

$$\text{total correction } C_d = C_a * \frac{\text{Measured distance (D)}}{\text{nominal tape length } (L_n)}$$

$$= 0.003 * \frac{220.45}{30} = 0.022 \text{ m}$$

$$\text{Corrected distance } (\bar{D}) = D + C_d$$

$$= 220.45 + 0.022 = 220.472 \text{ m}$$

2- Variation of temperature

Tapes are usually standardized at 20°C. Any variation above or below this value will cause the tape to expand or contract, giving rise to systematic errors.

$$C_t = D\,\alpha\,(T - T_s)$$

where

α: Coefficient of thermal expansion of the material of tape,/°C,
T: Mean temperature during measurement, °C,
T_s: Temperature at which tape is standardized, °C, (20°C)
D: total distance measured, m, and
C_t: total correction due to temperature, m.

$$\text{Corrected distance } (D') = D + C_t$$

baneen.mohammed.hilal@uomus.edu.iq

Example/A 30-m band standardized at 20°C was found to be 30.003 m. At what temperature is the tape exactly 30 m? Coefficient of expansion of steel = 0.000 011/°C?

$$C_t = D\,\alpha\,(T - T_s)$$

$$-0.003 = 30 * 0.000011\,(T - 20)$$

$$T = 11°C$$

3- Variation in tension

if the tension force that is used for pulling the tape is greater than the standard, tension errors exist which can be found by using the following formula:

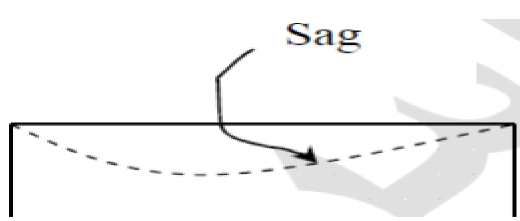
$$C_p = \frac{(P - P_s) * D}{AE}$$

where

E: Young's modulus of the material of tape, N/cm^2,
A: Cross-sectional area of the tape, cm^2,
P: Pull applied during measurement, N,
P_s: Standard pull, N,
D: total distance measured, m, and
C_p: total correction due to pull, m.

$$\text{Corrected distance } (D') = D + C_p$$

4- Sag correction



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$C_g = \frac{1}{24}(\frac{W}{P})^2 L$

w: weight of tape per span length, N,

P: Pull applied during measurement, N,

L: length measured between two support, m, and

C_s: total correction due to sag, m.

- This correction is always negative (-ve).

Corrected distance (D′) = D - C_s

Example. A base line was measured by tape suspended in catenary under a pull of 145 N, the mean temperature being 14°C. The lengths of various segments of the tape and the difference in level of the two ends of a segment are given in Table

Bay/Span	Length (m)	Difference in level (m)
1	29.988	+ 0.346
2	29.895	– 0.214
3	29.838	+ 0.309
4	29.910	– 0.106

If the tape was standardized on the flat under a pull of 95 N at 18°C determine the correct length of the line.

Take Cross-sectional area of the tape = 3.35 mm^2

Mass of the tape = 0.025 kg/m

Coefficient of linear expansion = 0.9 × 10–6 per °C Young 's modulus = 14.8 × 104 MN/m2

Solution:

It is given that

$$P_0 = 95\text{ N},\ P = 145\text{ N}$$
$$t_0 = 18°\text{C},\ t_m = 14°\text{C}$$
$$A = 3.35\text{ mm}^2,\ \alpha = 0.9 \times 10^{-6}\text{ per }°\text{C}$$
$$w = mg = 0.025 \times 9.81\text{ kg/m}$$

$$E = 14.8 \times 10^4\text{ MN/m}^2 = \frac{14.8\times10^4\times10^6}{10^6}\text{ N/mm}^2 = 14.8 \times 10^4\text{ N/mm}^2$$

$$H = 51.76\text{ m},\ R = 6370\text{ km}$$

Total length of the tape L = 29.988 + 29.895 + 29.838 + 29.910 = 119.631 m

Temperature correction

$$c_t = \alpha(t_m - t_0)L$$
$$= 0.9 \times 10^{-6} \times (14 - 18) \times 119.631 = -0.0004\text{ m}$$

Pull correction

$$c_p = \frac{(P - P_0)}{AE}L$$

$$= \frac{(145-95)\times119.631}{3.35\times14.8\times10^4} = 0.0121\text{ m}$$

baneen.mohammed.hilal@uomus.edu.iq

Sag correction

$$c_g = -\frac{1}{24}\left(\frac{W}{P}\right)^2 L$$

$$= -\left[\frac{1}{24}\left(\frac{wl_1}{P}\right)^2 l_1 + \frac{1}{24}\left(\frac{wl_2}{P}\right)^2 l_2 + \frac{1}{24}\left(\frac{wl_3}{P}\right)^2 l_3 + \frac{1}{24}\left(\frac{wl_4}{P}\right)^2 l_4\right]$$

$$= -\frac{w^2}{24P^2}\left(l_1^3 + l_2^3 + l_3^3 + l_4^3\right)$$

$$= -\frac{(0.025\times 9.81)^2}{24\times 145^2}\left(29.988^3 + 29.895^3 + 29.838^3 + 29.910^3\right)$$

$$= -\ 0.0128\ \text{m}$$

baneen.mohammed.hilal@uomus.edu.iq

Leveling

Leveling is the most widely used method for obtaining the elevations of ground points or their differences in elevation relative to a reference datum.

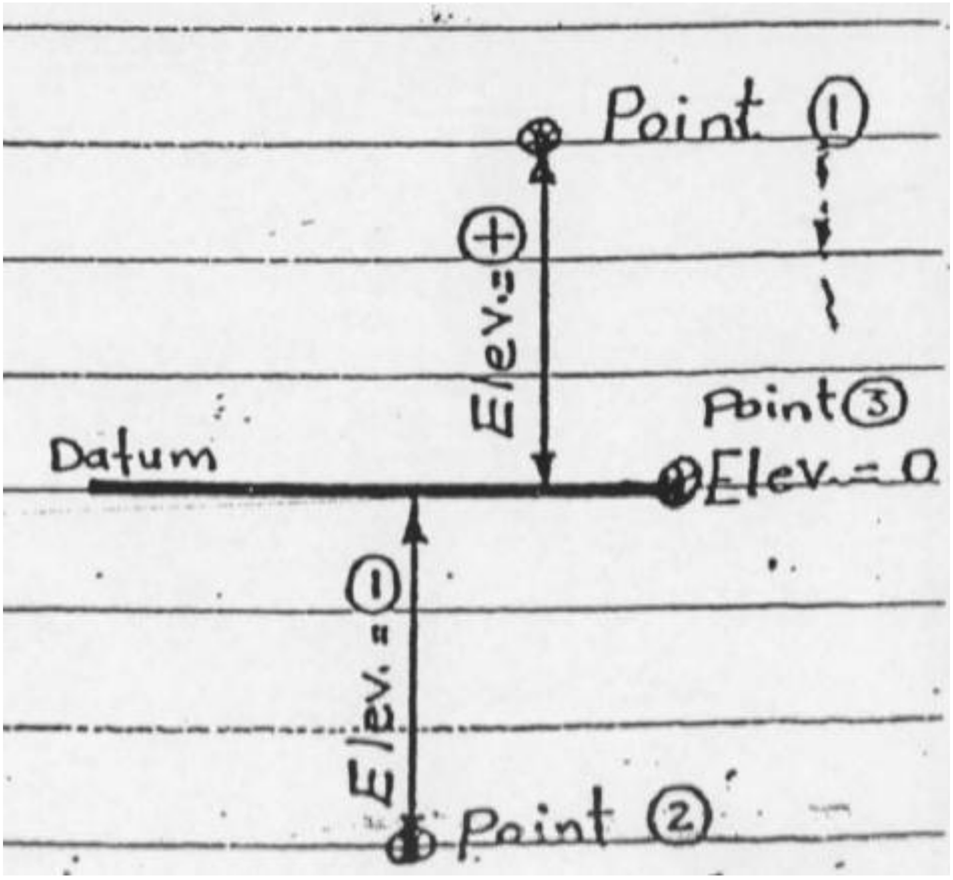
Basic variable in leveling

1- Datum

A datum is any reference surface to which the elevations of points are referred. The most commonly used datum is that of mean sea level (MSL).

2- Elevation

The distance measured along a vertical line from a vertical datum to a point or object.



3- Benchmark (B.M)

A fixed reference point or object, the elevation of which is known.

Level

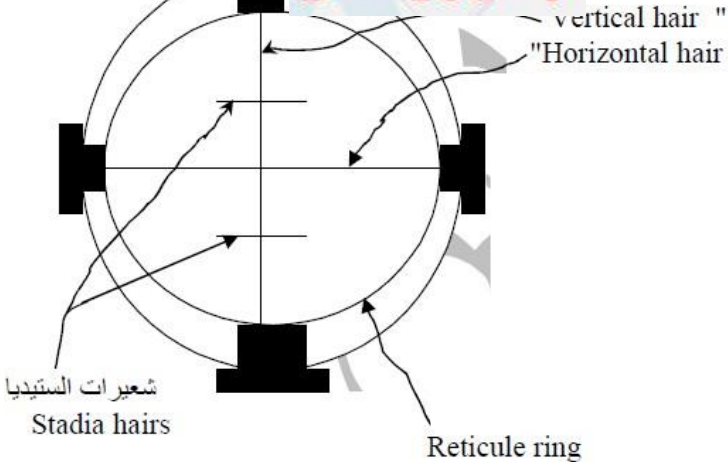
Rod (staff)

BasicComponents

1- Telescope

- objective lens
- eye piece lens
- Focusing lens
- Cross – hairs The stadia method determines the horizontal distance to points through the use of readings on the upper and lower (stadia)wires on the reticle.

$$D = 100 * I$$

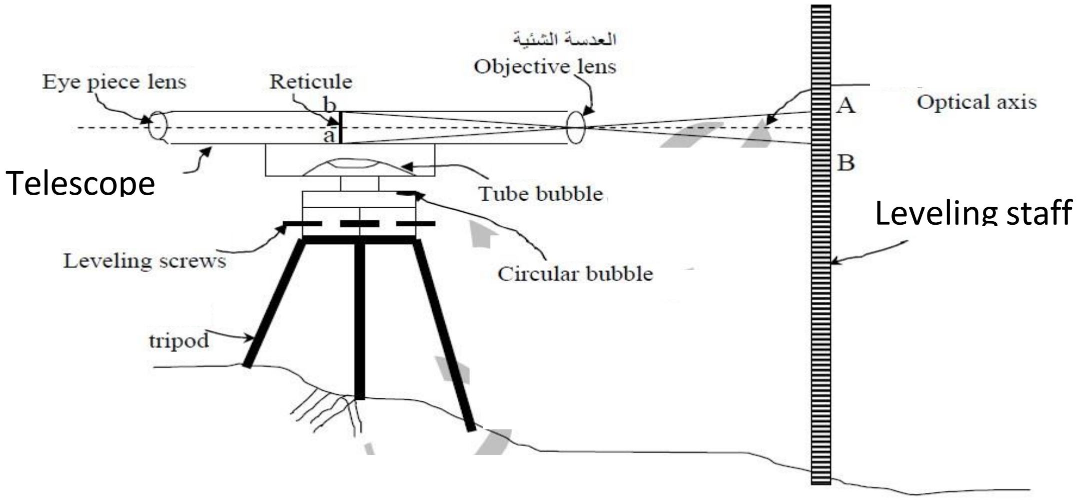


Where D is the distance from instrument to rod,and I is the stadia interval (upper minus lower rod reading)

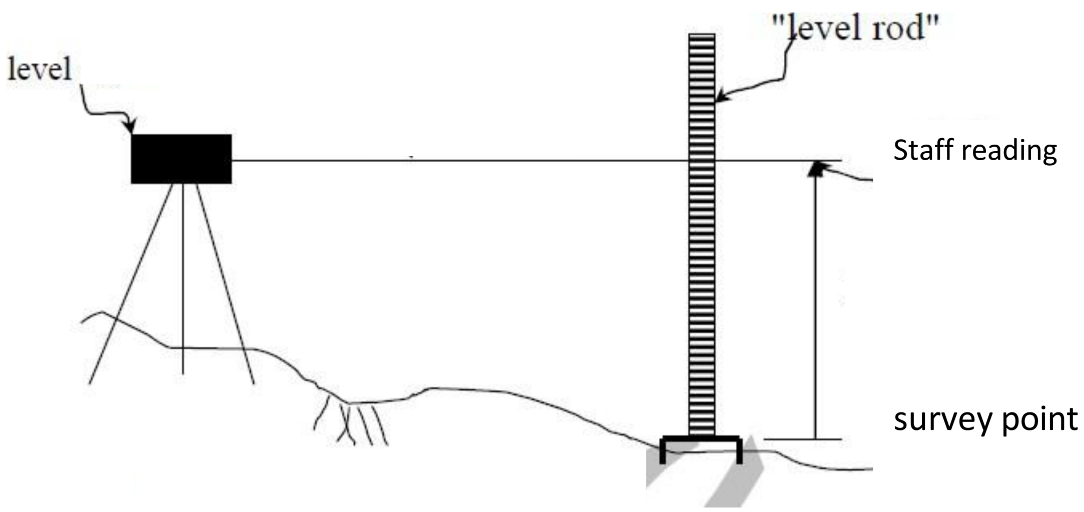
2-Circular bubble

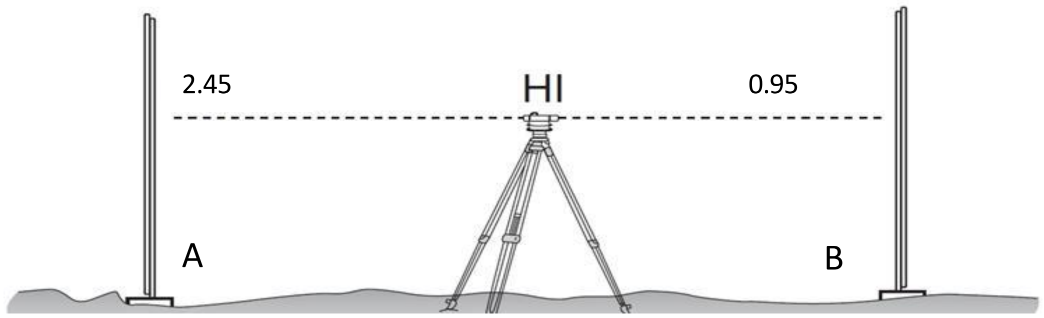
3-leveling screws

4-Tripod



Staff reading
The vertical distance from a survey point to the line of sight of the telescope.





1- Back sight reading (B.S)

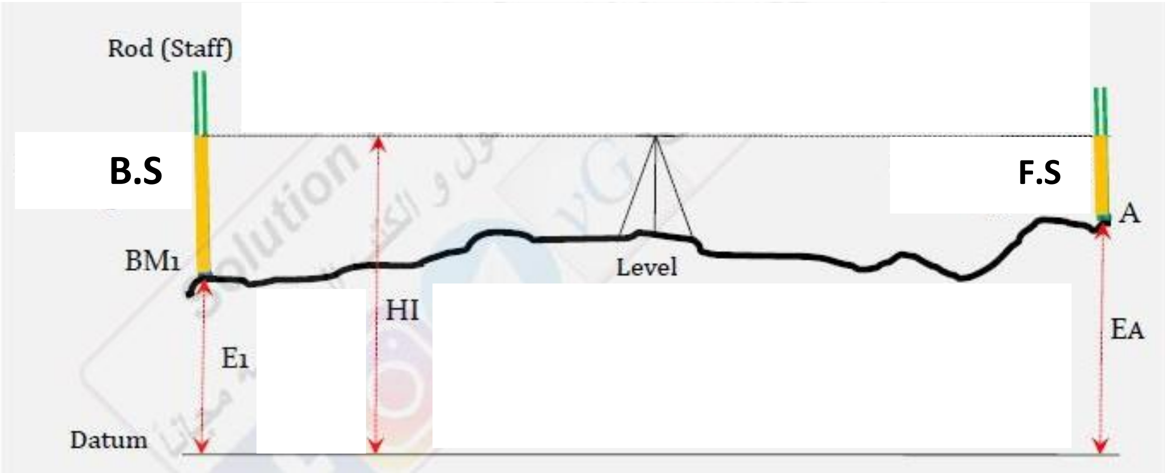
It is the sight taken on a level staff held on the point of known elevation. It is always the first staff reading after the instrument is set in a place.

2- Foresight reading (F.S)

It is the last staff reading taken from a setting of the level.

3- Intermediate sight reading (I.S)

It is any other staff reading taken from the setting of the level between the backsight reading and foresight reading



Turning point (T.P)

a point on which both fore sights and back sights are taken. After taking fore sight on this point instrument is set at another point and back sight is taken on the staff held at the same point.

Height of instrument (H.I)

The height of the line of sight of the telescope above a station or control point.

Differential leveling

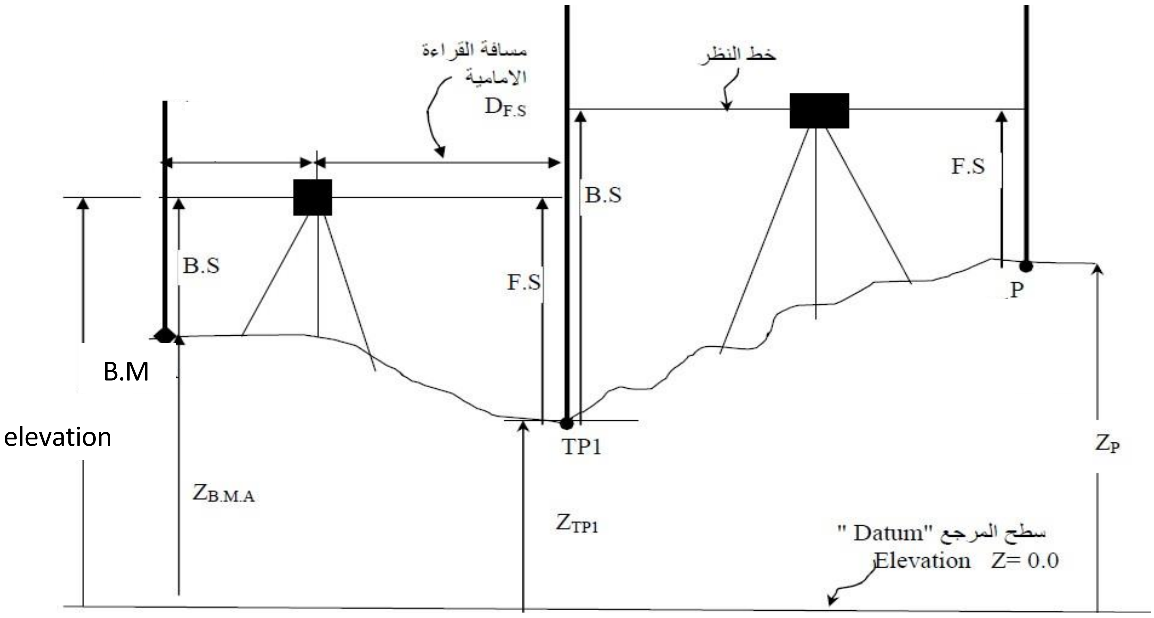
Methods of Computation

The following methods are adopted :-

1. Height of Instrument method

2. Rise and Fall method

1. Height of Instrument method



$$H.I_1 = Elevation\ (B.M)+B.S\ 1$$

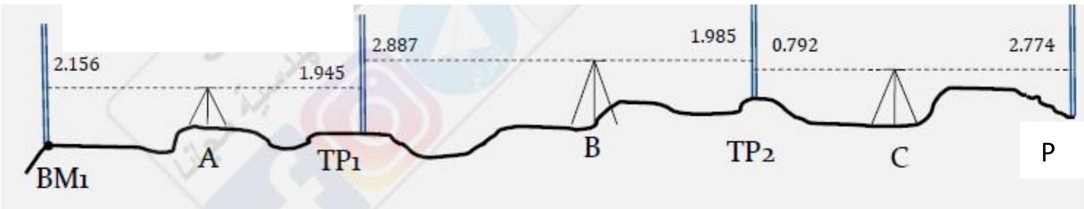
$$Elevation\ (T.P)=H.I_1-F.S_1$$

$$H.I_2 = Elevation\ (T.P)+B.S\ 2$$

$$Elevation\ (P)=H.I_2-F.S_2$$

Example

Find the elevation of all points by height of instrument method if the elevation of B.M is equal to 50.733



Solution

Station	B.S	H.I	F.S	Elev.
B.M	2.156			50.733
T.P 1	2.887		1.945	
T.P 2	0.792		1.985	
P			2.774	

Station	B.S	H.I	F.S	Elev.
B.M	2.156	52.889		50.733
T.P 1	2.887	53.831	1.945	50.944
T.P 2	0.792	52.638	1.985	51.846
P			2.774	49.864

$$\sum B.S - \sum F.S = Elev\ (p) - Elev\ (B.M)$$

$$(2.156 + 2.887 + 0.792) - (1.945 + 1.985 + 2.774) = 49.864 - 50.733$$

-0.869=-0.869