Al-Mansour University College

قسم الهندسة المدنية

Civil Eng. Dept.

المرحلة الثانية

2nd. Stage

Surveying

2022 - 2023

Lec.2

المساحة

Al-Mansour University College
Civil Engineering Department
Second Year/ 2015-2016

SURVEYING
CHAPTER- 3 / CHAIN SURVEYING

Asst. Lect. Ahmed Layth

Chain Surveying

Chain surveying or triangulation is a method of land surveying.

In chain surveying, only linear distances are measured, i.e. no angular measurements made.

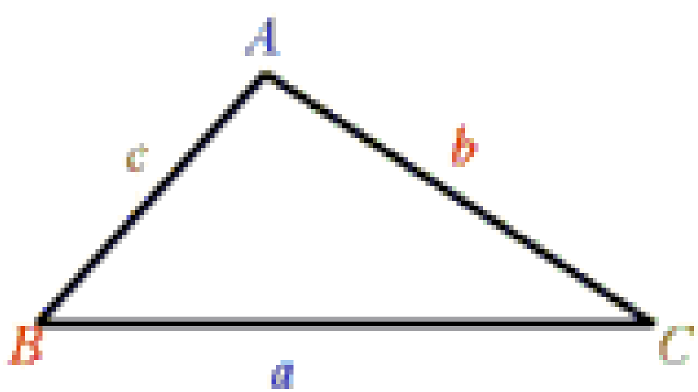
Angles less than 30° or larger than 120° always be avoided. Angles can be calculated using:

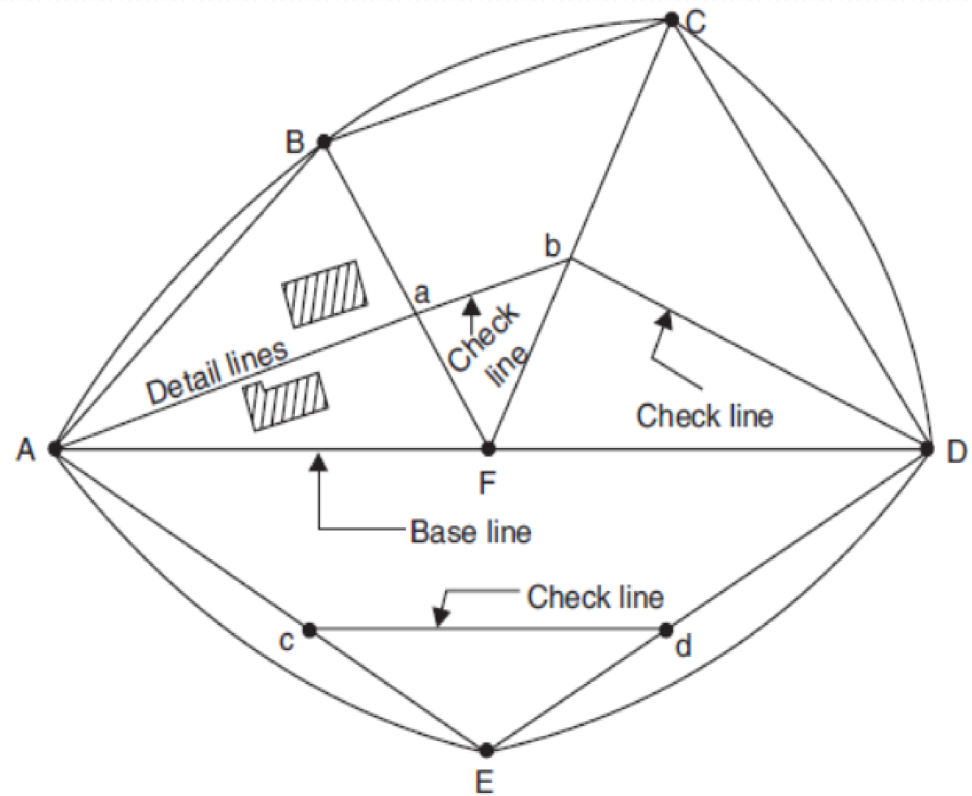
Cosine law:

$$a^2 = b^2 + c^2 - 2bc\cos(A)$$

Sine law:

$$\frac{\sin(A)}{a} = \frac{\sin(B)}{b} = \frac{\sin(c)}{c}$$





Network of triangles

Chain surveying is applicable if:

i. Area to be surveyed is relatively small.

ii. G l.

iii. Area is open.

iv. Details to be filled up are simple and less.

Obstacles in Chaining:

i. Obstacle to ranging.

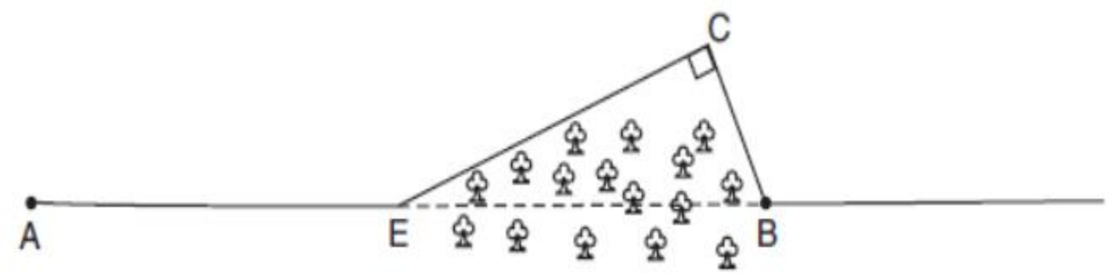
ii. Obstacle to chaining.

iii. Obstacle to both ranging and chaining.

i. <u>Obstacle to ranging:</u>

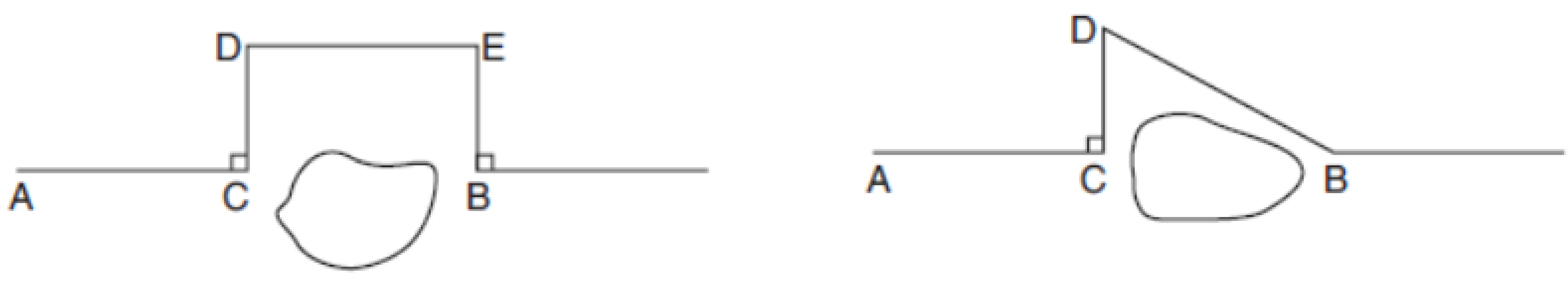
Chaining free; vision obstructed such as trees and bushes.

$$EB = \sqrt{EC^2 + CB^2}$$



ii. _

Chaining obstructed; vision free such as ponds and lakes.



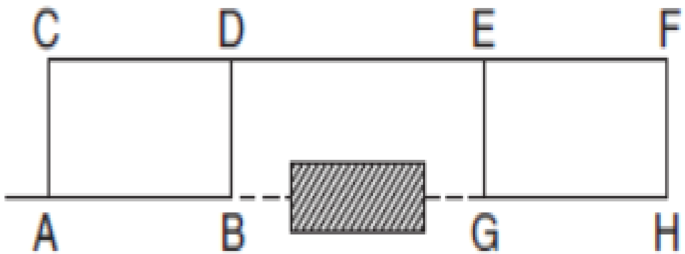
a) Set CD and BE perpendicular to AB so that CD = BE.

b) Set CD perpendicular to AB. Measure CD and DB. Then

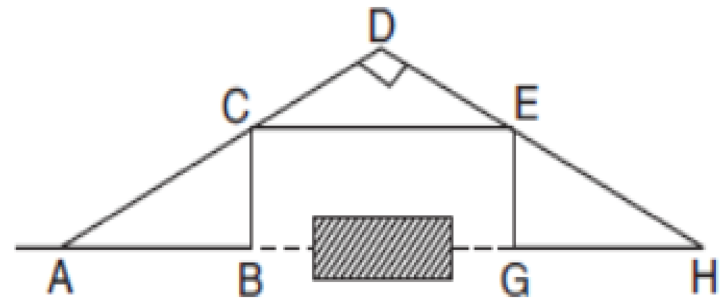
$$CB = \sqrt{BD^2 - CD^2}$$

iii. Obstacle to both ranging and chaining:

Chaining obstructed; vision obstructed. Building is a typical obstacle of this type.



(a)



(b)

a) Set AC and BD perpendicular to AB so that AC = BD. Extend line = BG.

b) Set BC ⊥ to AB. Select D on extended line of AC. Set perpendicular DH so that AD = DH. Select point E on DH so that DE = DC. Then EG = BC and HG = AB. GH is continuation of AB and BG = CE.

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SURVEYING
CHAPTER- 4 / LEVELS AND LEVELING

Asst. Lect. Ahmed Layth

Levels and Leveling

Leveling is the most widely used method for obtaining the elevations of ground points relative to a reference datum.

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

Mean Sea Level (MSL): is the average height of the sea for all stag

Leveling involves the measurement of vertical distance relative to a horizontal line of sight. Hence it requires a graduated staff for the vertical measurements and an instrument that will provide a horizontal line of sight.

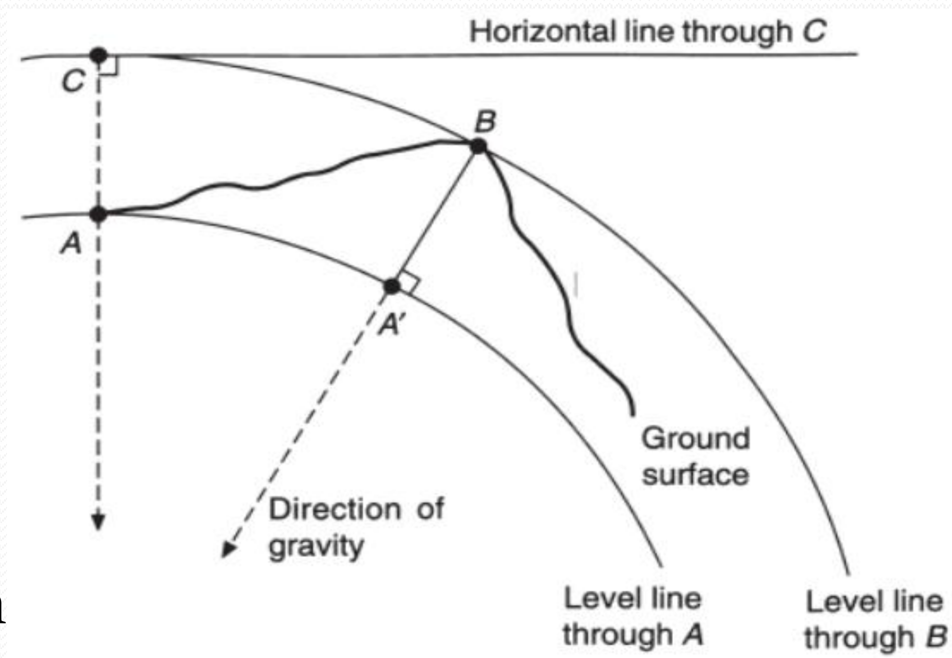
Principles of Leveling

Level Line or Level Surface: is one which at all points is normal to the direction of the force of gravity as defined by a freely suspended plumb-bob.

Vertical Line: A vertical line at a point is the line connecting the po nd *B* is the distance *A'B*,

provided that the non-parallelism of level surfaces is ignored.

Horizontal Line or Surface: is one that is normal to the direction of the force of gravity at a particular point shows a horizontal line through point *C*.



METHODS OF LEVELING

1. **<u>Hydrostatic Leveling:</u>**

It is suitable for measurements in buildings. The hydrostatic leveling works on the principle of communicating vessels: are associated

2. **<u>Direct Leveling:</u>**

In this method, horizontal sight is taken on a graduated staff and the difference in elevation between line of sight and ground at which staff is held can be calculated.

3. **<u>Indirect Leveling:</u>**

instruments such as theodolite and total station are used to measure the vertical angles. Then using trigonometric relations to calculate difference sin elevation, thus, it is called trigonometric leveling.

TERMS USED IN DIRECT METHOD OF LEVELLING

Back Sight (BS): It is the sight taken on a level staff held on the point of known elevation. It is always the first reading after the instrument is set in a place.

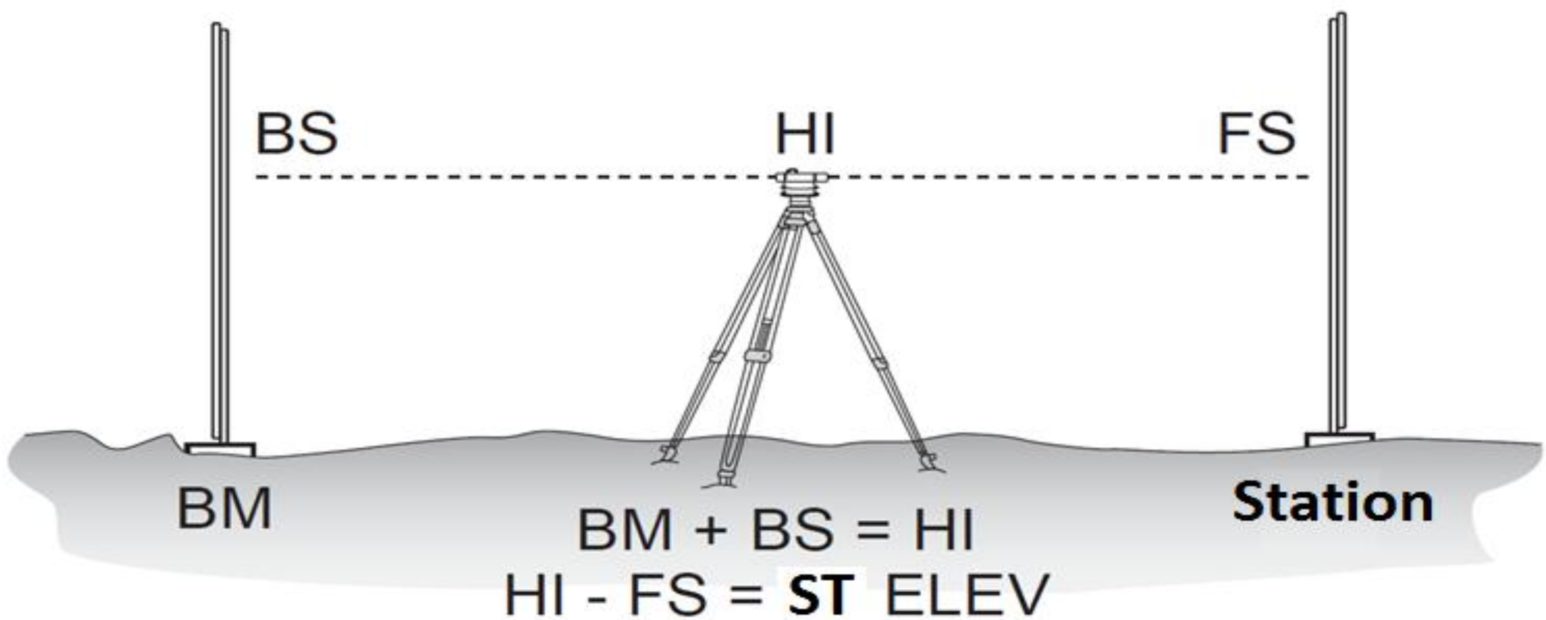
Fore Sight (FS): This is the last reading taken from the instrument station before shifting it or just before ending the work.

Intermediate Sight (IS): it is any other staff reading taken from the setting of the level between the back sight and fore sight.

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

Station: the point whose elevation is to be found out. It is the place where the staff is held in position. The point at which the level is set up is not a station.

Height of Instrument(H.I. trument is set at another point and back sight is taken on the staff held at the same point.



Methods of Computation

1. **<u>Height of Instrument:</u>**

HI = Elev. of BM + BS reading

Elev. of station = HI – (FS or IS) reading

2. **<u>Rise and Fall:</u>**

$$\Delta H = BS - (FS\ or\ IS)$$

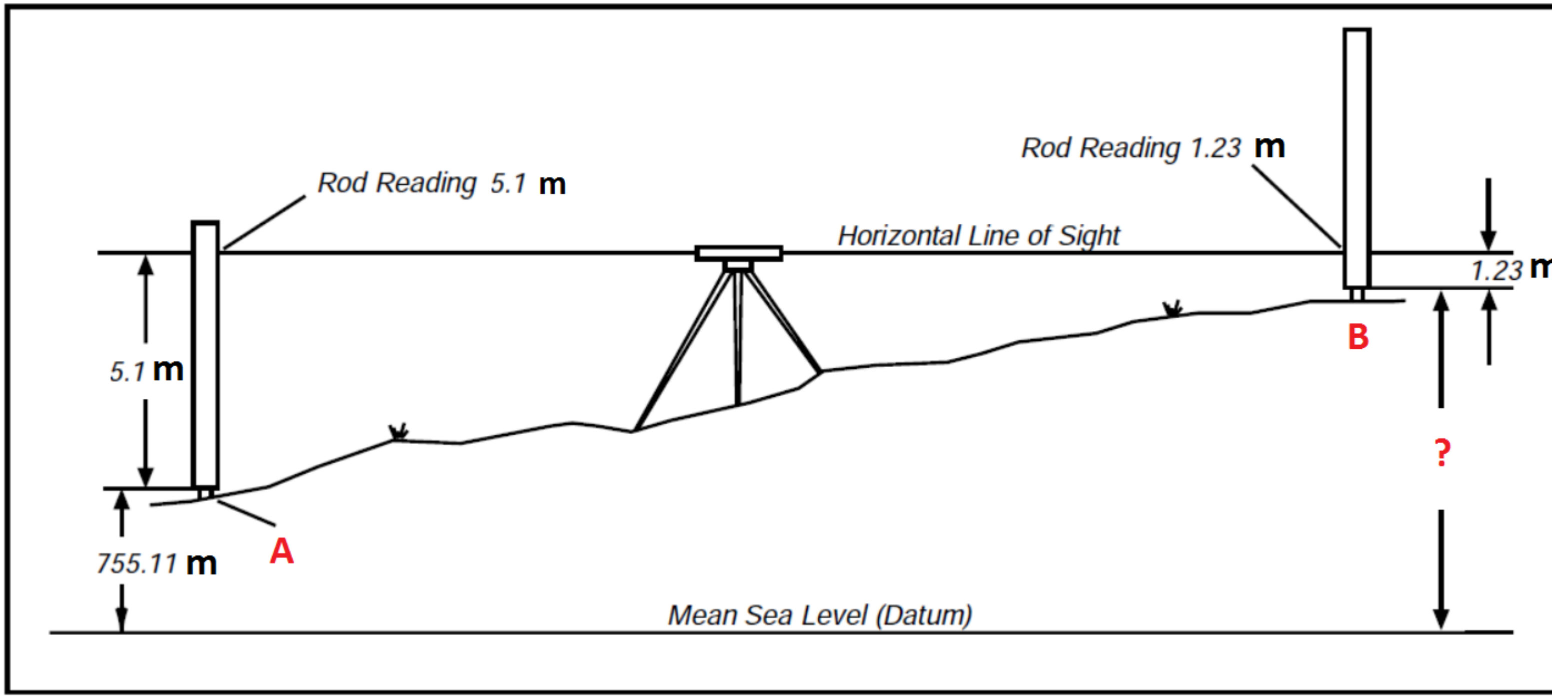
If ΔH is (+) then called Rise (R)

If ΔH is (-) then called fall (F)

$$Elev.of\ station = Last\ elev. \pm (R\ or\ F)$$

Example (1)

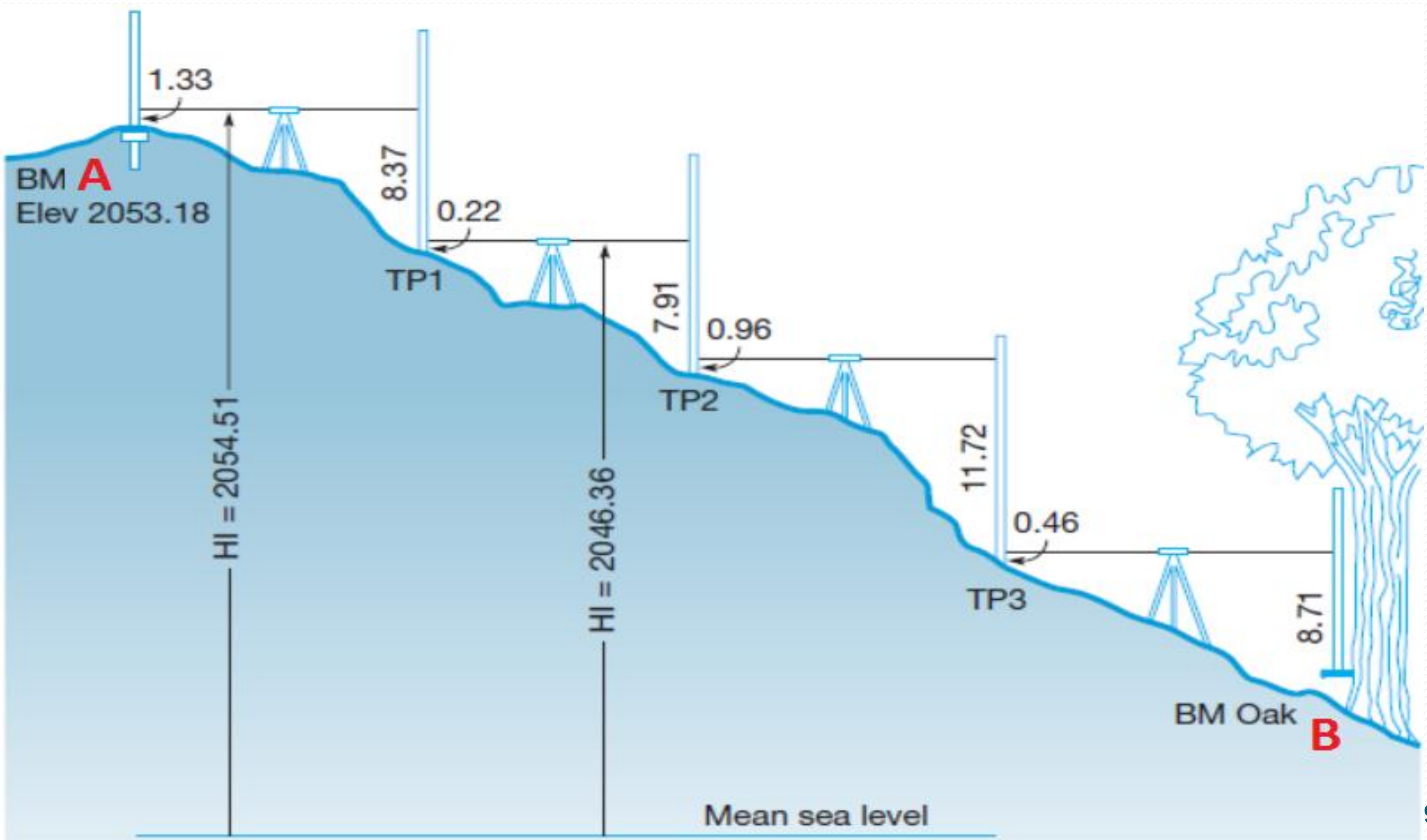
For a given figure below, find the elevation of point B.



Sol:

Height of Instrument Method	Rise and Fall Method
H.I = elev. (A) + BS = 755.11+5.1 FS = 760.21 – 1.23 = 758.98 m	ΔH = BS – FS (A) + R = 755.11 + 3.87= 758.98 m

Example (2) oth height of instrument and rise and fall methods and check the results (All dimensions are in foot).



1. **Height of Instrument Method:**

Station	BS	FS	HI	Elevation	Remarks
A	1.33		2054.51	2053.18	BM
B	0.22	8.37	2046.36	2046.14	TP1
C	0.96	7.91	2039.41	2038.45	TP2
D	0.46	11.72	2028.15	2027.69	TP3
E		8.71		2019.44	BM
Sum	2.97	36.71			

$\sum BS - \sum FS$ = Last Elev. – First Elev. = -33.74 m

2. **Rise and Fall Method:**

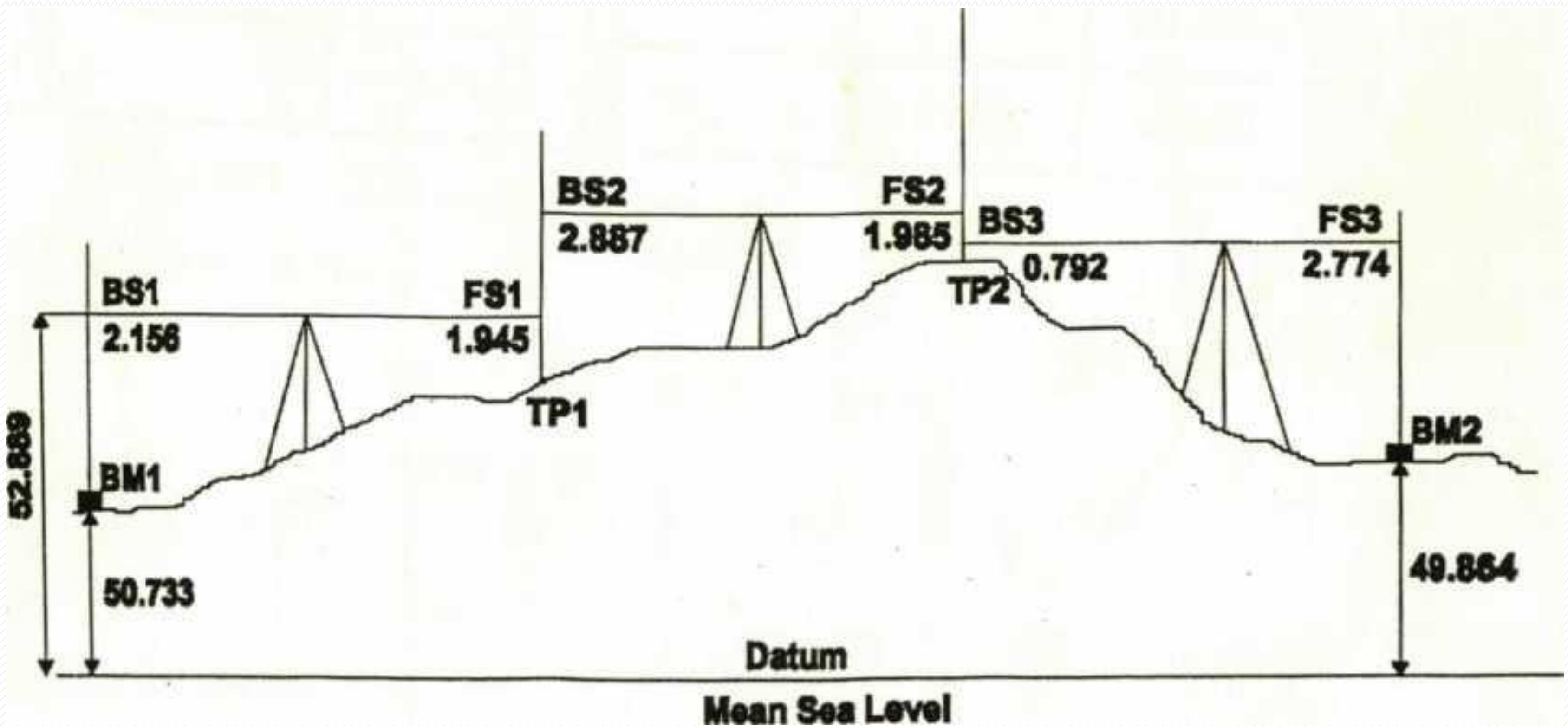
Station	BS	FS	R	F	Elevation	Remarks
A	1.33			7.04	50.733	BM
B	0.22	8.37		7.69	43.693	TP1
C	0.96	7.91		10.76	36.003	TP2
D	0.46	11.72		8.25	25.243	TP3
		8.71		0	16.993	BM
Sum	2.97	36.71		33.74		

$\sum BS - \sum FS = \sum R - \sum F$ = Last Elev. – First Elev. = -33.74 m

Example (3)

In a construction of housing complex project, the following set of reading was obtained: 2.156, 1.945, 2.887, 1.985, 0.792, and 2.774. The first reading was taken on a bench mark of 52.889 m elevation and the instrument was shifted after each two readings, compute the elevation of last reading which is nearby the project and fixed as BM using both HI and R&F methods and check the results.

Solution: Draw the sketch as follows:



1. **Height of Instrument Method:**

Station	BS	FS	HI	Elevation	Remarks
A	2.156		52.889	50.733	BM
B	2.887	1.945	53.831	50.944	TP1
C	0.792	1.985	52.638	51.846	TP2
D		2.774		49.864	BM
Sum	5.835	6.704			

$\sum BS - \sum FS$ = Last Elev. – First Elev. = - 0.869m

2. **Rise and Fall Method:**

Station	BS	FS	R	F	Elevation	Remarks
A	2.156		0.211		50.733	BM
B	2.887	1.945	0.902		50.944	TP1
C	0.792	1.985		1.982	51.846	TP2
D		2.774			49.864	BM
Sum	5.835	6.704	1.113	1.982		

$\sum BS - \sum FS = \sum R - \sum F$ = Last Elev. – First Elev. = - 0.869m

Example (4)

In a construction of railway, the following set of readings was obtained: 2.5, 1.0, 1.5, 1.8, 2.3, 2.9, 1.3, 3.2, 2.8, 2.0, and 1.5. The instrument was shifted after the fourth and seventh reading. The last reading was taken on a BM of elevation 253.40 m. Find the elevation of all points by both height of instrument and rise & fall methods.

Solution: Draw a sketch:

$\sum BS - \sum FS$ = Last Elev. – First Elev.

$8.0 - 4.6 = 253.4 - 1^{st}$ Elev.

1^{st} Elev. = 250.0 m

1. Height of Instrument Method:

Station	BS	IS	FS	HI	Elevation	Remarks
1	2.5			252.5	250.0	
2		1.0			251.5	
3		1.5			251.0	
4	2.3		1.8	253.0	250.7	T.P1
5		2.9			250.1	
6	3.2		1.3	254.9	251.7	T.P2
7		2.8			252.1	
8		2.0			252.9	
9			1.5		253.4	BM

2. Rise and Fall Method:

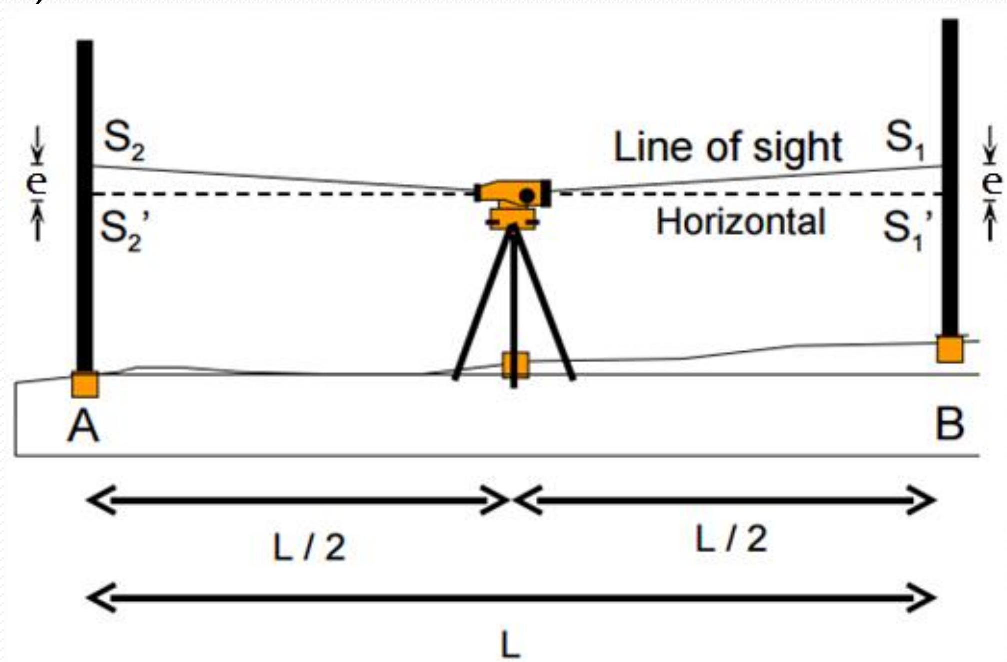
Station	BS	IS	FS	R	F	Elevation	Remarks
1	2.5					250.0	
2		1.0		1.5		251.5	
3		1.5			0.5	251.0	
4	2.3		1.8		0.3	250.7	T.P1
5		2.9			0.6	250.1	
6	3.2		1.3	1.6		251.7	T.P2
7		2.8		0.4		252.1	
8		2.0		0.8		252.9	
9			1.5	0.5		253.4	BM

Collimation Error

Surveying equipment receives continuous and often brutal use on construction sites. Therefore, it should be frequently tested and, if necessary, adjusted.

Collimation error occurs if the line of sight is not truly horizontal when the tubular bubble is centered, i.e. the line of sight is inclined up or down from the horizontal.

A check, known as two-peg test, is used to find this error as it was done in Surveying LAB- 5.



For instrument set up midway between two pegs *A* and *B*:

$$S'_1 = S_1 - e \quad ; \quad S'_2 = S_2 - e$$

$$\Delta H = S'_1 - S'_2$$

$$\Delta H = S_1 - e - (S_2 - e)$$

$$\Delta H = S_1 - S_2 \;\ldots\ldots (1)$$

Since the instrument is at the same distance from both two points, error, e, is equal and cancel out.

For instrument set up at C and in the line of *AB:*

$\Delta H = S'_3 - S'_4 \quad \rightarrow\rightarrow\rightarrow \quad S'_3 = S_3 - e_1 \quad ; \quad S'_4 = S_4 - e_2$

$\Delta H = S_3 - e_1 - (S_4 - e_2) = S_3 - d\, tan\alpha - S_4 + (d + L)\, tan\alpha$

$\Delta H = S_3 - S_4 + L\, tan\alpha \ldots\ldots (2)$

<u>Sub (1) into (2):</u>

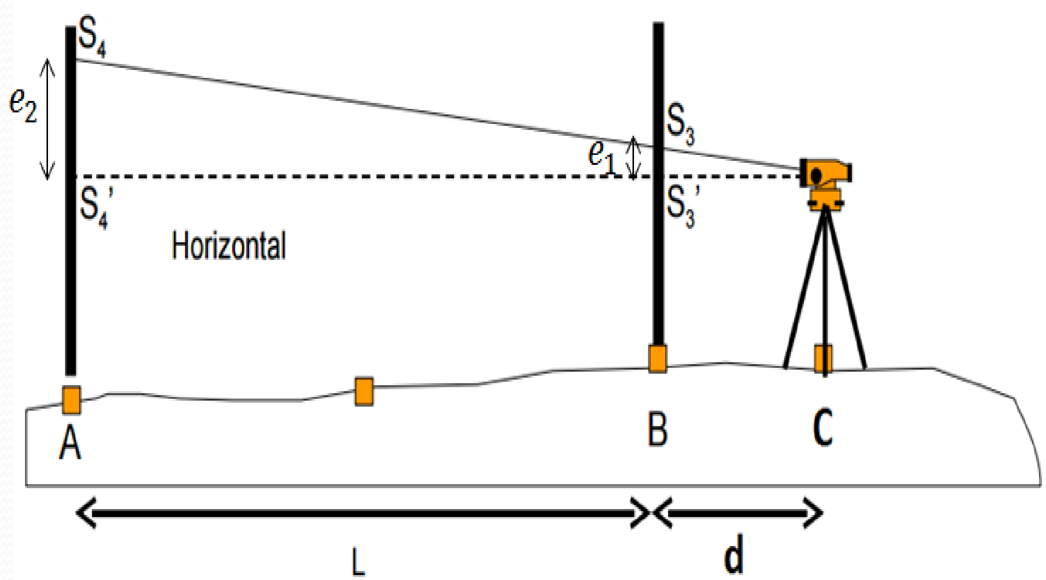
$S_1 - S_2 = S_3 - S_4 + L\, tan\alpha$

$(S_1 - S_2) - (S_3 - S_4) = L\, tan\alpha$

$$tan\alpha = \frac{(S_1 - S_2) - (S_3 - S_4)}{L}$$

$tan\alpha = e$

e is in mm/m

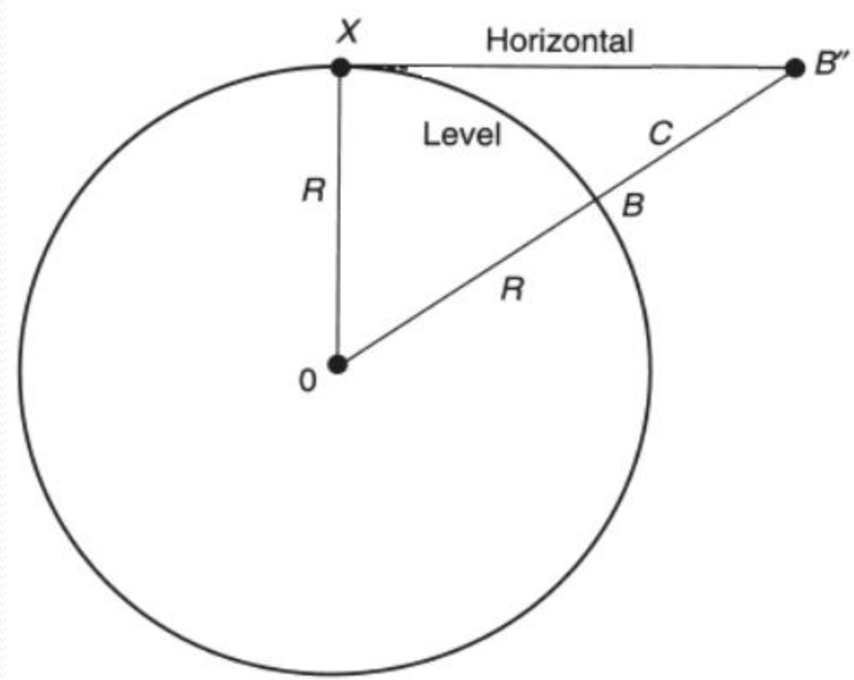


If (e) is (+); line of sight is down, vise versa.

Curvature Correction

The earth is being spheroid. Observations cannot be taken along this curved surface. A level generates a horizontal surface.

The line of sight is horizontal line (XB”) and level surface is defined as curvature correction.



$(R + C)^2 = D^2 + R^2$

$R^2 + 2RC + C^2 = D^2 + R^2$

$D^2 = 2RC + C^2$

As C is very small compared with R, C^2 may be ignored.

$$C = \frac{D^2}{2R} = \frac{D^2}{2 * 6370\ km} * 1000$$

$$C_{curv.} = 0.0785\ D^2$$

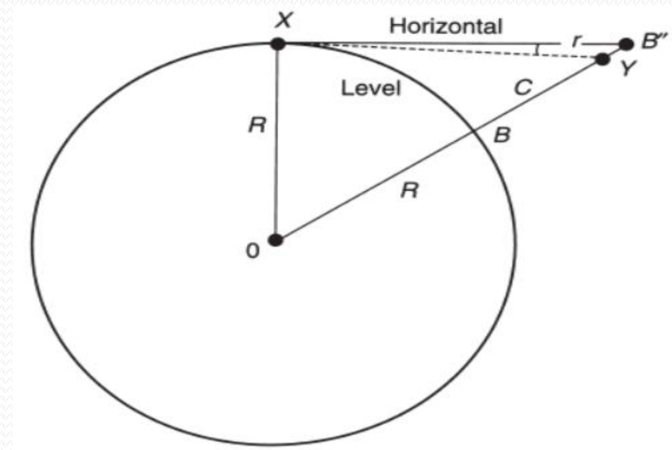
where;

$C_{curv.}$: *correction due to curvature, m*, and

D: distance, km.

Refraction Correction

In practice the staff reading would not be at B'' but at Y due to refraction of the line of sight through the atmosphere. In general it is considered that the effect is to bend the line of sight down reducing the effect of curvature by 1/7th. Thus the combined effect of curvature and refraction is as follows:



$$C_{\text{combined}} = C_{\text{curv.}} - C_{\text{Ref.}}$$

$$C_{\text{combined}} = C_{\text{curv.}} - \frac{1}{7}\, C_{\text{curv.}}$$

$$C_{\text{combined}} = 0.0785\, D^2 - \frac{1}{7} * 0.078\, D^2$$

$$\boxed{C_{\text{combined}} = 0.0673\, D^2}$$

$$\text{Corrected Staff Reading} = \text{Staff reading} - C_{\text{curv.}} + C_{\text{Ref.}}$$

$$= \text{Staff reading} - C_{\text{combined}}$$ → **Why?**

Example (5)

Calculate the error due to curvature and refraction for the following distances: a) 10m, b) 122m, c) 500m, and d) 1000m. Discuss your results.

$$C_{\text{combined}} = 0.0673\, D^2$$

a) $C_{\text{combined}} = 0.0673\, m * \left(\frac{10}{1000}\right)^2 * 1000 \frac{mm}{m} = 0.006\, mm$

b) $C_{\text{combined}} = 0.0673\, m * \left(\frac{122}{1000}\right)^2 * 1000 \frac{mm}{m} = 1\, mm$

c) $C_{\text{combined}} = 0.0673\, m * \left(\frac{500}{1000}\right)^2 * 1000 \frac{mm}{m} = 17\, mm$

d) $C_{\text{combined}} = 0.0673\, m * \left(\frac{1000}{1000}\right)^2 * 1000 \frac{mm}{m} = 67\, mm$

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SURVEYING
CHAPTER- 4 / PROFILE LEVELING-1

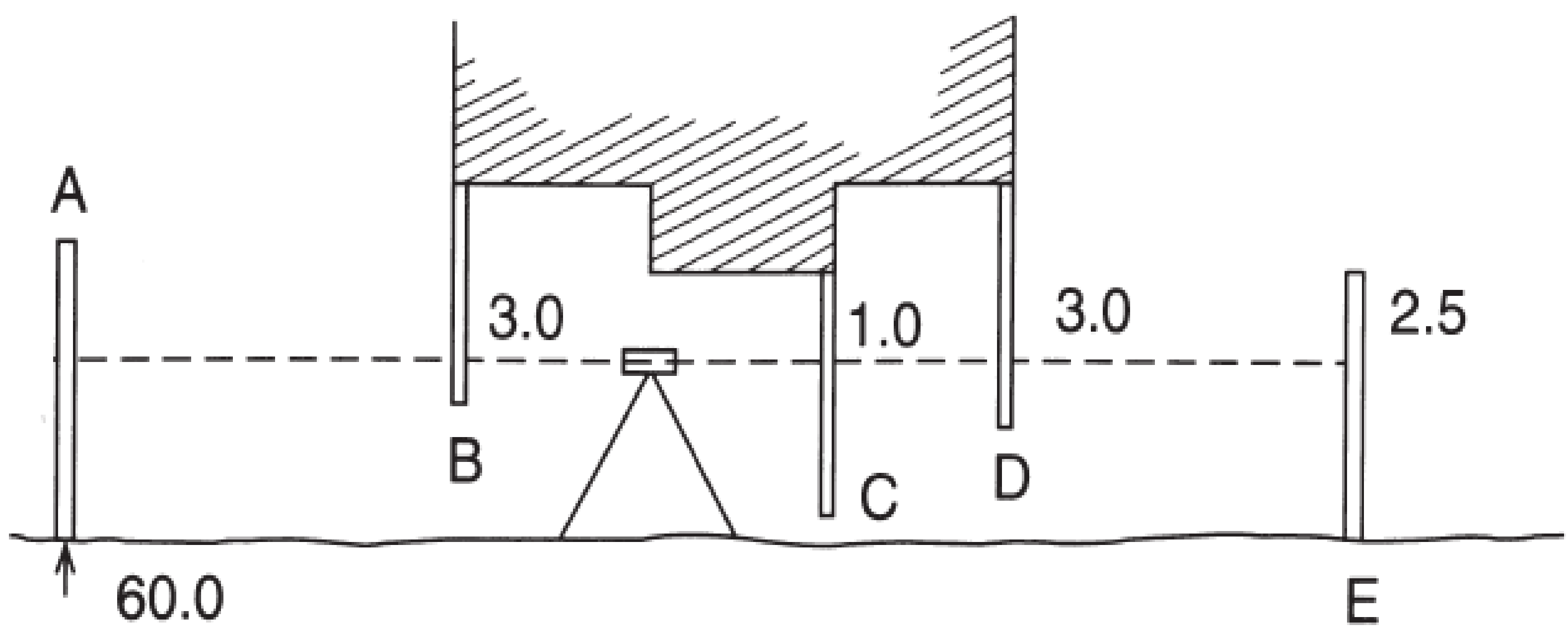
Asst. Lect. Ahmed Layth

Inverted Staff

Any inverted reading of a staff takes a negative sign (-).

Example (6)

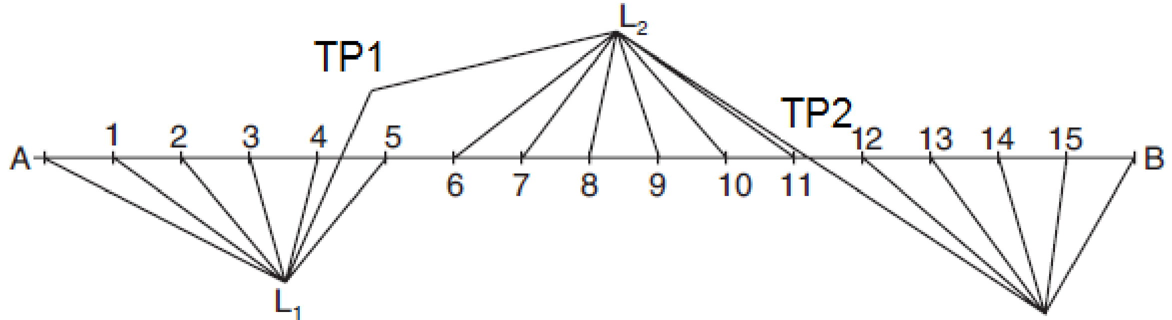
For a given figure below, inverted sights at *B*, *C* and *D* to the underside of a structure were taken. If the elevation of Station A is 60 m, find the elevations of the other points.



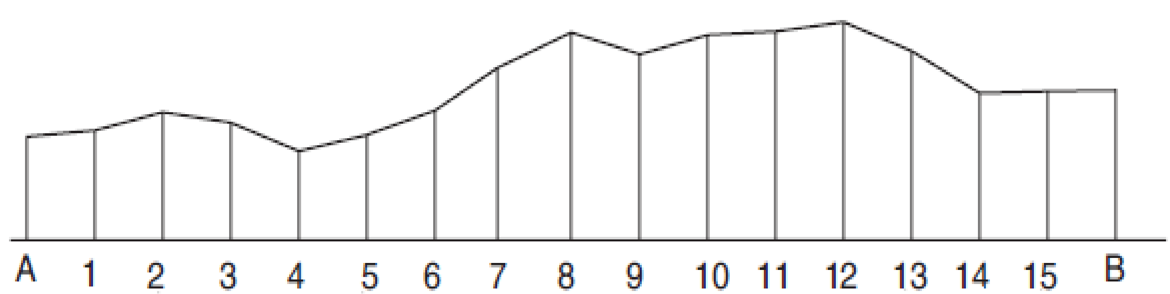
Profile Leveling

It is also known as longitudinal section. This type of levelling is used to produce ground profiles for use in the design of roads, railways, pipelines, etc.

The process of profile leveling obtains the elevations of a series of points along a continuous center line of a route. The results are then plotted using horizontal and vertical scales. This plot called a profile.

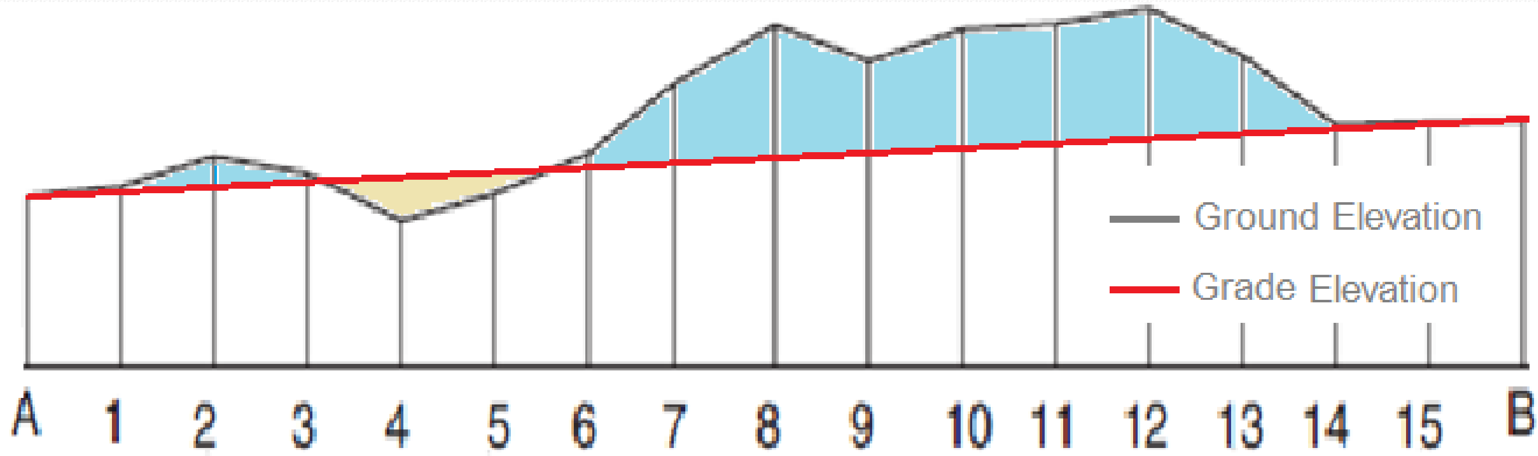


(a) Plan



(b) Profile

To construct a highway, railway, canal, drain, or pipeline for the profile, a grade line can be proposed as follows:



(c) Ground and grade

$$\textit{Ground Elevation} - \textit{Grade Elevation} = C \text{ or } F$$

If the result is positive (+) → → Ground – Grade = Cut (C)

If the result is negative (-) → → Ground – Grade = Fill (F)

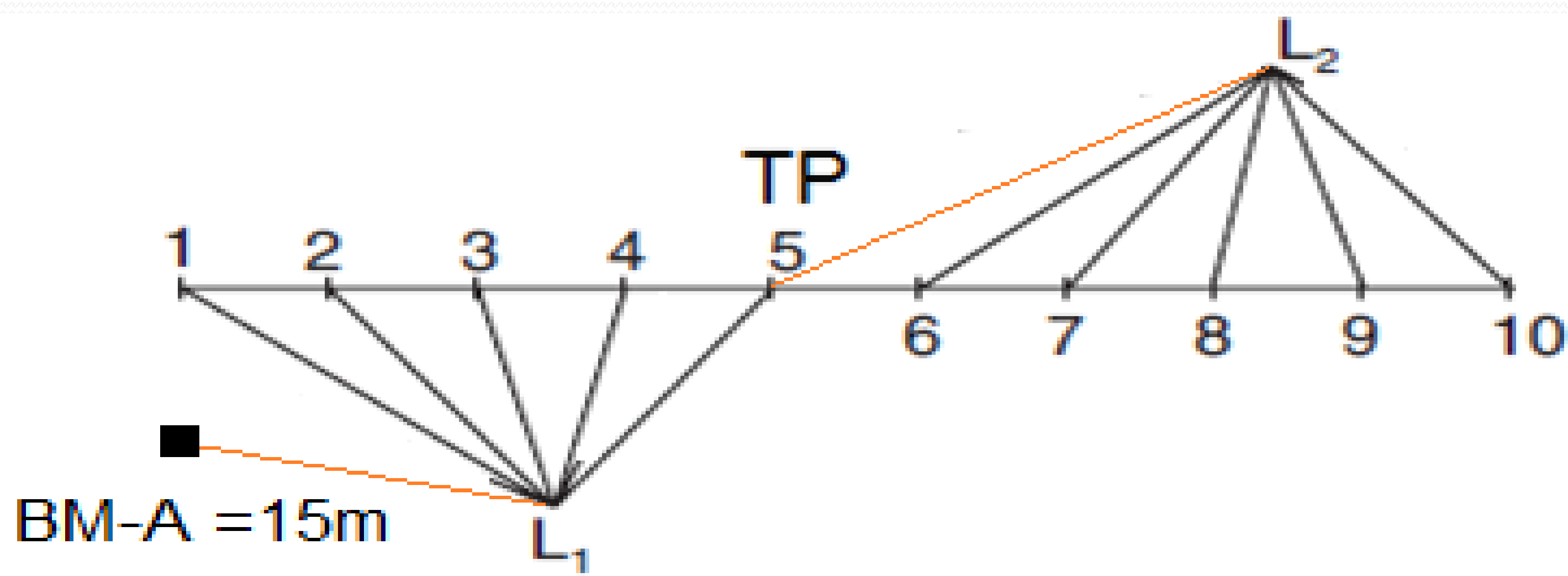
Next Grade = Preceding Grade ∓ Slope ∗ distance

If the direction of work is downward, substitute slope in (-).

If the direction of work is upward, substitute slope in (+).

Example 6

The following set of readings was taken along 10 stations of a proposed main sewer pipe: 1.3, 1.5, 2.5, 3.1, 3.3, 3, 2.2, 2, 2.4, 2.7, and 3 m and the instrument was shifted after the fifth station as shown in the figure below. Reading on BM-A was 0.9 m. The distance between each two stations is 50 m. Mainline sewer has to be constructed with 13.5 m at first station and of 0.1% slope downward. Calculate cut and fill depths for the proposed sewer.



Solution: First, find elevations of the stations.

Station	BS	IS	FS	HI	Ground Elevation	Remarks
BM	0.9			15.9	15	BM
1		1.3			14.6	
2		1.5			14.4	
3		2.5			13.4	
4		3.1			12.8	
5	3		3.3	15.6	12.6	TP
6		2.2			13.4	
7		2			13.6	
8		2.4			13.2	
9		2.7			12.9	
10			3		12.6	

Second, find grade elevations and cut and fill depths.

Station	Distance	Ground	Grade	Cut	Fill
BM		15	-		
1	0	14.6	13.5	1.1	0
2	50	14.4	13.45	0.95	0
3	50	13.4	13.4	0	0
4	50	12.8	13.35	0	0.55
5	50	12.6	13.3	0	0.7
6	50	13.4	13.25	0.15	0
7	50	13.6	13.2	0.4	0
8	50	13.2	13.15	0.05	0
9	50	12.9	13.1	0	0.2
10	50	12.6	13.05	0	0.45

Third, draw the profile of the proposed sewer pipe.