Surveying Engineering

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Subtraction of angles

1

48° 15` 38”
- 15° 09` 21”

2

48° 15` 38”
- 15° 09` 21”
17”

3

48° 15` 38”
- 15° 09` 21”
06` 17”

4

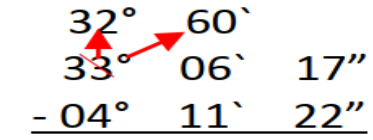
48° 15` 38”
- 15° 09` 21”
33° 06` 17”

Subtraction of angles

1

33° 06` 17”
- 04° 11` 22”

2



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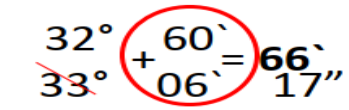

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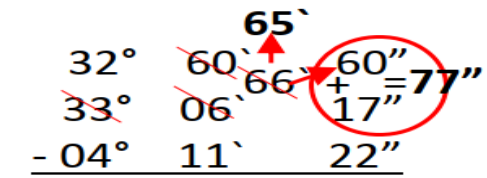


5

65`
32° 60` 60”
77”
33° 06` 17”
- 04° 11` 22”
54` 55”

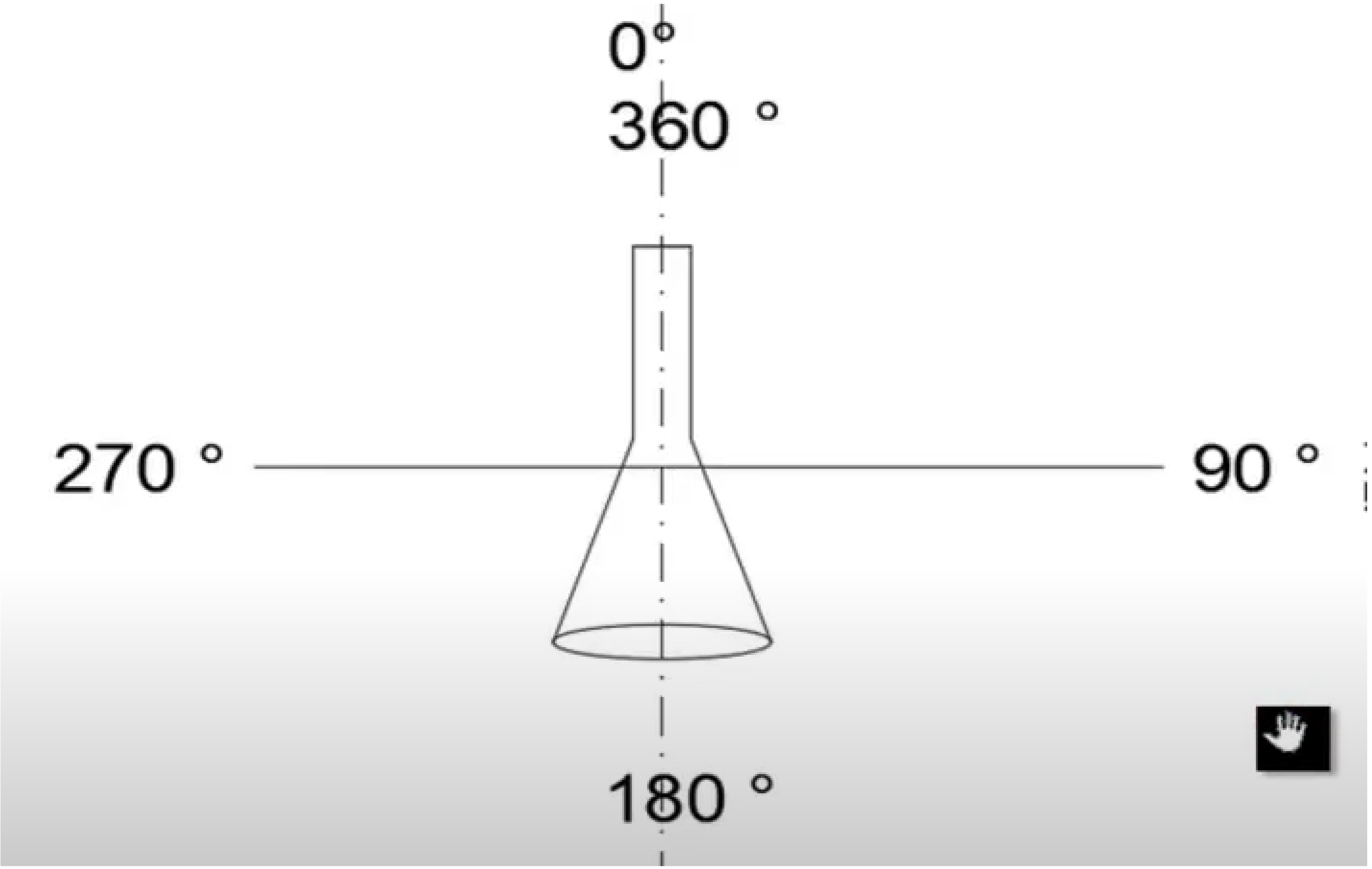
6

65`
32° 60` 60”
77”
33° 06` 17”
- 04° 11` 22”
28° 54` 55”

Vertical Angle (V)

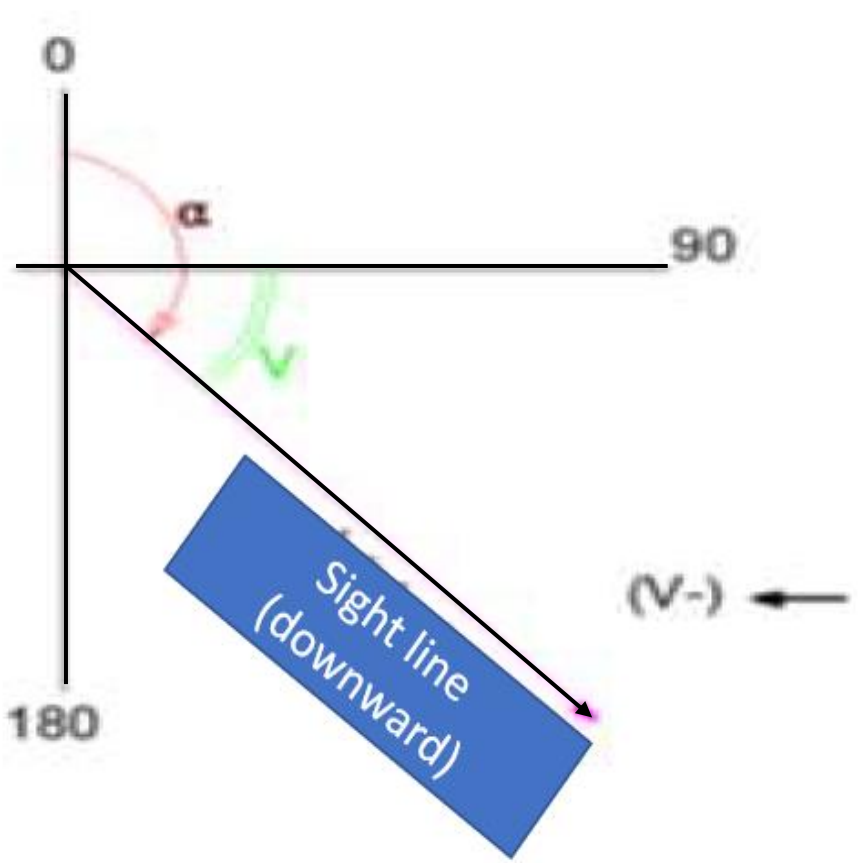
- The vertical angle is the angle between the horizon line and the direction of the guiding line. The theodolite device does not measure the vertical angle directly, but rather reads a certain reading on the vertical circle and it is called the reading of the vertical circle(α) and through this reading the value of the vertical angle can be obtained according to the monitoring position of the device (F.L or F.R), as follows:

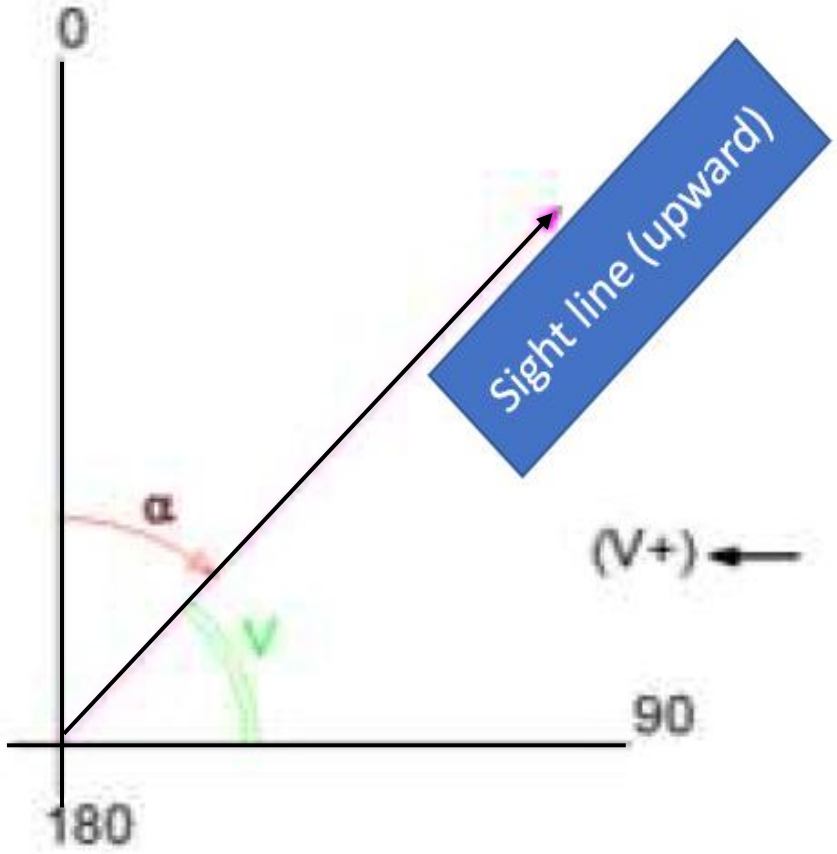
Vertical circle reading (α)
(180°-360°)
V= α-270
F.R.



Vertical circle reading (α)
(0°-180°)
V= 90 – α
F.L.

1- F.L Mode

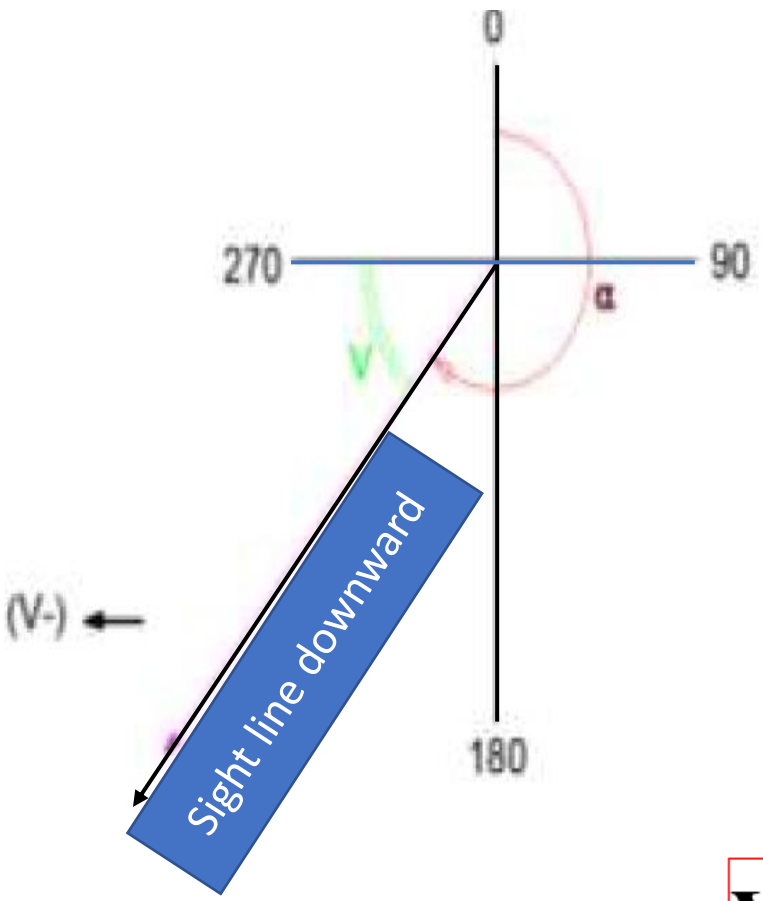


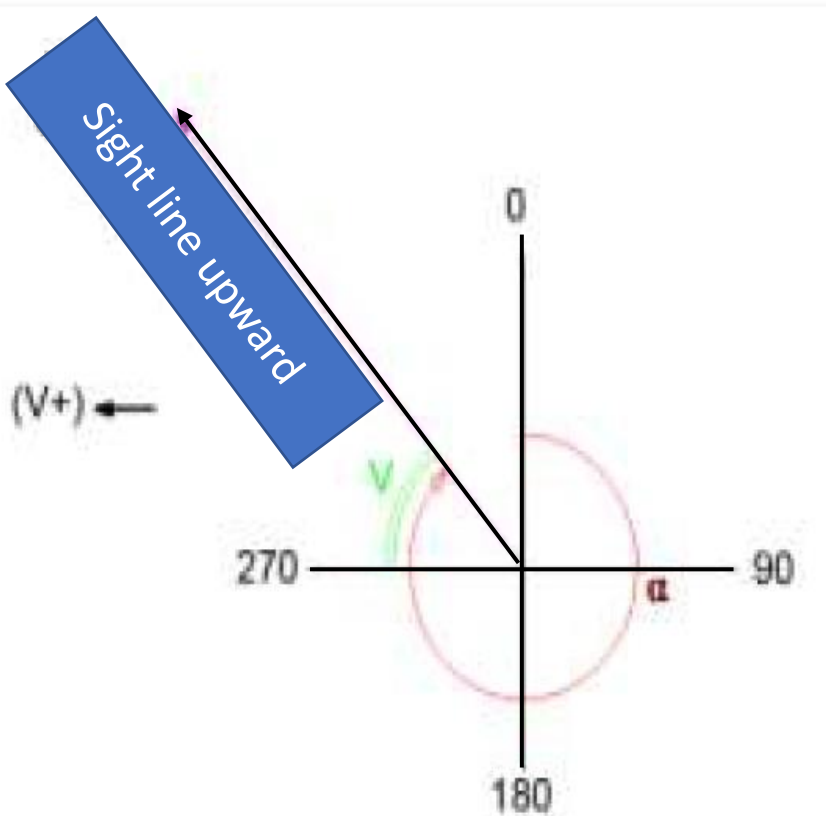


$V = 90 - \alpha$

The two case at F.L

2-F.R Mode





$$\mathbf{V = \alpha - 270}$$

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2}$$

- Example1: the vertical circle readings from the station A at the points B,C,D respectively as shown in table below :

Theodolite station	Observed point	Horizontal circle readings	
		F.L	F.R
A	B	85° 14' 10"	274° 45' 10"
	C	93° 27' 14"	266° 32' 36"
	D	97° 18' 50"	262°41' 18"

If the theodolite height at station A =1.5 m , and the elevation of point A was 30m. Find the elevation of points B,C and D if you know that the horizontal distance to these points (B, C and D)were equal to (50,100 and 150) m respectively ?

SOLUTION :

Line AB:

$$V \text{ at } F.L = 90 - \alpha = 90 - 85^{o}\ 14'\ 10'' = 4^{o}\ 45'\ 50''$$

$$V \text{ at } F.R = \alpha - 270 = 274^{o}\ 45'\ 10'' - 270 = 4^{o}\ 45'\ 10''$$

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{4°45'50'' + 4°45'10''}{2} = +4°45'30''$$ زاوية الارتفاع

Elev. B = Elev. A + H.I + H

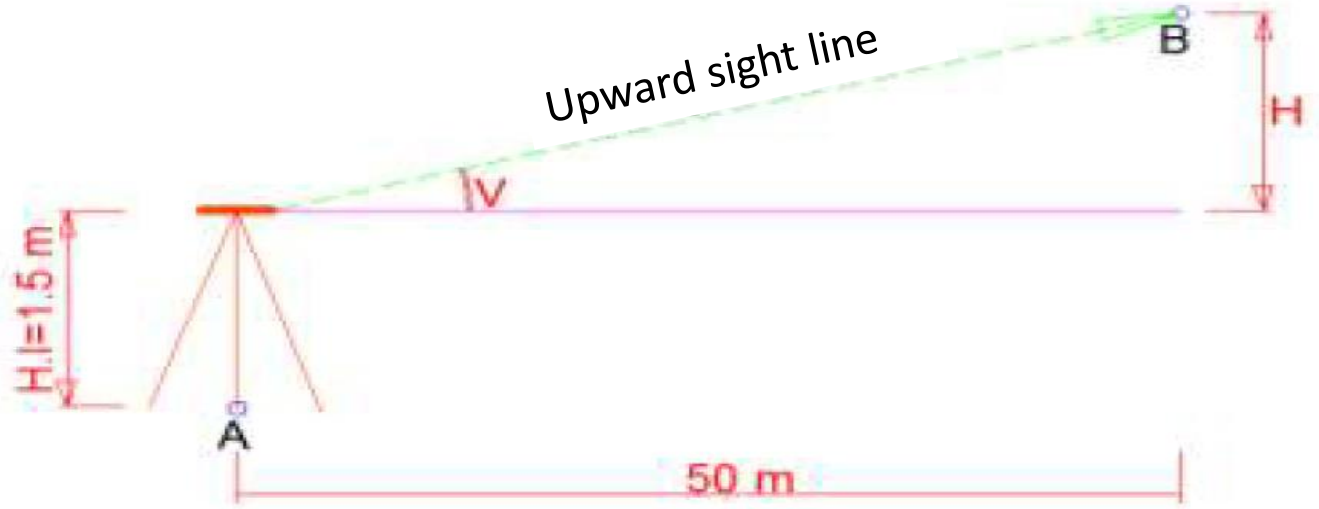
But H = 50 tan V

= 50 tan 4° 45' 30"

= 4.162 m

Elev. B = 30 + 1.5 + 4.162

= 35.622 m



Line CA:

V at F.L = 90 – α = 90 – 93° 27' 14" = – 3° 27' 14"

V at F.R = α – 270 = 266° 32' 36" – 270 = – 3° 27' 24"

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{-3°27'14" + (-3°27'24")}{2} = -3°27'19"$$ زاوية الانخفاض

Elev. C = Elev. A + H.I – H

But H = 100 tan V = 100 tan – 3° 27' 19" = – 6.038 m

Elev. C = 30 + 1.5 – 6.038 = 25.462 m

Line DA:

V at F.L = 90 – α = 90 – 97° 18' 50" = – 7° 18' 50"

V at F.R = α – 270 = 262° 41' 18" – 270 = – 7° 18' 42"

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{-7°18'\ 50" + (-7°18'\ 42")}{2} = -7°18'46"$$ زاوية الانخفاض

Elev. D = Elev. A + H.I – H

But H = 150 tan V = 150 tan (– 7° 18' 46") = – 19.249 m

Elev. D = 30 + 1.5 – 19.249 = 12.25 m

- Example2 : the point B was observed from station A by using A theodolite instrument , and the readings was as follow :

Theodolite station	Observed point	Horizontal circle readings	
		F.L	F.R
A	B	81° 20' 10"	278° 40' 20"

If point A elevation was 40 m , the theodolite height over this point (HI) was 1.5 m, and the horizontal distance of line AB was 100 m , find the elevation of point B?.

SOLUTION:

$$\text{V at F.L} = 90 - \alpha = 90 - 81^\circ\,20'\,10'' = 8^\circ\,39'\,50''$$

$$\text{V at F.R} = \alpha - 270 = 278^\circ\,40'\,20'' - 270 = 8^\circ\,40'\,20''$$

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{8^\circ 39'\,50'' + 8^\circ 40'\,20''}{2} = 8^\circ 40' 05''$$

$$\text{Elev. B} = \text{Elev. A} + \text{H.I} + \text{H}$$

$$\text{But H} = 100 \tan \text{V} = 100 \tan (8^\circ\ 40'\ 05'') = 15.245 \text{ m}$$

$$\text{Elev. B} = 40 + 1.5 + 15.245 = 56.745 \text{ m}$$

- Example 3 : What is the height of a certain building if it was observed by a theodolite instrument and the readings were as follow:

Theodolite position	Observed point	Horizontal circle readings		The horizontal distance from the theodolite station to the building
		F.I	F.R	
M	A (at the top of the building)	54° 12' 36"	305° 47' 30"	20 m
	B (at the bottom of the building)	93° 14' 53"	266° 45' 19	

SOLUTION:

- Line MA which directed to the top of the building :

$$\text{V at F.L} = 90 - \alpha = 90 - 54^{o}\ 12'\ 36'' = 35^{o}\ 47'\ 24''$$

$$\text{V at F.R} = \alpha - 270 = 305^{o}\ 47'\ 30'' - 270 = 35^{o}\ 47'\ 30''$$

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{35^{\circ}47'\ 24'' + 35^{\circ}47'\ 30''}{2} = 35^{\circ}47'27''$$

- Line MB which directed to the top of the building :

$$\text{V at F.L} = 90 - \alpha = 90 - 93^{o}\ 14'\ 53'' = -\ 3^{o}\ 14'\ 53''$$

$$\text{V at F.R} = \alpha - 270 = 266^{o}\ 45'\ 19'' - 270 = -\ 3^{o}\ 14'\ 41''$$

$$V_{final} = \frac{V\ at\ F.L + V\ at\ F.R}{2} = \frac{-3^{\circ}14'\ 53'' + (-3^{\circ}14'\ 41'')}{2} = -3^{\circ}14'47''$$

ارتفاع البناية (H) $= H_1 + H_2$

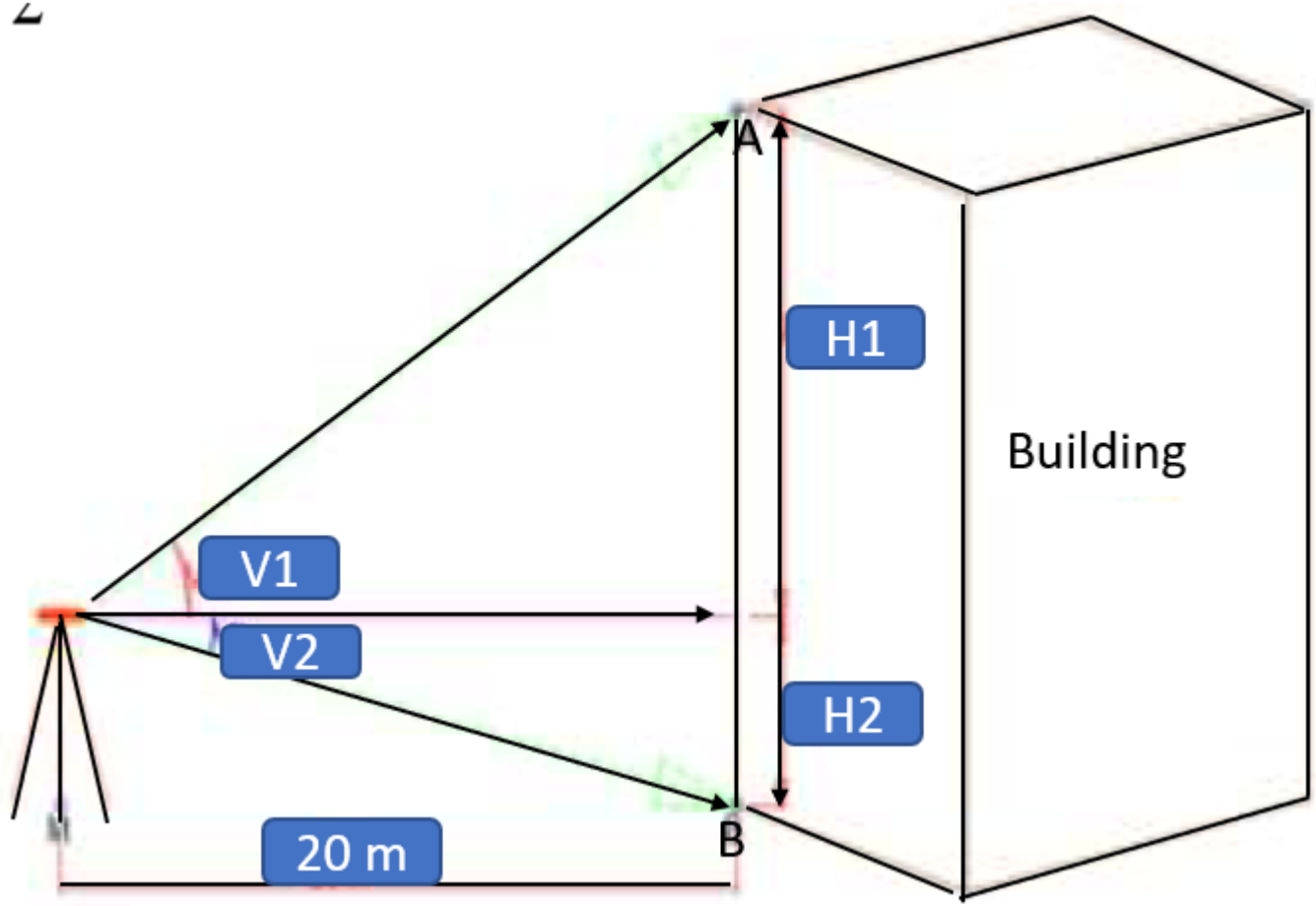
$H_1 = 20 \tan V_1$

$= 20 \tan 35^\circ 47' 27'' = 14.42$ m

$H_2 = 20 \tan V_2$

$= 20 \tan (-3^\circ 14' 47'') = 1.134$ m

$H = H_1 + H_2 = 14.42 + 1.134 = 15.554$ m



- Example 4 : if point A was located at the top of building of 15 m height, while point B was located at the bottom of this building . What is the theodolite readings for the vertical circle at the F.R and F.L mode for both point A and B, (HI=1.5).

Solution :

Line MA which directed to the top of the building :

$$V_1 = \tan^{-1}\frac{13.5}{20} \Rightarrow V_1 = 34^\circ\ 01'\ 10''$$

V_1 at F.L $= 90 - \alpha_1$ ➔ $34^\circ\ 01'\ 10'' = 90 - \alpha_1$ ➔ $\alpha_1 = 55^\circ\ 58'\ 50''$

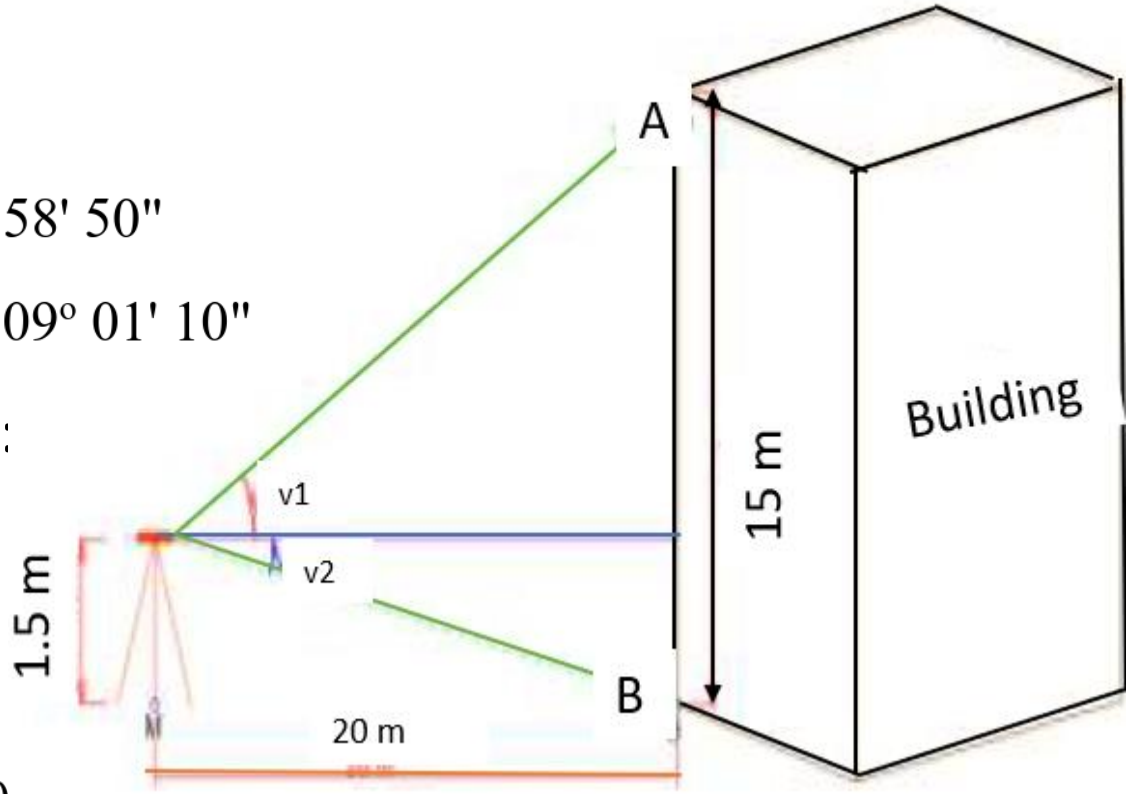
V_1 at F.R $= \alpha_1 - 270$ ➔ $34^\circ\ 01'\ 10'' = \alpha_1 - 270$ ➔ $\alpha_1 = 309^\circ\ 01'\ 10''$

Line MB which directed to the top of the building :

$$V_2 = \tan^{-1}\frac{1.5}{20} \Rightarrow V_2 = -4^\circ\ 17'\ 21''$$

V_2 at F.L $= 90 - \alpha_2$ ➔ $-4^\circ\ 17'\ 21'' = 90 - \alpha_2$ ➔ $\alpha_2 = 94^\circ\ 17'\ 21''$

V_2 at F.R $= \alpha_2 - 270$ ➔ $-4^\circ\ 17'\ 21 = \alpha_2 - 270$ ➔ $\alpha_2 = 265^\circ\ 42'\ 39$



Example5: If the vertical angle reading for a point located at 3.668 m above point B was equal to (-2° 9’ 00“). The telescope of theodolite was at 1.52 height above point A, and the horizontal distance of AB was equal to 60 m, point B elevation = 53.6 m. find the elevation of point A.

solution :

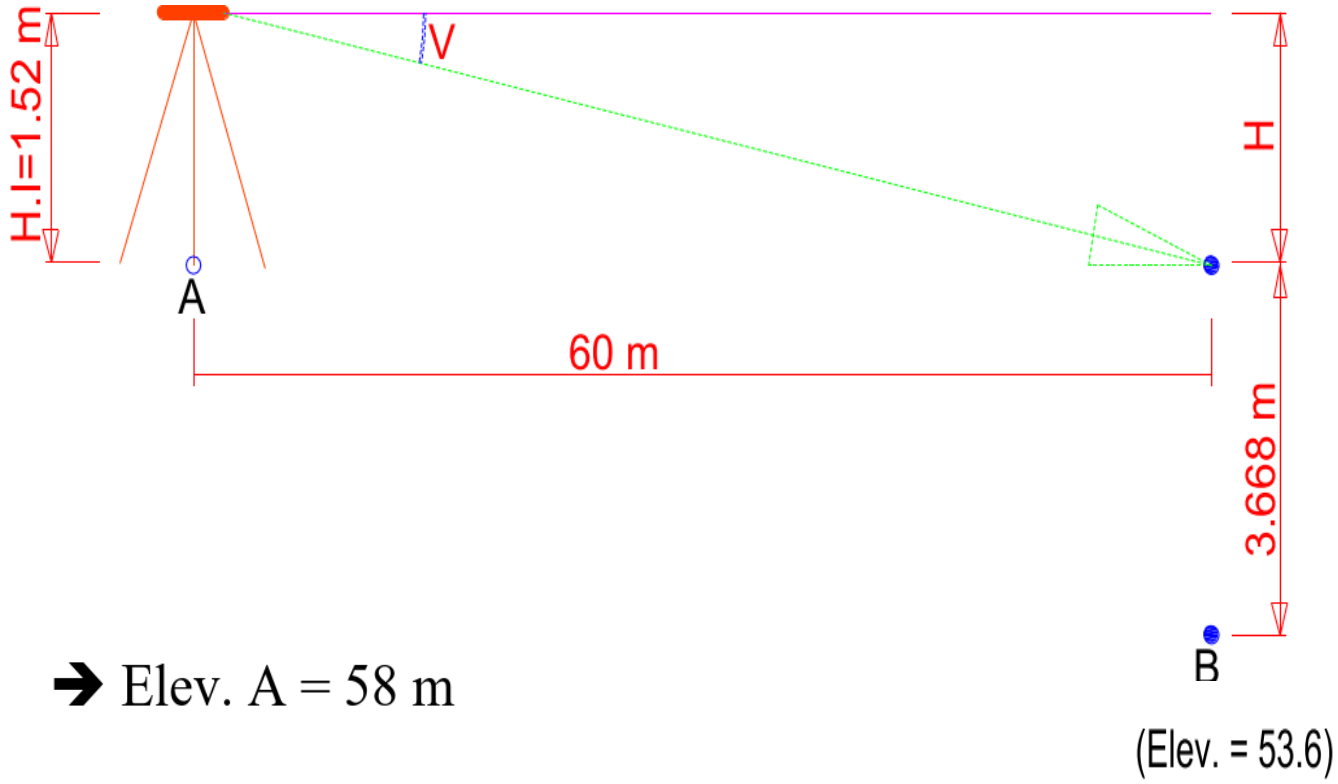
$$V = -2^\circ\ 9'\ 00''$$

$$\Delta H = 3.668\ m$$

$$H.I = 1.52\ m$$

$$H = 60 \tan -2^\circ\ 9'\ 00''$$

$$= 2.253\ m$$



Elev. A + H.I = Elev. B+ ΔH + H

Elev. A + 1.52 = 53.6 + 3.668 + 2.253 ➔ Elev. A = 58 m