Surveying

2nd year civil

Notes (3)

2012/2013

Notes:

* Vl Angles
  * V.C.R (0 ⟶ 180°) ⟶ F.L

    $\Rightarrow V = 90 - V.C.R$
  * V.C.R (180 ⟶ 360) ⟶ F.R

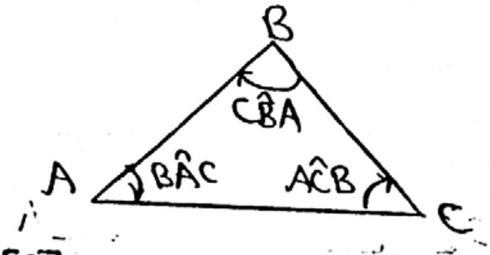
    $\Rightarrow V = V.C.R - 270°$

Where $V.C.R_{F.L} + V.C.R_{F.R} = 360°$

& (Index error) $= \dfrac{V.C.R_{F.L} + V.C.R_{F.R} - 360°}{2}$

* HZ Angles : are named in clockwise direction

$B\hat{A}C = H.C.R_{A \to C} - H.C.R_{A \to B}$

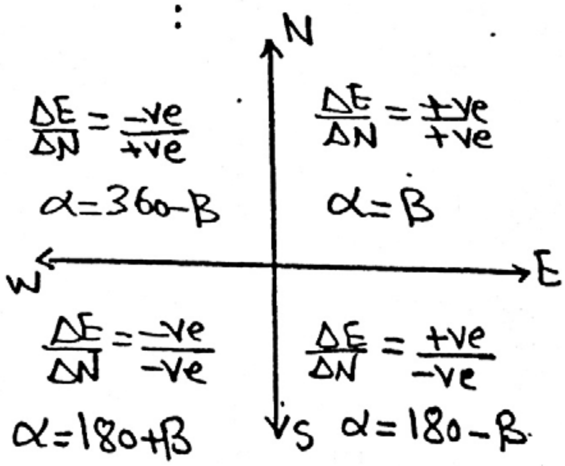


* Whole Circle Bearing [α] & Reduced Bearing [B]:

$\Delta E_{AB} = E_B - E_A$

$\Delta N_{AB} = N_B - N_A$

$\alpha_{AB} = \tan^{-1} \dfrac{\Delta E_{AB}}{\Delta N_{AB}}$



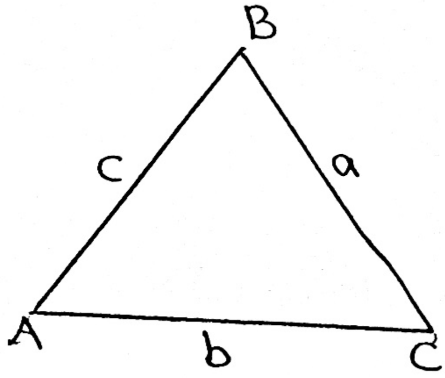
$\alpha_{AB} = \alpha_{BA} \pm 180°$

* Areas:

$$Area_{\Delta} = \frac{1}{2} a b \sin \hat{C}$$

$$= \sqrt{S(S-a)(S-b)(S-c)}$$

where $S = \frac{a+b+c}{2}$



Agricultural units (F K S) : $1F = 4200.83\ m^2$

$1F = 24\ K$ $\quad$ $1K = 24\ S$

* Relation between Angles and Bearing:

$$B\hat{A}C = \alpha_{AC} - \alpha_{AB}$$

2) Tacheometric leveling

* **Main idea :**

It is an indirect method to get the height difference (ΔH) between any two points using a Theodolite + staff and there are two methods for tacheometric leveling:

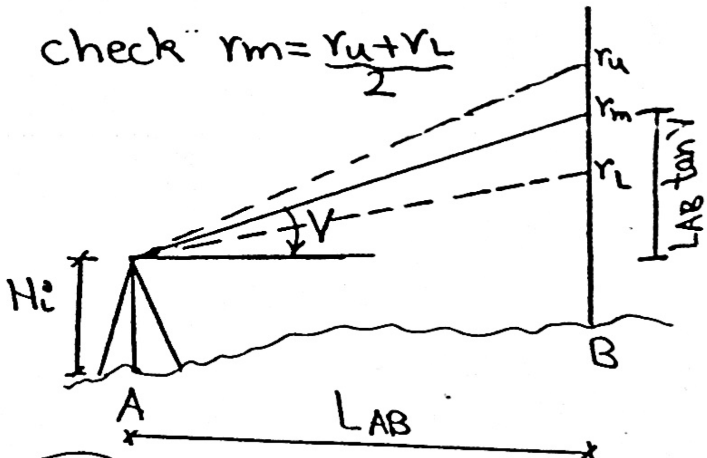
1) Stadia method   2) Tan angle method

1) Stadia Method :

$r_u - r_L = b$ (Staff base)   check $r_m = \frac{r_u + r_L}{2}$

H_i = (height of instrument)

V = (Vertical angle)

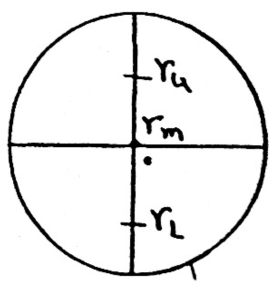


$\Delta H_{AB} = H_B - H_A$

$$\Delta H_{AB} = H_i + L_{AB} \tan V - r_m$$

where

$$L_{AB} = K b \cos^2 V + C \cos V$$



K : (Tacheometric constant) $\Rightarrow$ K = 100 (ideal case)
(Stadia interval factor)

$b = r_u - r_L$

C : (Additive constant) $\Rightarrow$ C = Zero (ideal case)

$$L_{AB} = 100\,(r_u - r_L)\cos^2 V$$

* **How can we get K & C ?**

1) نضع الجهاز على مسافه معلومه من القامه (L_1) ونكون معادله (1)

$$L_1 = K\,(r_{u_1} - r_{L_1})\cos^2 V_1 + C\cos V_1 \quad \ldots\ldots (1)$$

2) نضع الجهاز على مسافه أخرى معلومه من القامه (L_2) ونكون معادله (2)

$$L_2 = K\,(r_{u_2} - r_{L_2})\cos^2 V_2 + C\cos V_2 \quad \ldots\ldots (2)$$

وبحل المعادلتين يمكن حساب قيم (C و K)

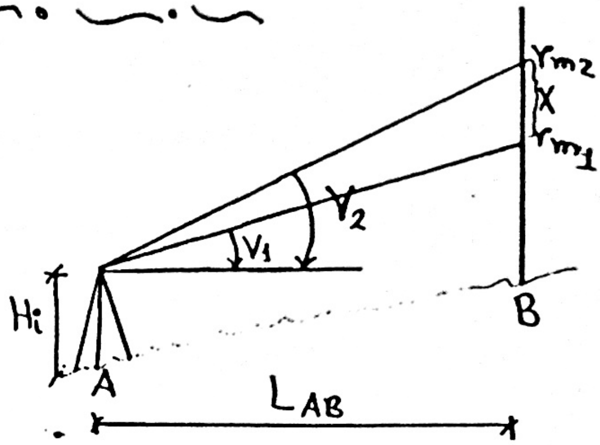
* يمكن إيجاد L_1 & L_2 عن طريق Tan angle method

2) Tan angle (Tangential) method

$$X = r_{m2} - r_{m1}$$

$$= L_{AB} \tan V_2 - L_{AB} \tan V_1$$

$$\therefore r_{m2} - r_{m1} = L_{AB} (\tan V_2 - \tan V_1)$$



$$\therefore L_{AB} = \frac{r_{m2} - r_{m1}}{\tan V_2 - \tan V_1}$$

$$\Delta H_{AB} = H_i + L_{AB} \tan V_1 - r_{m1}$$

$$\text{or} \quad = H_i + L_{AB} \tan V_2 - r_{m2}$$

* Difference between Stadia & tan angle ?

Stadia method	Tan angle method
١) يوجد فرصه للتأكد من الأرصاد $r_m = (r_u + r_L)/2$	١) لا يعتمد على الثوابت (C, K)
٢) Obs: (H_i, r_u, r_m, r_L, V)	٢) Obs. $(H_i, r_{m_1}, r_{m_2}, V_1, V_2)$
٣) يمكن استخدامها بالميزان	٣) لا يمكن استخدامها بالميزان
٤) لا يمكن التحكم في قاعدة المثلث المتكونه عند القامه	٤) يمكن التحكم في قاعدة المثلث المتكونه عند القامه

Notes:

* Accuracy of Calculated distances and height differences can be determined from the accuracy of theodolite, Instrument height and Staff reading through error propagation.

* Stadia method is more accurate as one vl angle only is measured.

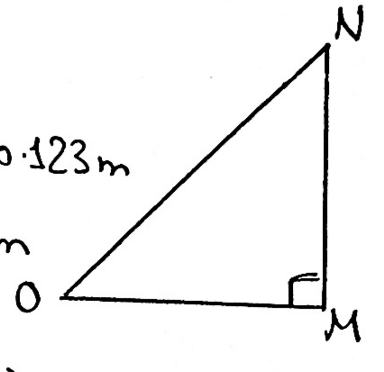
* Lower reading in tan angle method is prefered to be not less than 1m to avoid refraction of Line of sight due to the heat from ground near Earth Surface.

Ex: Three Stations M, N and O form a right-angle triangle at station M. A Theodolite was used to determine the tachometric data. The measured observations are recorded in the following table

Target Station	Vertical Angle	Staff Reading (m)		
		r_L	r_m	r_u
N	$-03^\circ 42'$	1.000	1.452	1.905
O	$02^\circ 36'$	2.000	2.354	2.707

Given that the theodolite height = 1.60 m and the elevation of point M = 108.530 m. Calculate the hz length NO and the elevation of points N and O.

Solution:



$MN = 100\,(1.905 - 1.00)\cos^2(-03^\circ 42') = 90.123\,m$

$MO = 100\,(2.707 - 2.000)\cos^2(02^\circ 36') = 70.555\,m$

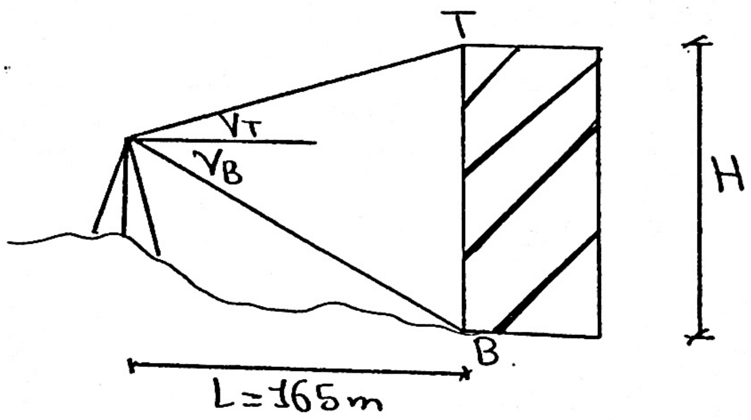
$NO = \sqrt{(MN)^2 + (MO)^2} = 114.456\,m$

$H_N = 108.530 + 1.6 + 90.123\tan(-03^\circ 42'') - 1.452 = 102.850\,m$

$H_O = 108.530 + 1.6 + 70.555\tan(02^\circ 36'') - 2.354 = 110.980\,m$

Ex: In order to determine the height of a building, the verticle circle readings were taken by a theodolite for the top and bottom of the building lying on the same vertical line. The readings were 277° 13' 20" and 267° 48' 19" respectively. If the theodolite lies 165 horizontally from the building. Find the height of that Building.

Sol:



$V_T = 277° 13' 20" - 270°$

$= 7° 13' 20"$

$V_B = 267° 48' 19" - 270°$

$= -2° 11' 41"$

$\therefore H = L \sin V_T + L \sin V_B$ ↳ without negative

$= 27$ m

Ex: The following observations were taken using a theodolite and a Staff:

Occ. Station	Target	Staff Reading (m)			V.C.R
		r_L	r_m	r_u	
A	B	1.03	1.13	1.23	89° 11′ 22″
	C	2.05	2.25	2.45	88° 08′ 05″
	D	1.56	1.77	1.98	91° 30′ 19″
	E	2.35	2.70	3.05	89° 42′ 35″

Knowing that the height of the theodolite over point (A) was 1.66 m and the elevation of point (A) is (18.956 m), Calculate the elevations of point B, C, D and E.

Solution :

$$\Delta H_{AB} = H_i + 100\,(r_u - r_L)\cos^2 V \tan V - r_m$$

$$= 1.66 + 100(1.23 - 1.03)\cos^2(90 - 89^\circ 11' 22'')\tan(90 - 89^\circ 11' 22'') - 1.13 = 0.813\,m$$

$$\Delta H_{AB} = H_B - H_A$$

$$\therefore H_B = \Delta H_{AB} + H_A$$

$$= 0.813 + 18.956 = 19.769\,m$$

using the Same Law

$\Delta H_{AC} = 0.711\,m \longrightarrow H_C = 19.667\,m$

$\Delta H_{AD} = -1.213\,m \longrightarrow H_D = 17.743\,m$

$\Delta H_{AE} = -0.685\,m \longrightarrow H_E = 18.271\,m$

Ex:

The following observations were taken to get the elevations of points R and T:

Occ. Station	Target	r_m	V.C.R
M	R	1.32 2.36	90° 10' 20" 88° 37" 26"
	T	2.98 2.11	88° 00' 14" 89° 10' 30"

Point M is a Bench mark with elevation 111.232 m and the height of the instrument above M was 1.54 m. Find the difference in level between points R and T.

Solution:

$$\Delta H_{MR} = H_i + L_{MR}(\tan V) - r_m.$$

Where : $L_{MR} = \dfrac{r_{m_2} - r_{m_1}}{\tan V_2 - \tan V_1}$

$r_{m_2} = 2.36\,m$, $r_{m_1} = 1.32\,m$

$V_2 = 90 - 88^\circ 37' 26'' = 1^\circ 22' 34''$

$V_1 = 90 - 90^\circ 10' 20'' = -0^\circ 10' 20''$

$\therefore L_{MR} = 38.478\,m$

$\therefore \Delta H_{MR} = 1.54 + 38.478(\tan 1^\circ 22' 34'') - 2.36$

$= 0.104\,m$

$H_R = \Delta H_{MR} + H_M$

$= 0.104 + 111.232 = 111.336$ #

By The same way:

$L_{MT} = 42.537\,m$

$\Delta H_{HT} = 0.043m$

$H_T = \Delta H_{HT} + H_H$

$= 0.043 + 111.232 = 111.275m$ #

$\Delta H_{RT} = H_T - H_R$

$= 111.275 - 111.336 = -0.061m$ ※

Ex: T1 and T2 are two trees obstructed by an obstacle. A Staff is located at each tree and a theodolite ($H_i = 1.65m$) was set on point A (105 m, 2600 m), taking the following observations:

Occ. Station	Target	Staff Readings (m)			H.C.R	V.C.R
		R_L	R_m	R_u		
A	T1	2.200	2.500	2.798	128° 56' 13"	89°48' 23"
	T2	--	1.500 3.000	---	162° 19' 17"	90° 05' 48" 88° 56' 40"

Calculate :

i- The distance between the two trees

ii- Coordinates of T1, If the bearing of AT1 is 146° 19' 25".

Solution :

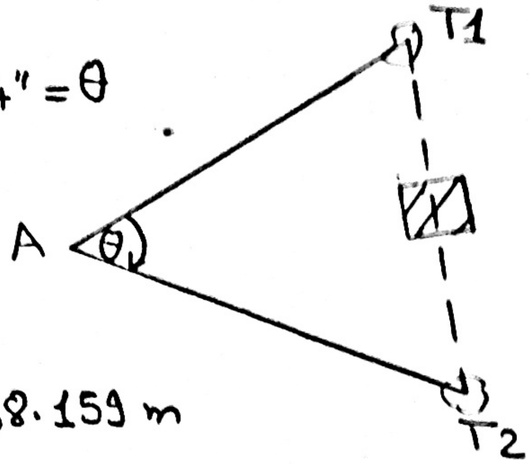
i- $AT1 = 100(2.798 - 2.200)\cos^2(90^\circ - 89^\circ 48' 23'') = 59.80\ m$

$$AT2 = \frac{3.00 - 1.50}{\tan(90 - 88^\circ 56' 40'') - \tan(90 - 90^\circ 05' 48'')} = 74.582\ m$$

$T1\hat{A}T2 = H.C.R_{AT2} - H.C.R_{AT1} = 33^\circ 23' 04'' = \theta$

$\therefore T1T2 = \sqrt{59.8^2 + 74.582^2 - 2 * 59.8 * 74.582 * \cos\theta}$

$= 41.114\ m$



ii- $E_{T1} = 105 + 59.8 \sin 146^\circ 19' 25'' = 138.159\ m$

$N_{T1} = 2600 + 59.8 \cos 146^\circ 19' 25'' = 2550.235\ m$

Ex: Following observations were taken at point A (1000,2200)m once with a theodolite to points B and C and them with a total Station to point D:

Occ. Station	Target	Staff Readings (m)			HCR	VCR	Slope Distance (m)
		R_L	R_m	R_u			
A	B	1.23	1.41	1.59	12°55'02"	88°54'19"	
	C		1.00 3.00		96°36'15"	89°20'48" 88°41'22"	
	D					87°14'07"	478.66

*Given that the theodolite and total Station heights at point A were both equal to 1.65m and the reflector height at D was 2.16 m

a) If the stadia interval factor is 99 and the additional constant 0.001, Calculate the length of the line AB and AC

b) Determine the area of triangle ABC in agricultural units.

c) If the bearing of AC is 123° 31'42", Calculate the coordinates of point M, given that point M is the midpoint of AC.

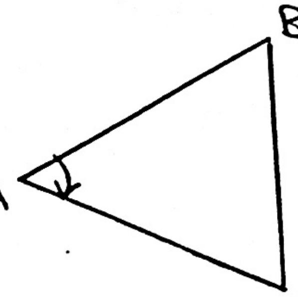
d) If the elevation of point A is (105.50 m), Calculate the elevation of point D.

Sol: $V = 90 - V.C.R$

a) $V_B = 1°15'41''$ $V_{C1} = 0°39'12''$ $V_{C2} = 1°18'38''$ $V_D = 2°45'53''$

$L_{AB} = 99\,(1.59 - 1.23)\cos^2 1°15'41'' + 0.001\cos 1°15'41'' = 35.658\,m$

$$L_{AC} = \frac{3 - 1}{\tan 1°18'38'' - \tan 0°39'12''} = 174.304\,m$$



b) $B\hat{A}C = H.C.R_{AC} - H.C.R_{AB} = 83°41'13''$

$A_{\Delta ABC} = \frac{1}{2}\,AB\,AC\sin B\hat{A}C = 3088.821\,m^2$

$A_{feddan} = 3088.821/4200.83 = 0.735\,F$

$A_K = 0.735 * 24 = 17.647\,K$

$A_{sahm} = 0.647 * 24 = 15.5\,S$ => Area = of 17K 15.5S

c) $L_{AM} = L_{AC}/2 = 87.152$ $\alpha_{AM} = \alpha_{AC} = 123°31'42''$

$E_M = E_A + L_{AM}\sin\alpha_{AM} = 1072.651\,m$

$N_M = N_A + L_{AM}\cos\alpha_{AM} = 2151.862\,m$

d) $L_{AD} = 478.66\cos(2°45'53'') = 478.103\,m$

$H_D = H_I + L_{AD}\sin V_D - H_R = 128.128\,m$