Yildiz Technical University
Faculty of Civil Engineering
Department of Geomatic Engineering

TOPOGRAPHY (HRT3351)

Lecture Notes

Prof. Dr. Burak AKPINAR

Title	Code	Local Credit	ECTS	Lecture (hour/week)	Practical (hour/week)	Laboratory (hour/week)
Topography	HRT3351	3	4	3	0	0

Course Objectives	The aim of this course, gains required skills of basic of surveying techniques, mathematical definitions using for large scale map production.

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WEEKLY SUBJECTS

Week	Subject
1	Introduction to Topography
2	Measurement Units and Sources of Measurement Errors
3	Types of Errors
4	Coordinate Systems and Map Projections
5	Geodetic Network Points and Distance Measurements
6	Direction Measurements
7	Traverse Computations
8	Height Measurements
9	Midterm exam 1
10	Area and Volume Computations
11	Field work
12	Field work
13	Geographic Information System, GIS
14	Midterm exam 2
15	GNSS Global Positioning Systems
16	Final exam

Week-6
Direction Measurements and Geodetic Fundamental Computations

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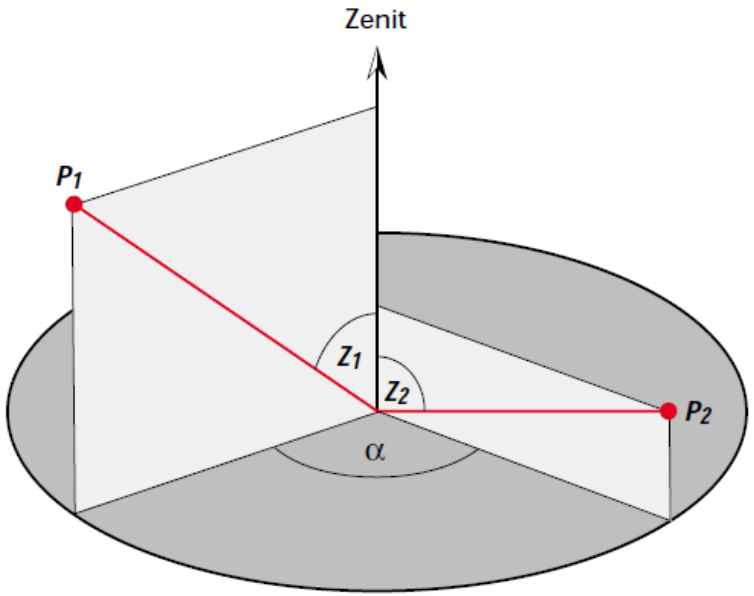
Direction and Angle

An angle is defined as the difference in direction between two convergent lines.



$$\alpha = r_2 - r_1$$

$$Z_1, Z_2 \rightarrow Vertical\ Angle$$

Angle Measurement Equipments

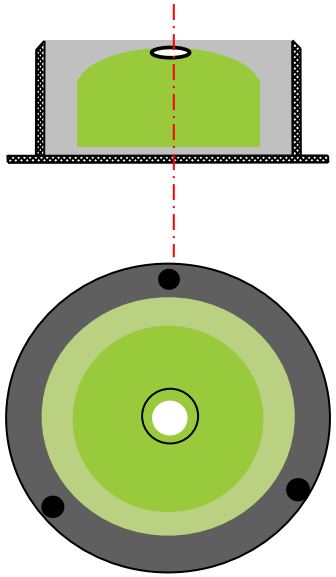
Mechanical Theodolite

Electronic Theodolite

Total Station

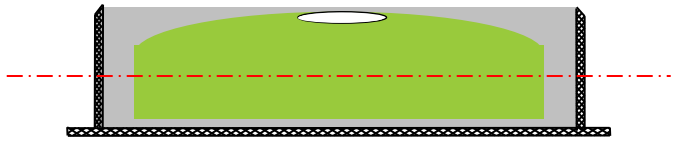
Angle Measurement Equipments

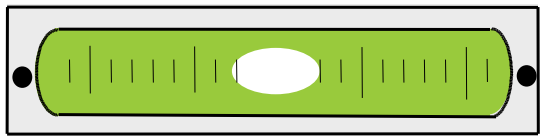
Circular Level

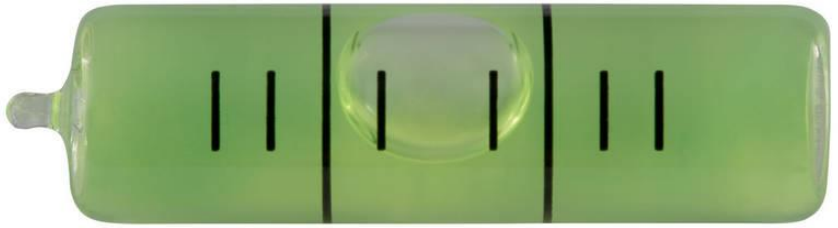


Precision :5 '-10'

Cylindrical Level

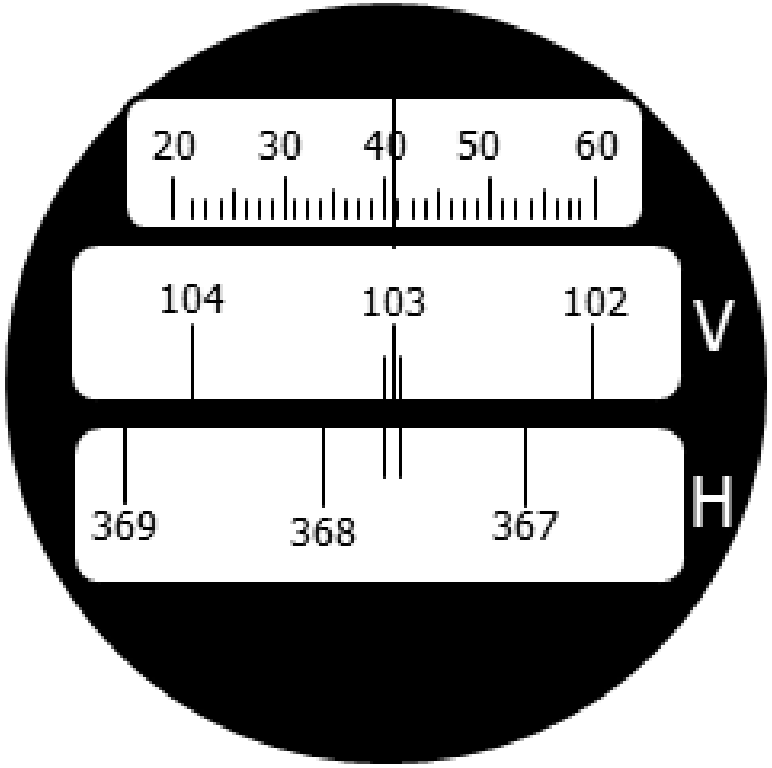




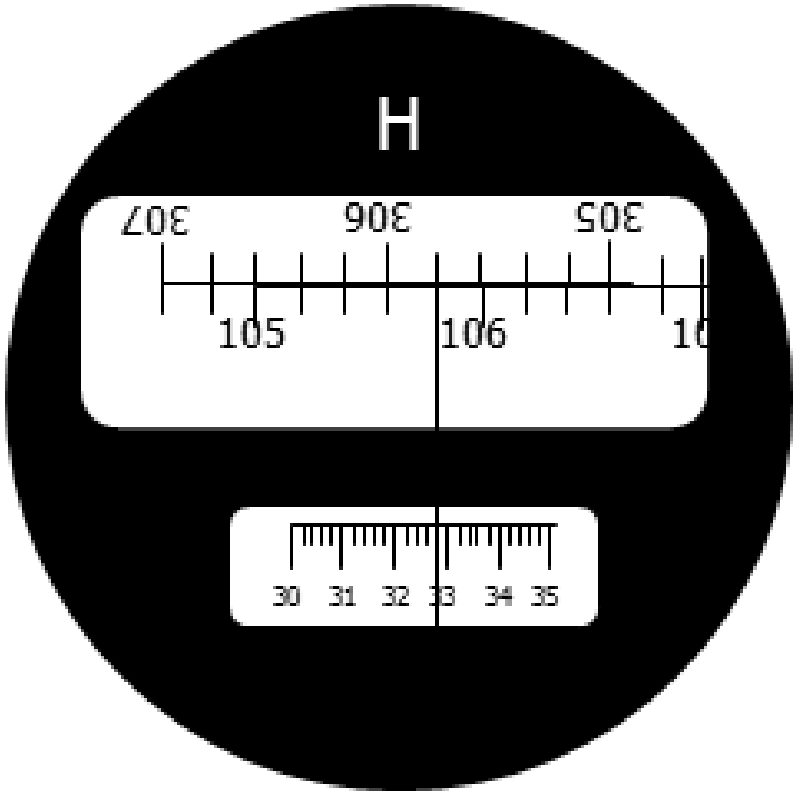


Precision :10 " - 30"

Direction Measurement



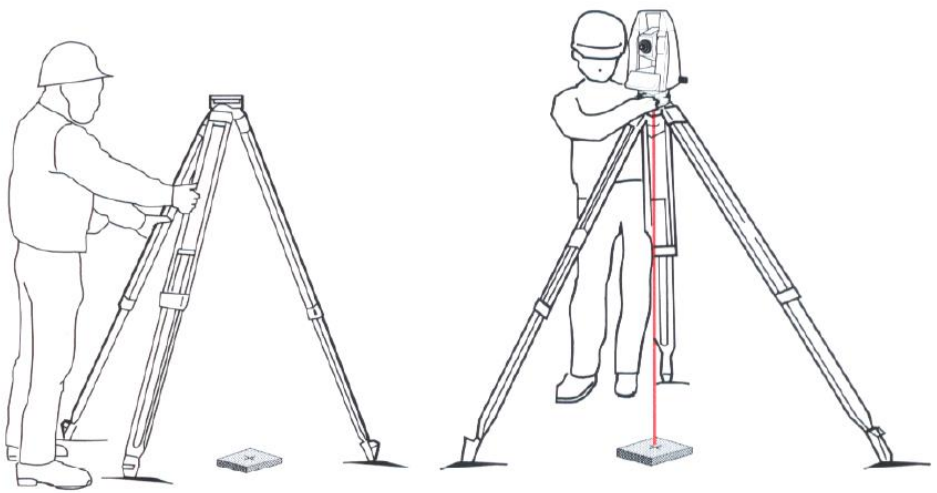
V:103.405 gon



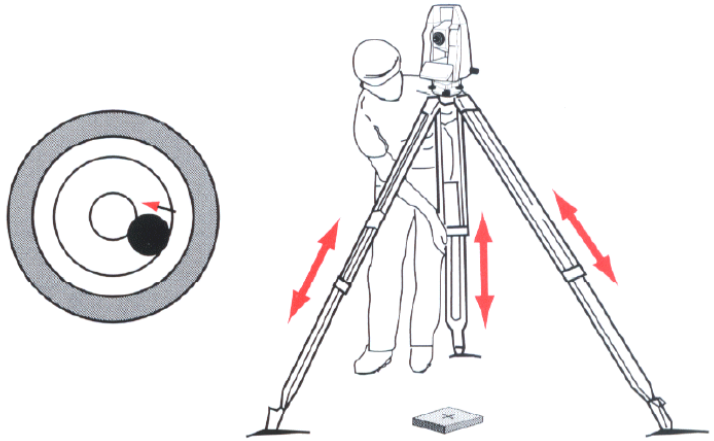
H: 105.8328 gon

Setting up the Theodolite

1. Centering

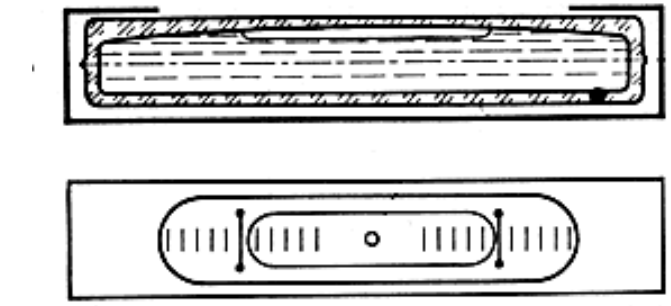


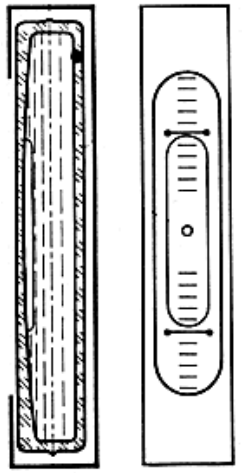
2. Circular Level

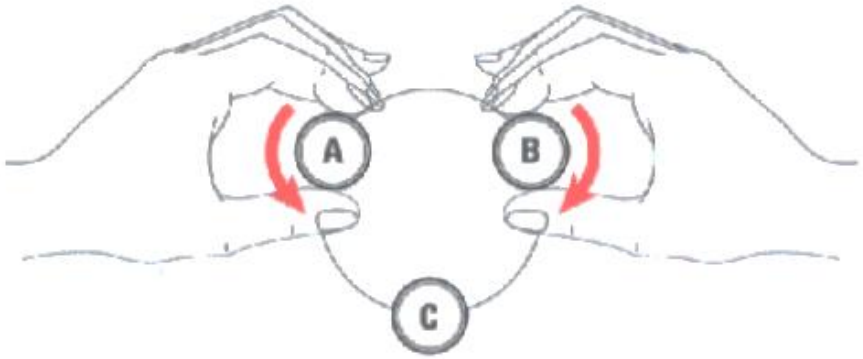


Setting up the Theodolite

3. Cylindrical Level

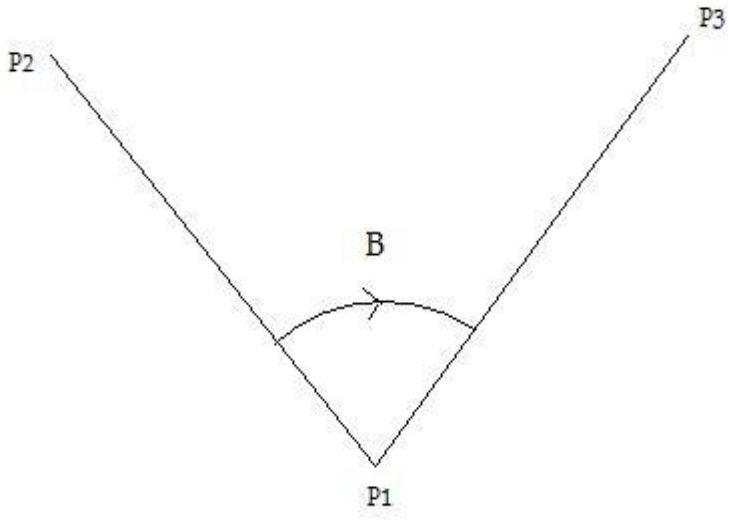






Setting up the Theodolite

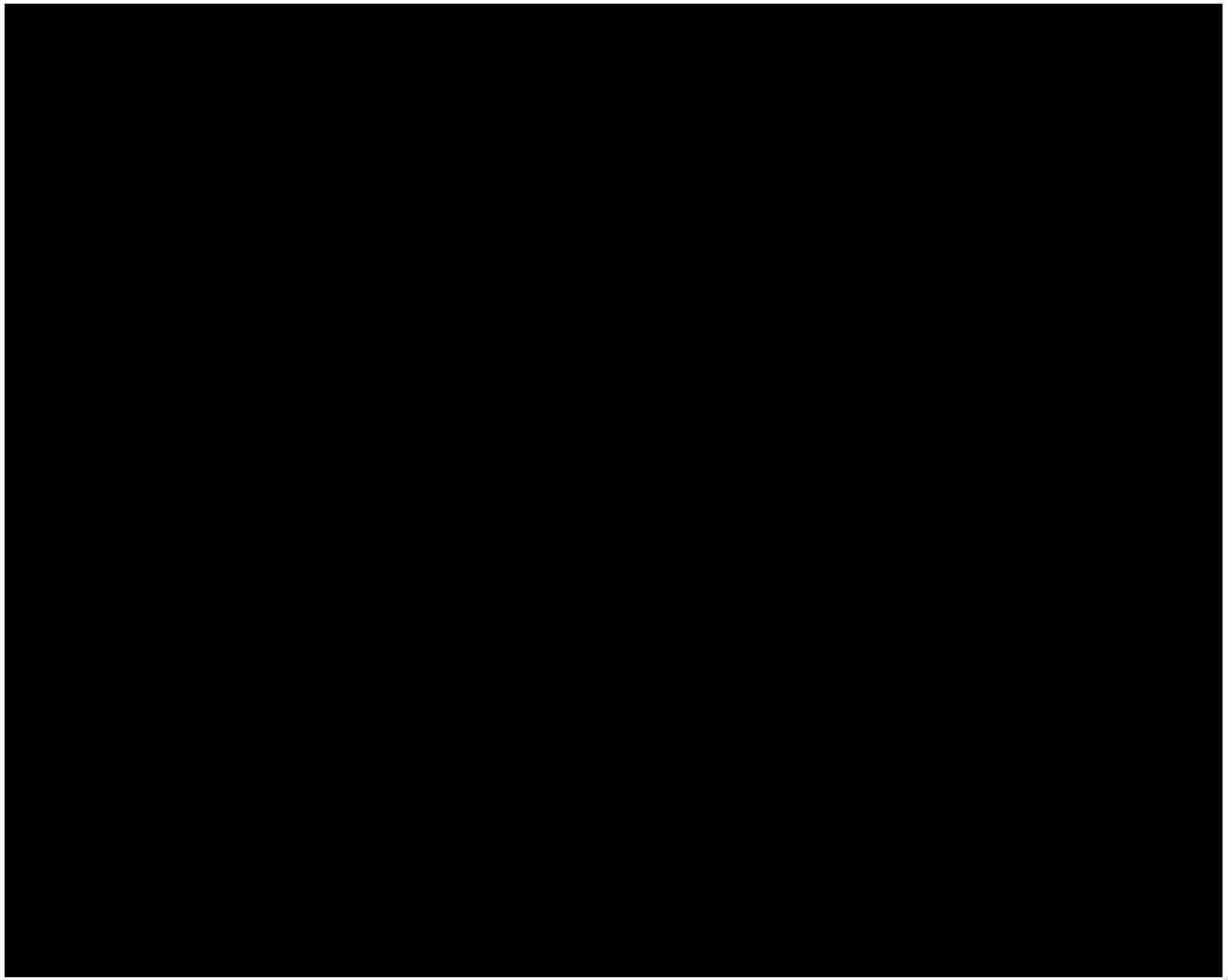
Horizontal Angle Measurement



P2 – left target (back sight)
P3 – right target (foresight)
B : horizontal angle (clockwise)

Face I = P2 then P3 observations
Face II =P3 then P2 observations

Horizontal Angle Measurement



DIRECTION MEASUREMENTS AND GEODETIC FUNDAMENTAL COMPUTATIONS

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Horizontal Angle Measurement

FIELD BOOK FOR ANGULAR MEASUREMENTS - HORIZONTAL ANGLE							
	Station	Target	Horizontal Direction (GRAD)		Mean	Reduced	mean of sets
	Point	Point	Face I	Face II	$(F_{II} - 200 + F_I)/2$	directions(GRAD)	(GRAD)
SET1	P_2	P_1	0.650	200.652	0.651	0.0000	
		P_3	149.298	349.296	149.297	148.646	148.647
SET2	P_2	P_1	100.323	300.325	100.324	0.0000	
		P_3	248.971	48.973	248.972	148.648	

PROJECT :		GROUP NO:		
LOCATION:		BOOKER:		
WEATHER:		OPERATOR:		
EQUIPMENT:		DATE:		

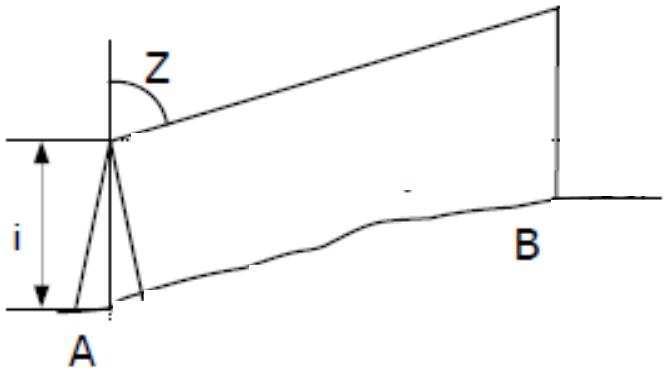
Horizontal Angle Measurement

		Directions		Reduction to 0		Mean	Final Directions	d	v	vv
DN	BN	1. Durum	2. Durum	1. Durum	2. Durum			(cc)	(cc)	(cc)
P_1	P_2	$0^g.00\ 45$	$200^g.00\ 48$	$0^g.00\ 00$	$0^g.00\ 00$	$0^g.00\ 00$	$0^g.00\ 00$	0	1.7	2.89
	P_3	11.28 34	211.28 46	11.27 89	11.27 98	11.27 94	11.27 90	-4	-2.3	5.29
	P_4	226.36 64	26.36 84	226.36 19	226.36 36	226.36 27	226.36 26	-1	0.7	0.49
		(0.00 56	*200.00 65)*					**-5**		
							5/ 3 =	-1.7		
P_1	P_2	100.00 43	300.00 45	0.00 00	0.00 00	0.00 00		0	-1.7	2.89
	P_3	111.28 31	311.28 29	11.27 88	11.27 84	11.27 86		4	2.3	5.29
	P_4	326.36 68	126.36 71	226.36 25	226.36 26	226.36 25		1	-0.7	0.49
		(100.00 49	*300.00 54)*					**5**		**17.34**
							5/ 3 =	1.7		

$$m = \mp\sqrt{\frac{[vv]}{(n-1)(s-1)}} = \mp\sqrt{\frac{17.34}{(2-1)(3-1)}} = \mp\sqrt{\frac{17.34}{2}} = \mp 2^{cc}.94$$

$$M = \mp\frac{m}{\sqrt{n}} = \mp\frac{2.94}{\sqrt{2}} = \mp 2^{cc}.08$$

Vertical Angle Measurement



DN	BN	Set	Face	Vertical Angle (Z)	δ	Corrected Angle (Z)	Mean of Set(Z)	v_δ	V_δ^2
A	B	1	I	95^g.7718	-30^{cc}	95^g.7688	95^g.7689	-3	9
			II	304.2342	-30^{cc}	304.2312			
				400.0060		400.0000			
		2	I	95.7730	-40^{cc}	95.7690		+7	49
			II	304.2350	-40^{cc}	304.2310			
				400.0080		400.0000			
	C	1	I	107.3641	-35^{cc}	107.3606	107.3601	+2	4
			II	292.6429	-35^{cc}	292.6394			
				400.0070		400.0000			
		2	I	107.3623	-27^{cc}	107.3596		-6	36
			II	292.6431	-27^{cc}	292.6404			
				400.0054	δ_{ort}=-33	400.0000			

Geodetic Fundamental Computations

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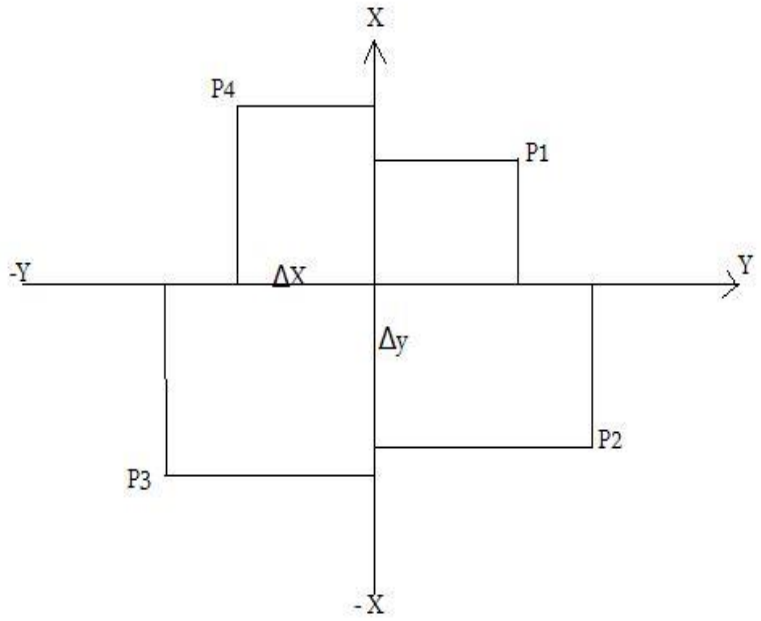
Rectangular Coordinate System

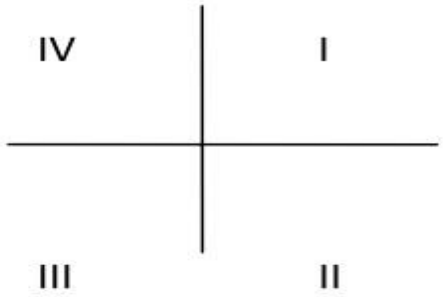


In plane surveys it is convenient to perform the work in a rectangular *XY* coordinate system.

Direction of +X refers to north,

Direction of +Y refers to east,

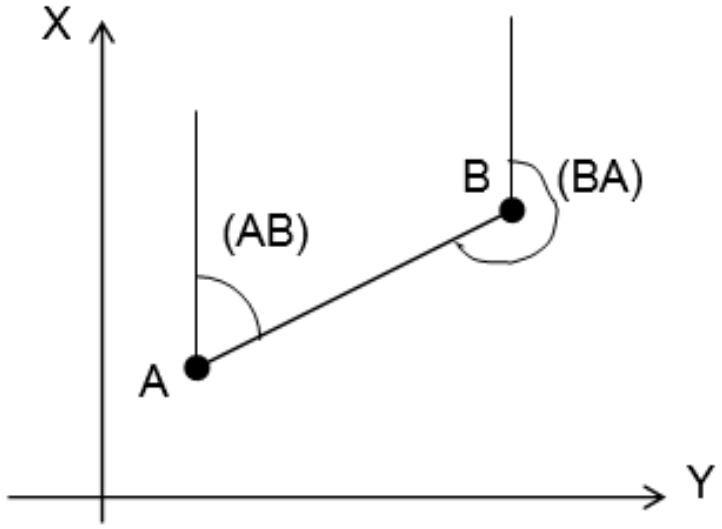
Rectangular Coordinate System



The *x* and *y* axes divide the plane into four parts. The quadrants are numbered clockwise starting with the upper right quadrant.

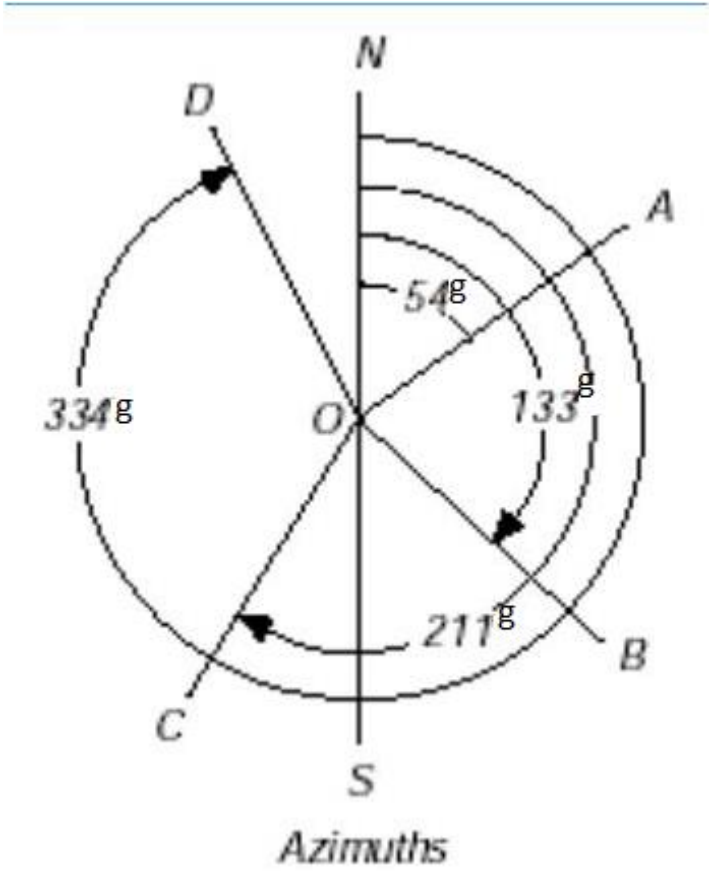
QUADRANT	ΔX	ΔY
I. QUADRANT	+	+
II.QUADRANT	-	+
III.QUADRANT	-	-
IV.QUADRANT	+	-

Azimuth



- The azimuth of a line on the ground is its horizontal angle measured clockwise from the meridian to the line.
- Azimuth gives the direction of the line with respect to the meridian.
- In plan surveying azimuths are generally measured from the north.
- Azimuths may have values between 0^g and 400^g (0 – 360 degrees).

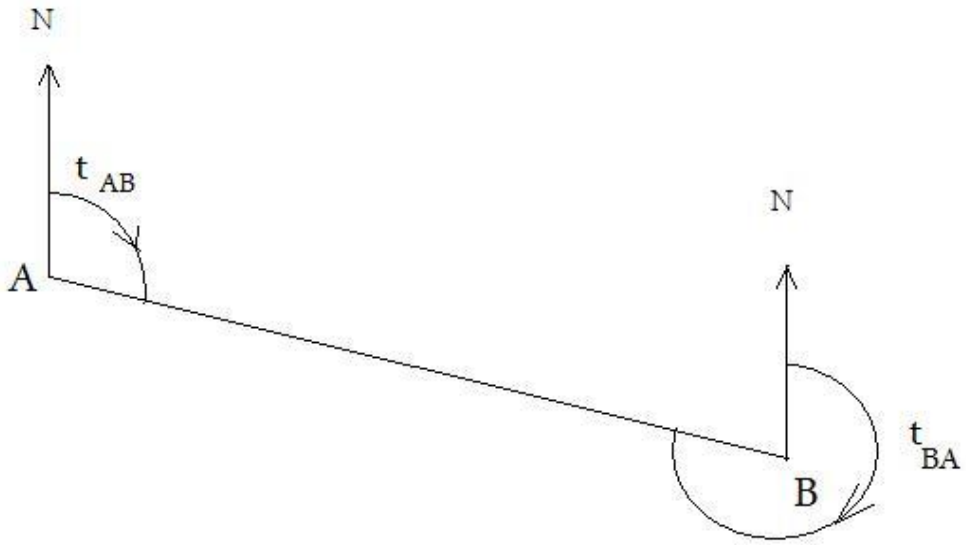
Azimuth



Azimuths

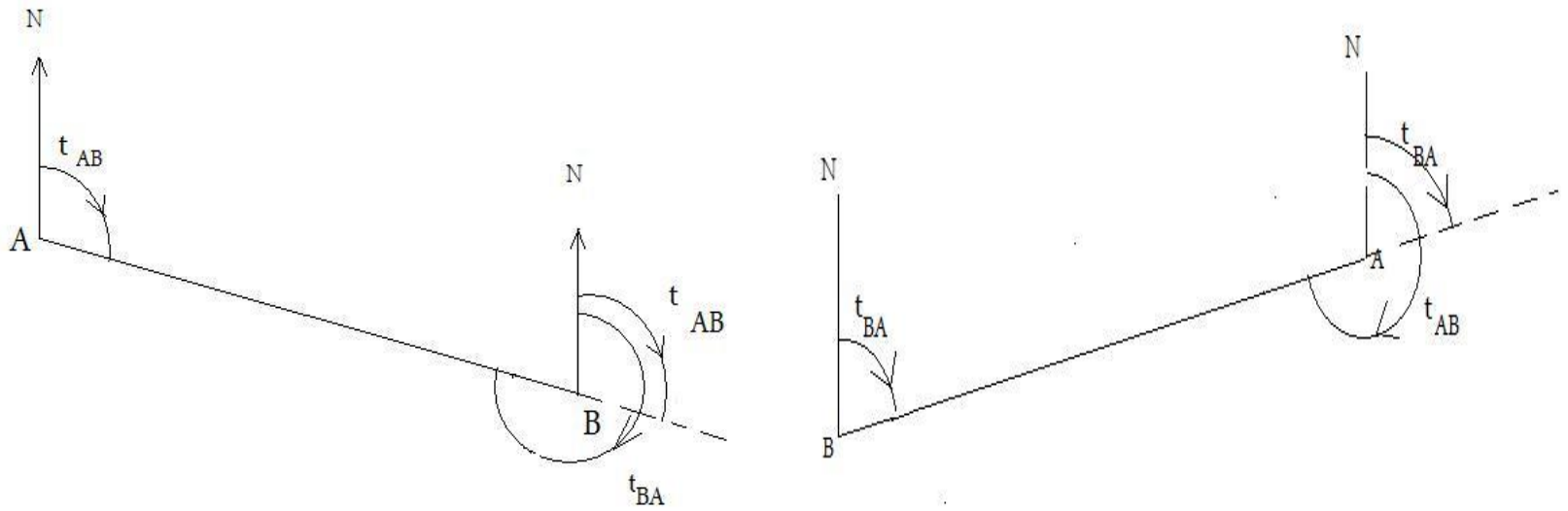
Line	Azimuth
O – A	54g
O – B	133g
O – C	211g
O - D	334g

Azimuth



t_{AB} = forward azimuth of AB line
t_{BA} = back azimuth of AB line

Azimuth

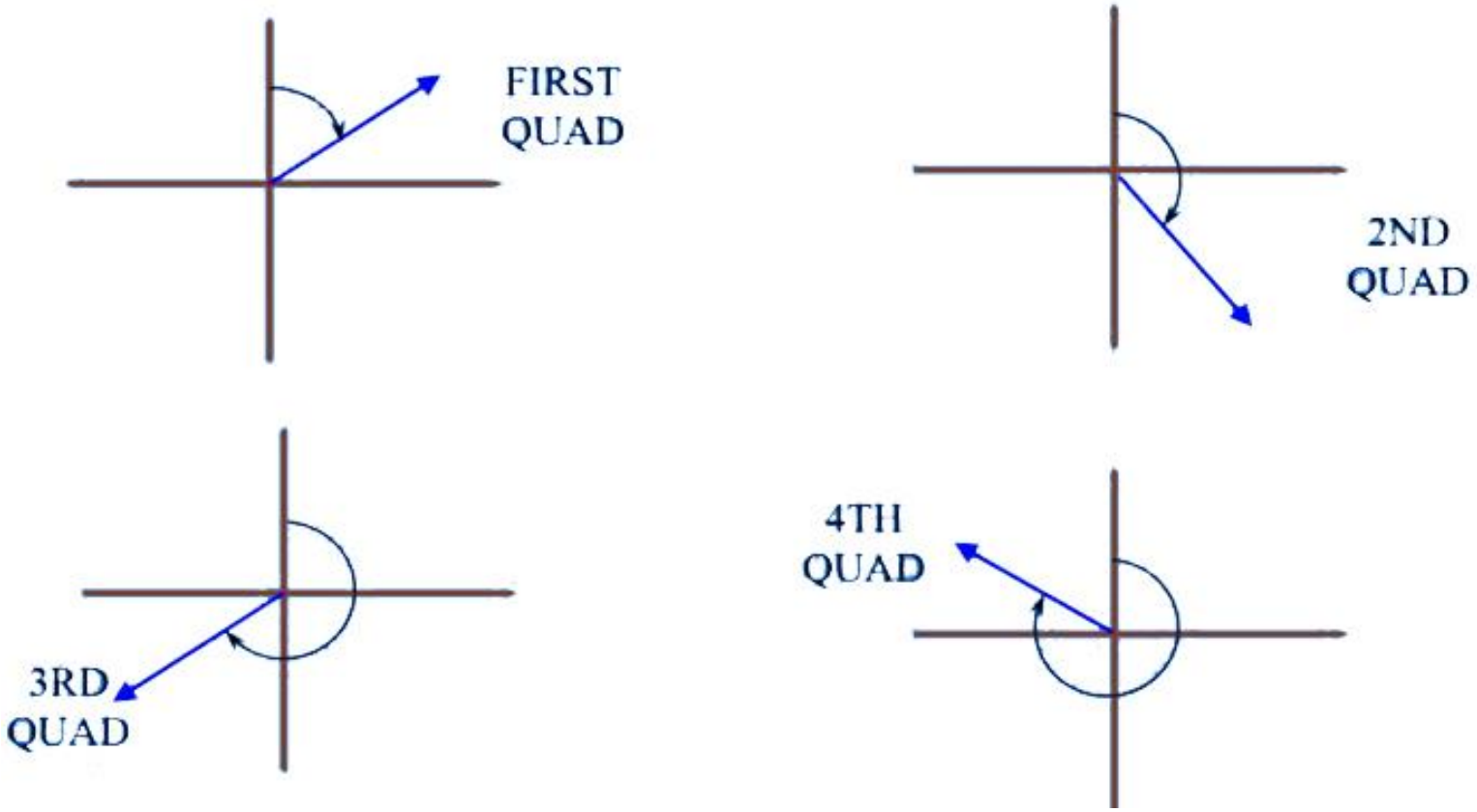


In plane surveying, forward azimuths are converted to back azimuths, and vice versa, by adding or subtracting 200^g .

$$t_{AB} < 200^g \longrightarrow t_{BA} = t_{AB} + 200^g$$

$$t_{AB} > 200^g \longrightarrow t_{BA} = t_{AB} - 200^g$$

Rectangular Coordinate System



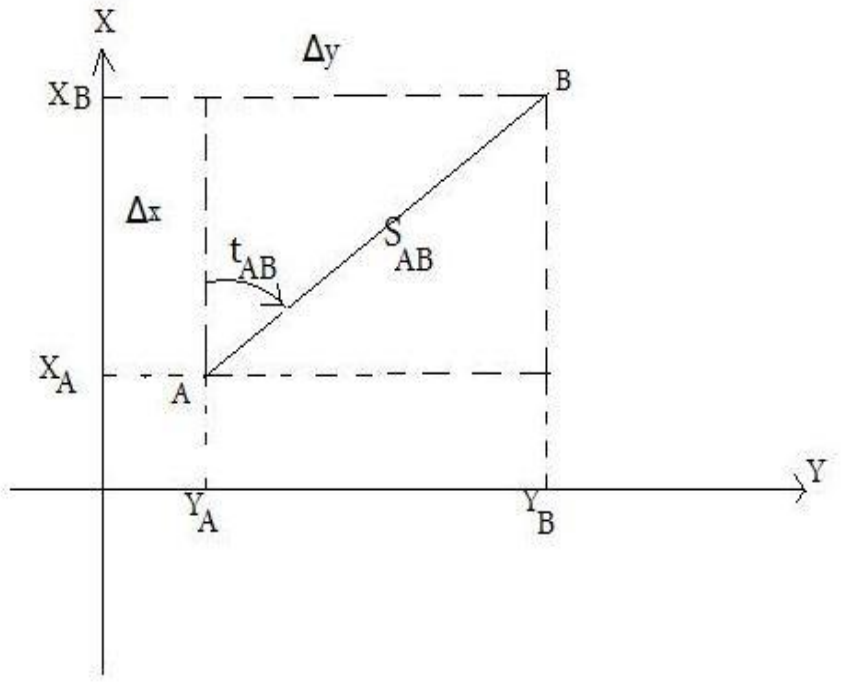
Fundamental Computation - 1

Known: $A\ (X_A, Y_A)$

S_{AB}

$t_{AB} = \alpha$

Unknown: $B\ (X_B, Y_B)$



$$Sin\alpha = \frac{\Delta Y}{S} \rightarrow \Delta Y = S \cdot Sin\alpha$$

$$Cos\alpha = \frac{\Delta X}{S} \rightarrow \Delta X = S \cdot Cos\alpha$$

$$Y_B = Y_A + \Delta Y = Y_A + S \cdot Sin\alpha$$

$$X_B = X_A + \Delta X = X_A + S \cdot Cos\alpha$$

Fundamental Computation - 1

EXAMPLE - 1

Known:

- A (Y_A = 9417.41 m ; X_A = 8418.62 m)
- S_{AB} = 94.17 m , $t_{AB} = \alpha$ = 347^g .3540

Unknown:

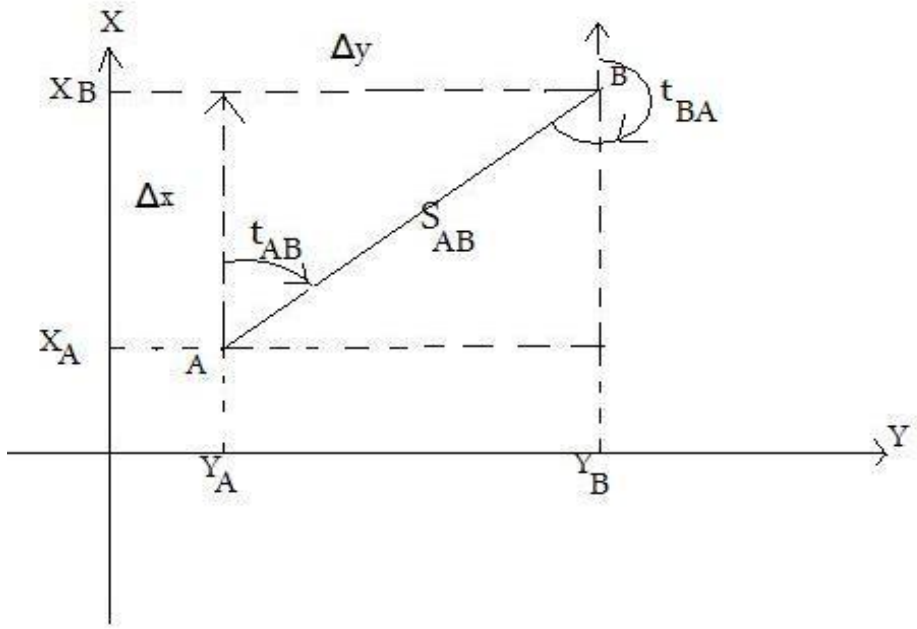
B (Y_B ; X_B) = ???

- Y_B = 9417.41 + (94.17 * sin(347.3540)) = 9417.41 + 69.30 = 9348.11 m
- X_B = 8418.62 + (94.17 * cos(347.3540)) = 8418.62 + 63.76 = 8482.38 m

Fundamental Computation - 2

Known: A (X_A , Y_A)
B (X_B , Y_B)

Unknown: S_{AB} , t_{AB} , t_{BA}



$\Delta Y = Y_B - Y_A$
$\Delta X = X_B - X_A$

$$\tan(AB) = \frac{Y_B - Y_A}{X_B - X_A} \rightarrow (AB) = \arctan\frac{Y_B - Y_A}{X_B - X_A} = \arctan\frac{\Delta Y}{\Delta X} = atn\frac{\Delta Y}{\Delta X}$$

$$AB = S = \sqrt{\Delta Y^2 + \Delta X^2}$$

Fundamental Computation - 2

$$\tan t_{AB} = \frac{\Delta Y_{AB}}{\Delta X_{AB}}$$

This equation is used for calculating the azimuth in first quadrant.

$$t_{AB} = \arctan\left(\frac{\Delta Y_{AB}}{\Delta X_{AB}}\right)$$

$$t'_{AB} = \arctan\left(\frac{\Delta Y_{AB}}{\Delta X_{AB}}\right)$$

QUADRANT	Δy / Δx	Azimuth
FIRST QUADRANT	+ / +	t = t'
SECOND QUADRANT	+ / -	t = 200^g + t'
THIRD QUADRANT	- / -	t = 200^g +t'
FOURTH QUADRANT	- / +	t = 400^g + t'

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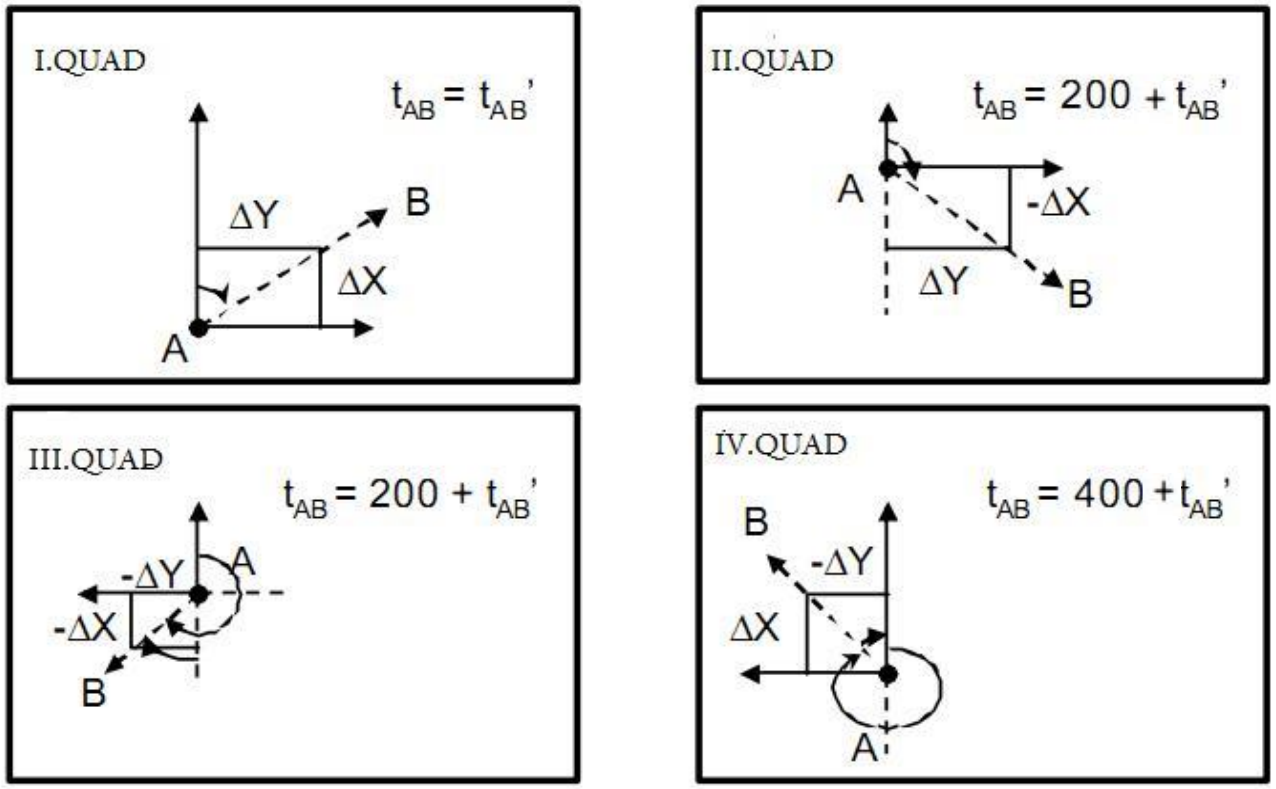
Fundamental Computation - 2



Fundamental Computation - 2

EXAMPLE - 2

$Y_A = 500$ m , $Y_B = 675$ m	(AB) = ?
$X_A = 500$ m , $X_B = 620$ m	AB = S = ?

$$(AB) = atn\frac{Y_B - Y_A}{X_B - X_A} = atn\frac{675-500}{620-500} = atn = \frac{175}{120} \rightarrow \alpha = 61^g.7345$$

$$(AB) = \alpha = 61^g.7345$$

$$AB = \sqrt{\Delta Y^2 + \Delta X^2} = \sqrt{175^2 + 120^2} = 212.19m$$

Fundamental Computation - 2

EXAMPLE - 3

$Y_A = 500$ m , $Y_B = 650$ m	(AB) = ?
$X_A = 500$ m , $X_B = 425$ m	AB = S = ?

$$(AB) = atn\frac{Y_B - Y_A}{X_B - X_A} = atn\frac{650-500}{425-500} = atn = \frac{150}{-75} \rightarrow \alpha = -70^g.4833$$

$$(AB) = \alpha + 200 = -70^g.4833 + 200 = 129^g.5167$$

$$AB = \sqrt{\Delta Y^2 + \Delta X^2} = \sqrt{150^2 + (-75)^2} = 167.71m$$

Fundamental Computation - 2

EXAMPLE - 4

$Y_A = 500$ m , $Y_B = 330$ m | (AB) = ?

$X_A = 500$ m , $X_B = 425$ m | AB = S = ?

$$(AB) = atn\frac{Y_B - Y_A}{X_B - X_A} = atn\frac{330-500}{425-500} = atn = \frac{-170}{-75} \rightarrow \alpha = 73^g.5490$$

$$(AB) = \alpha + 200 = 73^g.5490 + 200 = 273^g.5490$$

$$AB = \sqrt{\Delta Y^2 + \Delta X^2} = \sqrt{(-170)^2 + (-75)^2} = 185.81m$$

Fundamental Computation - 2

EXAMPLE - 5

$Y_A = 500$ m , $Y_B = 330$ m | (AB) = ?

$X_A = 500$ m , $X_B = 620$ m | AB = S = ?

$$(AB) = atn\frac{Y_B - Y_A}{X_B - X_A} = atn\frac{330-500}{620-500} = atn = \frac{-170}{120} \rightarrow \alpha = -60^g.8693$$

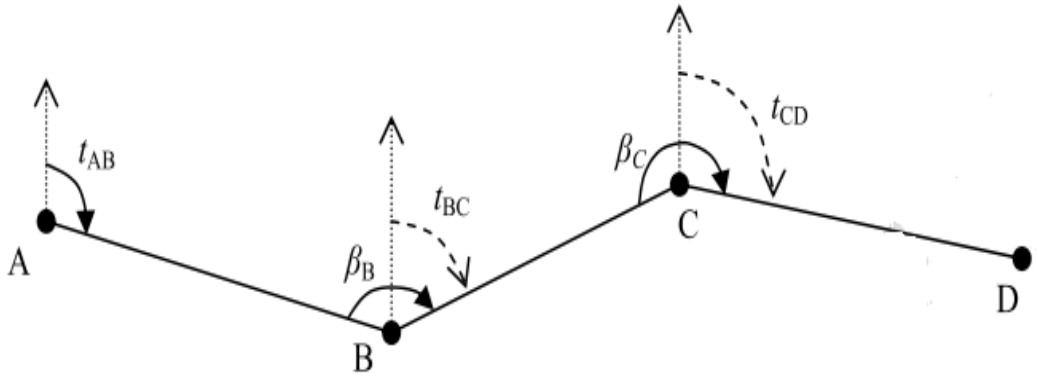
$$(AB) = \alpha + 200 = -60^g.8693 + 400 = 339^g.1307$$

$$AB = \sqrt{\Delta Y^2 + \Delta X^2} = \sqrt{(-170)^2 + 120^2} = 208.09m$$

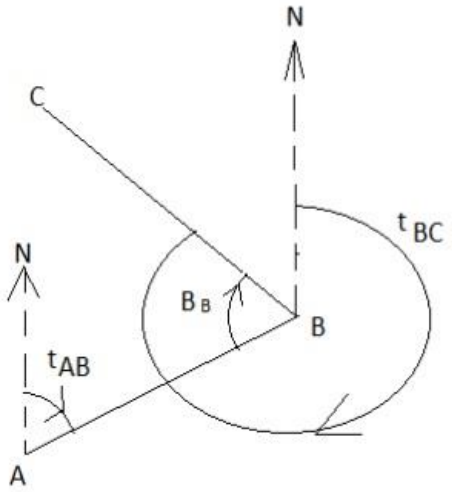
Fundamental Computation - 3

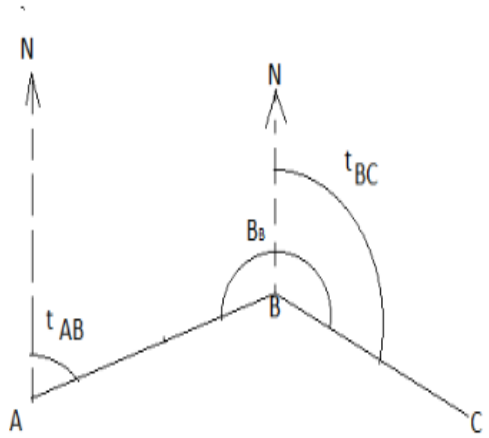
Relation Between Azimuth and Traverse Angles

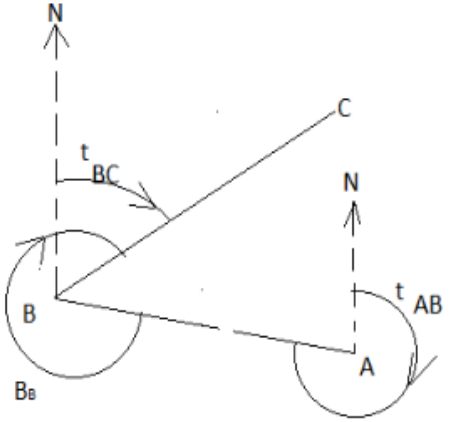
Known:
t_{AB} , β_B
Unknown:
t_{BC}



Fundamental Computation - 3



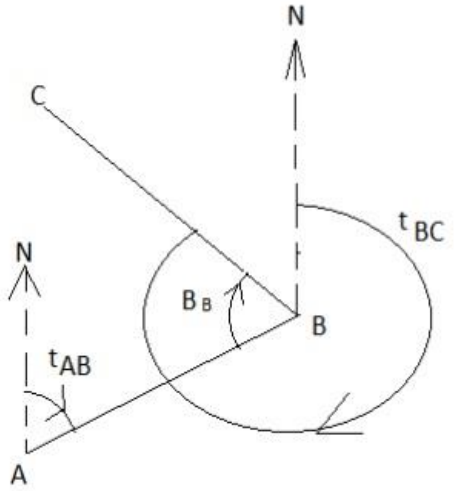


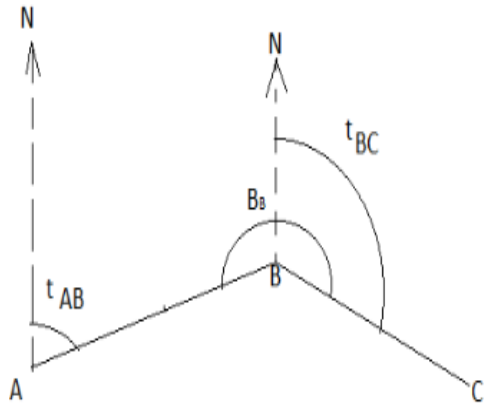


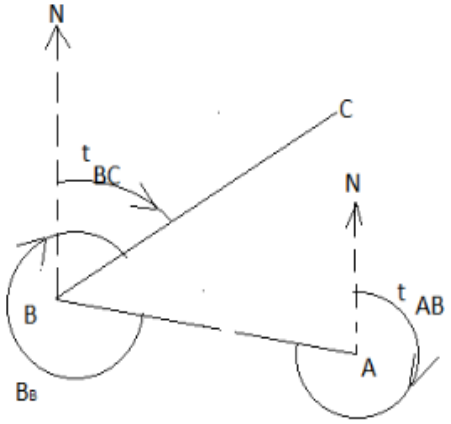
Fundamental Computation - 3

$$t_{AB} + \beta_B = K$$

- $K < 200^g$; $K + 200^g$; $t_{BC} = t_{AB} + \beta_B + 200^g$
- $200^g < K < 600^g$; $K - 200^g$; $t_{BC} = t_{AB} + \beta_B - 200^g$
- $K > 600^g$; $K - 600^g$; $t_{BC} = t_{AB} + \beta_B - 600^g$







Fundamental Computation - 3

EXAMPLE - 6

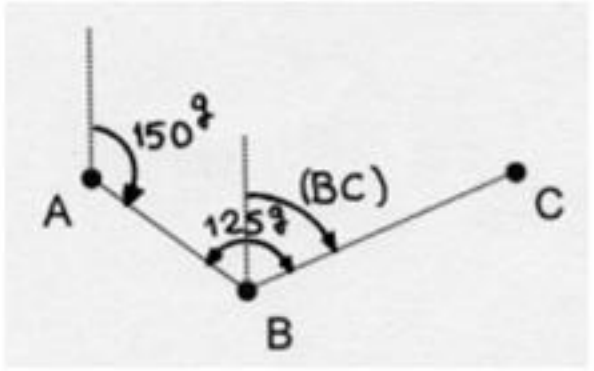
Known

$(AB) = 150^g$

$\beta = 125^g$

Unknown

$(BC) = ?$



$$(BC) = (AB) + \beta \pm 200^g = 150^g + 125^g \pm 200^g = 275^g - 200^g = 75^g$$

Fundamental Computation - 3

EXAMPLE - 7

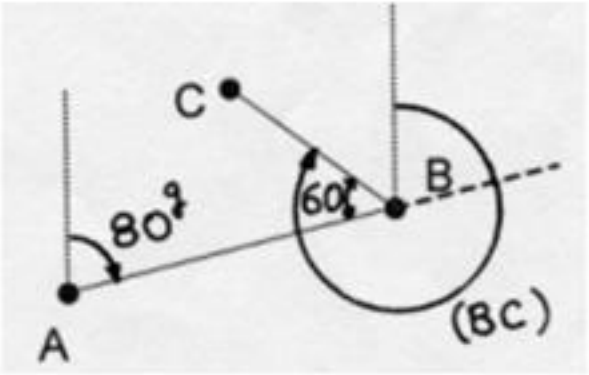
Known

$(AB) = 80^g$

$\beta = 60^g$

Unknown

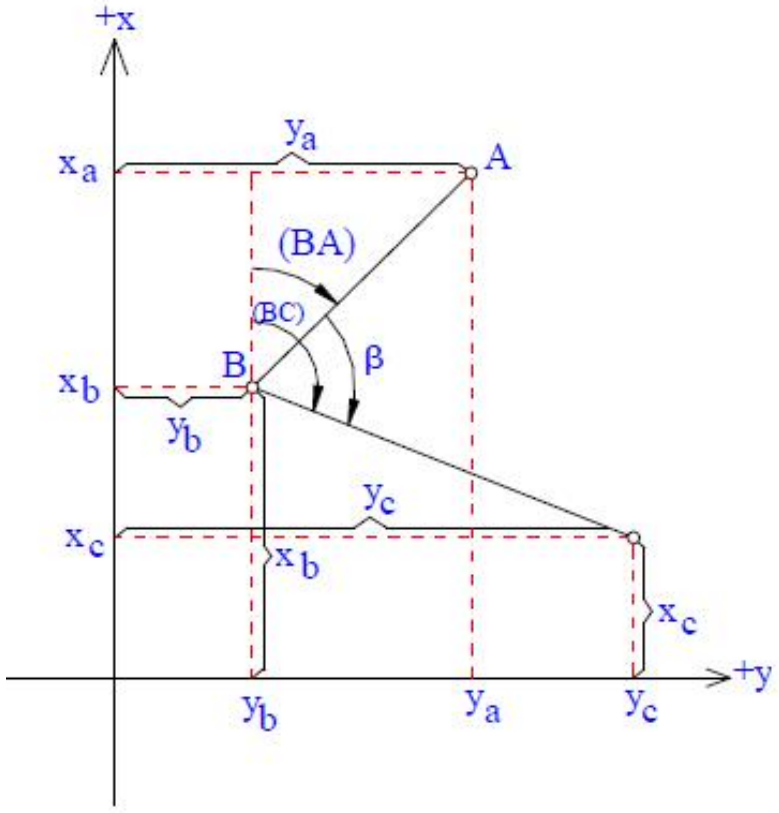
$(BC) = ?$



$$(BC) = (AB) + \beta \pm 200^g = 80^g + 60^g \pm 200^g = 140^g + 200^g = 340^g$$

Fundamental Computation - 4

Relation Between Azimuth and Traverse Angles



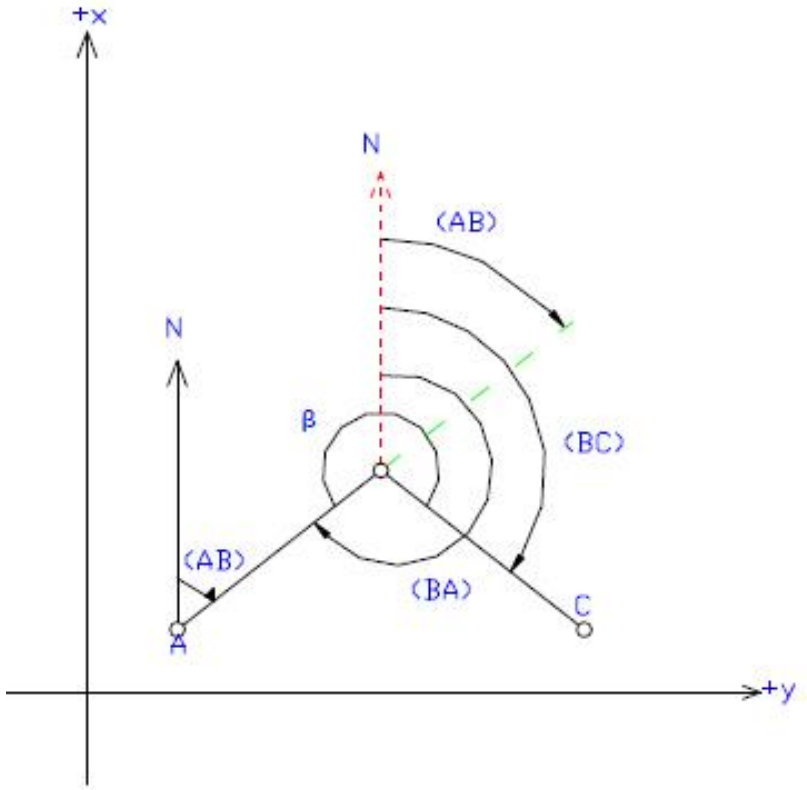
Known	Unknown
A (Y,X) B (Y,X) C (Y,X)	β = ?

$$\beta = (BC) - (BA)$$

$$(BC) = atn\frac{Y_C - Y_B}{X_C - X_B}$$

$$(BA) = atn\frac{Y_A - Y_B}{X_A - X_B}$$

Fundamental Computation - 4



Known	Unknown
A (Y,X) B (Y,X) C (Y,X)	β = ?

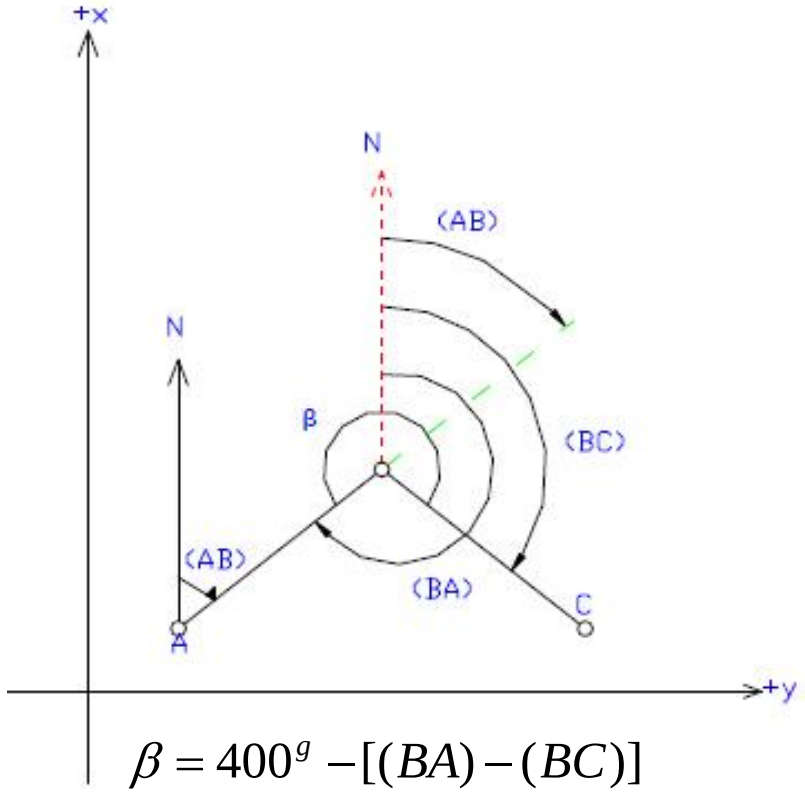
$$\beta = 400^g - [(BA) - (BC)]$$

$$(BC) = atn\frac{Y_C - Y_B}{X_C - X_B}$$

$$(BA) = atn\frac{Y_A - Y_B}{X_A - X_B}$$

Fundamental Computation - 4

EXAMPLE - 7



Nokta	Y	X
A	585 m	640 m
B	650 m	530 m
C	755 m	465 m

β = ?

$$\beta = 400^g - [(BA) - (BC)]$$

$$(BC) = atn\frac{Y_C - Y_B}{X_C - X_B}$$

$$(BA) = atn\frac{Y_A - Y_B}{X_A - X_B}$$

$$(BC) = atn\frac{Y_C - Y_B}{X_C - X_B} = atn\frac{755-650}{465-530} = atn\frac{105}{-65} = -64^g.7117$$

$$(BC) = -64^g.7117 + 200^g = 135^g.2883$$

$$(BA) = atn\frac{Y_A - Y_B}{X_A - X_B} = atn\frac{585-650}{640-530} = atn\frac{-65}{110} = -33^g.9769$$

$$(BA) = -33^g.9769 + 400^g = 366^g.0231$$

$$\beta = 400^g - [366.0231 - 135.2883]$$

$$\beta = 169^g.2652$$

Week-7
Traverse Computations

TOPOGRAPHY (HRT3351)

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