Faculty of Engineering Civil Eng. Department Dr. Suhail A. Almadani	Homework (3) Covering Lectures: 12-18 (4 points)	Surveying (CE 371) Fall 2018

Problem (1) (6 points)

A theodolite is used to determine the length and direction of line AC. Points A and C are not intervisible. The theodolite is set up at point B from which both A and C are visible. the angle at B is measured as 100.1672 deg. The lengths of the two sides are AB= 145.265 m, and BC= 91.218 m. Compute length of AC and internal angles A, and C of triangle ABC.

Solution:

AC = sqrt($(AB)^2 + (BC)^2 - (AB)(BC)\cos B$)

AC = sqrt[$145.265^2 + 91.218^2 - 2(145.265)(91.218)\cos 100.1672^\circ$] = 184.664 m.

Angle A = $\sin^{-1}((BC/AC)\sin B) = \sin^{-1}((91.218/184.664)\sin 100.1672^\circ) = 29.0918^\circ$

Angle C = $180 - A - B = 180 - 29.0918^\circ - 100.1672^\circ = 50.7409^\circ$

Or

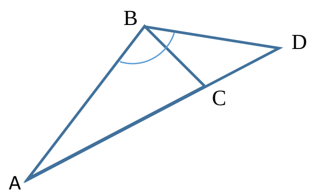
Angle C = $\sin^{-1}((AB/BC)\sin A) = \sin^{-1}((145.265/91.218)\sin 29.0918^\circ) = 50.7409^\circ$

Problem (2) (8 points)

Compute the angle at B in problem (1) to prolong the line AC 50 m to a new point D.

Solution:

Angle at B from A to D = ABD°



AD = AC + CD = 184.664 + 50.000 = 234.664 m

In triangle ABD: AB= 145.265 m, AD = 234.664 m, A° = BAD° = 29.0918°

$BD^2 = AB^2 + AD^2 - 2(AB)(AD)\cos(BAD)$

$BD^2 = 145.265^2 + 234.664^2 - 2(145.265)(234.664)\cos(29.0918^\circ)$

Therefore, BD = 128.815 m

Since $AD^2 = AB^2 + BD^2 - 2(AB)(BD)\cos(ABD)$

Therefore, angle ABD° = $\cos^{-1}((AB^2 + BD^2 - AD^2)/(2(AB)(BD)))$

Angle ABD° = $\cos^{-1}[(145.265^2 + 128.815^2 - 234.664^2)/(2(145.265)(128.815))]$

Angle ABD° = 117.6575°

Problem (3) (9 points)
In triangle ABC, azimuth of **AB** is 60° 30′ 14” , azimuth of **BC** is 190° 00’ 30”and azimuth of **AC** is 154° 22’ 55”. Compute interior angles at A, B and C.

Solution:
From Azimuth of AB and azimuth of BC we can say that the polygon is a CW polygon and, therefore, the interior angles are angles to the left.

Az_{BC} = BAz_{AB} - Al_B (where Al_B is the angle to the left at B)

Al_B = (60° 30’ 14” + 180°) - 190° 00’ 30” = 50° 29’ 44” which is the interior angle at B

Therefore, **Angle B = 50° 29’ 44”**

Az_{CA} = BAz_{AC} = 154° 22’ 55” + 180° = 334° 22’ 55”

Az_{CA} = BAz_{BC} – Al_C (where Al_C is the angle to the left at C)

Al_C = (190° 00’ 30” – 180°) - 334° 22’ 55” = -144° 22’ 25” (Add 180) = 35° 37’ 35”

Therefore, **Angle C = 35° 37’ 35”**

Az_{AB} = BAz_{CA} – Al_A (where Al_A is the angle to the left at A)

Al_A = (334° 22’ 55” – 180°) - 60° 30′ 14” = 93° 52’ 41”

Therefore, **Angle A = 93° 52’ 41”**

Check: A + B + C = 93° 52’ 41” + 50° 29’ 44” + 35° 37’ 35” = 180° 00’ 00” (OK)

Problem (4) (9 points)
An open traverse ABCDE is run by <u>deflection</u> angles. Measured angles are B= 132° 43’ 23”, C= -79° 15’ 07”, D= 141° 19’ 22”. If Az_{AB}=40° 00’ 00”, compute Bearing and azimuth of each side.

Solution:
For side BC
Az_{BC} = Az_{AB} + Def_B = 40° 00’ 00” + 132° 43’ 23” = 172° 43’ 23”

Br_{BC} = S (180° - 172° 43’ 23”) E = **S** 7° 16’ 37”**E**

For side CD
Az_{CD} = Az_{BC} + Def_C = 172° 43’ 23” + (-79° 15’ 07”) = 93° 28’ 16”

Br_{CD} = S (180° - 93° 28’ 16”) E = **S** 86° 31’ 44”**E**

For side DE
Az_{DE} = Az_{CD} + Def_D = 93° 28’ 16” + 141° 19’ 22” = 234° 47’ 38”

Br_{DE} = S (234° 47’ 38” - 180°) E = **S** 54° 47’ 38”**W**

Problem (5) (14 points)

The lengths of traverse sides of Problem (4) are: AB=200.00 m, BC=280.00 m, CD=350.00 m, and DE=170.00 m. If coordinates of A= (200.00,350.00) m, compute: (a) Length and azimuth of BE, (b) Point of intersection of BC with AD.

Solution:

(a) Length and azimuth of BE

$X_B = X_A + L_{AB} \sin Az_{AB} = 200.00 + 200.00 \sin(40^\circ\ 00'\ 00'') \quad = 328.56$ m

$Y_B = Y_A + L_{AB} \cos Az_{AB} = 350.00 + 200.00 \cos(40^\circ\ 00'\ 00'') \quad = 503.21$ m

$X_C = X_B + L_{BC} \sin Az_{BC} = 328.56 + 280.00 \sin(172^\circ\ 43'\ 23'') \quad = 364.03$ m

$Y_C = Y_B + L_{BC} \cos Az_{BC} = 503.21 + 280.00 \cos(172^\circ\ 43'\ 23'') \quad = 225.47$ m

$X_D = X_C + L_{CD} \sin Az_{CD} = 364.03 + 350.00 \sin(93^\circ\ 28'\ 16'') \quad = 713.39$ m

$Y_D = Y_C + L_{CD} \cos Az_{CD} = 225.47 + 350.00 \cos(93^\circ\ 28'\ 16'') \quad = 204.28$ m

$X_E = X_D + L_{DE} \sin Az_{DE} = 713.39 + 170.00 \sin(234^\circ\ 47'\ 38'') \quad = 574.49$ m

$Y_E = Y_D + L_{DE} \cos Az_{DE} = 204.28 + 170.00 \cos(234^\circ\ 47'\ 38'') \quad = 106.27$ m

$L_{BE} = \text{sqrt}\ (\Delta X^2 + \Delta Y^2)$

Length of BE = $L_{BE} = \text{sqrt}[(574.49 - 328.56)^2 + (106.27 - 503.21)^2\ ]$ = **466.95 m**

$Az_{BE} = \tan^{-1}\ [\ (574.49 - 328.56) / (106.27 - 503.21)\ ] + 180^\circ =$

Azimuth of BE = $Az_{BE} = -31.7809^\circ + 180^\circ = 148.2191^\circ$ = **148° 13' 9"**

(b) Point of intersection of BC with AD

	Line BC	Line AD
a	$\Delta Y_{BC} = 225.47 - 503.21 = -277.74$	$\Delta Y_{AD} = 204.28 - 350.00 = -145.72$
B	$-\Delta X_{BC} = -(\ 364.03 - 328.56\ ) = -35.47$	$-\Delta X_{AD} = -(\ 713.39 - 200.00\ ) = -513.39$
C	$Y_B\ \Delta X_{BC} - X_B\ \Delta Y_{BC} =$ 503.21(35.47)- 328.56(-277.74) = 109103.11	$Y_A\ \Delta X_{AD} - X_A\ \Delta Y_{AD} =$ 350.00(513.39)- 200.00(-145.72) = 208830.50
Eqn.	-277.74 x - 35.47 y + 109103.11 = 0	-145.72 x - 513.39 y + 208830.50 = 0

Solving the two equations simultaneously gives **point of intersection = (353.70, 306.37)**

Problem (6) (6 points)
Four interior angles of a five-sided polygon traverse were observed as A = 98° 33″ 26′, B = 111° 04′ 37″, C = 123° 43′ 58″, and D = 108° 34′ 25″. The angle at E was not observed. If all observed angles are assumed to be correct, what is the value of angle E?

Solution:
Sum of interior angles = 180° (n -2) = 180° (5 -2) = 540° 00’ 00”
Sum of the angles A through D = A + B + C + D
Sum = 98° 33’ 26”+ 111° 04’37” + 123° 43’ 58” + 108° 34’ 25” = 441.9406° = 441° 56’ 26”
Angle E = 540° 00’ 00” - 441° 56’ 26” = 98.0594° = **98° 03’ 34”**

Problem (7) (10 points)
Coordinates of the a stations polygon traverse are A(220.00, 320.00) m, B(-150.00, 200.00) m, and C(100.00, -50.00) m. Compute: (a) Length and Azimuth of BA, (b) Azimuth of BC, (c) Angle to the right at B from A to C.

Solution:
(a) Length and Azimuth of BA
$\Delta X_{BA} = X_A – X_B = 370.00$ m
$\Delta Y_{BA} = Y_A – Y_B = 120.00$ m

$L_{BA} = sqrt((X_A – X_B)^2 + (Y_A – Y_B)^2) = 388.973$

$Az_{BA} = tan^{-1}((X_A – X_B)/ (Y_A – Y_B)) = tan^{-1}(370.00/120) = 72.03086° = 72\ 1’\ 51”$

(b) Azimuth of BC
$\Delta X_{BC} = X_C – X_B = 250.00$ m
$\Delta Y_{BC} = Y_C – Y_B = -250.00$ m

$Az_{BC} = tan^{-1}((X_C – X_B)/ (Y_C – Y_B)) = -45°$ (Add 180)

$Az_{BC} = -45° + 180° = 135°$

(c) Angle to the right at B from A to C

$Az_{BC} = BAz_{AB} + Ar_B = Az_{BA} + Ar_B$

$Ar_B = Az_{BC} - Az_{BA} = 135° - 72.03086° = 62.9691° = 62°\ 58’\ 9”$

Problem (8) (4 points)
What is the angular misclosure for a six-sided polygon traverse with observed interior angles of 121°36 ′06″, 125°16 ′04″, 123°21′ 44″, 121°09′ 58″, 120°30′ 12″, and 108°06′ 08″.

Solution:
Computed sum of measured angles = 720° 00’ 12”

Theoretical sum = 180(6-2) = 720°

Angular misclosure = computed sum – theoretical sum = 720° 00’ 12” - 720° = 12”

Problem (9) (20 points)

A closed counterclockwise traverse ABCDEA is carried out by measuring interior angles. Angles are: A= 45.9387^g , B= 130.9388^g, C= 160.5010^g, D= 95.1591^g, and E= 167.4524^g. Measured sides are: AB= 679.130 m, BC= 447.432 m, CD= 214.252 m, DE= 226.576 m, EA= 848.917 m. Azimuth of AB= 320.0000^g, and coordinates of A are (750.000, 1000.000) m. Perform complete traverse adjustment. Compute traverse precision. Is this traverse job accepted? why?

Solution:

	ang grad	adj ang	Az grad	length	dx	dy	adj dx	adj dy	x	y
A	45.9387	45.9407							750	1000
			320.0000	679.13	-645.891	209.8627	-645.764	209.7656		
B	130.9388	130.9408							104.236	1209.766
			250.9408	447.432	-321.023	-311.672	-320.939	-311.736		
C	160.5010	160.5030							-216.703	898.0294
			211.4438	214.252	-38.3066	-210.8	-38.2665	-210.83		
D	95.1591	95.1611							-254.97	687.199
			106.6049	226.576	225.3577	-23.465	225.4	-23.4974		
E	167.4524	167.4544							-29.5699	663.7016
			74.0593	848.917	779.4112	336.4197	779.5699	336.2984		
A		45.9407							750	1000
Sum	599.9900	600.0000	320.0000	2416.307	-0.45173	0.345405	0	0		

closure error = -0.0100 grads

correction per angle = 0.0020 grads

Linear misclosure = 0.568652 m

Traverse precision = 1/ 4249.182 which is less than 1/3000

Therefore, Job Accepted

Problem (10) (15)

A geometrically open traverse ABCDE has two control points at the first point A(500.000, 300.000) m, and last points E(677.270, 488.496) m. the azimuth of AB = 140°. The measured angles to the right are: B= 116.8792°, C= 85.9861°, and D= 125.6867°. Measured distances are: AB= 389.207 m, BC= 513.704 m, CD= 207.243 m, DE= 540.282 m. Do complete traverse adjustment to compute adjusted coordinates of points B, C, and D. Compute traverse precision.

Solution:

points	Measured angles	prelim azimuth	sides	dx	dy	X	Y	adj x	adj y
A						500	300	500	300
		140	389.207	250.1774	-298.15				
B	116.8792					750.1774	1.85014	750.1934	1.872428
		76.8792	513.704	500.293	116.6133				
C	85.9861					1250.47	118.4635	1250.502	118.508
		342.8653	207.243	-61.0578	198.0445				
D	125.6867					1189.413	316.5079	1192.413	316.5748
		288.552	540.282	-512.206	171.8989				
E						677.2063	488.4069	677.27	488.496
			1650.436			677.27	488.496		

departure misclosure =	- 0.063666857	Latitude misclosure =	-0.08915	
correction to dep =	0.015916714	correction to y latitude =	0.022287	
Linear misclosure =	0.109549472	Traverse precision =	1/ 15065.67	Accepted