11 COORDINATE GEOMETRY IN SURVEYING CALCULATIONS

Asterisks (*) indicate problems that have partial answers given in Appendix G.

11.1 The *X* and *Y* coordinates (in meters) of station Shore are 379.241 and 819.457, respectively, and those for station Rock are 437.854 and 973.482, respectively. What are the azimuth, bearing, and length of the line connecting station Shore to station Rock?

Az = 20°50'02"; Brg = N 20°50'02" E; Distance = 164.800 m

11.2 Same as Problem 11.1, except that the *X* and *Y* coordinates (in feet) of Shore are 2058.97 and 6980.06, respectively, and those for Rock are 1408.03 and 6980.06, respectively.

Az = 343°08'40"; Brg = N 16°51'20" W; Distance = 2244.92 ft

11.3* What are the slope, and y-intercept for the line in Problem 11.1?

m = **2.62783; *b* = −177.124 m**

11.4 What are the slope, and the y-intercept for the line in Problem 11.2?

m = **−3.30057**; *b* = **11,627.36 ft**

11.5* If the slope (*XY* plane) of a line is 0.800946, what is the azimuth of the line to the nearest second of arc? (*XY* plane)

51°18'26"

11.6 If the slope (*XY* plane) of a line is −0.689443, what is the azimuth of the line to the nearest second of arc? (*XY* plane)

124°35'02" or **304°35'02″**

11.7* What is the perpendicular distance of a point from the line in Problem 11.1, if the *X* and *Y* coordinates (in meters) of the point are 422.058 and 932.096, respectively?

0.044 m

$Az_{SR} = 20°48'47''$; $SR = 120.502\,\text{m}$

By (11.11): $\alpha = 0°01'15''$

By (11.12):

$SP = 120.502 \sin 0°01'15'' = 0.044$

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11.8 What is the perpendicular distance of a point from the line in Problem 11.2, if the *X* and *Y* coordinates (in feet) of the point are 1848.30 and 5528.73, respectively?

$Az_{SR} = 343°11'08.2''$; $SR = 728.276$ ft

0.52 ft

By (11.11): $\alpha = 0°02'28.6''$

By (11.12): $SP = 728.2761 \sin 0°02'28.6'' = 0.525$

11.9* A line with an azimuth of 105°46′33″ from a station with *X* and *Y* coordinates of 5885.31 and 5164.15, respectively, is intersected with a line that has an azimuth of 200°31′24″ from a station with *X* and *Y* coordinates of 7337.08 and 5949.99, respectively. (All coordinates are in feet.) What are the coordinates of the intersection point?

(6932.18, 4868.39)

D_{12} = 1650.81 ft; Az_{12} = 61°34'24"; ∠1 = 44°12'09"; ∠*P* = 94°44'51" D_{2P} = 1154.90 ft

11.10 A line with an azimuth of 164°28′17″ from a station with *X* and *Y* coordinates of 2443.94 and 3563.84, respectively, is intersected with a line that has an azimuth of 81°19′04″ from a station with *X* and *Y* coordinates of 2126.86 and 3235.93, respectively. (All coordinates are in feet.) What are the coordinates of the intersection point?

(1725.06, 1454.41)

D_{12} = 368.688 ft; Az_{12} = 98°15'09"; ∠1 = 23°35'35"; ∠2 = 23°40'55" D_{1P} = 201.58 ft

11.11 Same as Problem 11.9 except that the bearing of the first line is S 22°12′04″ E and the bearing of the second line is S 38°12′11″ W.

(6169.87, 4466.89)

D_{12} = 1650.81 ft; Az_{12} = 61°34'24"; ∠1 = 96°13'09"; ∠*P* = 23°21'51" D_{2P} = 752.81 ft

11.12 In the accompanying figure, the *X* and *Y* coordinates (in meters) of station *A* are 2084.274 and 5579.124, respectively, and those of station *B* are 3012.870 and 3589.315, respectively. Angle *BAP* was measured as 310°20′25″ and angle *ABP* was measured as 44°21′58″. What are the coordinates of station *P*?

(3568.763, 5172.375)

D_{12} = 2195.821 m; Az_{12} = 154°58'58"; ∠1 = 49°39'35"; ∠*P* = 85°58'27" D_{1P} = 1539.205 m; Az_{1P} = 105°19'22.6"

11.13* In the accompanying figure, the *X* and *Y* coordinates (in feet) of station *A* are 1248.16 and 3133.35, respectively, and those of station *B* are 1509.15 and 1101.89, respectively. The length of *BP* is 2657.45 ft, and the azimuth of line *AP* is 98°25′00″. What are the coordinates of station P?

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(3560.56, 2791.19)

Az_{AB} = 172°40'45"; D_{AB} = 2048.157; D_{AP} = 2337.576 or −1226.525; ∠*PAB* = 74°15'45";

a = 1; *b* = 1111.051; *c* = −2,867,094.99;

11.14 In the accompanying figure, the *X* and *Y* coordinates (in feet) of station *A* are 3539.51 and 5971.30, respectively, and those of station *B* are 3401.79 and 2708.06, respectively. The length of *AP* is 1987.54 ft, and angle *ABP* is 35°22′43″? What are the possible coordinates for station *P*?

(5408.77, 5295.88) or (4658.84, 4328.92)

Az_{BA} = 2°24'59.9"; Az_{BP} = 37°47'42.9"; D_{AB} = 3266.145; D_{BP} = 3274.873 or 2051.190; *a* = 1; *b* = 5326.063; *c* = 6,717,386.86;

11.15* A circle of radius 798.25 ft, centered at point *A*, intersects another circle of radius 1253.64 ft, centered at point *B*. The *X* and *Y* coordinates (in feet) of *A* are 3548.53 and 2836.49, respectively, and those of *B* are 4184.62 and 1753.52, respectively. What are the coordinates of station *P* in the figure?

(4330.13, 2998.69) or (3026.23, 2232.83)

AB = 1255.96; Az_{AB} = 149°34'18.7"; ∠*PAB* = 71°17'43.6"; Az_{AP} = 78°16'35" or 220°52'02"

11.16 The same as Problem 11.15, except the radii from *A* and *B* are 853.34 ft and 1389.54 ft, respectively, and the *X* and *Y* coordinates (in feet) of *A* are 2058.74 and 4311.32, respectively, and those of station *B* are 2581.52 and 2344.21, respectively.

(2683.45, 3730.01) or (1805.05, 3496.56)

AB = 2035.392; Az_{AB} = 165°07'01.4"; ∠*PAB* = 32°10'40.4"; Az_{AP} = 132°56'21.0" or 197°17'41.9"

11.17 For the subdivision in the accompanying figure, assume that lines *AC*, *DF*, *GI*, and *JL* are parallel, but that lines *BK* and *CL* are parallel to each other, but not parallel to *AJ*. If the *X* and *Y* coordinates (in feet) of station *A* are (5000.00, 5000.00), what are the coordinates of each lot corner shown?

Station	*X*	*Y*	Method
A	5000.00	5000.00	Given
B	5149.99	4997.99	Forward
C	5299.97	4995.99	Forward
D	5013.14	5078.91	Forward
E	5162.53	5076.92	Direction-Direction
F	5312.52	5074.91	Direction-Distance
G	5026.27	5157.83	Forward
H	5175.08	5155.84	Direction-Direction
I	5325.07	5153.83	Direction-Distance

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J	5039.40	5236.74	Forward
K	5187.63	5234.76	Direction-Direction
L	5337.61	5232.75	Direction-Distance

11.18 If the *X* and *Y* coordinates (in feet) of station *A* are (1000.00, 1000.00), what are the coordinates of the remaining labeled corners in the accompanying figure?

Station	*X*	*Y*	Method
A	1000.00	1000.00	Given
B	1000.00	1400.01	Forward
C	1430.00	1400.01	Forward
D	1430.00	1000.00	Direction-Direction
E	1235.58	1193.82	Forward or Direction-Distance
F	1194.42	1193.82	Forward or Direction-Distance
G	1215.00	1171.99	Forward or Direction-Direction
H	1200.00	1146.01	Direction-Distance
I	1230.00	1146.01	Direction-Distance
J	1200.00	1000.00	Forward
K	1230.00	1000.00	Forward

11.19* In Figure 11.8, the *X* and *Y* coordinates (in feet) of *A* are 1234.98 and 5415.48, respectively, those of *B* are 3883.94 and 5198.47, respectively, and those of *C* are 6002.77 and 5603.25, respectively. Also angle *x* is 36°59′21″ and angle *y* is 44°58′06″. What are the coordinates of station *P*?

(4538.67, 2940.13)

Az_{BA} = 274°41'00.1"; Az_{BC} = 79°11'04.4"; BC(a) = 2157.148; AB(c) = 2657.834;
$\forall$ = 195°29'55.7"; A+C = 82°32'37.3"; A = 32°09'34.9"; C = 50°23'02.4";
$\forall_1$ = 110°51'04.1"; *AP* = 4128.165; Az_{AP} = 126°50'35.1"

11.20 In Figure 11.8, the X and Y coordinates (in feet) of *A* are 4371.56 and 8987.63, those of *B* are 8531.05 and 8312.57, and those of *C* are 10,240.98 and 8645.07, respectively. Also angle *x* is 50°12'45″ and angle *y* is 44°58′06″. What are the coordinates of station *P*?

(6971.30, 6801.51)

Az_{BA} = 347°31'46.5"; Az_{BC} = 121°58'49.1"; BC(a) = 2142.543; AB(c) = 1888.525;
$\forall$ = 225°32'57.4"; A+C = 44°22'27.6"; A = 20°04'39.3"; C = 24°17'48.3";
$\forall_1$ = 123°33'52.7"; *AP* = 2654.469; Az_{AP} = 187°36'25.8"

11.21 In Figure 11.9, the following *EN* and *XY* coordinates for points *A* through *C* are given. In a 2-D conformal coordinate transformation, to convert the *XY* coordinates into the *EN* system, what are the

(a)* Scale factor? **0.3048277** *AB* = 500.5768 m; *ab* = 1642.163 ft

(b) Rotation angle? **23°12'53.0"**; Az_{AB} = 45°24'51.8"; Az_{ab} = 68°37'44.8"

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(c) Translations in X and Y? **Tx = 718,971.604 m** and **Ty = 109,056.362 m**

(d) Coordinates of points *C* in the *EN* coordinate system?

***E* = 720,218.768 m** and ***N* = 111,593.722**

	State Plane Coordinates (m)		Arbitrary Coordinates (ft)	
Point	**E**	**N**	**X**	**Y**
A	719,542.829	111,493.468	4873.67	6609.04
B	719,899.341	11,844.860	6402.92	7207.45
C			7041.22	6037.23

11.22 Do Problem 11.21 with the following coordinates.

	State Plane Coordinates (m)		Arbitrary Coordinates (m)	
Point	**E**	**N**	**X**	**Y**
A	678,805.266	121,851.804	6182.848	6323.893
B	679,481.136	121,952.112	5430.607	3816.422
C			3957.467	5101.501

(a) Scale factor? **0.2610028** *AB* = 683.273; *ab* = 2617.876

(b) Rotation angle? **115°08'27.8"**; Az_{AB} = 81°33'29.4"; Az_{ab} = 196°41'57.3"

(c) Translations in X and Y? **Tx = 680,985.048** and **Ty = 121,092.177**

(d) Coordinates of points *C* in the *EN* coordinate system?

***E* = 679,340.853** and ***N* = 121,461.546**

11.23 In Figure 11.12, the elevations of stations *A* and *B* are 100.00 ft, and 98.45 ft, respectively. Instrument heights hi_A and hi_B are 5.20 ft, and 5.06 ft, respectively. What is the average elevation of point P if the other field observations are:

$AB = 128.46$ ft

$A = 62°06'00''$ $B = 50°12'07''$

$v_1 = 36°33'59''$ $v_2 = 33°22'46''$

Elev = 184.34 ft

AI = 106.676; *BI* = 122.707; IP_A = 79.128; IP_B = 80.848

11.24 In Problem 11.23, assume station *P* is to the left of the line *AB*, as viewed from station *A*. If the *X* and *Y* coordinates (in feet) of station *A* are 159.19 and 101.20, respectively, and the azimuth of line *AB* is 69°22′32″ what are the *X* and *Y* coordinates of the inaccessible point?

(172.70, 207.02); Az_{AI} = 7°16'32"

11.25 In Figure 11.12, the elevations of stations *A* and *B* are 1106.78 ft, and 1116.95 ft, respectively. Instrument heights hi_A and hi_B are 5.14 and 5.43 ft, respectively. What is the average elevation of point P if the other field observations are:

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$AB = 438.18$ ft

$A = 49°31'00''$ $B = 52°35'26''$

$v_1 = 27°40'57''$ $v_2 = 27°20'51''$

Elev = 1322.81 ft

$AI = 355.971$; $BI = 340.859$; $IP_A = 186.750$; $IP_B = 224.580$

11.26 In Problem 11.25, assume station *P* is to the left of line *AB* as viewed from station *A*. If the *X* and *Y* coordinates (in feet) of station *A* are 8975.18 and 7201.89, respectively, and the azimuth of line *AB* is 347°22′38″, what are the *X* and *Y* coordinates of the inaccessible point?

(8660.47, 7368.24); $Az_{AI} = 297°51'38"$

11.27 In Figure 11.13, the *X*, *Y*, and *Z* coordinates (in feet) of station *A* are 5111.82, 4452.50, and 492.40, respectively, and those of *B* are 5627.41, 4440.12, and 501.65, respectively. Determine the three-dimensional position of the occupied station *P* with the following observations:

$v_1 = 32°14'00''$ $PA = 513.06$ ft $hr_A = 6.53$ ft $\gamma = 79°06'19''$

$v_2 = 37°06'00''$ $PB = 467.02$ ft $hr_B = 5.33$ ft $hi_P = 5.35$ ft

(5410.30, 4137.45, 219.92)

$AB = 515.739$; $Az_{AB} = 91°22'31.7"$; $PC = 433.989$; $PD = 372.488$; $\angle DCP = 45°10'18.5"$

$AC = 273.650$; $BC = 281.710$

11.28 Adapt Equations (11.43) and (11.47) so they are applicable for zenith angles.

(11.43): $PC = PA \sin(z_1)$; $PD = PB \sin(z_2)$

(11.47): $PA = PA \cos(z_1)$; $BD = PB \cos(z_2)$

11.29 In Figure 11.13, the *X*, *Y*, and *Z* coordinates (in meters) of station *A* are 1671.392, 1168.484, and 252.796, respectively, and those of *B* are 1569.635, 1395.155, and 245.809, respectively. Determine the three-dimensional position of occupied station *P* with the following observations:

$z_1 = 110°33'54''$ $PA = 200.285$ m $hr_A = 1.676$ m $\gamma = 89°40'58''$

$z_2 = 113°23'37''$ $PB = 177.196$ m $hr_B = 1.678$ m $hi_P = 1.676$ m

(1971.858, 1543.278, 428.459)

$AB = 248.4637$; $Az_{AB} = 335°49'25.6"$; $PC = 480.3649$; $PD = 428.6304$; $\angle DCP = 62°53'41.5"$; $Az_{AP} = 38°43'07.1"$; $AC = -180.222$; $BC = -185.428$

11.30 Use WOLFPACK to do Problem 11.9. (See solution to 11.9)

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11.31 Use WOLFPACK to do Problem 11.10. (See solution to 11.10)

11.32 Use WOLFPACK to do Problem 11.12. (See solution to 11.12)

11.33 Use WOLFPACK to do Problem 11.13. (See solution to 11.13)

11.34 Use WOLFPACK to do Problem 11.15. (See solution to 11.15)

11.35 Use WOLFPACK to do Problem 11.16. (See solution to 11.16)

11.36 Use WOLFPACK to do Problem 11.17. (See solution to 11.17)

11.37 Write a computational program that solves Example 11.6 using matrices. (Solution will vary.)

11.38 Write a computational program that solves Example 11.8. (Solutions will vary.)

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