10 TRAVERSE COMPUTATIONS

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

10.1 What are the usual steps followed in adjusting a closed traverse?

From Section 10.1, paragraph 3: "The usual steps followed in making elementary traverse computations are (1) adjusting angles or directions to fixed geometric conditions, (2) determining preliminary azimuths (or bearings) of the traverse lines, (3) calculating departures and latitudes and adjusting them for misclosure, (4) computing rectangular coordinates of the traverse stations, and (5) calculating the lengths and azimuths (or bearings) of the traverse lines after adjustment."

10.2* The sum of seven interior angles of a closed-polygon traverse each read to the nearest 3″ is 899°59′39″. What is the misclosure, and what correction would be applied to each angle in balancing them by method 1 of Section 10.2?

Misclosure = −21"; Apply +3" correction per angle

10.3 Similar to Problem 10.2, except the angles were read to the nearest 2″ and their sum was 720°00′12″ for a six-sided polygon traverse.

Misclosure = +12"; Apply −2" correction per angle.

10.4 Similar to Problem 10.2, except the angles were read to the nearest 1″ and their sum for a nine-sided polygon traverse was 1259°59′42″.

Misclosure = −18"; Apply +2" correction per angle.

10.5* Balance the angles in Problem 9.22. Compute the preliminary azimuths for each course.

Preliminary computations are in the solution of Problem 9.22. The misclosure was 14".

Balanced angles (Correction −2" per angle):
$A = \mathbf{136°15'38''}$, $B = \mathbf{119°15'34''}$, $C = \mathbf{93°48'52''}$, $D = \mathbf{136°04'14''}$, $E = \mathbf{108°30'08''}$, $F = \mathbf{42°48'00''}$, **and** $G = \mathbf{63°17'14''}$.

Preliminary azimuths: ***AB* = 348°28'14"; *BC* = 287°43'48"; *CD* = 201°32'40"; *DE* = 157°36'54"; *EF* = 86°07'02"; *FG* = 308°55'02"**

10.6 Balance the following interior angles (angles-to-the-right) of a five-sided closed polygon traverse using method 1 of Section 10.2. If the azimuth of side *AB* is fixed at 122°32′16″, calculate the azimuths of the remaining sides. $A = 105°13'14''; B = 92°36'06''; C = 67°15'22''; D = 217°24'30''; E = 57°30'38''$. (Note: line *BC* bears NE.)

Misclosure = −10"; Correction = +2" per angle

Balanced angles: $A = 105°13'16''; B = 92°36'08''; C = 67°15'24''; D = 217°24'32''; E = 57°30'40''$.

Azimuths: *AB* = 122°32'16"; *BC* = 35°08'24"; *CD* = 282°23'48"; *DE* = 319°48'20"; *EA* 197°19'00"

10.7* Compute departures and latitudes, linear misclosure, and relative precision for the traverse of Problem 10.6 if the lengths of the sides (in feet) are as follows: $AB = 2157.34; BC = 1722.58; CD = 1318.15; DE = 1536.06;$ and $EA = 1785.58$. (Note: Assume units of feet for all distances.)

Course	Length	Dep	Lat
AB	2,157.34	1818.717	−1160.337
BC	1,722.58	991.476	1408.637
CD	1,318.15	−1287.417	282.978
DE	1,536.06	−991.348	1173.333
EA	1,785.58	−531.483	−1704.647
∑ =	8,519.71	−0.054	−0.037

LEC = 0.065 ft; Relative precision = 1:130,000

10.8 Using the compass (Bowditch) rule, adjust the departures and latitudes of the traverse in Problem 10.7. If the coordinates of station *A* are *X* = 20,000 ft and *Y* = 15,000 ft, calculate (a) coordinates for the other stations, (b) adjusted lengths and azimuths of lines *AB* and *DE*, and (c) the final adjusted angles at stations *A* and *C*.

(a) Balanced departures and latitudes and coordinates.

Course	Dep	Lat	Point	X	Y
AB	1818.731	−1160.328	*A*	20,000.00	15,000.00
BC	991.487	1408.644	*B*	21,818.73	13,839.67
CD	−1287.409	282.984	*C*	22,810.22	15,248.32
DE	−991.338	1173.339	*D*	21,522.81	15,531.30
EA	−531.471	−1704.640	*E*	20,531.47	16,704.64

(b) AB = 2157.35 ft, Az_{AB} = 122°32'15"; DE = 1536.06 ft, Az_{DE} = 319°48'22"

(c) Adjusted angles at *A* and *C*.

Point	Angle
A	105°13'16"

C	67°15'25"

10.9 Balance the following interior angles-to-the-right for a polygon traverse to the nearest 1″ using method 1 of Section 10.2. Compute the azimuths assuming a fixed azimuth of 202°40′04″ for line *AB*. $A = 119°37'20''; B = 106°12'58''; C = 104°39'22''; D = 130°01'54''; E = 79°28'16''$. (Note: Line *BC* bears SE.)

Station	Obs. Angle	**Adj. Angle**
A	119°37'20"	**119°37'22"**
B	106°12'58"	**106°13'00"**
C	104°39'22"	**104°39'24"**
D	130°01'54"	**130°01'56"**
E	79°28'16"	**79°28'18"**
Misclosure		**−10"**

Course	**Azimuth**
AB	202°40'04"
BC	128°53'04"
CD	53°32'28"
DE	3°34'24"
EA	263°02'42"

10.10 Determine departures and latitudes, linear misclosure, and relative precision for the traverse of Problem 10.9 if lengths of the sides (in meters) are as follows: $AB = 223.011; BC = 168.818; CD = 182.358; DE = 229.024;$ and $EA = 207.930$.

Course	**Length**	**Dep**	**Lat**
AB	223.011	−85.9456	−205.7845
BC	168.818	131.4102	−105.9758
CD	182.358	146.6675	108.3655
DE	229.024	14.2760	228.6087
EA	207.930	−206.4000	−25.1782
	∑ = 1011.141	0.0082	0.0357

Linear misclosure = 0.0366; Relative precision = 1:27,600

10.11 Using the compass (Bowditch) rule adjust the departures and latitudes of the traverse in Problem 10.10. If the coordinates of station *A* are *X* = 310,630.892 m and $Y = 121,311.411$ m, calculate (a) coordinates for the other stations and, from them, (b) the lengths and bearings of lines *BC* and *EA*, and (c) the final adjusted angles at *B* and *D*.

(a)

Course	**Dep**	**Lat**	**Point**	**X**	**Y**

AB	−85.9474	−205.7924	*A*	310,630.892	121,311.411
BC	131.4089	−105.9817	*B*	310,544.945	121,105.619
CD	146.6660	108.3591	*C*	310,676.353	120,999.637
DE	14.2742	228.6006	*D*	310,823.019	121,107.996
EA	−206.4017	−25.1855	*E*	310,837.294	121,336.597

(b)

Course	Distance	Bearing
BC	168.821	S51°06'49"E
EA	207.933	S83°02'35"W

(c) $B =$ **106°13'08"**; $D =$ **130°01'50"**

10.12 Same as Problem 10.9, except assume line *AB* has a fixed azimuth of 147°36′25″ and line *BC* bears *NE*.

Station	Obs. Angle	**Adj. Angle**
A	119°37'20"	**119°37'22"**
B	106°12'58"	**106°13'00"**
C	104°39'22"	**104°39'24"**
D	130°01'54"	**130°01'56"**
E	79°28'16"	**79°28'18"**
misclosure		**−10"**

Course	Azimuth
AB	147°36'25"
BC	73°49'25"
CD	358°28'49"
DE	308°30'45"
EA	207°59'03"

10.13 Using the lengths from Problem 10.10 and azimuths from Problem 10.12, calculate departures and latitudes, linear misclosure, and relative precision of the traverse.

Course	Azimuth	Length	Dep	Lat
AB	147°36'25"	223.011	119.4724	−188.3089
BC	73°49'25"	168.818	162.1343	47.0319
CD	358°28'49"	182.358	−4.8363	182.2939
DE	308°30'45"	229.024	−179.2284	142.6286
EA	207°59'03"	207.93	−97.5665	−183.6145
		∑1011.141	−0.0245	0.0272

Linear misclosure = 0.0366; Relative precision = 1:27,600

10.14 Adjust the departures and latitudes of Problem 10.13 using the compass (Bowditch) rule, and compute coordinates of all stations if the coordinates of station *A* are

$X = 243{,}605.596$ m and $Y = 25{,}393.201$ m. Compute the length and azimuth of line *CD*.

Course	Dep	Lat	Point	X	Y
AB	119.4779	−188.3149	*A*	243,605.596	25,393.201
BC	162.1383	47.0274	*B*	243,725.074	25,204.886
CD	−4.8319	182.2890	*C*	243,887.212	25,251.913
DE	−179.2229	142.6224	*D*	243,882.380	25,434.202
EA	−97.5614	−183.6239	*E*	243,703.157	25,576.825

Course	Length	Azimuth
CD	182.353	358°28'54"

10.15 Compute and tabulate for the following closed-polygon traverse: (a) preliminary bearings (b) unadjusted departures and latitudes (c) linear misclosure and (d) relative precision. (Note: line *BC* bears *NE*.)

Course	Azimuth	Length (m)	Interior Angle (Right)
AB	179°50′39″	2862.392	A = 120°05'50"
BC		4189.033	*B* = 91°57'50"
CD		3815.353	*C* = 121°44'06"
DE		3645.450	*D* = 82°02'08"
EA		3490.014	*E* = 124°10'11"

(a) Preliminary azimuths are listed below.

(b) Unadjusted latitudes and departures are listed below.

(c) **0.0235 m**

(d) **1:78,000**

From WolfPack:

Station	Obs. Angle	Adj. Angle
A	120°07'50"	120°05'49"
B	91°57'50"	91°57'49"
C	121°44'06"	121°44'05"
D	82°02'08"	82°02'07"
E	124°10'11"	124°10'10"
Misclosure	5"	

Course	Length	Azimuth	Dep (m)	Lat (m)
AB	2862.392	179°50'39"	7.7851	−2862.3814
BC	4189.033	91°48'28"	4186.9481	−132.1491
CD	3815.353	33°32'33"	2108.1938	3180.0059
DE	3545.450	295°34'40	−3288.1961	1573.8718
EF	3490.014	239°44'50"	−3014.7128	−1758.3244
Sum	1843.455		0.0182	1.0228

Linear	**misclosure**	**1.0229**
Relative	**Precision**	**1:17,600**

10.16* In Problem 10.15, if one side and/or angle is responsible for most of the error of closure, which is it likely to be?

The azimuth of the misclosure line is 10°05'23". The line most closely matching this bearing is *AB*. Thus *AB* is the line most likely course with a distance blunder.

10.17* Adjust the traverse of Problem 10.15 using the compass rule. If the coordinates in meters of point *A* are 6521.951 E and 7037.072 N, determine the coordinates of all other points. Find the length and bearing of line *AE*.

Course	Dep	Lat	Station	X	Y
AB	7.7822	−2862.5440	*A*	6,521.951	7037.072
BC	4186.9438	−132.3871	*B*	6,529.733	4174.528
CD	2108.1900	3179.7891	*C*	10,716.677	4042.141
DE	−3288.1997	1573.6647	*D*	12,824.867	7221.930
EF	−3014.7163	−1758.5227	*E*	9,536.667	8795.595

***AE* = 3490.117 m; Az_{AE} = 59°44'40"**

For the closed-polygon traverses given in Problem 10.18 through 10.19 (lengths in feet), compute and tabulate: (a) unbalanced departures and latitudes (b) linear misclosure (c) relative precision and (d) preliminary coordinates if $X_A = 10{,}000.00$ and $Y_A = 5000.00$. Balance the traverses by coordinates using the compass rule.

	Course	*AB*	*BC*	*CD*	*DA*
10.18	Bearing	N8°17′02″E	N87°02′05″E	S14°47′06″W	N68°43′20″W
	Length	403.73	622.63	653.16	550.84
10.19	Azimuth	111°18′00″	25°03′12″	312°43′05″	205°05′04″
	Length	385.94	1016.88	403.50	1164.49

10.18 Solution from WolfPack

Course	Length	Bearing	Unbalanced Dep	Unbalanced Lat
1-2	403.73	N8°17'02.0"E	58.169	399.518
2-3	622.63	N87°02'05.0"E	621.796	32.209
3-4	653.16	S14°47'06.0"W	-166.682	-631.534
4-1	550.84	N68°43'20.0"W	-513.290	199.894
Sum =	2,230.36		-0.007	0.087

Balanced Dep	Balanced Lat	Point	Coordinates X	Coordinates Y
58.170	399.502	1	10,000.00	5,000.00
621.798	32.185	2	10,058.17	5,399.50
-166.680	-631.559	3	10,679.97	5,431.69
-513.289	199.873	4	10,513.29	4,800.13

```
Linear misclosure  = 0.087
Relative Precision = 1 in 25,600

Area: 302,000 sq. ft.
       6.933 acres {if distance units are feet}

 Adjusted Observations
 ---------------------
     Course    Distance   Bearing
 ---------------------------------
  1-2      403.71  N8°17'04"E
  2-3      622.63 N87°02'13"E
  3-4      653.18 S14°47'03"W
  4-5      550.83 N68°43'27"W
```

10.19 Solutions from WolfPack

```
                                                 Unbalanced
Course      Length       Azimuth         Dep         Lat
-----------------------------------------------------------
 1-2        385.94    111°18'00.0"   359.577   -140.193
 2-3      1,016.88     25°03'12.0"   430.610    921.206
 3-4        403.50    312°43'05.0"  -296.452    273.731
 4-1      1,164.49    205°05'04.0"  -493.690  -1054.660
         ----------                  ---------  ---------
  Sum =   2,970.81                     0.045      0.084

            Balanced                        Coordinates
        Dep        Lat     Point         X              Y
-------------------------------------------------------------
      359.571   -140.204     1      10,000.00       5,000.00
      430.594    921.177     2      10,359.57       4,859.80
     -296.458    273.720     3      10,790.17       5,780.97
     -493.707  -1054.693     4      10,493.71       6,054.69

Linear misclosure  = 0.095
Relative Precision = 1 in 31,300

Area: 419,700 sq. ft.
       9.635 acres {if distance units are feet}

 Adjusted Observations
 ---------------------
 Course    Distance   Azimuth
 ---------------------------------
  1-2      385.94  111°18'07"
  2-3     1016.85   25°03'12"
  3-4      403.50  312°42'59"
  4-5     1164.53  205°05'04"
```

10.20 Compute the linear misclosure, relative precision, and adjusted lengths and azimuths for the sides after the departures and latitudes are balanced by the compass rule in the following closed-polygon traverse.

Length	Departure	Latitude

Course	(m)	(m)	(m)
AB	2119.287	−2014.119	+662.335
BC	4460.292	−1656.601	−4358.126
CA	5209.110	+3670.793	+3695.957

Linear Misclosure = 0.181
Relative Precision: 1: 65,000

Course	Length	Dep	Lat	Adj Dep	Adj Lat	Length	Azimuth
AB	2119.287	−2014.119	662.335	−2014.132	662.305	2120.230	288°12'09"
BC	4469.292	−1656.601	−4358.126	−1656.629	−4358.189	4662.427	200°48'46"
CA	5209.110	3670.793	3695.957	3670.761	3695.884	5209.034	44°48'17"
	11,788.689	0.073	0.166	0.000	0.000		

10.21 The following data apply to a closed link traverse [like that of Figure 9.1(b)]. Compute preliminary azimuths, adjust them, and calculate departures and latitudes, misclosures in departure and latitude, and traverse relative precision. Balance the departures and latitudes using the compass rule, and calculate coordinates of points *B*, *C*, and *D*. Compute the final lengths and azimuths of lines *AB*, *BC*, *CD*, and *DE*.

Station	Measured Angle (to the right)	Adjusted Azimuth	Measured Length (ft)	X (ft)	Y (ft)
$AzMk_1$					
		342°09'28"			
A	258°12'18.0"			2,521,005.86	379,490.84
			200.55		
B	215°02'53"				
			253.84		
C	128°19'11"				
			205.89		
D	237°34'05"			2,521,575.16	379,714.76
		101°18'31"			
$AzMk_2$					

From WolfPack:

```
Angle Summary
Station   Unadj. Angle     Adj. Angle
--------------------------------------
    A     258°12'18.0"     258°12'27.0"
    B     215°02'53.0"     215°03'02.0"
    C     128°19'11.0"     128°19'20.0"
    D     237°34' 5.0"     237°34'14.0"

Angular misclosure (sec): -36"

                                      Unbalanced
Course      Length       Azimuth        Dep        Lat
-----------------------------------------------------
```

```
 AB         200.55     60°21'55.0"   174.317     99.166
 BC         253.84     95°24'57.0"   252.707    -23.958
 CD         205.89     43°44'17.0"   142.345    148.757
          ----------                 ---------  ---------
  Sum =     660.28                   569.369    223.965

Misclosure in Departure = 569.369 - 569.300 = 0.069
Misclosure in Latitude  = 223.965 - 223.920 = 0.045

            Balanced                          Coordinates
        Dep        Lat     Point         X              Y
-------------------------------------------------------------
      174.296     99.152     A   2,521,005.86     379,490.84
      252.680    -23.975     B   2,521,180.16     379,589.99
      142.323    148.743     C   2,521,432.84     379,566.02
                             D   2,521,575.16     379,714.76

     Linear misclosure  = 0.082
     Relative Precision = 1 in 8,100

Adjusted Observations
---------------------
    Course    Distance   Azimuth     Point      Angle
-----------------------------------------------------
       AB      200.53   60°21'57"      A  258°12'29"
       BC      253.82   95°25'13"      B  215°03'16"
       CD      205.87   43°44'11"      C  128°18'58"
                                       D  237°34'14"
```

10.22 Similar to Problem 10.21, except use the following data:

Station	Measured Angle (to right)	Adjusted Azimuth	Measured Length (m)	X (m)	Y (m)
$AzMk_1$					
		250°57′23″			
A	253°03′38″			194,325.090	25,353.988
			224.111		
B	91°32′06″				
			116.738		
C	242°25′54″				
			231.566		
D	111°12′02″				
			97.217		
E	295°31′13″			193,819.150	25,514.391
		344°42′26″			
$AzMk_2$					

From WolfPack:

```
Angle Summary
Station   Unadj. Angle     Adj. Angle
---------------------------------------
    A     253°03'38.0"     253°03'40.0"
```

```
B      91°32'06.0"      91°32'08.0"
C     242°25'54.0"     242°25'56.0"
D     111°12'02.0"     111°12'04.0"
E     295°31'13.0"     295°31'15.0"

Angular misclosure (sec): -10"

                                                 Unbalanced
Course      Length       Azimuth         Dep         Lat
-----------------------------------------------------------
 1-2       224.111    324°01'03.0" -131.6738   181.3498
 2-3       116.738    235°33'11.0"  -96.2680   -66.0320
 3-4       231.566    297°59'07.0" -204.4886   108.6611
 4-5        97.217    229°11'11.0"  -73.5777   -63.5411
          ----------                 ---------  ---------
  Sum =    669.632                 -506.0081   160.4379

Misclosure in Departure = -506.0081 - -505.9400 = -0.0681
Misclosure in Latitude  = 160.4379 - 160.4030 = 0.0349

            Balanced                          Coordinates
        Dep        Lat     Point         X              Y
-------------------------------------------------------------
    -131.6510   181.3382     A    194,325.090     25,353.988
     -96.2562   -66.0381     B    194,193.439     25,535.326
    -204.4650   108.6491     C    194,097.183     25,469.288
     -73.5678   -63.5461     D    193,892.718     25,577.937
                             E    193,819.150     25,514.391

     Linear misclosure  = 0.0765
     Relative Precision = 1 in 8,800

Adjusted Observations
---------------------
    Course   Distance    Azimuth     Point      Angle
-----------------------------------------------------
       AB     224.088 324°01'13.7"   A   253°03'50.7"
       BC     116.732 235°32'50.3"   B    91°31'36.6"
       CD     231.540 297°59'07.4"   C   242°26'17.1"
       DE      97.213 229°10'49.2"   D   111°11'41.8"
                                     E   295°31'15.0"
```

The azimuths (from north of a polygon traverse are $AB = 38°17'02''$, $BC = 121°26'30''$, $CD = 224°56'59''$, and $DA = 308°26'56''$. If one observed distance contains a mistake, which course is most likely responsible for the closure conditions given in Problems 10.23 and 10.24? Is the course too long or too short?

10.23* Algebraic sum of departures = 5.12 ft latitudes = −3.13 ft.

Az_{LEC} = 121°26'19", which matches course ***BC*** closely

10.24 Algebraic sum of departures = −3.133 m latitudes = +2.487 m.

Az_{LEC} = 308°26'34", which closely matches course ***DA*** closely

10.25 Determine the lengths and bearings of the sides of a lot whose corners have the following *X* and *Y* coordinates (in feet): *A* (5000.00, 5000.00); *B* (5289.67, 5436.12); *C* (4884.96, 5354.54); *D* (4756.66,5068.37).

Course	Length	Azimuth
AB	523.55	33°35'31"
BC	412.85	258°36'12"
CD	313.61	204°08'54"
DA	252.76	223°10'58"

10.26 Compute the lengths and azimuths of the sides of a closed-polygon traverse whose corners have the following X and Y coordinates (in meters): A (8000.000, 5000.000); B (2650.000, 4702.906); C (1752.028, 2015.453); D (1912.303, 1511.635).

Course	Length	Azimuth
AB	5358.24	266°49'18"
BC	2833.51	198°28'35"
CD	528.70	162°21'11"
DA	7016.32	231°40'28"

10.27 In searching for a record of the length and true bearing of a certain boundary line which is straight between *A* and *B*, the following notes of an old random traverse were found (survey by compass and Gunter's chain, declination 4°45′W). Compute the true bearing and length (in feet) of *BA*.

Course	***A*-1**	**1-2**	**2-3**	**3-*B***
Magnetic bearing	Due North	N20°00′E	Due East	S46°30′E
Distance (ch)	11.90	35.80	24.14	12.72

Course	**BA**
Distance (ch)	58.60
Bearing	S55°51'50"W

Convert direction to true north and then compute departures and latitudes shown below.

Course	***A*-1**	**1-2**	**1-3**	**3-*B***	**Total**
Departure	0.985	14.988	24.057	8.470	48.501
Latitude	11.859	32.512	−1.999	−9.490	32.882

10.28 Describe how a blunder may be located in a traverse.

From Section 10.16: If a single blunder in a distance exists, the azimuth of the misclosure line will closely approximate the azimuth of the course with the blunder. If

the blunder is in an angle, the perpendicular bisector of the misclosure line will come close to bisecting the angle with the blunder.

Instructor's Note: The Mathcad worksheet C10.xmcd and its equivalent html file demonstrate a traverse with a single angle blunder. A graphic of the traverse contained in the files shows how the perpendicular bisector of the misclosure line points at the station with the angular blunder.