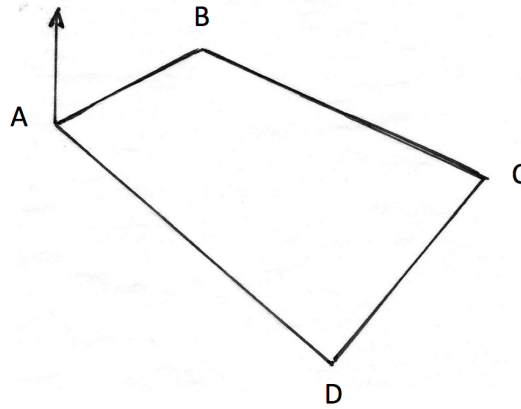


3.5 Procedure for balancing a closed traverse

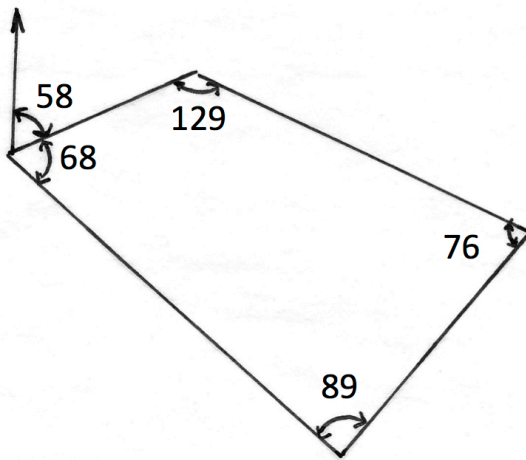
The following four-point traverse was conducted in the field to determine the area of the enclosed parcel of land:



Station	Direction	Distance	Slope
A			
	58°	102	0
B			
	109°	130	0
C			
	213°	132	0
D			
	306°	172	0
A			
Total		536	

1. Compute the sum of the *measured* interior angles and balance them. Balancing is done so that their measured sum equals the true geometric sum of interior angles, S , for a polygon with n sides, given by: $S = 180 \times (n - 2)$.

If the sum of your measured angles is different from S , then they must be balanced (corrected), usually by adding or subtracting the discrepancy to one or more of the angles. The adjustment may be made to an angle (or angles) where difficulties were experienced in measurement or at an angle adjacent to two short sides. Corrections should be at least as large as the smallest angular measurement that could be read on the compass.



The measured sum is 362, so subtract 2 deg. from angle B (makes azimuth reading 2 degrees larger).

2. If azimuths were recorded, then “translate” them to bearings.

Station	Dir. (Az.)	Distance	Slope	Station	Bearing	Distance	Slope
A				A			
	58	102	0		N 58 W	102	0
B				B			
	111	130	0		S 69 E	130	0
C				C			
	213	132	0		S 33 W	132	0
D				D			
	306	172	0		N 54 W	172	0
A				A			
Total		536		Total		536	

3. Compute the latitude and departure of each of the courses.

“Latitude” is the orthographic projection of the course onto the N-S axis

“Departure” is the orthographic projection of the course onto the E-W axis

$$\text{Latitude} = [\cos (\text{Bearing})] (\text{Length})$$

$$\text{Departure} = [\sin (\text{Bearing})] (\text{Length})$$

$$\text{Lat}_{AB} = [(\cos (58))] (102) = 54.0 \text{ ft}$$

$$\text{Dep}_{AB} = [\sin(58)] (102) = 86.5 \text{ ft}$$

Label each north latitude and east departure positive and each south latitude and west departure negative.

Station	Bearing	Distance	Slope	Lat	Dep
A	N 58 E	102	0	54.1	86.5
B	S 69 E	130	0	-46.6	121.4
C	S 33 W	132	0	-110.7	-71.9
D	N 54 W	172	0	101.1	-139.2
A					
Total		536		-2.1	-3.2

4. Determine the Error of Closure (EC) in both latitude and departure and the linear error of closure.

$$EC_{LAT} = (\text{sum of all Latitudes}) = -2.1$$

$$EC_{DEP} = (\text{sum of all Departures}) = -3.2$$

$$EC_{LIN} = \sqrt{(EC_{LAT})^2 + (EC_{DEP})^2} = \sqrt{(-2.1)^2 + (-3.2)^2} = 3.8$$

5. Determine the ratio of error and compare with the allowable ratio of error.
 a. First compute the total distance around the perimeter of the traverse:

$$\text{Total Distance} = 102 + 130 + 132 + 172 = 536 \text{ ft}$$

b. Ratio of Error = $3.8 / 536 = 1 / 140$

c. Compare with the allowable linear error of closure.

6. Compute the corrections in latitude and departures using the compass rule if error is allowable which states:

“The correction in the latitude (departure) of a course is proportional to the total error in latitude (departure) as the length of the course is to the perimeter of the traverse.”

That is:

$$\frac{\text{Correction in } \begin{bmatrix} Lat \\ Dep \end{bmatrix} \text{ for } AB}{\text{Error of Closure in } \begin{bmatrix} Lat \\ Dep \end{bmatrix}} = \frac{\text{Length of } AB}{\text{Tot. Perimeter}}$$

For the example: $\frac{C_{Lat:AB}}{EC_{Lat}} = \frac{102}{536} \Rightarrow C_{Lat:AB} = EC_{Lat} \times \frac{102}{536} = -2.1 \times 0.19 = -0.4$,

Similarly, $C_{Dep:AB} = EC_{Dep} \times \frac{102}{536} = -3.2 \times 0.19 = 0.6$

7. Subtract the corrections in latitude and departure for each line from the latitude and departure for that line to obtain the adjusted latitudes and departures. Be sure to verify that the correction results in a change in the correct direction. The sum of adjusted latitudes should equal zero, as should the sum of adjusted departures. (For example, a negative EC_{LAT} indicates southern latitudes exceeded northern, so northern latitudes should be made “more positive,” and southern latitudes should be made “less negative” – same for departures.)

Station	Bearing	Distance	Slope	Lat	Dep	C.lat	C.dep	Adj.Lat	Adj.Dep
A									
	N 58 E	102	0	54.1	86.5	-0.4	-0.6	54.5	87.1
B									
	S 69 E	130	0	-46.6	121.4	-0.5	-0.8	-46.1	122.2
C									
	S 33 W	132	0	-110.7	-71.9	-0.5	-0.8	-110.2	-71.1
D									
	N 54 W	172	0	101.1	-139.2	-0.7	-1	101.8	-138.2
A									
Total		536		-2.1	-3.2	-2.1	-3.2	0	0

8. Compute the total latitudes and departures around the course.

If the coordinates of the initial point are known to some reference grid system, they may be used. Otherwise, assume the initial coordinates to be 0, 0.

Station	Bearing	Distance	Slope	Lat	Dep	C.lat	C.dep	Adj.Lat	Adj.Dep	Y-coord.	X-coord.
A										0	0
	N 58 E	102	0	54.1	86.5	-0.4	-0.6	54.5	87.1		
B										54.5	87.1
	S 69 E	130	0	-46.6	121.4	-0.5	-0.8	-46.1	122.2		
C										8.4	209.3
	S 33 W	132	0	-110.7	-71.9	-0.5	-0.8	-110.2	-71.1		
D										-101.8	138.2
	N 54 W	172	0	101.1	-139.2	-0.7	-1	101.8	-138.2		
A										0	0
Total		536		-2.1	-3.2	-2.1	-3.2	0	0		

This procedure provides a check on the balancing procedure and gives the coordinates of each station on the traverse. Progress around the traverse adding Latitudes algebraically to obtain the N-S (Latitude) coordinates at each station. The same procedure is used for Departures.

The closure on the initial point should result in the same coordinates as the original point. If not, some calculation has been done incorrectly between the field data and this point.

9. Compute area of closed traverse by coordinates.

Areas are determined using the so-called Double Meridian Distance Method. The area is equal to 1/2 the sum of the products of each abscissa value times the difference between the two adjacent ordinate values.

$$area = \frac{1}{2} \left| X_1(Y_n - Y_2) + X_2(Y_1 - Y_3) + \dots + X_n(Y_{n-1} - Y_1) \right|$$

For calculation purposes, an equivalent expression (after collecting like-signed terms) is:

$$area = \frac{1}{2} \left| (X_1Y_2 + X_2Y_3 + \dots + X_nY_1) - (X_2Y_1 + X_3Y_2 + \dots + X_1Y_n) \right|$$

For this example:

Station	Adj.Lat	Adj.Dep	Y-coord.	X-coord.	Pos. sum	Neg. sum
A			0	0	0	0
	54.5	87.1				
B			54.5	87.1	731.64	11406.85
	-46.1	122.2				
C			8.4	209.3	-21306.74	1160.88
	-110.2	-71.1				
D			-101.8	138.2	0	0
	101.8	-138.2				
A			0	0		
Total	0	0			-20575.1	12567.73

Double Area = -33142.83

Area = 16571.415

$$area = \frac{1}{2} \left| (-20575.1) - (12567.73) \right| = 16571.4$$