Chapter 4
Angles and Directions

4.1 General Background

Angles in surveying are measured with

- A transit / theodolite , or
- Total station

4.2 Reference Directions for Vertical Angles

Vertical angles are referenced to:

1. The horizon by up (+), or down (-)
2. Zenith
3. Nadir

Note:

Zenith: is directly **above** the observer

Nadir : is directly **below** the observer

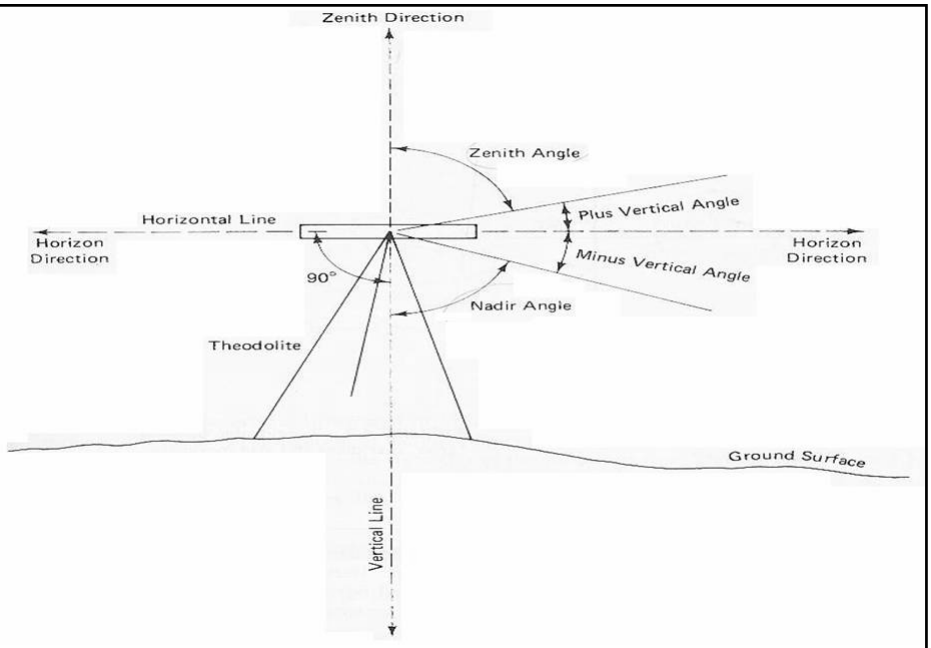


Figure 4.1 the three reference directions for vertical angles: horizontal, zenith, and nadir.

4.3 Meridians

A line on the mean surface of the earth joining north and south poles is called ***meridian***.

Note:

Geographic meridians are fixed, magnetic meridians vary with time and location.

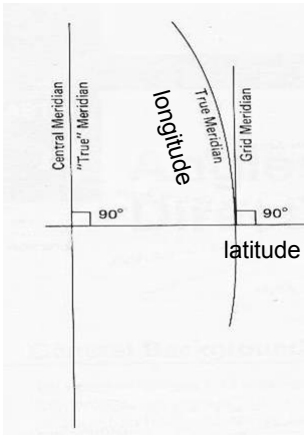


Figure 4.2
Relationship between "true" meridian and grid meridians

4.4 Horizons Angles

Horizontal angles are usually measured with a theodolite or total stations whose precision can range from 1 second to 20 seconds

For all closed polygons of *n* sides, the sum of the interior angles will be

$(n-2)x\ 180^{o}$

For all closed polygons of *n* sides, the sum of the exterior angles equal to

$(n+2)180^{\circ}$

4.4 Horizons Angles (Cont'd)

A _ 87° 05'
B _ 120° 28'
C _ 118° 37'
D _ 105° 22'
E _ 108° 28'
538° 120'
= 540° 00'

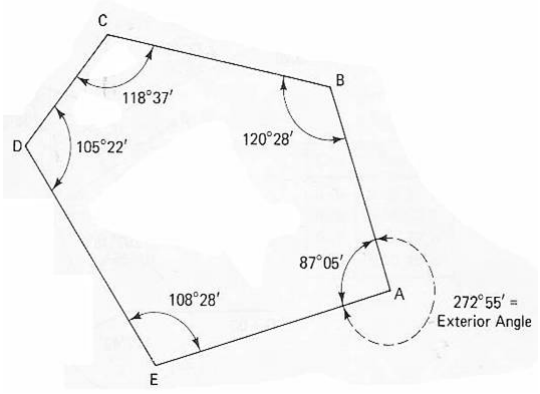
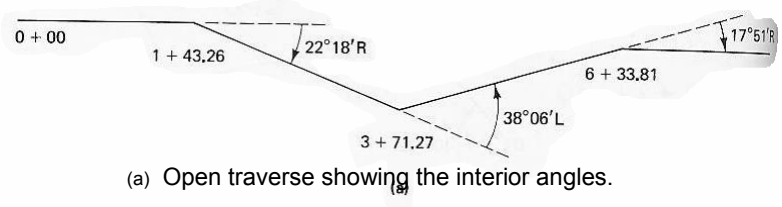


Figure 4.3 Closed traverse showing the interior angles.

4.4 Horizons Angles (Cont'd)



(a) Open traverse showing the interior angles.

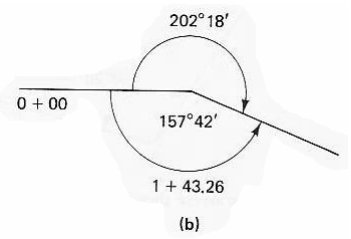


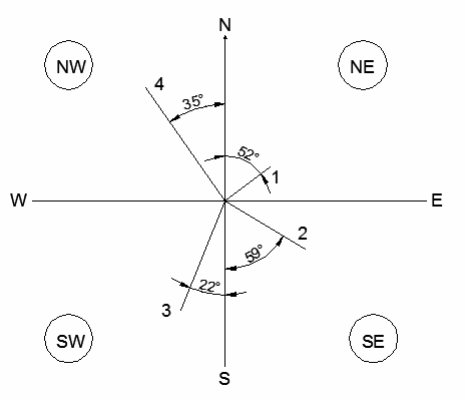
Figure 4.4

Same traverse showing angle right (202° 18') and angle left (157° 42')

4.5 Azimuths

- An azimuths is direction of line as given by an angle measured clockwise (usually) from the north end of a meridian.
- Azimuths range is magnitude from 0^o to 360^o

4.5: Azimuths:

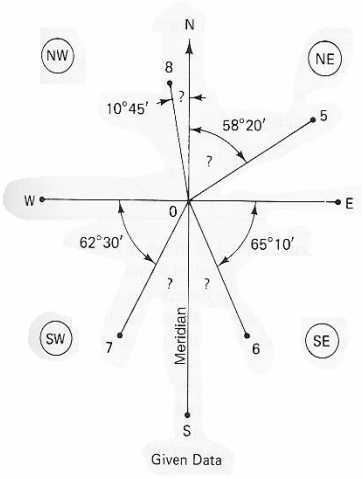


Line	Azimuth
0-1	52˚
0-2	121˚
0-3	202˚
0-4	325˚

4.6 Bearings

- Bearings is the direction of a line as given by the acute angle between the line and a meridian.
- The bearing angle, is always accompanied by letters that locate the quadrant in which the line falls (NE, NW, SE, or SW).

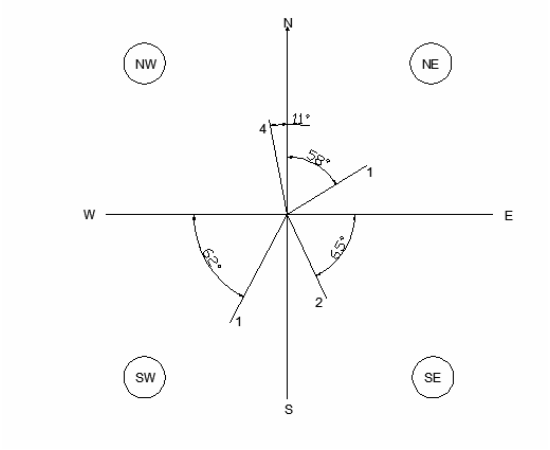
4.6 Bearings (Cont'd)



Line	Bearings
0 - 5	N 58^{o} 20' E
0 - 6	S 24^{o} 50' E
0 – 7	S 27^{o} 30' W
0 – 8	N 10^{o} 45' W

Figure 4.6
Bearings calculated from given data

Line	Bearing
0-1	N58˚00'E
0-2	S25˚00'E
0-3	S28˚00'W
0-4	N10˚00'W



4.7 Relationships Between Bearings and Azimuths

- To convert from azimuths to bearings by using this table:

quadrant	*quadrant letters*	*Numerical value*
From 0˚ to 90˚	NE	bearing = azimuth
From 90˚ to 180˚	SE	bearing= 180˚- azimuth
From 180˚ to 270˚	SW	bearing= azimuth - 180˚
From 270˚ to 360˚	NW	bearing= 360˚- azimuth

4.7 Relationships Between Bearings and Azimuths

- To convert from bearings to azimuths by using this relationships:

1. NE quadrant ⟶ azimuth = bearing
2. SE quadrant ⟶ azimuth = 180˚– bearing
3. SW quadrant ⟶ azimuth = 180 ˚+ bearing
4. NW quadrant ⟶ azimuth = 360˚– bearing

- *Example:* convert :
    1. 200˚58’ = S20˚58’W
    2. N2˚21’W = 357˚39’

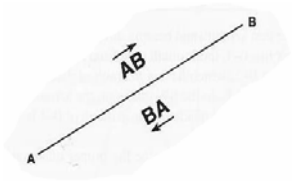
4.8: Reverse Directions:

- It can be said that every line has two direction.
- Forward direction is direction that oriented in the direction of fieldwork or computation staging.
- Back direction is direction that oriented in the reverse of the direction fieldwork or computation staging.

4.8 Reverse Direction

- In figure 4.8 , the line
  - AB has a bearing of N 62º 30’ E
  - BA has a bearing of S 62º 30’ W

    To reverse bearing: reverse the direction



Line	Bearing
AB	N 62º 30’ E
BA	S 62º 30’ W

Figure 4.7
Reverse Directions

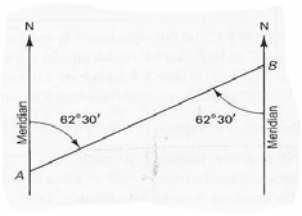
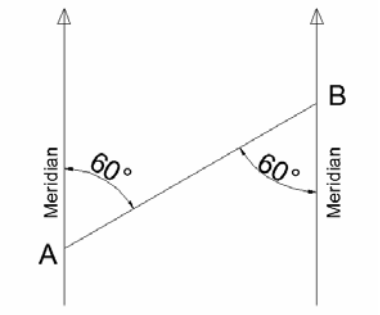


Figure 4.8
Reverse Bearings

• To reverse a bearing … Reverse the direction letters.

Example:

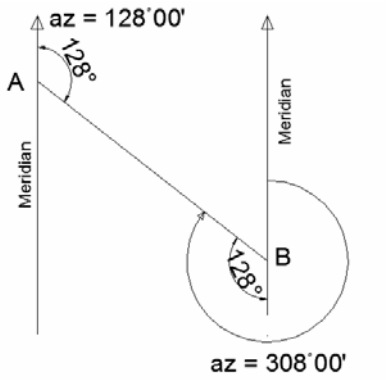
Line	Bearing
AB	N 60˚00’ E
BA	S 60˚00’ W



- To reverse an azimuth …. Add 180˚to the original direction.

Example:

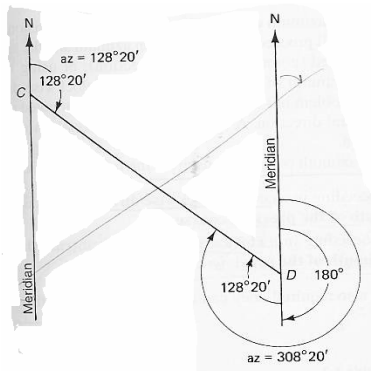
Line	Azimuth
AB	128˚00’
BA	308˚00’



4.8 Reverse Direction

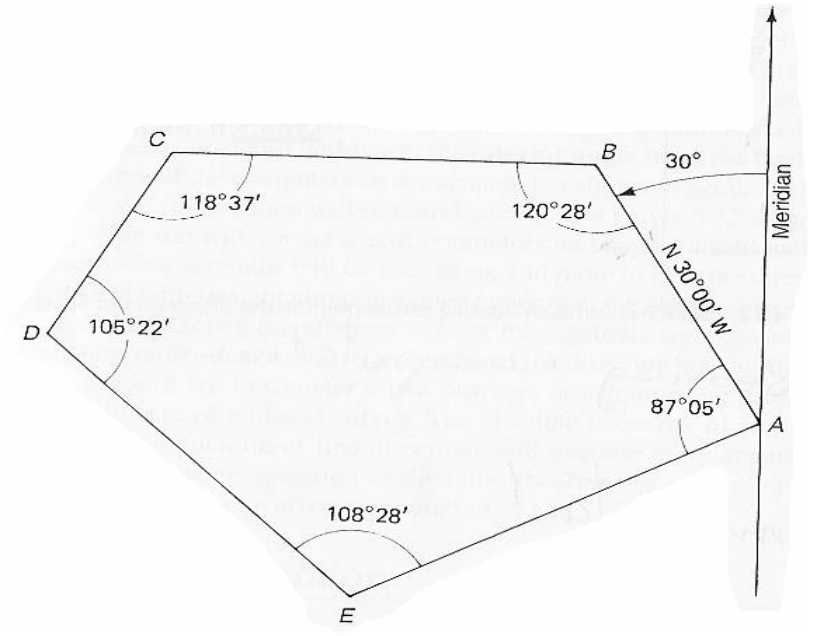
- In figure 4.9 , the line
  - CD has an azimuths of 128º 20’
  - DC has an azimuths of 308º 20’

    To reverse azimuths: add 180º

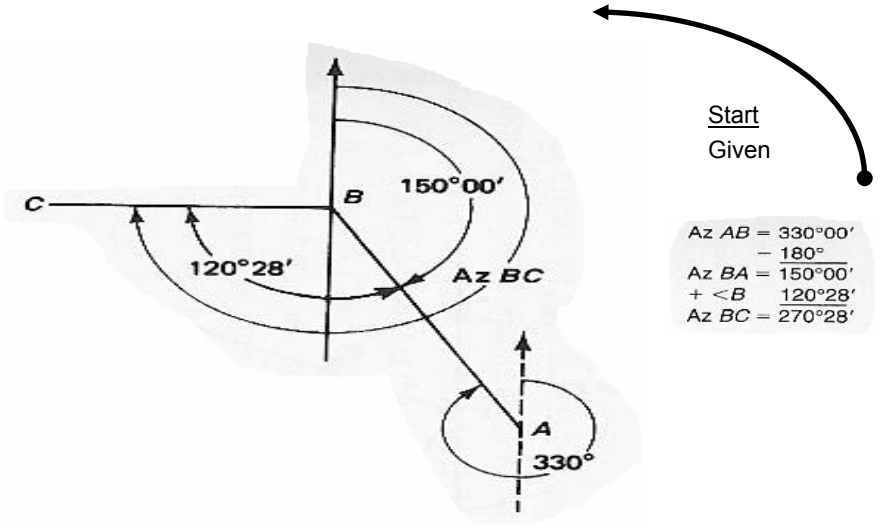


Line	Azimuths
CD	128º 20’
DC	308º 20’

Figure 4.8
Reverse Bearings



4.8 Counterclockwise Direction (1)

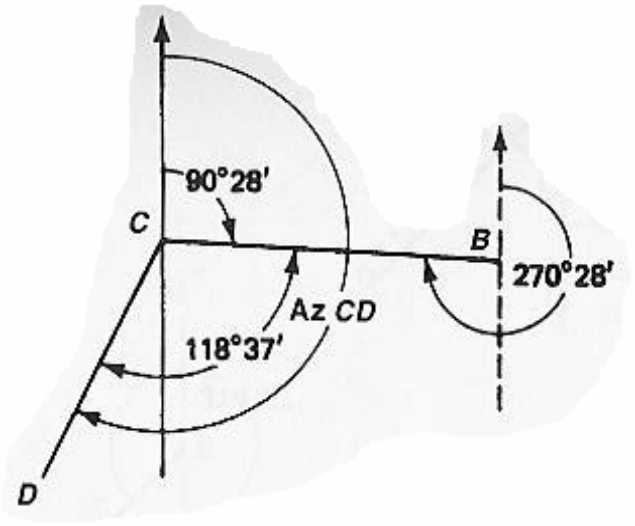


Start

Given

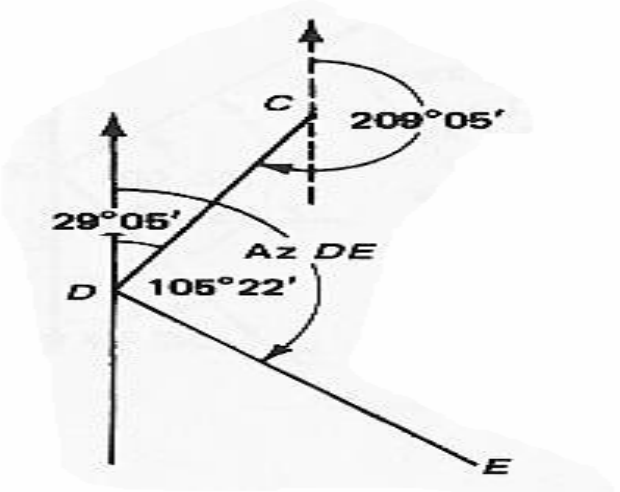
Az *AB* =	330°00′
	− 180°
Az *BA* =	150°00′
+ ∠*B*	120°28′
Az *BC* =	270°28′

4.8 Counterclockwise Direction (2)



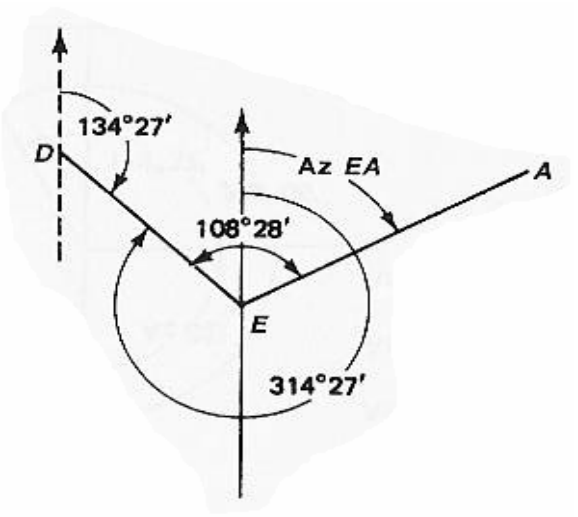
Az BC = 270°28′
− 180°
Az CB = 90°28′
+ $<C$ 118°37′
Az CD = 208°65′
Az CD = 209°05′

4.8 Counterclockwise Direction (3)



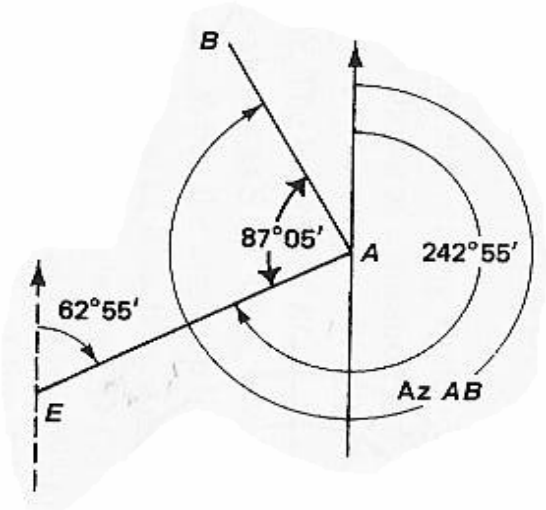
Az CD = 209°05′
− 180°
Az DC = 29°05′
+ $<D$ 105°22′
Az DE = 134°27′

4.8 Counterclockwise Direction (4)



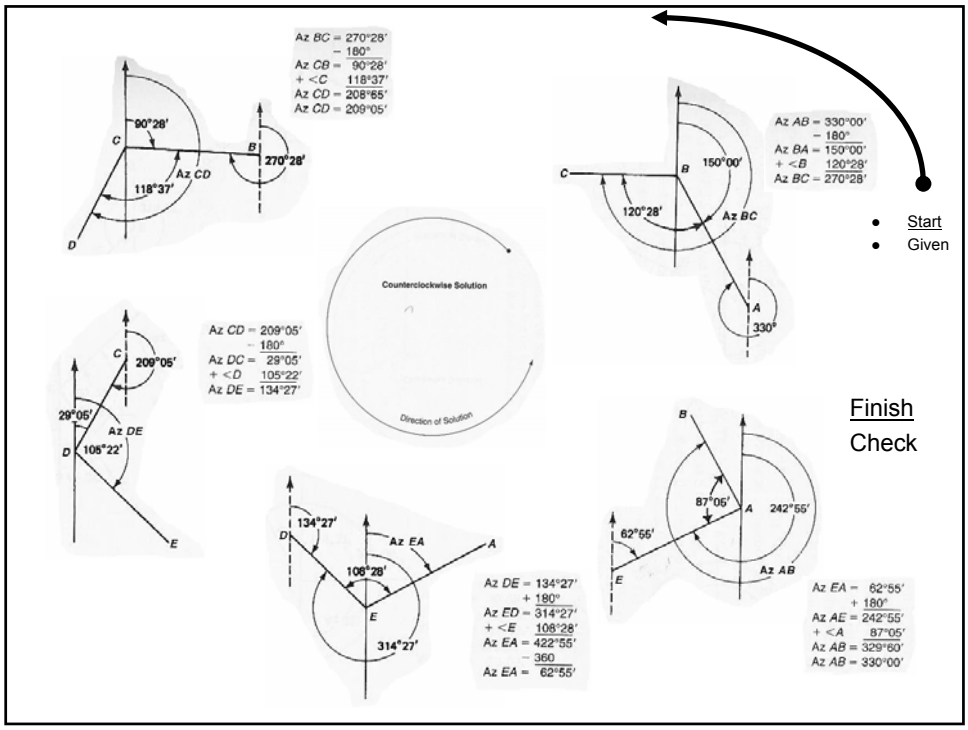
Az *DE* = 134°27′
+ 180°
Az *ED* = 314°27′
+ <*E* 108°28′
Az *EA* = 422°55′
− 360
Az *EA* = 62°55′

4.8 Counterclockwise Direction (5)

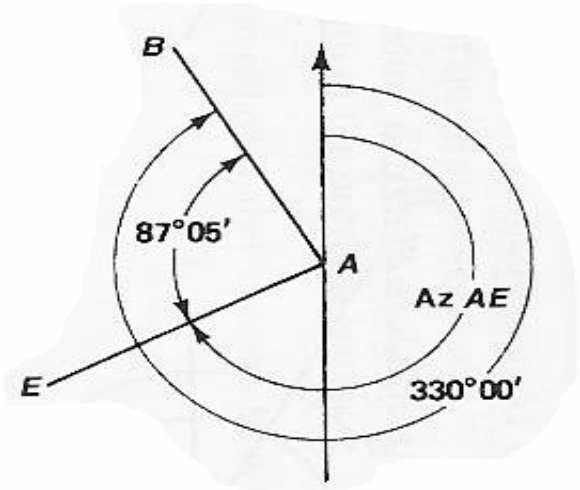


Finish
Check

Az *EA* = 62°55′
+ 180°
Az *AE* = 242°55′
+ <*A* 87°05′
Az *AB* = 329°60′
Az *AB* = 330°00′



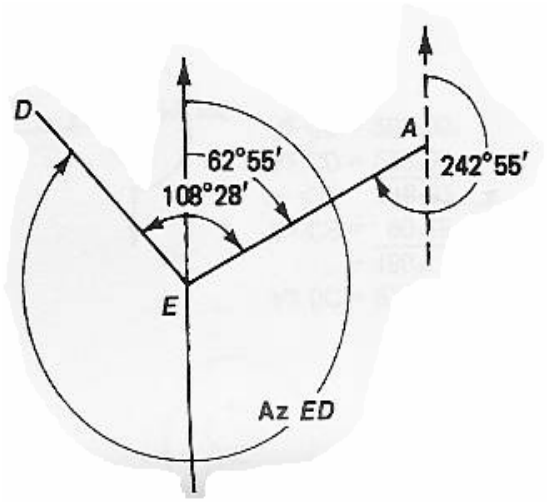
4.8 Clockwise Direction (1)



Az AB = 330°00′
− <A 87°05′
Az AE = 242°55′

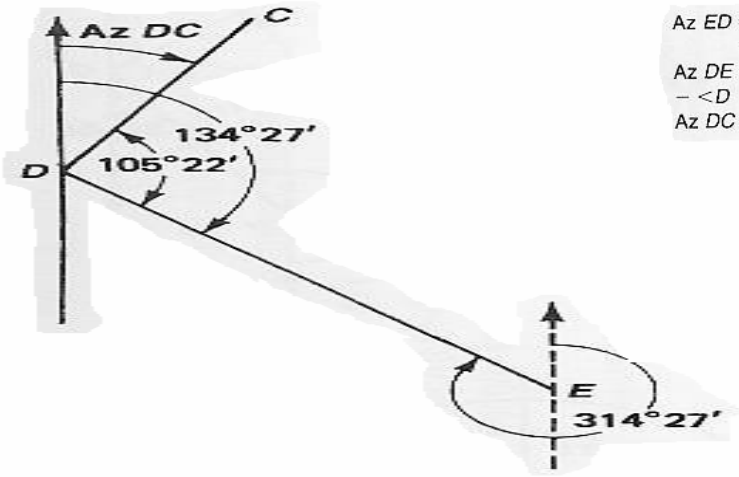
Start
Given

4.8 Clockwise Direction (2)



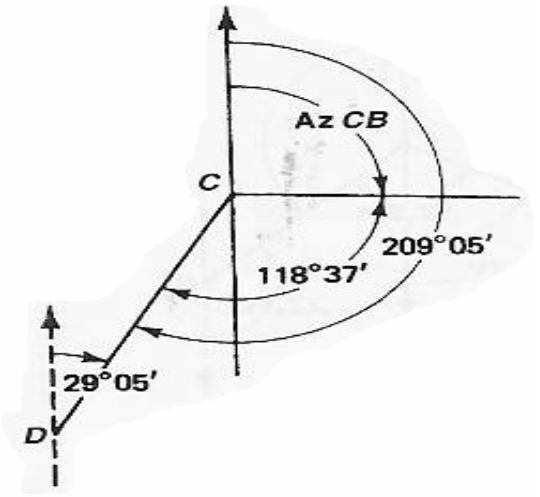
Az AE = 242°55′
− 180°
Az EA = 62°55′
+ 360° (to enable subtraction)
Az EA = 422°55′
− $<E$ 108°28′
Az ED = 314°27′

4.8 Clockwise Direction (3)



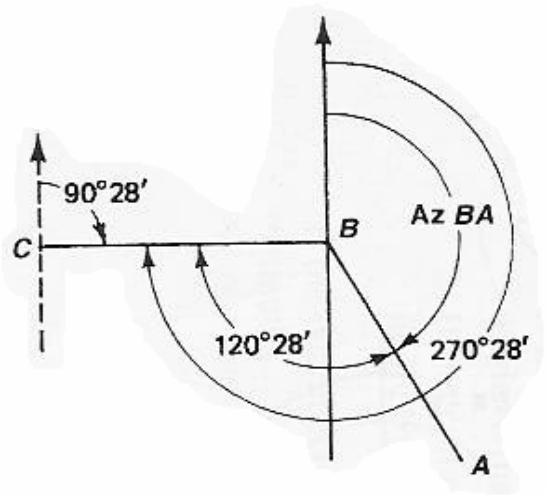
Az ED = 314°27′
− 180°
Az DE = 134°27′
− $<D$ 105°22′
Az DC = 29°05′

4.8 Clockwise Direction (4)



Az DC = 29°05′
+ 180°
Az CD = 209°05′
− $<C$ 118°37′
Az CB = 90°28′

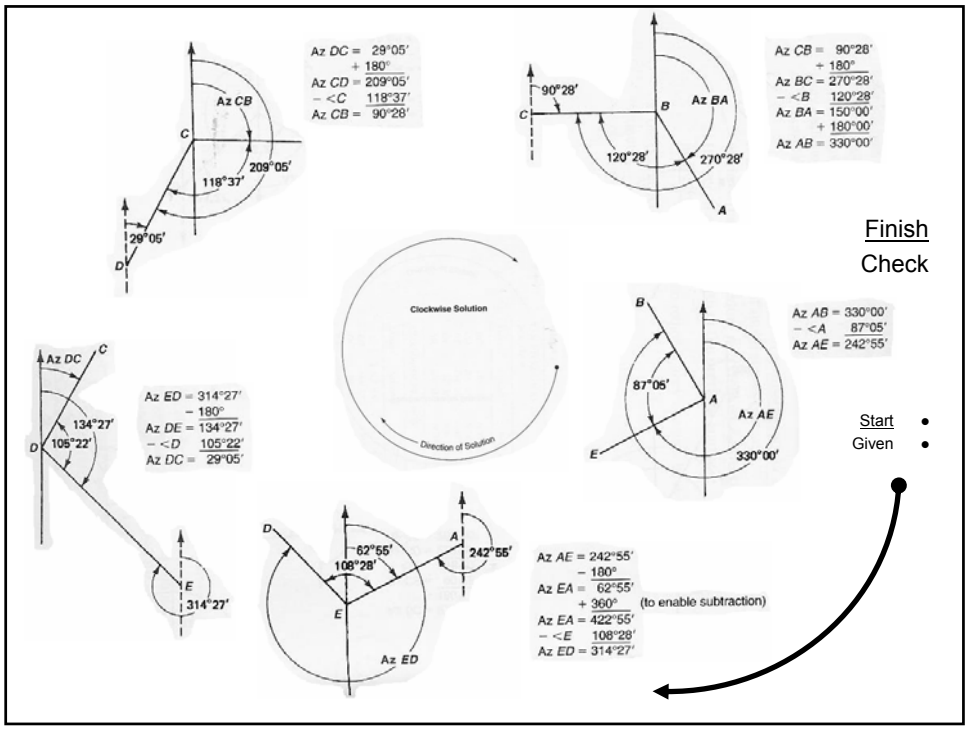
4.8 Clockwise Direction (5)



Az CB = 90°28′
+ 180°
Az BC = 270°28′
− $<B$ 120°28′
Az BA = 150°00′
+ 180°00′
Az AB = 330°00′

Finish

Check



4.9 Azimuths Computation

- Counterclockwise direction: add the interior angle to the back azimuth of the previous course

Course	Azimuths	Bearing
BC	270° 28’	N 89° 32’ W
CD	209° 05’	S 29° 05’ W
DE	134° 27’	S 45° 33’ E
EA	62° 55’	N 62° 55’ E
AB	330° 00’	N 30° 00’ W

4.9 Azimuths Computation

- Clockwise direction: subtract the interior angle from the back azimuth of the previous course

Course	Azimuths	Bearing
AE	242° 55’	S 62° 55’ W
ED	314° 27’	N 45° 33’ W
DC	29° 25’	N 29° 05’ E
CB	90° 28’	S 89° 32’ E
BA	150° 00’	S 30° 00’ E

4.10 Bearing Computation

- Computation can proceed in a Clockwise or counterclockwise

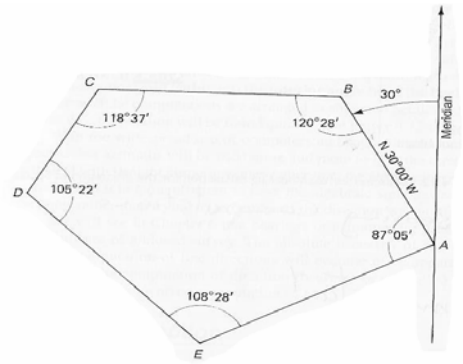
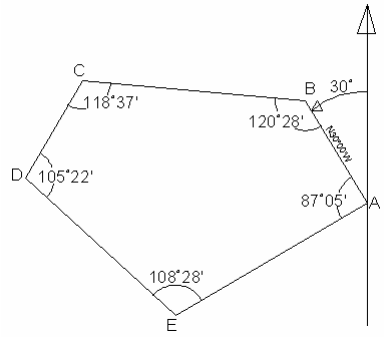
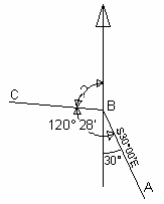


Figure 4.11
Sketch for Bearings Computations

4.10: Bearing Computation:



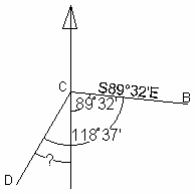


Line BC:

(?)= 180 – (120˚28'- 30˚)

(?)= 89˚32' in N.W quad.

i.e., N 89˚32' W

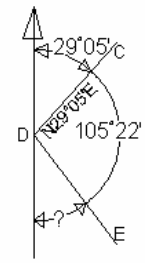


Line CD:

(?)= 118˚37'- 89˚32'

(?)= 29˚05' in S.W quad.

i.e., S 29˚05' W

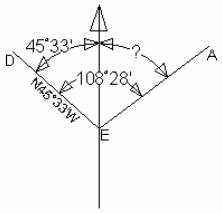


Line DE:

(?)= 180˚– (105˚22'+29˚05')

(?)= 45˚33' in S.E. quad.

i.e., S 45˚33' E

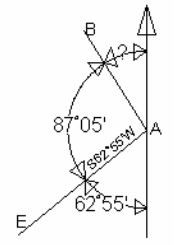


Line EA:

(?)= 108˚28'- 45˚33'

(?)= 62˚55' in N.E. quad.

i.e., N 62˚55' E



Line AB:

(?)= 180˚– (62˚55'+ 87˚05')

(?)= 30˚00' in N.W. quad.

i.e., N 30˚00' W

CHECK (Line AB was S 30˚00' E)

4.11 Comments on Bearing and Azimuths

Advantage of computing bearings directly from the given data in a closed traverse, is that the final computation provides a check on all the problem, ensuring the correctness of all the computed bearings

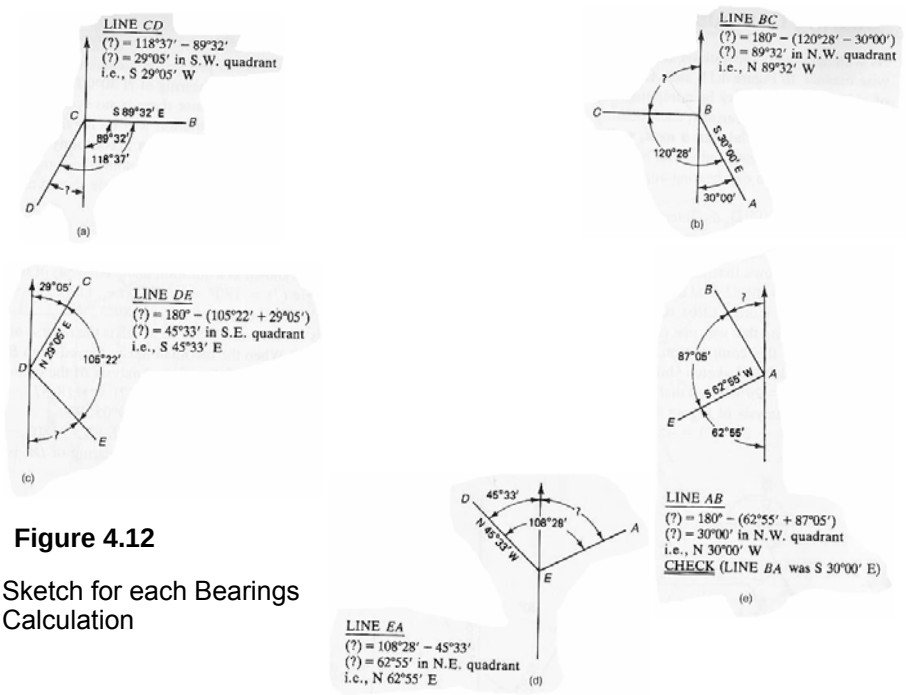


Figure 4.12

Sketch for each Bearings Calculation

4.11 Comments on Bearing and Azimuths

Disadvantages associated with computing bearings directly from the data in a closed traverse is that there is no systematic approach to the overall solution. Each bearing computation is unique, requiring individual analysis.

4.11 Comments on Bearing and Azimuths

The computation of azimuths involves a highly systematic routine: **add (subtract) the interior angle** from the back azimuths of the previous course.

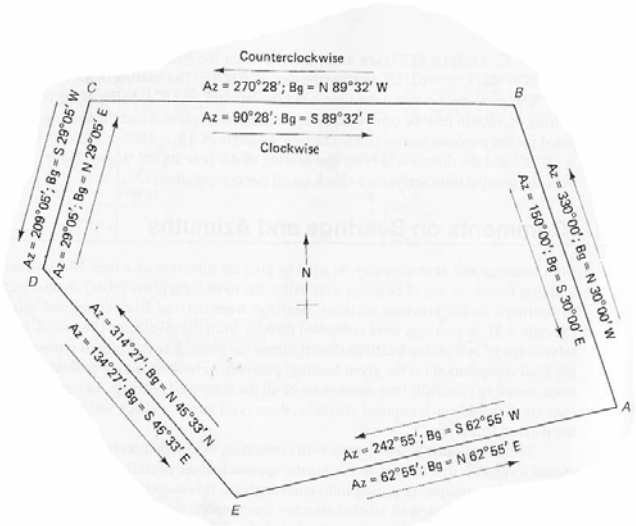


Figure 4.13

Summery of Results from clockwise and counterclockwise approaches

4.12: Magnetic Direction:

- Magnetic Direction is the horizontal angle between magnetic north and geographic north.
- Isogonic chart is line joining points of the earth surface having equal magnetic declination.

Geographic Bearing of survey Line = 18˚36'+ 10˚30'