Surveying & Measurement

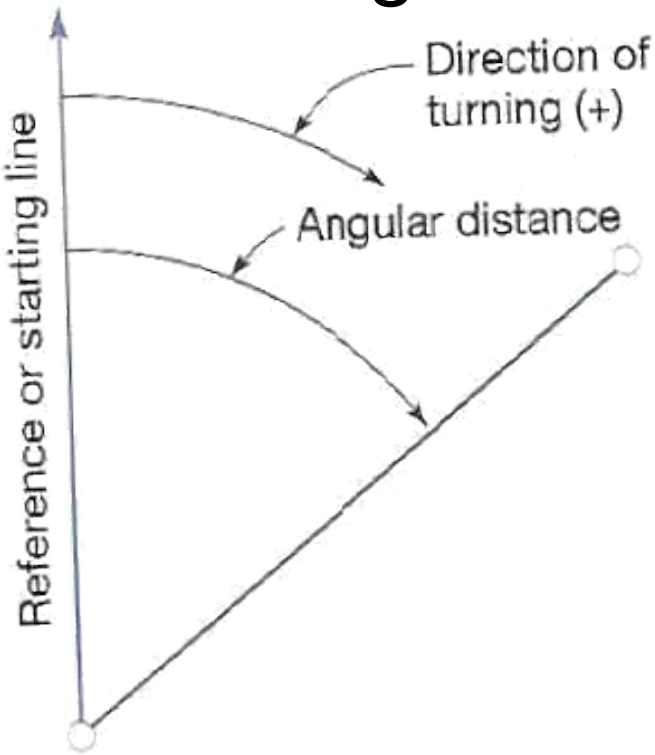
Angles, Azimuths and Bearings

Introduction

- Finding the locations of points and orientations of lines depends on measurements of angles and directions.
- In surveying, directions are given by azimuths and bearings.
- Angels measured in surveying are classified as
  - Horizontal angels
  - Vertical angles

Introduction

- Total station instruments are used to measure angels in the field.
- Three basic requirements determining an angle:
  - Reference or starting line,
  - Direction of turning, and
  - Angular distance
    (value of the angel)



Units of Angel Measurement

In the United States and many other countries:

- The sexagesimal system: degrees, minutes, and seconds with the last unit further divided decimally. (The circumference of circles is divided into 360 parts of degrees; each degree is further divided into minutes and seconds)

- In Europe
  - Centesimal system: The circumference of circles is divided into 400 parts called gon (previously called grads)

Units of Angel Measurement

- Digital computers
  - Radians in computations: There are 2π radians in a circle (1 radian = 57.30°)
- Mil - The circumference of a circle is divided into 6400 parts (used in military science)

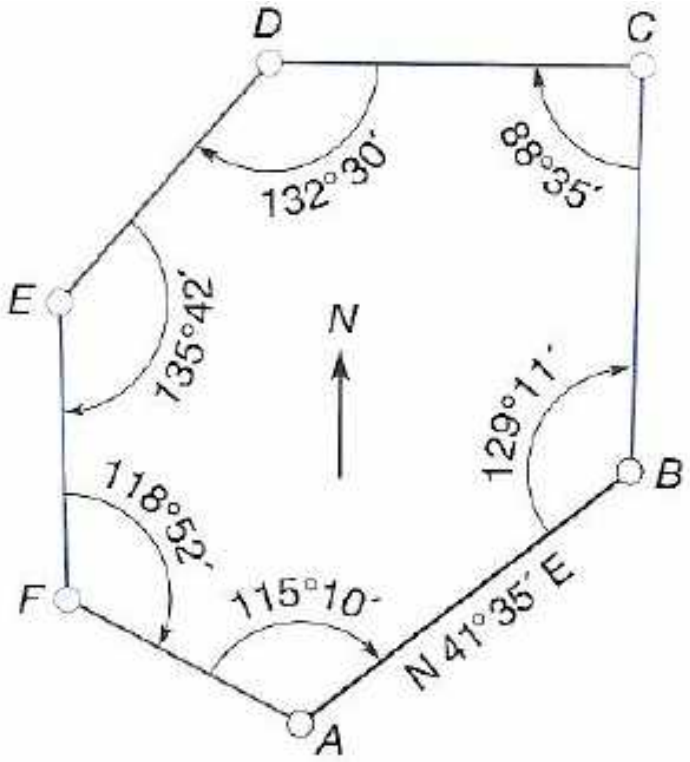
Kinds of Horizontal Angles

- The most commonly measured horizontal angles in surveying:
  - Interior angles,
  - Angles to the right, and
  - Deflection angles
- Because they differ considerably, the kind used must be clearly identified in field notes.

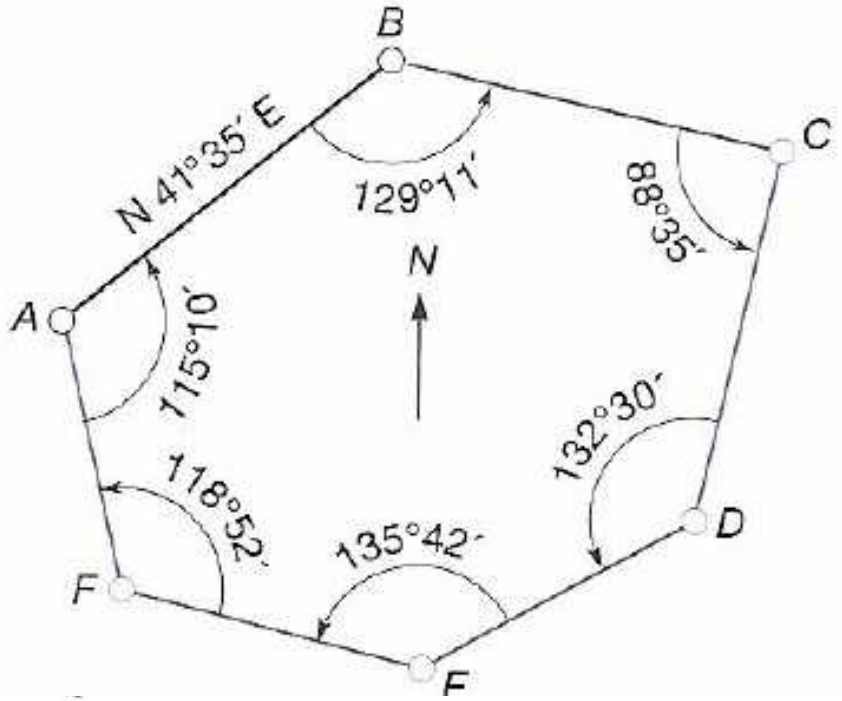
Interior Angles

- It is measured on the inside of a closed polygon (traverse) or open as for a highway.
- Polygon: closed traverse used for boundary survey.
- A check can be made because the sum of all angles in any polygon must equal
- **(n-2)180**° where **n** is the number of angles.

Interior Angles



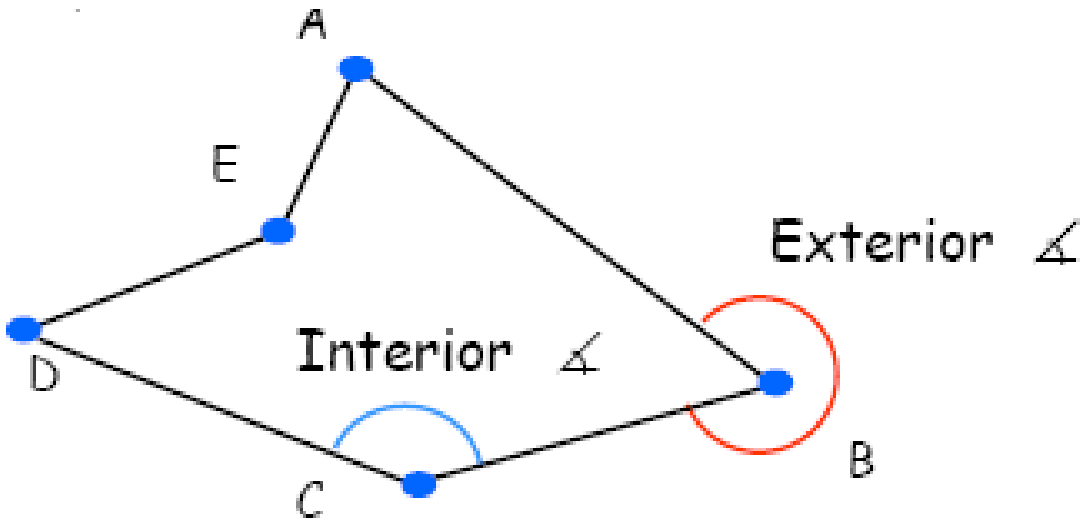
Clockwise interior angles (angles to the right).



Counterclockwise interior angles (angles to the left).

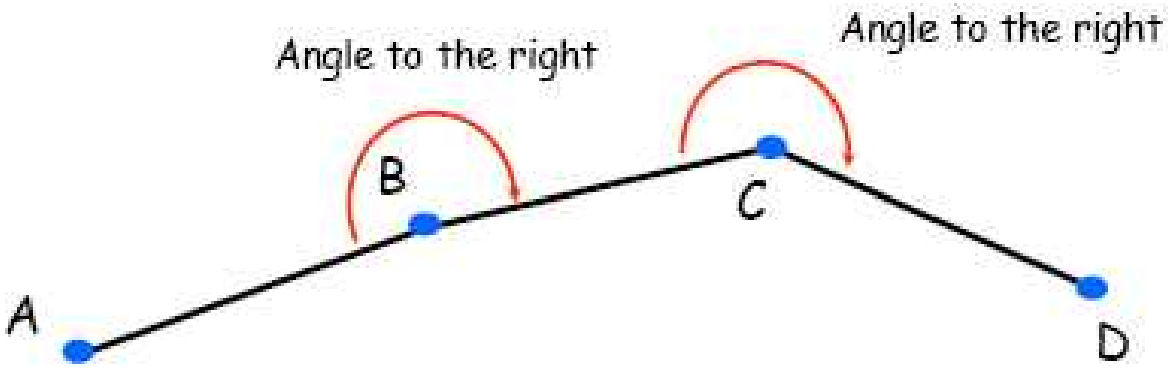
Exterior Angles

- Located outside a closed polygon.
- The advantage to be gained by measuring this angle is their use as another check.
- Interior Angel + Exterior Angle = 360°



Angels to the Right

- The measured clockwise angle between the preceding line and the next line of the a traverse (clockwise from the rear to the forward station).
- As a survey progresses, stations are identified by consecutive alphabetic letters.
- Most automatic data collectors require that angles to the right be measured in the field.

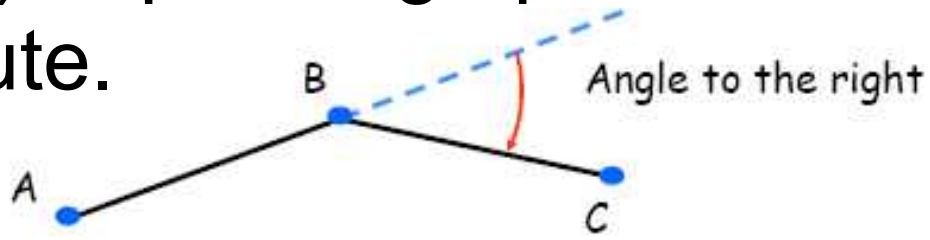


Angels to the Left

- Turned counterclockwise from the rear station.
- A serious mistake occurs if counterclockwise angles are measured and recorded or assumed to be clockwise.
- To avoid this confusion, always measure angel to the right and note the direction of turning in the filed book with a sketch.

Deflection Angles

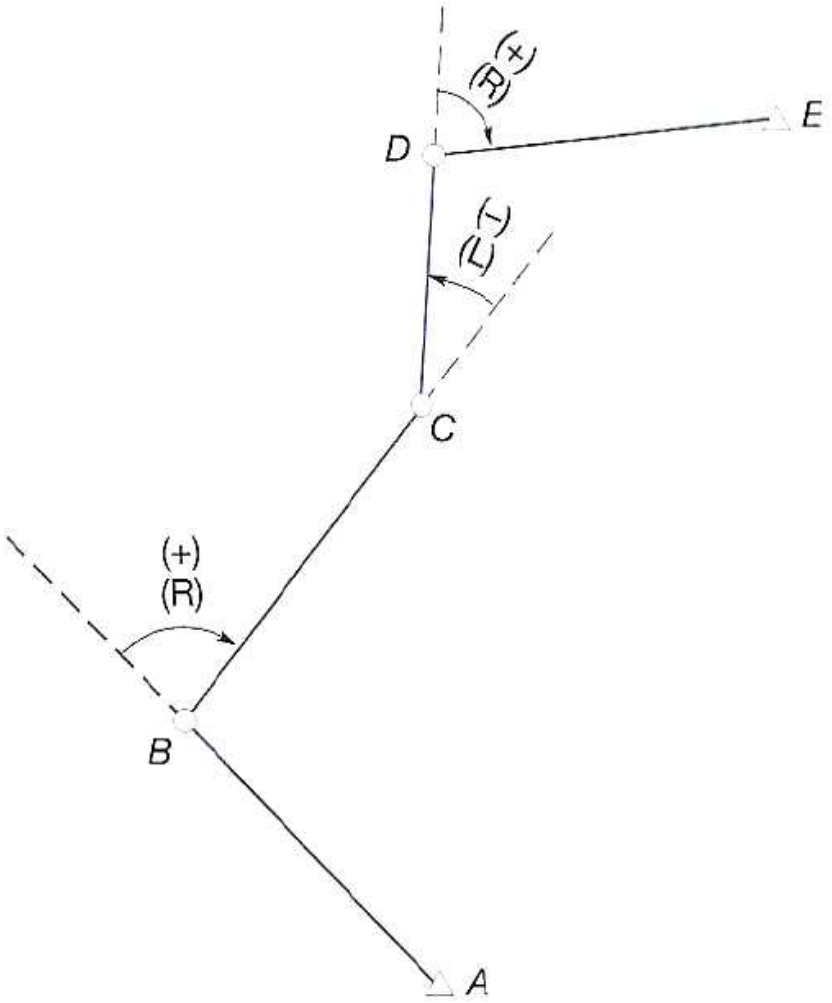
- Measured from an extension of the back line, to the forward station.
- Used principally on the long linear alignments of route surveys.
- Deflection angles may be measured to the right (clockwise) or to the left (counterclockwise) depending upon the direction of the route.



23° 25' Angle to the right

Deflection Angles

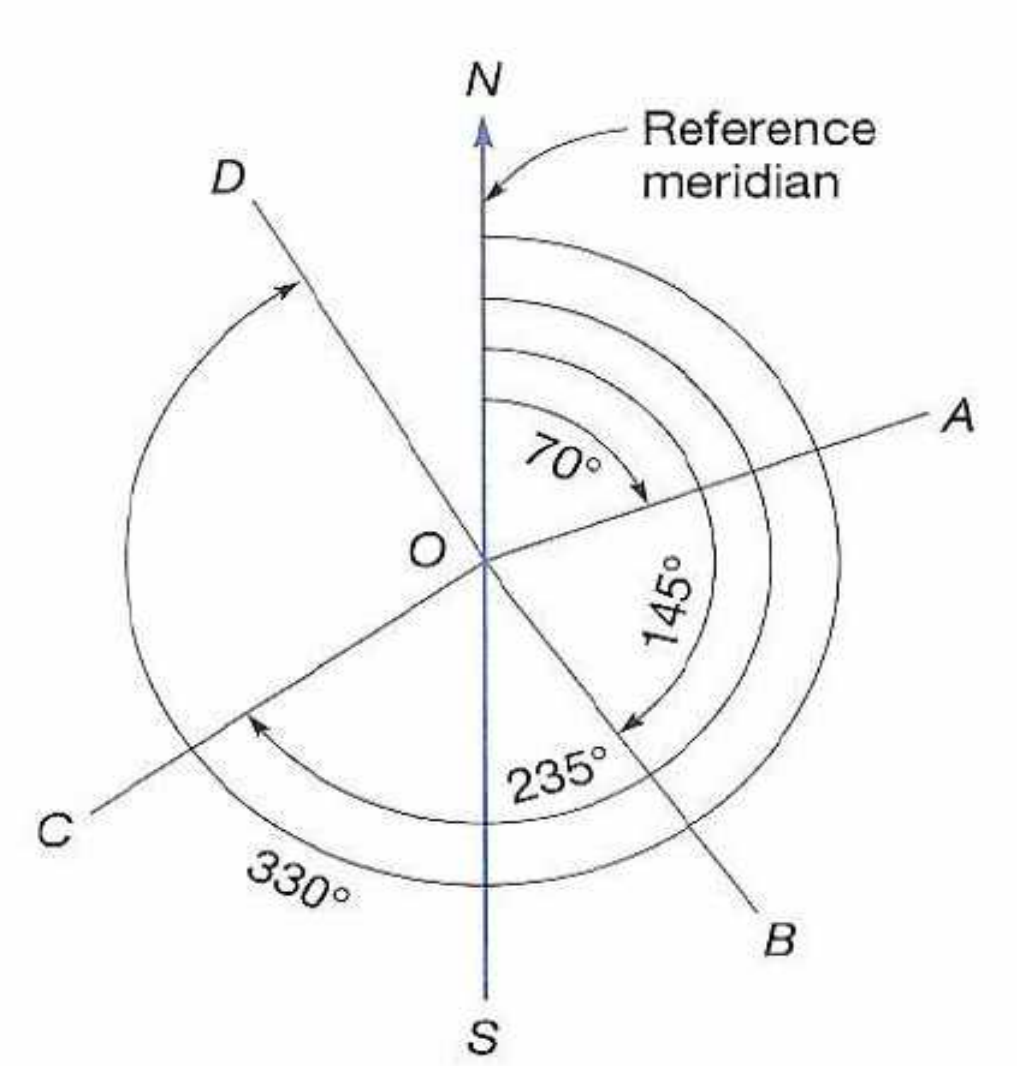
- Clockwise (+) and Counterclockwise (-)
- Deflection angles are always < 180°
- The direction of turning is identified by appending an R or L to the numerical value.



Azimuths

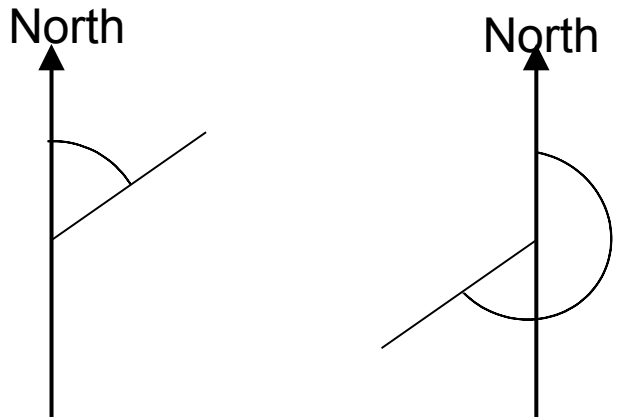
- Azimuths are horizontal angles measured clockwise from any reference meridian.
- In plane surveying, azimuths are generally measured from north.
- Azimuths are used advantageously in boundary, topographic, control, and other kinds of surveys, as well as in computations.

Azimuths



Azimuths

- Every line has two azimuths (forward and back) and their values differ by 180°
- Azimuth are referred to astronomic, magnetic, or assumed meridian
- For example: the **forward azimuth** of line AB is 50° - the **back azimuth** or azimuth of BA is 230°



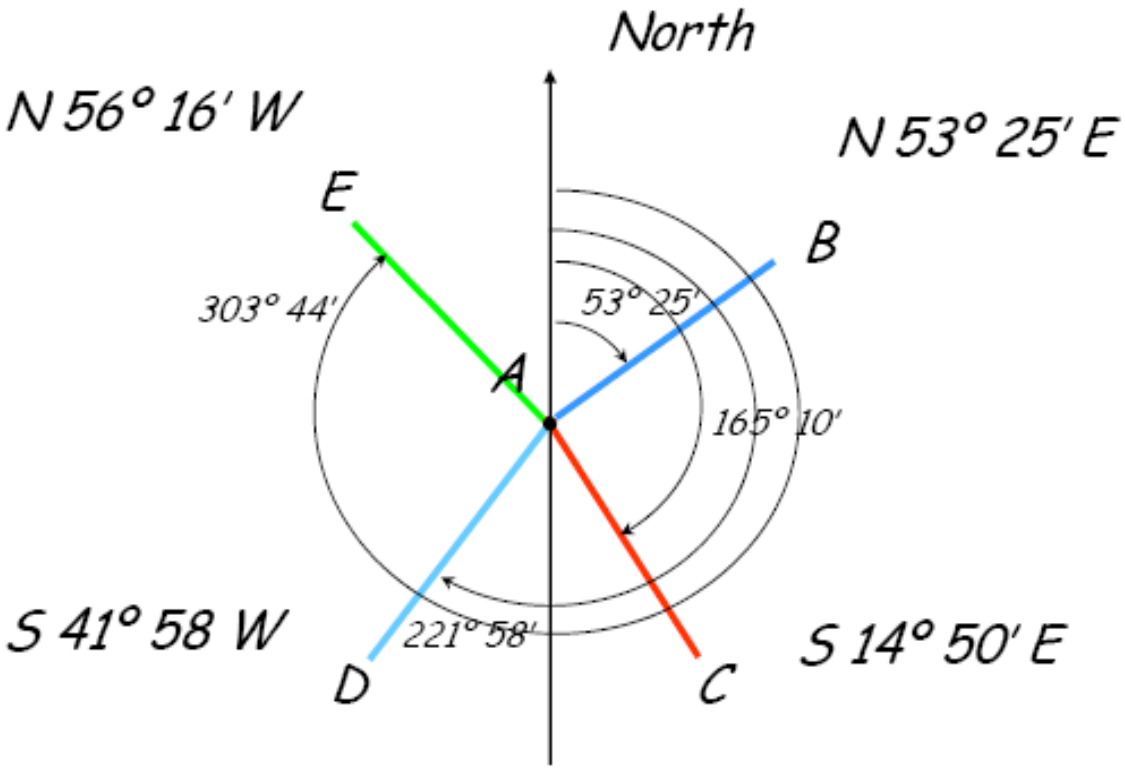
Meridians

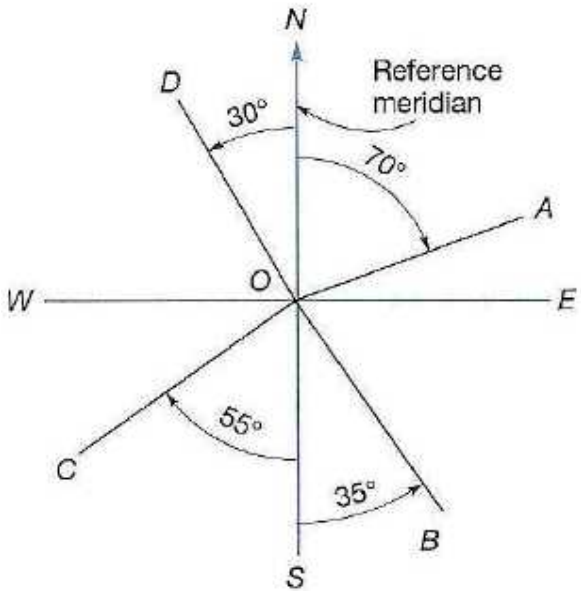
- There are three types of **meridians**
  - **Astronomic** - direction determined from the shape of the earth and gravity; also called **geodetic north**
  - **Magnetic** - direction taken by a magnetic needle at observer's position
  - **Assumed** - subjective direction taken for convenience

Bearing

- Bearings are another systems for designating directions of lines.
- The bearing of a line is defined as the acute horizontal angle between a reference meridian and the line.
- Measured from either the north or south toward the east or west, to give a reading smaller than 90°.
- For example; N70°E, N30°W, S35°E, and S55°W

Bearing


North
N 56° 16′ W
N 53° 25′ E
E
B
303° 44′
53° 25′
A
165° 10′
S 41° 58 W
221° 58′
S 14° 50′ E
D
C

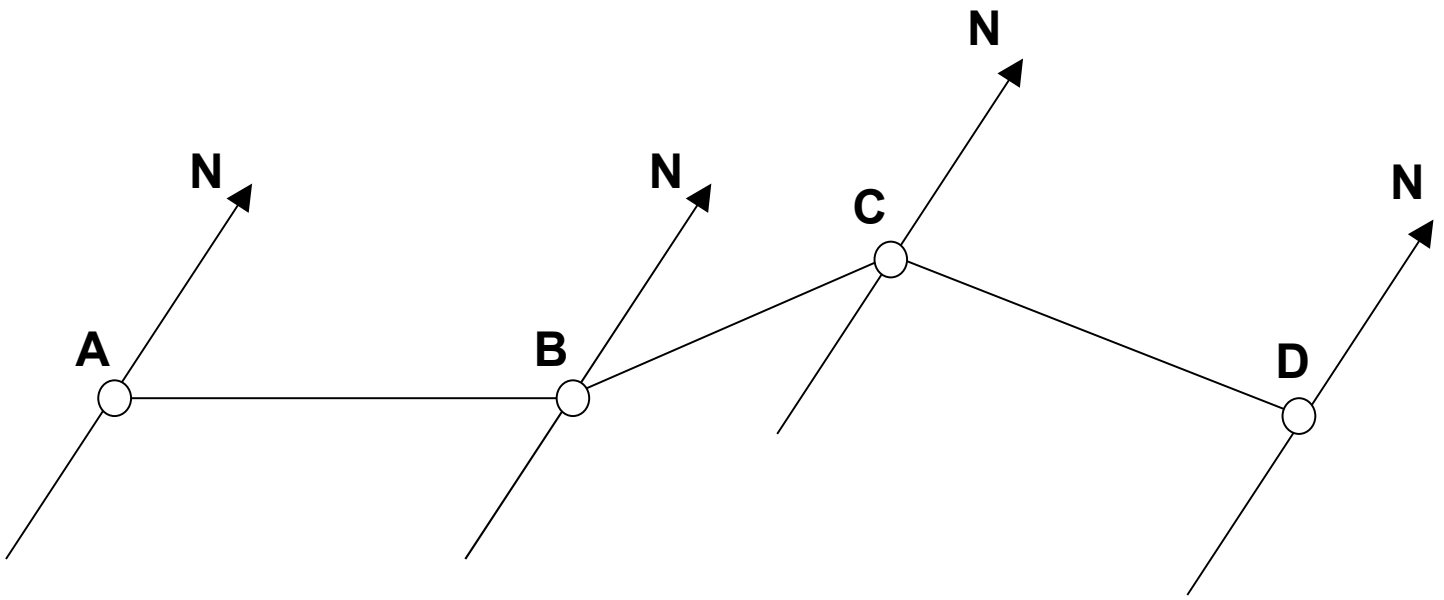

N
D
30°
Reference
meridian
70°
A
W
O
E
55°
C
35°
B
S

Bearing

- Assume that total station is set up at points A, B, C, and D; bearings read on lines AB, BA, BC, CB, CD, and DC.
- AB, BC, and CD are Forward bearings
- BA, CB, and DC are Back bearings
- Back bearings should have the same numerical values as forward bearings but opposite letters.

Bearing

- Bearing AB = N44°E, bearing BA =S44°W



Azimuths and Bearings

Azimuths	Bearings
Vary from 0 to 360°	Vary from 0 to 90°
Require only a numerical value	Require two letters and a numerical value
May be geodetic, astronomic, magnetic, grid, assumed, forward or back	Same as azimuths
Are measured clockwise only	Are measured clockwise and counterclockwise
Are measured either from north only, or from south only on a particular survey	Are measured from north and south

Example directions for lines in the four quadrants (azimuths from north)

Azimuth	Bearing
54°	N54°E
112°	S68°E
231°	S51°W
345°	N15°W

Azimuths and Bearings

Example 1

- The azimuth of the boundary line is 128°13'46". Convert this to a bearing.

  180°-128°13'46" = 51°46'14" = S 51°46'14" E

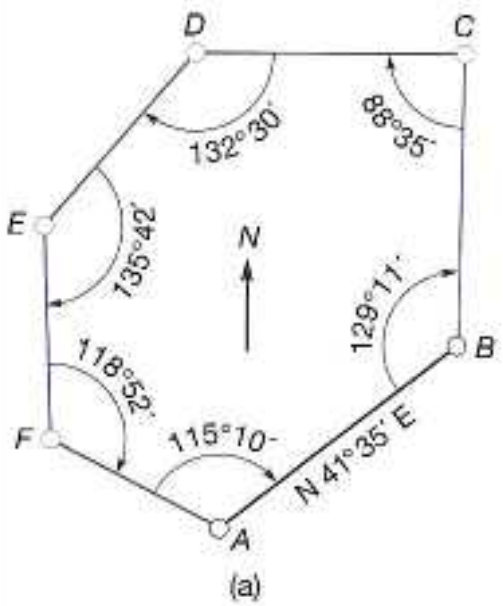
Example 2

- The first course of a boundary survey is written as N 37°13' W. What is its equivalent azimuth?

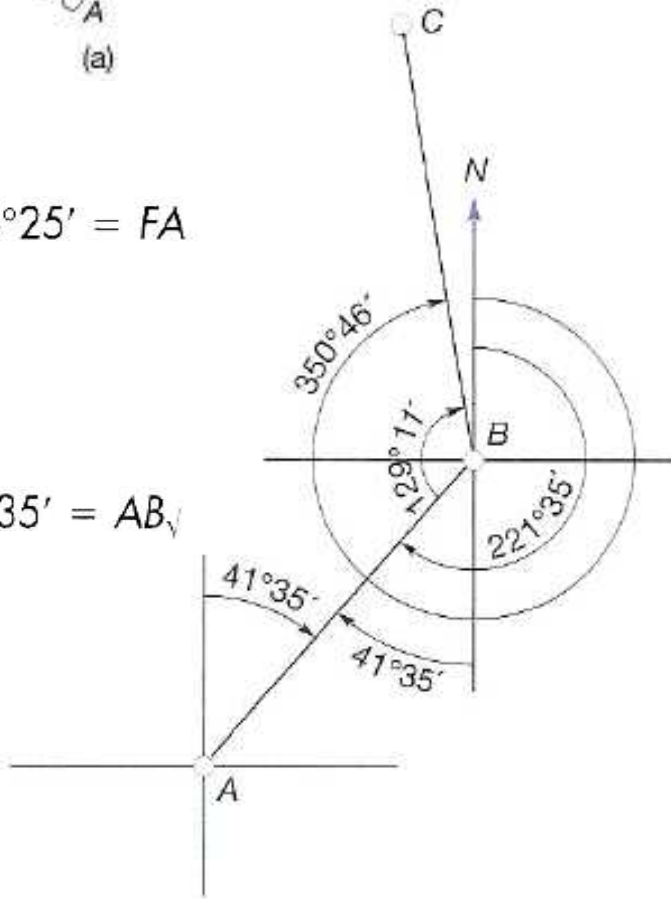
  Since the bearing is in the northwest quadrant, the azimuth is 360°-37°13' = 322°47'

$$
\begin{aligned}
&41°35' = AB\\
&-180°00'\\
&221°35' = BA\\
&+129°11'\\
&350°46' = BC\\
&-180°00'\\
&170°46' = CB\\
&+88°35'\\
&259°21' = CD\\
&-180°00'\\
&79°21' = DC\\
&+132°30'\\
&211°51' = DE
\end{aligned}
$$

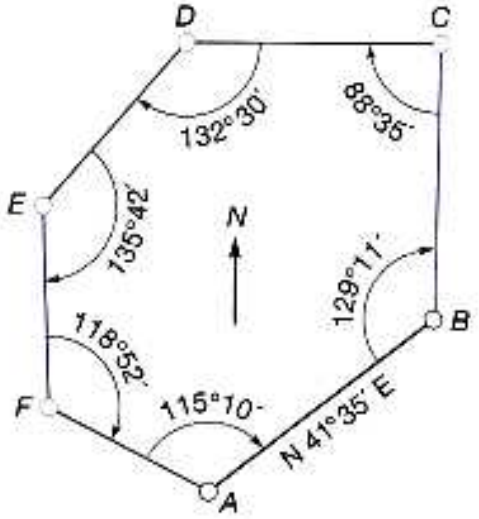
$$
\begin{aligned}
&211°51' = DE\\
&-180°00'\\
&31°51' = ED\\
&+135°42'\\
&167°33' = EF\\
&+180°00'\\
&347°33' = FE\\
&+118°52'\\
&466°25' - {}^{*}360° = 106°25' = FA\\
&-180°00'\\
&286°25' = AF\\
&+115°10'\\
&401°35' - {}^{*}360° = 41°35' = AB_{\surd}
\end{aligned}
$$



(a)



When a computed azimuth exceeds 360°, the correct azimuth is obtained by subtracting 360°



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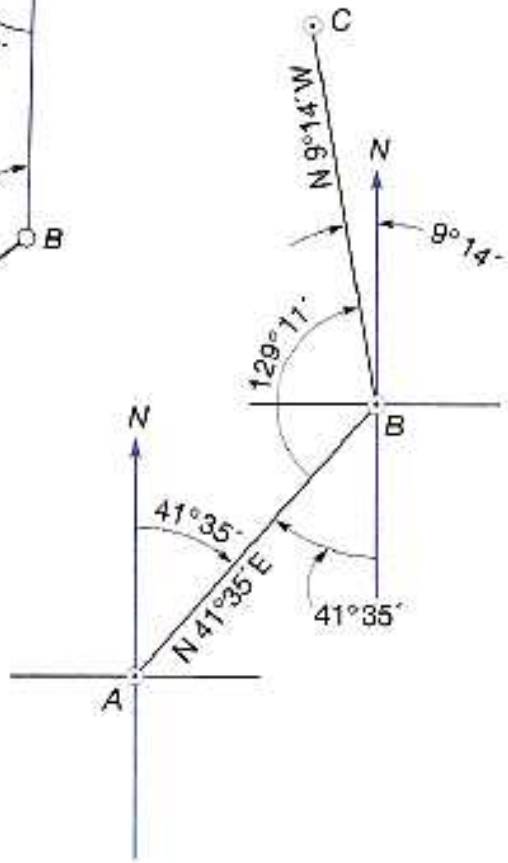
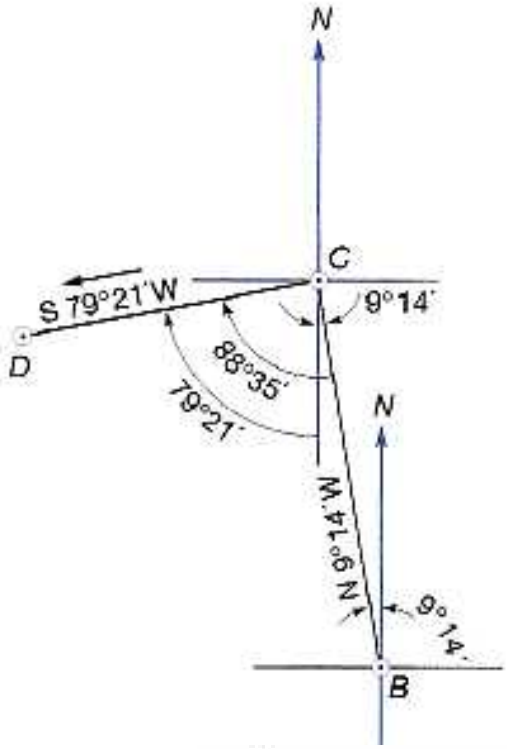




Course	Bearing
AB	N41°35′E
BC	N9°14′W
CD	S79°21′W
DE	S31°51′W
EF	S12°27′E
FA	S73°35′E
AB	N41°35′E

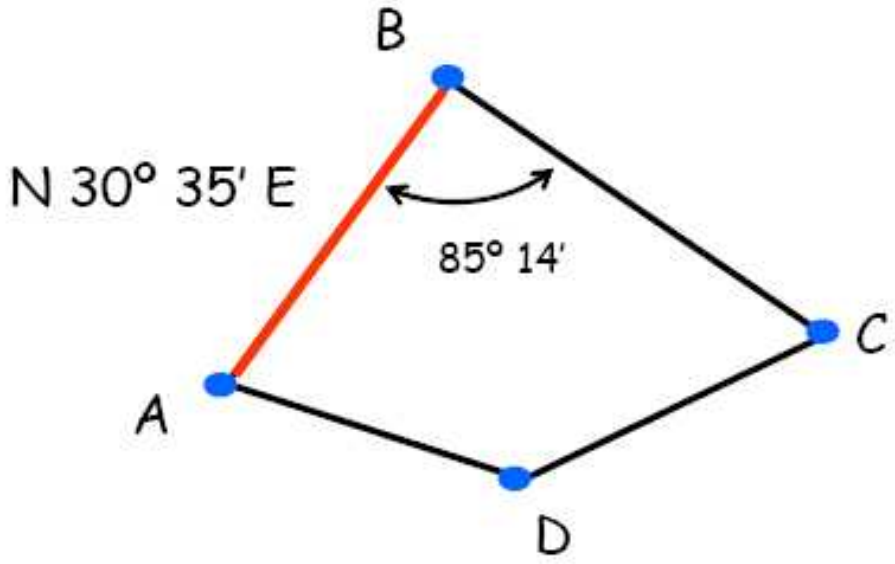
Azimuths and Bearings

- If the **bearing or azimuth** of one side of traverse has been determined and the angles between the sides have been measured, the **bearings** or **azimuths** of the other sides can be computed

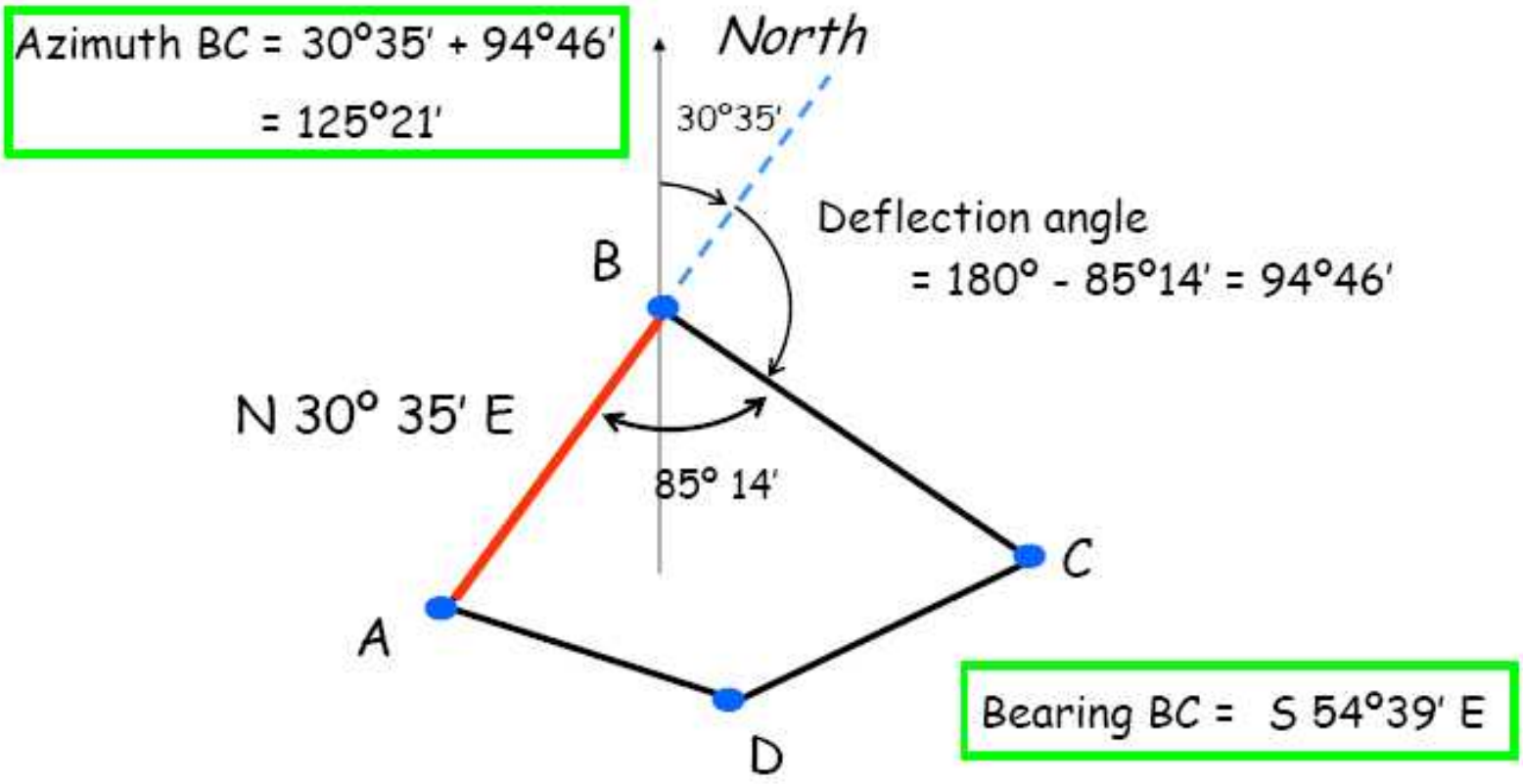
- One technique to solve most of these problems is to use the deflection angles

Azimuths and Bearings
Example 5

- From the traverse shown below compute the azimuth and bearing of side BC

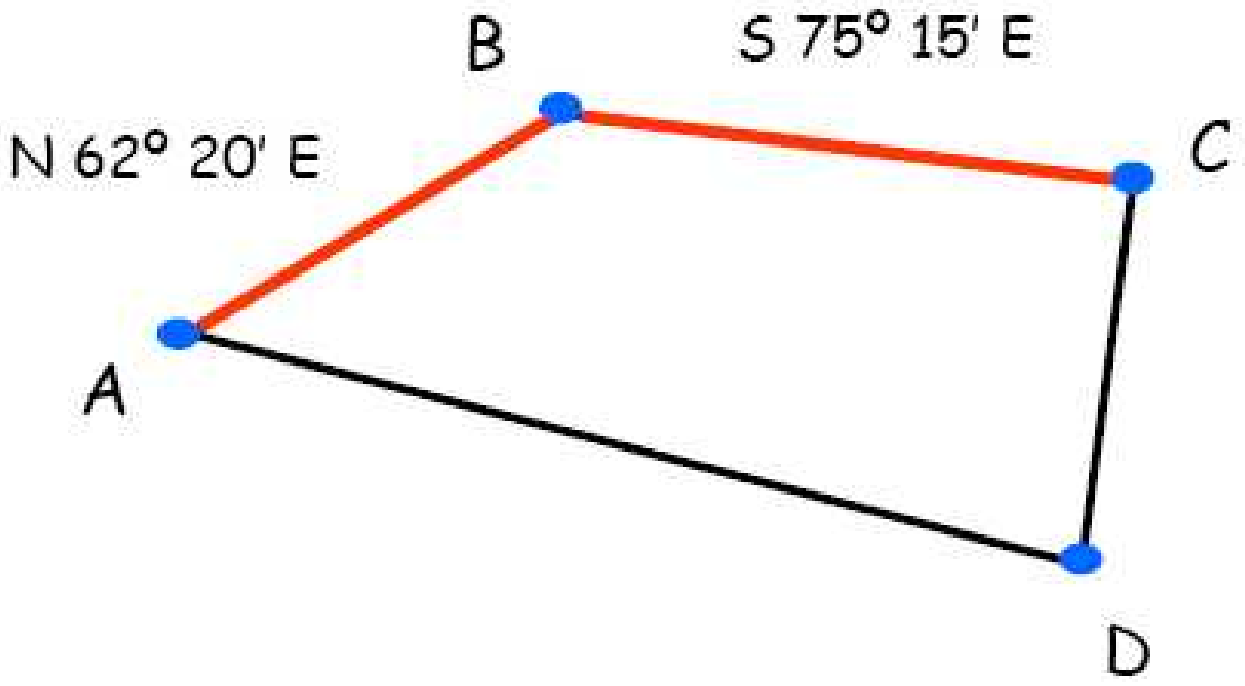


Azimuths and Bearings
Example 5

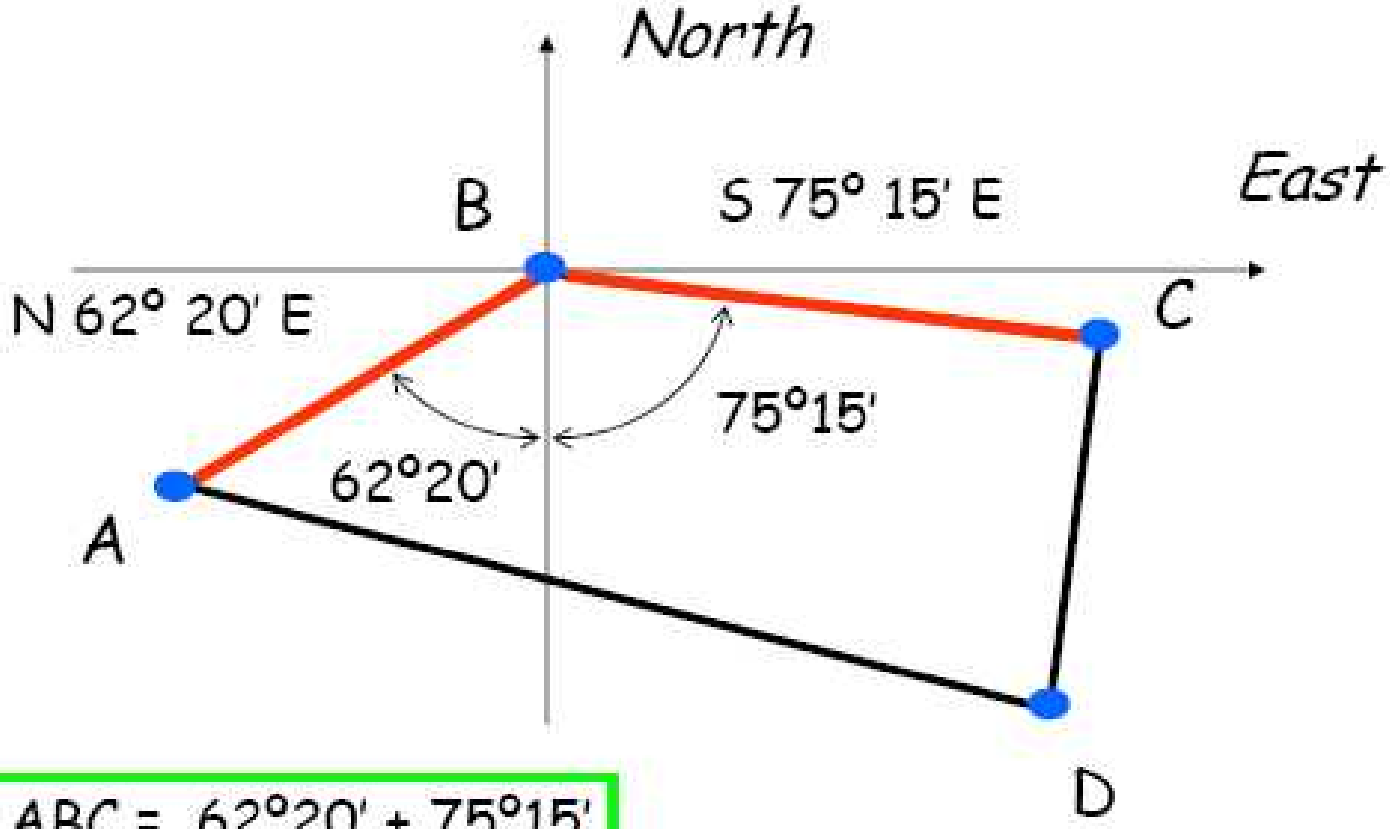


Azimuths and Bearings Example 6

- Compute the interior angle at B



Azimuths and Bearings
Example 6



Interior ABC = $62°20' + 75°15'$

$= 137°35'$