Surveying

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Lectures
Spring
Semester

Lecture 8: **THEODOLITE**

Errors in Theodolite

Error in the measurement of angle occurs because of instrumental, personal or natural factors.

Instrumental errors

- Non adjustment of plate bubble
- Line of collimation not being perpendicular to horizontal axis
- Horizontal axis not being perpendicular to vertical axis
- Line of collimation not being parallel to axis of telescope
- Eccentricity of inner and outer axes
- Graduation not being uniform
- Verniers being eccentric

Personal errors

Human errors that affect angle measurements are gross errors and random errors. Gross errors arise from carelessness and can be avoided with careful observation. They include sighting the wrong target, mixing clockwise and counter clockwise readings, turning the wrong screw, reading the circles wrongly, and booking incorrectly. Random errors are caused by imperfections in human sight which make it impossible to bisect the target accurately and read the circles correctly. However, they are small and of little significance. They are minimized by taking several observations and accepting the mean.

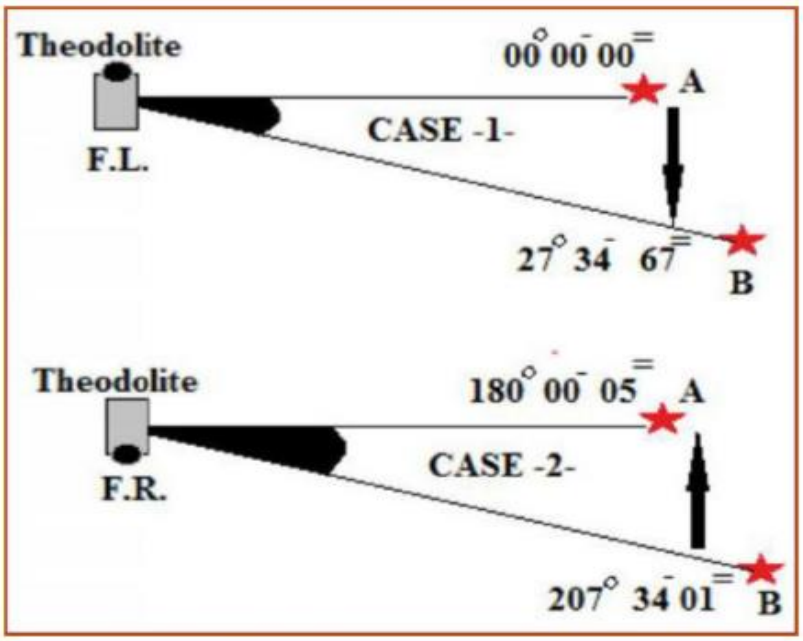
Natural errors

- High temperature causes error due to irregular refraction.
- High winds cause vibration in the instrument, and this may lead to wrong readings on verniers.
- Ensure that the line of sight does not pass near sources of heat such as chimneys or open fires.

Horizontal Angle - Observation Techniques

1. Change of face: In this method, angle is measured at two cases, after that determining average reading for angles. This method is generally used and very important for user theodolite. Face right and face left are determining, after that determining average of two reading, see the figure below.

2. Change of zero: In this method setting zero at point one and reading point two, after that setting zero at point two and reading point one, later determining average data for two reading.



Booking of Field Data
A typical template table (Data Sheet) for booking (Horizontal Angle):

Station	Observed Station	Face	Ovserved Horizontal Circle	Mean	Horizontal Angle	Remarks
A	B	F.L				
		F.R				
	C	F.L				
		F.R				
D	E	F.L				
		F.R				
	F	F.L				
		F.R				
G	H	F.L				
		F.R				
	I	F.L				
		F.R				

Vertical Angle

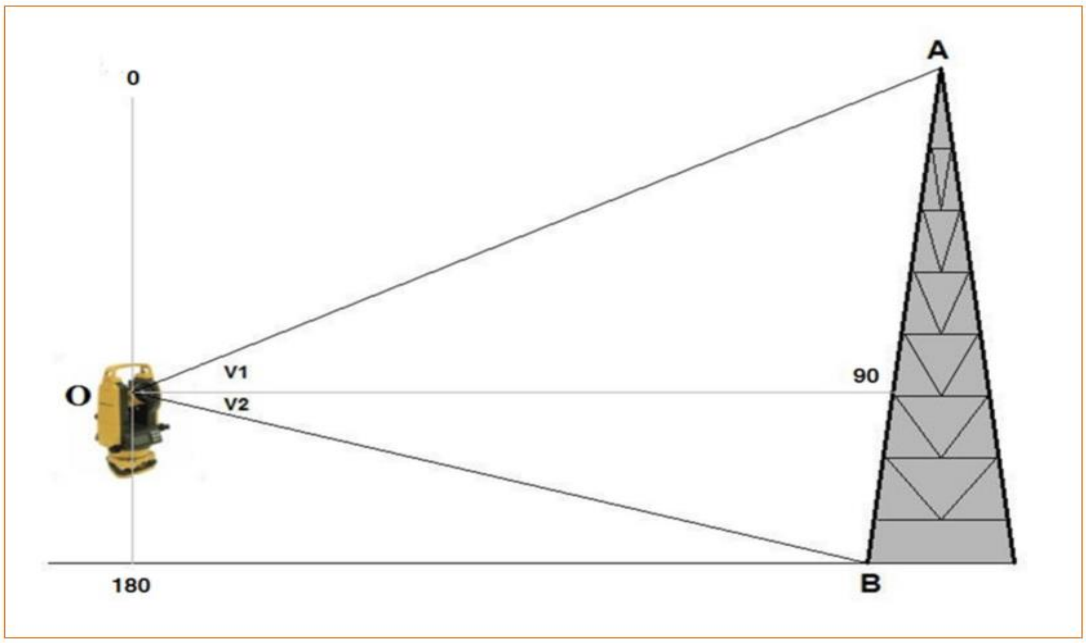
A vertical angle is an angle between the inclined line of sight and the horizontal. It may be an angle of elevation or depression according as the object is above or below the horizontal plane.

For determining vertical angle two following rules are use:

$V_{F.L} = 90 - V.C.R$

$V_{F.R} = V.C.R - 270$

$While: V.C.R = the\ reading from the theodolite$



Booking of Field Data

A typical template table (Data Sheet) for booking (Vertical Angle):

Station	Observed Station	Face	Ovserved Vertical Circle	Reduced Vertical Angle	Mean	Remarks
A	B	F.L				
		F.R				
	C	F.L				
		F.R				
D	E	F.L				
		F.R				
	F	F.L				
		F.R				
G	H	F.L				
		F.R				
	I	F.L				
		F.R				

TRAVERSING

Traversing is one of the simple stand most popular methods of establishing control networks in engineering surveying.

A series of connected straight lines each joining two points on the ground, is called a 'traverse'. End points are known as traverse stations & straight lines between two consecutive stations, are called traverse legs.

A traverse survey is one in which the framework consists of a series of connected lines, the lengths and directions of which are measured with a chain or a tape, and with an angular instrument respectively.

Traverse networks have the following advantages:

(1) Little reconnaissance is required compared with that needed for an interconnected network of points.

(2) Observations only involve three stations at a time so planning the task is simple.

(3) Traversing may permit the control to follow the route of a highway, pipeline or tunnel, etc., with the minimum number of stations.

Traverses may be either a closed traverse or an open traverse:

1. **Closed Traverse (Polygonal traverse):** A traverse is said to be closed when a complete circuit is made, i.e. when it returns to the starting point forming a closed polygon or when it begins and ends at points whose positions on plan are known. The work may be checked and "balanced". It is particularly suitable for locating the boundaries of lakes, woods, etc. and for the survey of moderately large areas.

2. **Open Traverse (Link traverse)**: A traverse is said to be open or unclosed when it does not form a closed polygon. It consists of a series of lines extending in the same general direction and not returning to the starting point. Similarly, it does not start and end at the points whose positions on plan are known. It is most suitable for

the survey of a long narrow strip of country e.g. the valley of a river, the coast line, a long meandering road, or railway, etc.

1 – Open & closed traverses

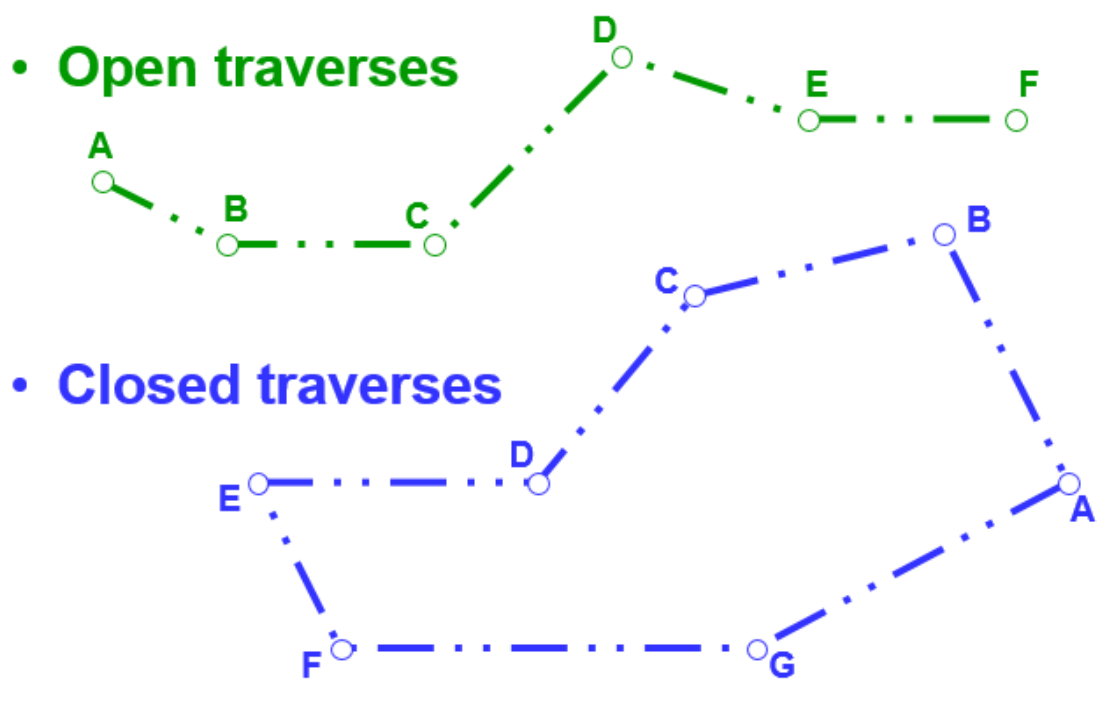
2 – Angular closure of closed traverses

3 – Bearings and Azimuths – definitions

4 – Bearing/Azimuth conversion

5 – Calculating bearings

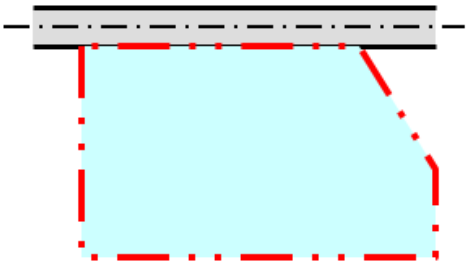
TRAVERSE TYPES



TRAVERSE USES

- **Open traverses**
  - **Define a path from one point to another**
    - Centerlines of:
      - Roads
      - Pipelines
      - Utilities (sewer, water, power, telephone, cable, etc.)

- **Closed traverses**
  - **Enclose an area**
    - Boundaries of:
      - Properties
      - Easements
      - Rights-of-way (highways, railroads, etc.)

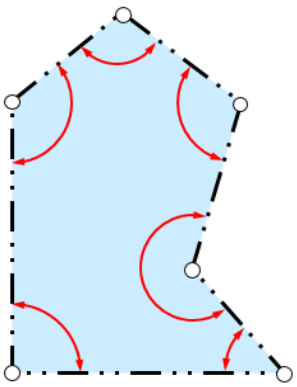


TRAVERSE ANGLES

Open traverse: angles cannot be balanced because they do not add up to a specific number.

Closed traverse: angles must add up to a specific number depending upon type of angles measured and number of angles.

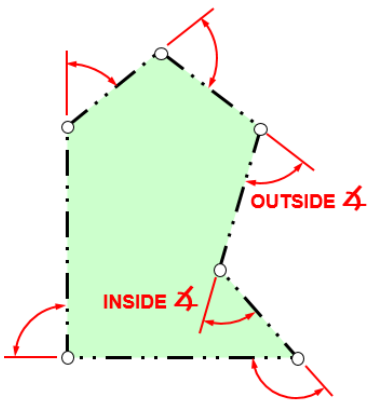
ANGLE TYPES:



Interior Angles

- Zero on backsight, turn to foresight.
- May turn right (clockwise) or left (counterclockwise) directions.

Deflection Angles



- Zero on backsight, flop telescope, turn to foresight.
- May turn right (clockwise) or left (counterclockwise) directions. Direction is determined after ‘scope is flopped.

ANGULAR CLOSURE FORMULAS

(CLOSED TRAVERSES ONLY)

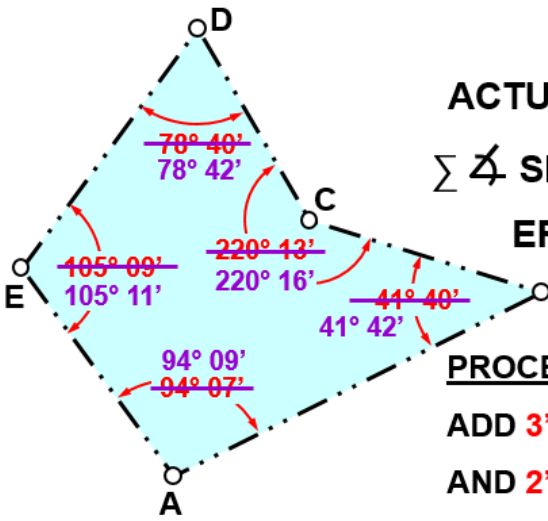
INTERIOR ANGLES:

$\sum \measuredangle = (N-2) \times 180°$ (N = NUMBER OF ANGLES)

DEFLECTION ANGLES:

$\sum \text{OUTSIDE} - \sum \text{INSIDE} = 360°$

EXAMPLE – INTERIOR ANGLES:



ACTUAL ∑ = 539° 49'

∑ ∠ SHOULD BE 540°

ERROR = - 0° 11'

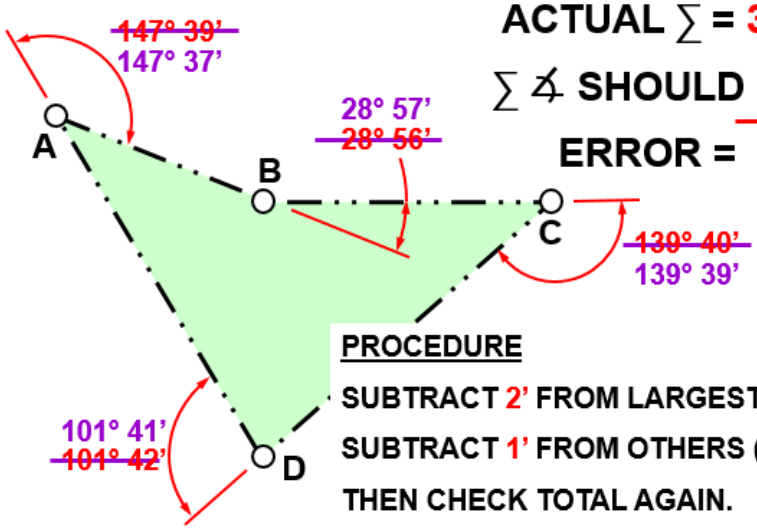
PROCEDURE

ADD 3' TO LARGEST ANGLE,

AND 2' TO ALL OTHERS,

THEN CHECK TOTAL AGAIN.

EXAMPLE – DEFLECTION ANGLES:



ACTUAL ∑ = 360° 05'

∑ ∠ SHOULD BE 360°

ERROR = + 0° 05'

PROCEDURE

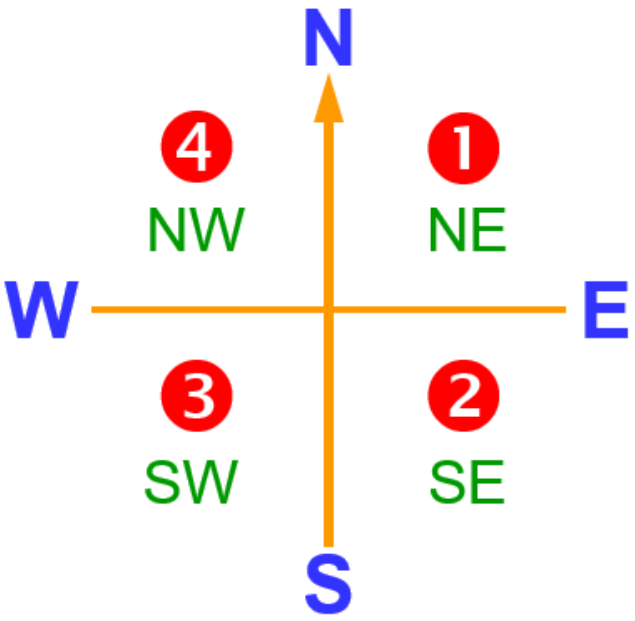
SUBTRACT 2' FROM LARGEST ANGLE,

SUBTRACT 1' FROM OTHERS (+1' TO INSIDE),

THEN CHECK TOTAL AGAIN.

SURVEYING DIRECTIONS

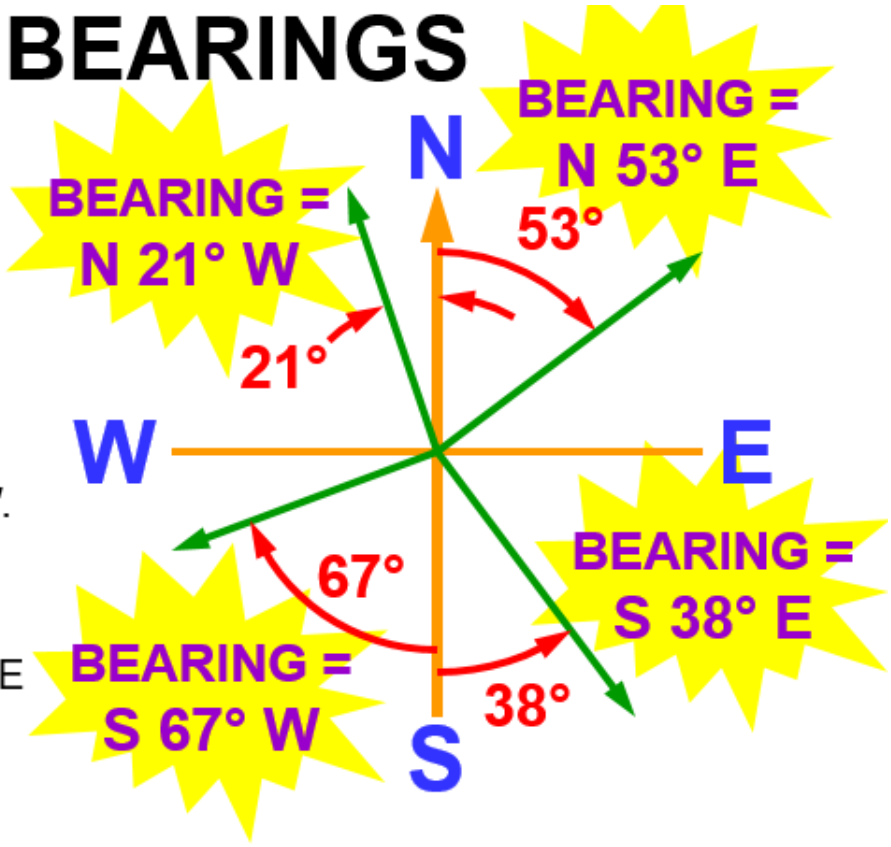
QUADRANTS



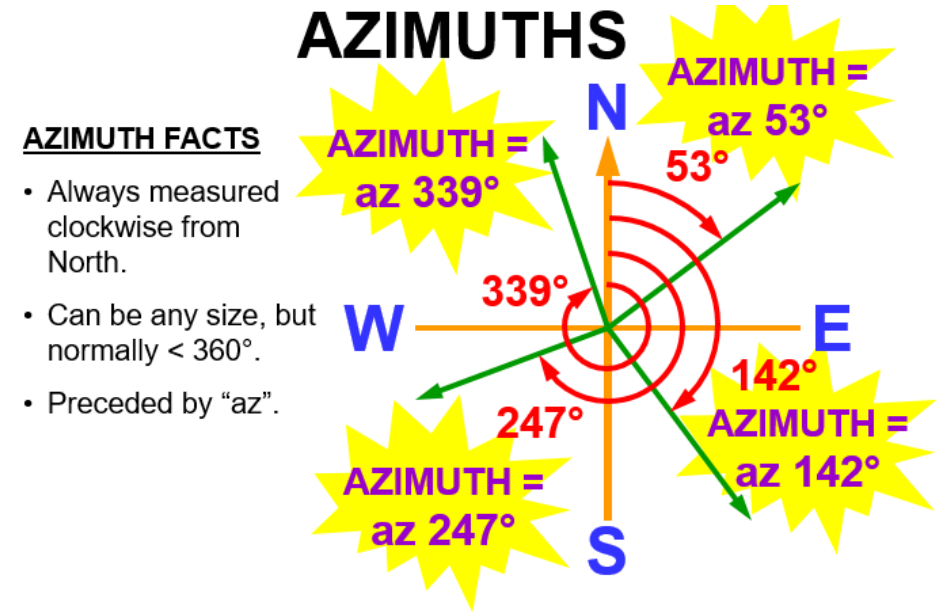
SURVEYING DIRECTIONS

BEARING FACTS

- Always measured from North or South, never from East or West.
- Always < 90°.
- Always preceded by N or S and followed by E or W.
- Lines lying on an axis are listed as DUE NORTH, DUE SOUTH, DUE EAST, or DUE WEST.



SURVEYING DIRECTIONS

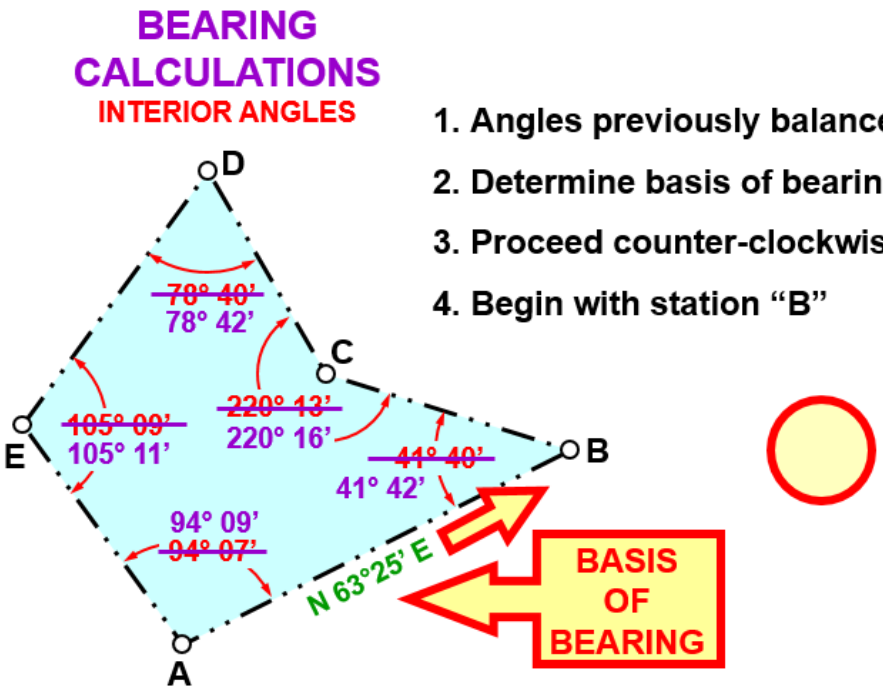


CALCULATING BEARINGS

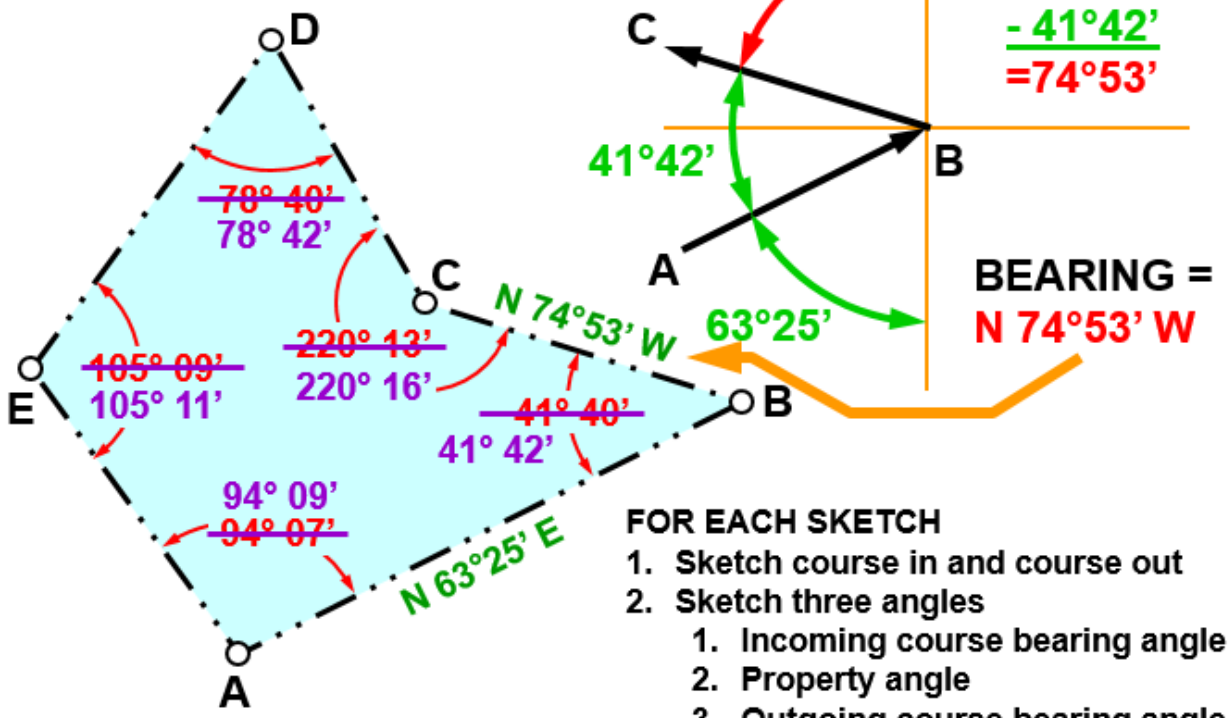
Bearings are calculated by adding and subtracting angles

Bearing calculation process:

1- Balance angles (closed traverses only).
2- Determine the basis of bearing for the traverse.
3- Determine direction to proceed around the traverse.
4- Determine which station to use for first calculation.
5- Sketch each station and calculate bearings around the traverse (see following slides).
6- Calculate beginning bearing to check accuracy.



BEARING CALCULATIONS

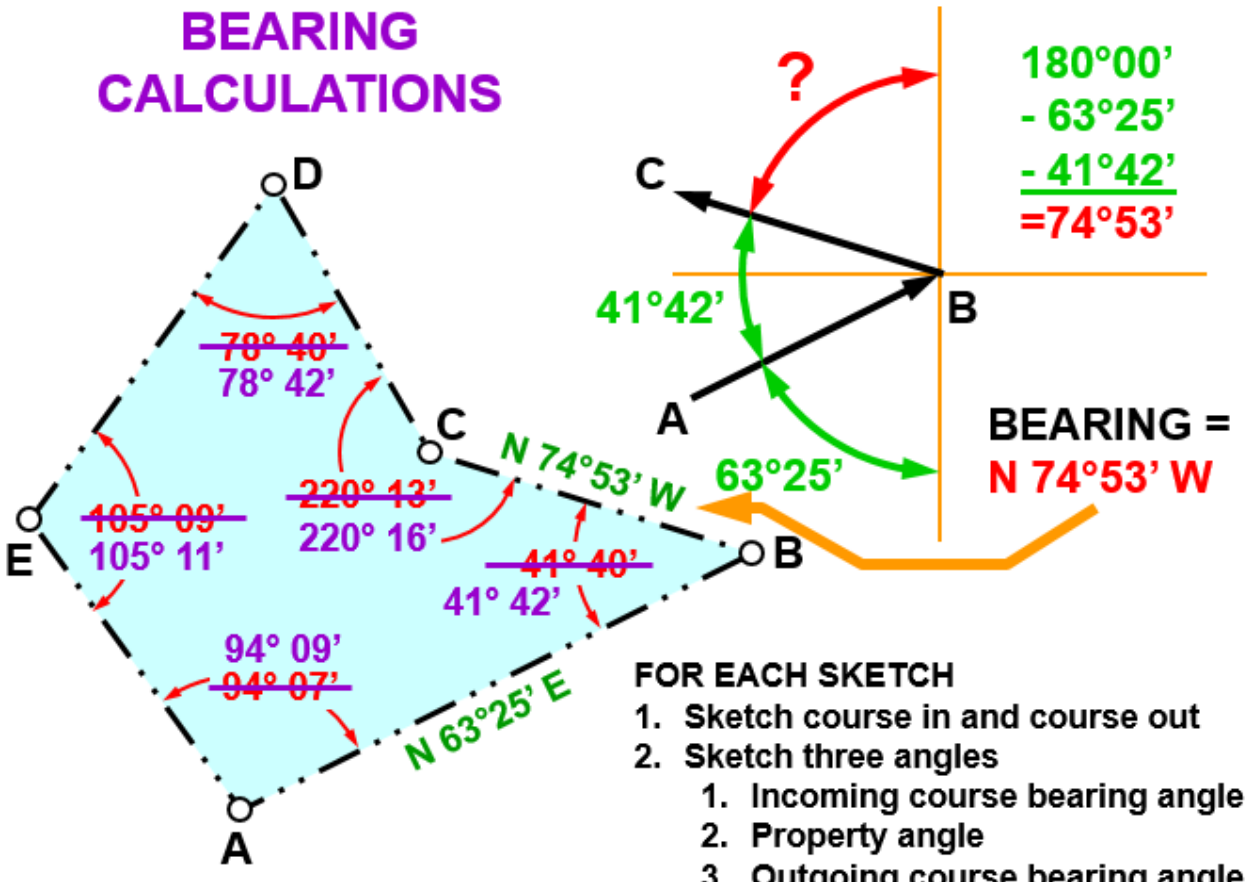


INTERIOR ANGLES

FOR EACH SKETCH

1. Sketch course in and course out
2. Sketch three angles
    1. Incoming course bearing angle
    2. Property angle
    3. Outgoing course bearing angle
3. Calculate outgoing course bearing

BEARING CALCULATIONS



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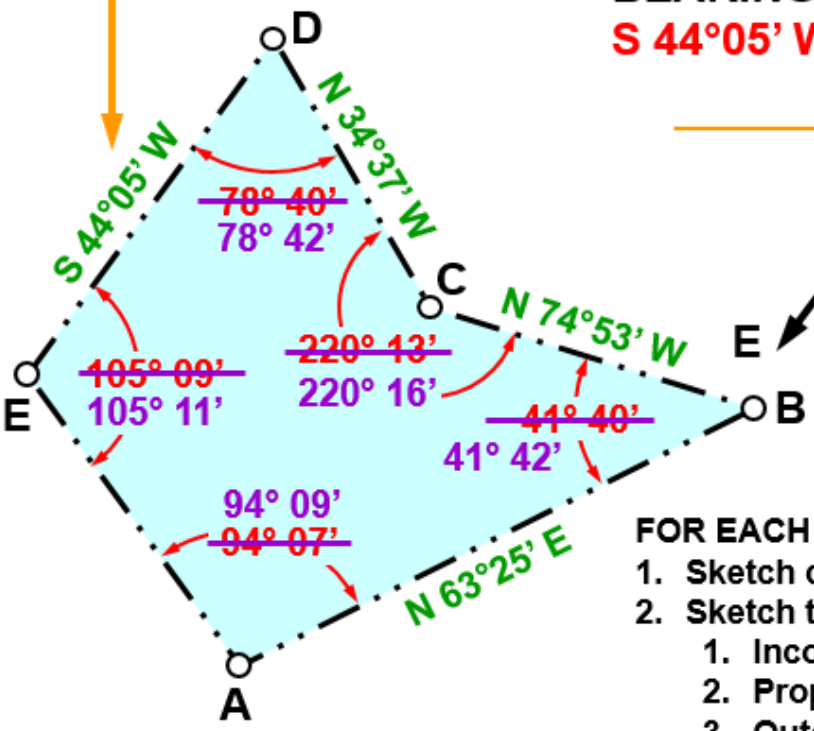
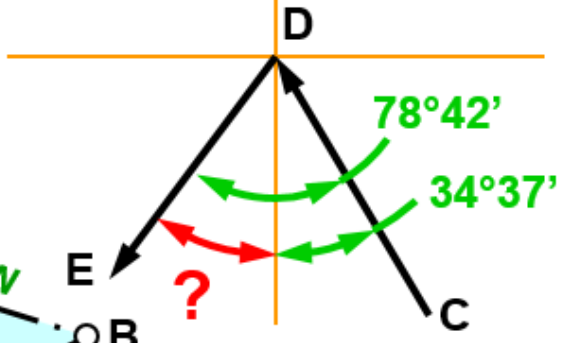


INTERIOR ANGLES

BEARING =
S 44°05' W

78°42'
- 34°37'
= 44°05'



FOR EACH SKETCH

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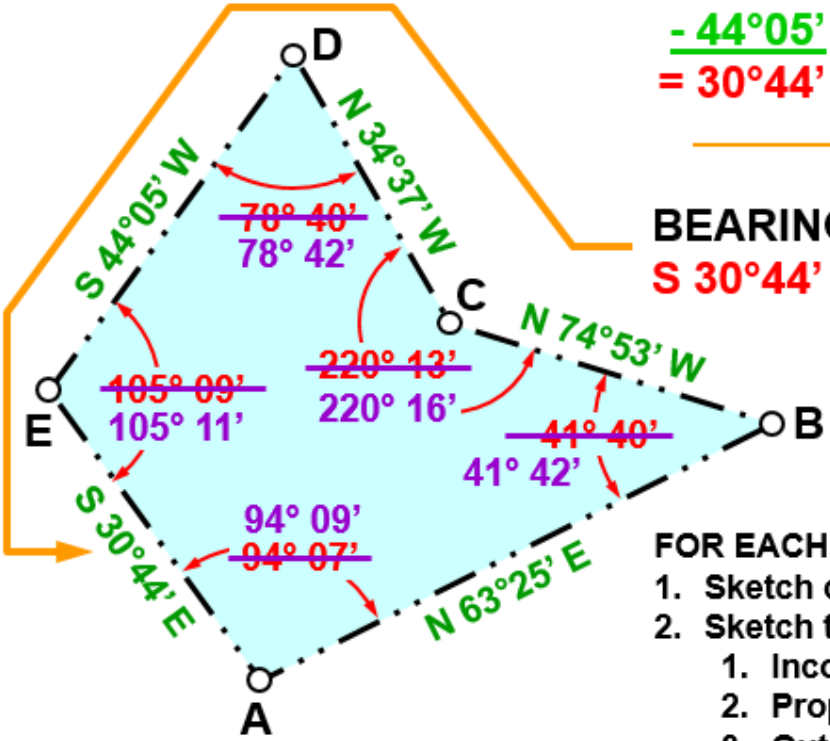
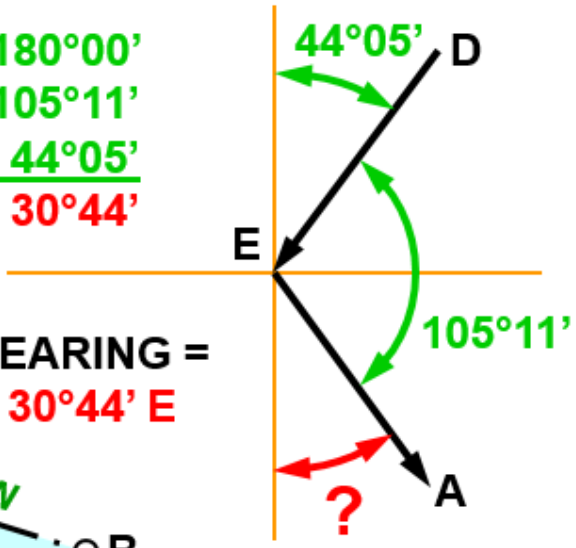
BEARING CALCULATIONS



INTERIOR ANGLES

180°00'
- 105°11'
- 44°05'
= 30°44'

BEARING =
S 30°44' E



FOR EACH SKETCH

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2. Sketch three angles
   1. Incoming course bearing angle
   2. Property angle
   3. Outgoing course bearing angle
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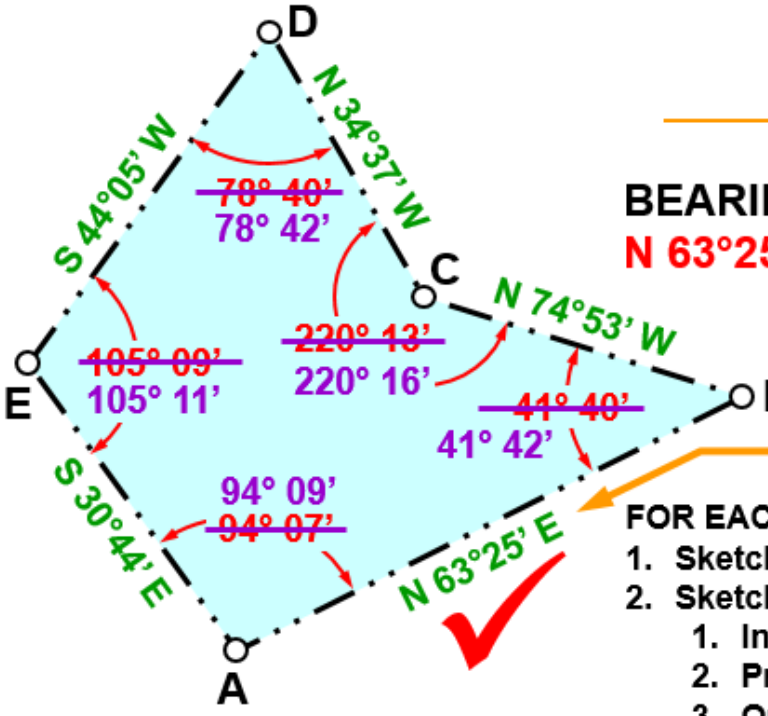
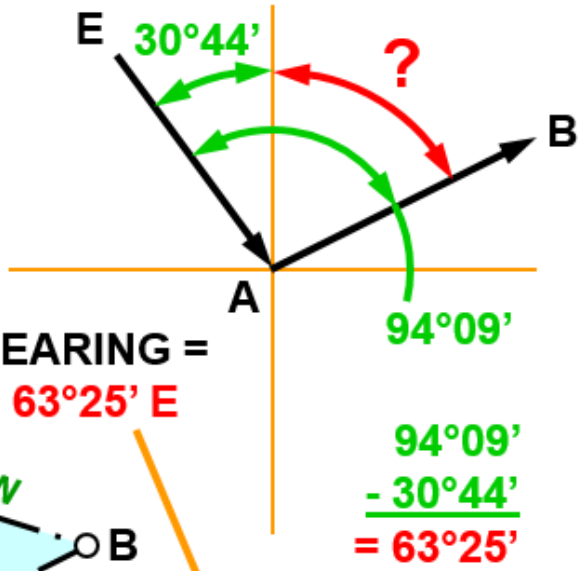
BEARING CALCULATIONS



INTERIOR ANGLES



BEARING =
N 63°25' E

94°09'
- 30°44'
= 63°25'

FOR EACH SKETCH

1. Sketch course in and course out
2. Sketch three angles
    1. Incoming course bearing angle
    2. Property angle
    3. Outgoing course bearing angle
3. Calculate outgoing course bearing

COMPLETED BEARINGS