

Chapter – Four

4. Angle and Directions

4.1. Introduction

Determining the locations of points and orientations of lines frequently depends on measurements of angles and directions. In surveying, directions are given by *bearings and azimuths*.

4.2. Angles

Depending on the plane in which they are measured, angles are classified as

- ✓ Horizontal angles
 - Basic measurement for determining bearing and azimuths.
- ✓ Vertical angles
 - For trigonometric leveling
 - For stadia measurement.
 - For reducing measured slope distances to horizontal.

Angles in surveying are measured with

- ✓ A transit / theodolite, or
- ✓ Total station

There are three basic requirements to determine an angle. They are

1. Reference/starting lines
2. Direction of turning.
3. Angular distances (Values of the angle)

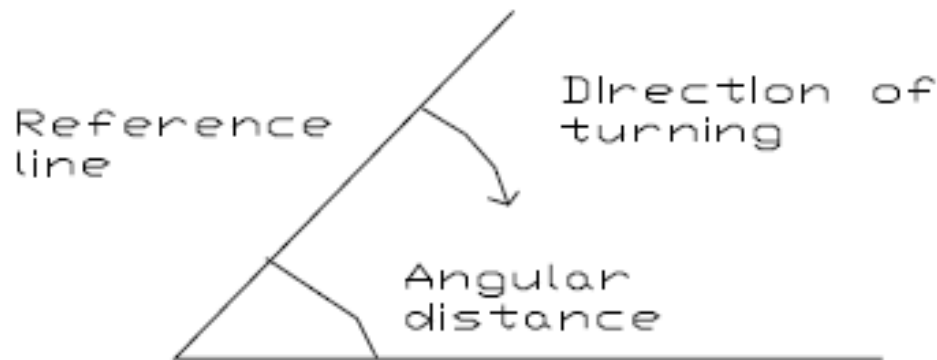


Fig. 4.1. The three determinants of an angle

4.3. Measurement of horizontal and vertical angles

An angle is defined as the difference in direction between two convergent lines. A horizontal angle is formed by the directions to two objects in a horizontal plane. A vertical angle is formed by two intersecting lines in a vertical plane, one of this lines horizontal. A zenith angle is a complementary

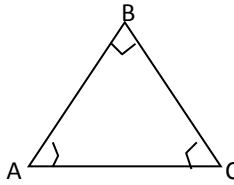
angle to the vertical angle and is formed by two intersecting lines in a vertical plane, one of these lines directed towards the zenith.

4.3.1. Horizontal angle measurement: - are measured through the theodolite's vertical circle by adjusting the upper and lower clumps as well as the upper and the lower tangent screws. Then it is done by rotating the theodolite's telescope either forward or backward (i.e. towards clockwise or counter clockwise direction) in the horizontal plane.

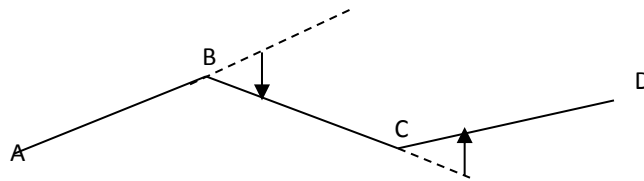
4.4. Methods of Describing Angles

4.4.1. Interior angles: It is angle between two adjacent sides in a closed polygon. In a polygon having n number of sides the sum of interior angles is $(n-2) 180$.

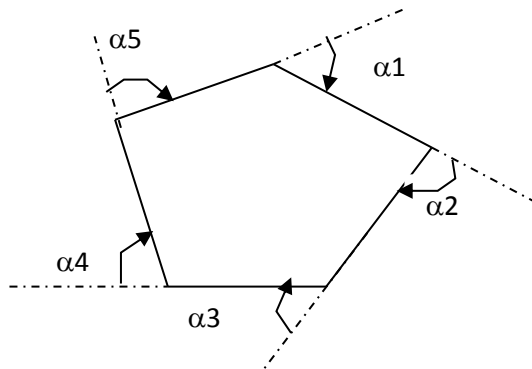
$$\begin{aligned} & \hat{A} + \hat{B} + \hat{C} \\ \text{Total angle} = & \\ = & (n-2) 180 \\ = & (3-2)180=180^0 \end{aligned}$$



4.4.2. Deflection angles: It is the angle between a line and the prolongation of the preceding line. Deflection angle can be to the right or to the left depending on the deflection from the prolongation of the preceding line.

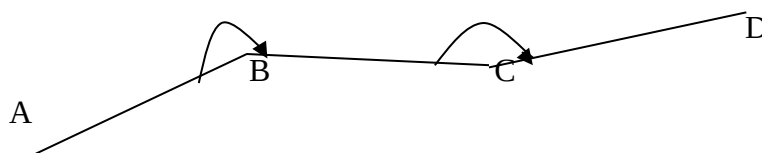


In any closed polygon the algebraic sum of the deflection angle (considering right deflections as of sign opposite to left deflections) is 360^0 .



$$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 = 360^0$$

4.4.3. Angles to the right: angles may be determined by clockwise measurements from the preceding to the following line. such angles are called angles to the right or azimuths from back line.



Example:

Given the azimuth of lines in a polygon, find interior angle, deflections angles to the right and bearing of lines.

Line	AB	BC	CD	DE	EF
Azim	45^0	150^0	180^0	290^0	315^0
uth	$25'$	$37'$	$12'$	$20'$	$15'$

4.5. Direction of a Line

The direction of a line is the horizontal angle between it and an arbitrary closed reference line called a **Meridian**. Meridian is a line on the mean surface of the earth joining the north and south poles.

- The direction of a line is defined by the horizontal angle between the line and an arbitrarily chosen reference line called a **meridian**.
- The horizontal angle between a given line and a specified reference line is called the **direction of the line**.
- A line on the mean surface of the earth joining the north and south poles is called a **meridian**.
- All lines of meridians are called **longitude**.

There are four basic types of meridians:

1. **Astronomic meridian** or **true meridian** or **geographic meridian**: It is an imaginary line on the earth's surface passing through the north-south geographical poles.
2. **Magnetic meridian**: are meridians that are parallel to the directions taken by freely moving magnetized needles, as in a compass. Whereas true meridians are fixed, magnetic meridians vary with time.
3. **Grid meridian**: A line through a point parallel to the central (true) meridian or y-axis of a rectangular coordinate system.
4. **Arbitrary (Assumed) meridian**: An arbitrary chosen line with a directional value assigned by the observer.

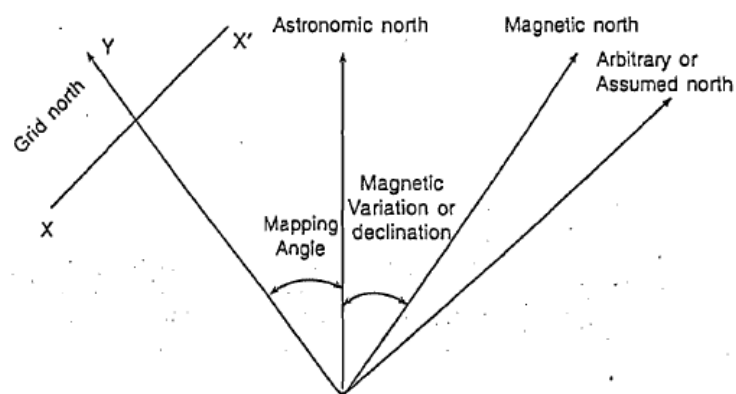


Fig. 8.3 Different north directions.

4.5.1 Magnetic Declinations:

The position of the magnetic north and south poles do not coincide with the geographic north and south poles. Magnetic declination is the horizontal angle observed from the geographic meridian to the magnetic meridian. when magnetic meridian is inclined to the true meridian and this deviation is called magnetic declination.

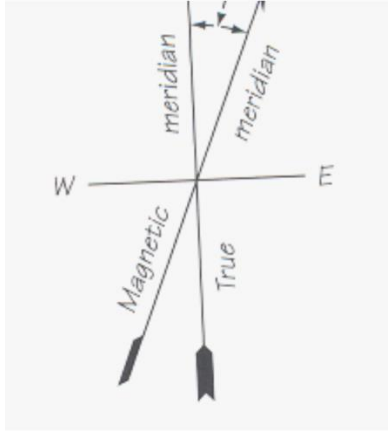


Fig Declination East

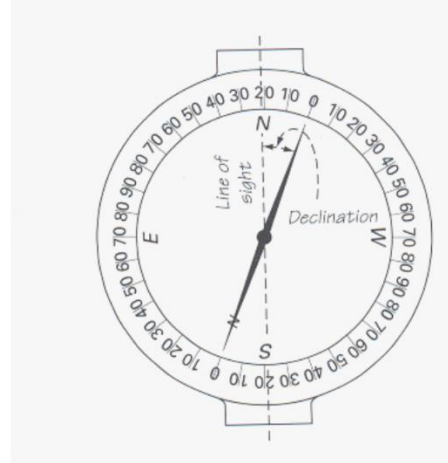


Fig. 7.12. Declination set off on a compass circle

The following are the two main horizontal angles measured from the reference directions.

- I. Azimuths (whole circle bearings) and
 - II. Bearings (quadrantal bearings)
- I. **Azimuths (whole circle bearing)**
 - Azimuth is an angle measured clockwise from the reference north direction.
 - It is always measured clockwise and north direction and ranges from 0° - 360° .
 - Unlike bearing the cardinal direction symbols will never be mentioned.
 - Azimuth is sometimes called **whole circle bearing**

Example: look at the following diagram'

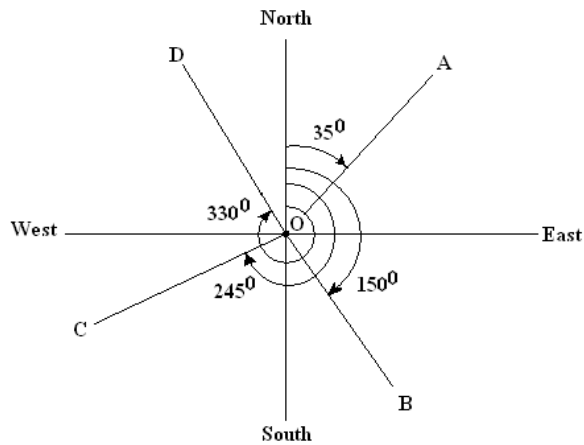


Fig. 4.1

- Azimuth of line **OA** is 35° Azimuth of line **OC** is 250°
- Azimuth of line **OB** is 150° Azimuth of line **OD** is 330°

II. Bearings (Fore bearings)

- Bearing of a line is a horizontal angle measured either from the reference north or south towards either east or west direction i.e. towards clockwise or counterclockwise direction is sometimes called quadrantal bearing or fore bearing. Or it is the acute angle between the reference meridian and the line is known as the *bearing*.
- It is always measured from either of the two references to west or east direction depending on whichever is nearer to the line for which bearing is to be measured.
- It only measures angle from 0° - 90° .
- It is shown with the cardinal direction (N, S, and E, W) within which it is referenced.
- Bearing always accompanied by letters that locate the quadrant in which the line falls (NE, NW, SE or SW).

Look at the following diagram

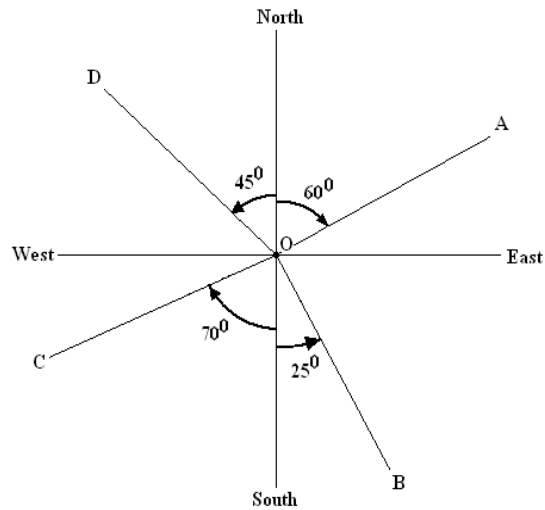


Fig. 4.2

- Bearing of line **OA** is **N 60° E** Bearing of line **OC** is **S 70° W**
- Bearing of line **OD** is **N 45° W** Bearing of line **OB** is **S 25° E**

Relationship between bearing and azimuth

The relationship between azimuth and bearing is different in different quadrants.

I. In the first quadrant

Angular value of bearing is equal to azimuth.

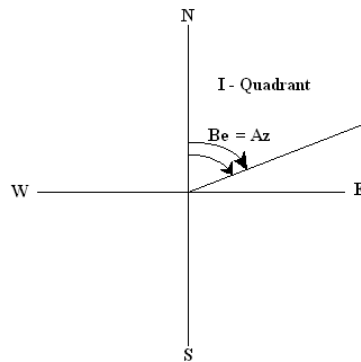


Fig. 4.3

II. In the second Quadrant:

Bearing is obtained by subtracting azimuth from 180°

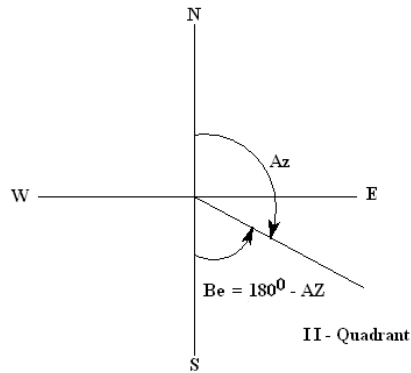


Fig. 4.4

III. In the third quadrant

Bearing is obtained by subtracting 180^0 from the given azimuth.

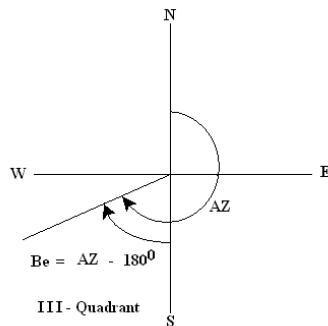


Fig. 4.5

IV. In the fourth Quadrant

Bearing is equal to 360^0 minus the angular value of the given azimuth.

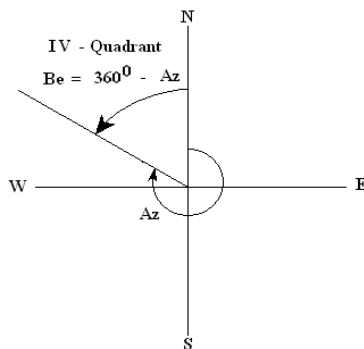


Fig. 4.6

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

<i>quadrant</i>	<i>quadrant letters</i>	<i>Numerical value</i>
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

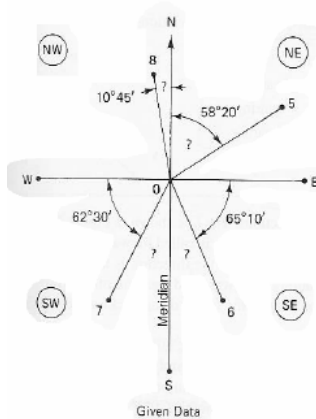
To convert from bearings to azimuths by using this relationships:

1. NE quadrant $\longrightarrow$ azimuth = bearing
2. SE quadrant $\longrightarrow$ azimuth = $180^\circ - \text{bearing}$
3. SW quadrant $\longrightarrow$ azimuth = $180^\circ + \text{bearing}$
4. NW quadrant $\longrightarrow$ azimuth = $360^\circ - \text{bearing}$

• Example: convert :

1. $200^\circ 58' = S20^\circ 58'W$

2. $N2^\circ 21'W = 357^\circ 39'$



Line	Bearings
0 - 5	N $58^\circ 20'$ E
0 - 6	S $24^\circ 50'$ E
0 - 7	S $27^\circ 30'$ W
0 - 8	N $10^\circ 45'$ W

Reverse Directions:

It can be said that every line has two directions.

- 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.

Back azimuth: - is the reverse of the forward azimuth whose angular difference between them is 180° and as a result is sometimes called reverse azimuth or that is the azimuth of a line opposite to the direction of the survey progress.

- ✓ To reverse an azimuth Add or subtract 180° to the original direction.

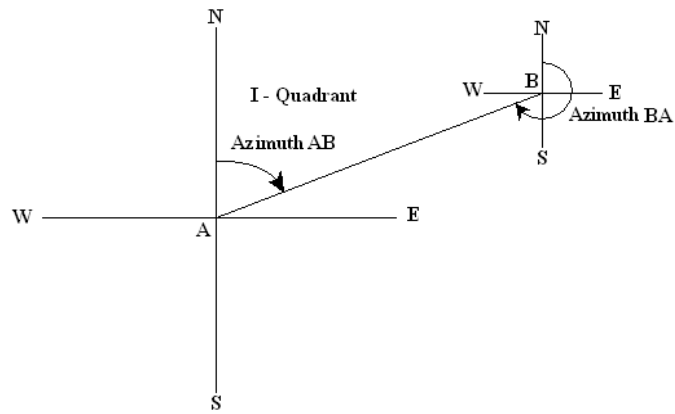
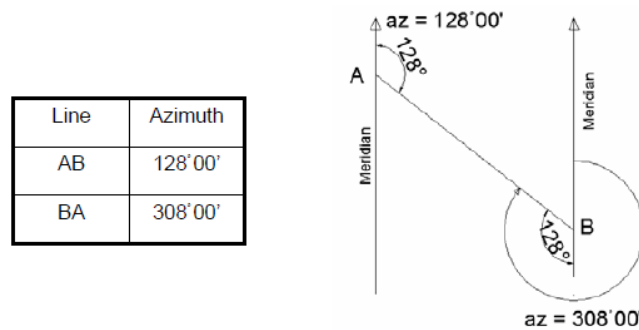


Fig. 4.7

Back azimuth of AB = Azimuth of BA



Back bearing: - is the bearing of a line in the opposite direction of progress of survey is known as back bearing or reverse bearing. Geometrically bearing and back bearing are opposite interior angles of any straight line intersecting two parallel lines (i.e. they are equal in magnitude but different in Direction).

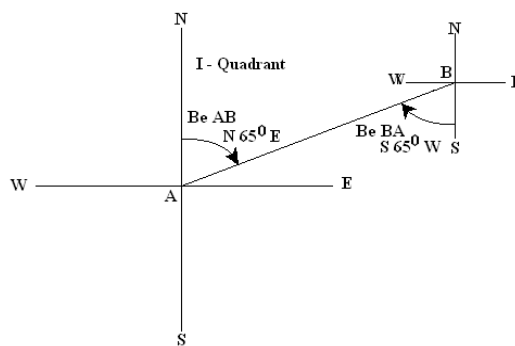
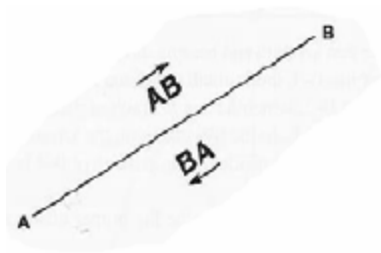
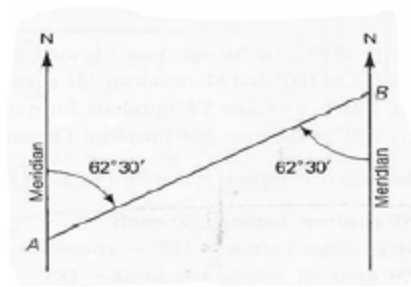


Fig. 4.8

Back bearing of AB = Bearing of BA or N 65° E = S 65° W respectively.



Line	Bearing
AB	N 62° 30' E
BA	S 62° 30' W



4.6 Vertical angle measurement

A vertical angle may be defined as the angle subtended by the inclined line of sight and the horizontal line of sight at the in a vertical plane. If the point sighted is above the horizontal axis of the theodolite, the vertical angle formed is known as **angle of elevation** and if the point that is sighted is below the horizontal axis, the vertical angle formed is **angle of depression**. The maximum range of angle of elevation and angle depression is from **zero degree** up to **normal (i.e. right angle)** in both East and West directions. Angle of elevation is represented by **plus** sign while angle of depression is by **minus** sign whenever they are identified through their names. An angle measured from the reference vertical axis of the theodolite **downward** towards the positive horizontal axis up to the point to be observed (line of sight of the theodolite) is known as **Zenith angle** where an angle which on the other hand is measured from the reference vertical axis of the theodolite **upward** towards the positive horizontal axis of the theodolite up to the theodolite's line of sight is known as **Nadir angle**.

4.6.1 Algebraic relationship between the vertical angles

The interrelationship between vertical angles depends on the target to be observed. For instance look the following diagrammatic representation of the theodolite set up on point **A** whose line of sight is a target on the staff held on point **B**. The line of sight relates the three angles except angle of depression.

4.6.2 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

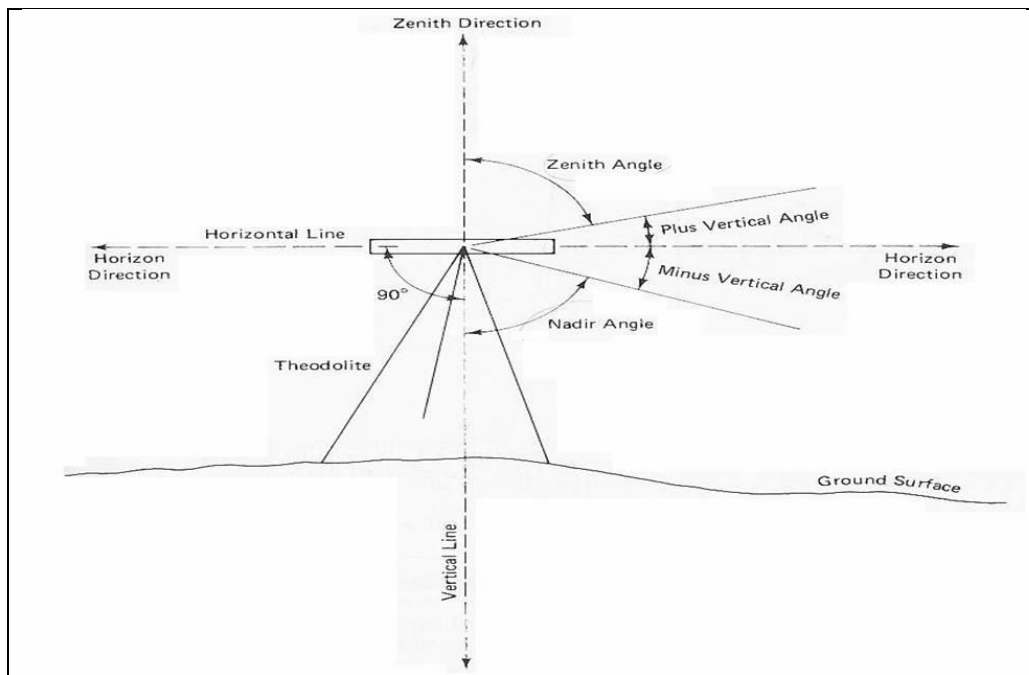


Figure 4.2 The three reference directions for vertical angles: horizontal, zenith, and nadir

Relation Ship between Zenith and Vertical angle

