Surveying

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Lectures
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Semester

Lecture 7: THEODOLITE

Theodolite is an instrument used to measure horizontal and vertical angles.

The most important instrument for exact survey work, and many types are available to meet varying requirements of accuracy and precision, with direct readings of the circle ranging from 5 min to 0.1 sec.

Uses of Theodolite:

i) Measurement of Horizontal and vertical angles.
ii) Setting out lines and angles
iii) Optical distance measurement
iv) Plumbing tall building
v) Setting out of Railway curves
vi) Locating the position of piers for Bridge etc.
vii) Geographical position fixing from observation of sun and stars.
viii) Alignment control in tunnel construction.

CLASSIFICATION

Theodolite may be classified into transit and non-transit theodolites.

1- Transit theodolite

A theodolite is said to be transit one when its telescope can be revolved through 180° in a vertical plane about its horizontal axis, thus directing the telescope in exactly opposite direction.

2- Non-transit theodolite

A theodolite is said to be a non-transit one when its telescope cannot be revolved through 180° in a vertical plane about its horizontal axis.

TYPE OF THEODOLITE

In general, theodolite is divided into three types based on angles, which are vernier, optical and electronic.

1- Vernier Theodolite
- Uses vernier scale

2- Optical Theodolite
- Uses optical with horizontal and vertical circles made from transparent glasses and graduated scale

3- Electronic Theodolite

- Has a screen with digits for angles on front and back of the instrument.
- The face of the current observation (telescope position) is the side on which the vertical circle is, when viewed from the eyepiece, which is either face left or face right
- The telescope has its own clamp and tangent screws. (The clamp screws require only finger tip pressure)

4- Basically Transit Theodolite are those in which the telescope can revolve through a complete revolution about its Horizontal axis in vertical plane.

5- Components of Transit Theodolite Transit theodolite consists of the following parts:

1. Levelling Head
2. Lower Plate or Scale Plate
3. Upper Plate or Vernier Plate
4. The standard or A Frame
5. T-Frame or Index Bar.
6. Plate Levels
7. Telescope

Angles and Directions

In general surveying is used to determine relative positions of existing points and to establish predefined locations on or near the surface of the earth. These purposes are achieved by distance, angle and directions. In this chapter the equipment and methods of angle and direction measurement will be discussed.

Angle Systems: There are three different systems for dividing circles:

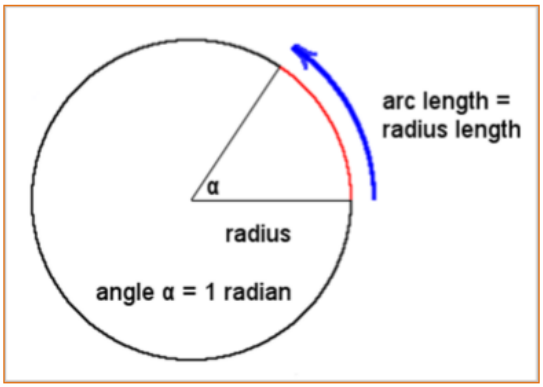
1- Sexagesimal system: It is also called (degree – minute – second) system. In this system, the circle is divided into 360 parts, each part is called a degree $()^0$. Each degree is subdivided into 60 parts called minute () `, and each minute includes 60 seconds () ``. For example: ($124^0$ 34` 55``), right angle = 90^o

2- Centesimal system (Grade System): In this system, the circle divided into 400 parts called grade () ^{g}, each grade divided into 100 parts called cent-grade $()^c$, and each cent-grade divided in to 100 cent-grade () ^{cc}. For example: 392^g 84^c 71^{cc}

3- Radian system: Radian is a central angle for the circle arc is equal to the radius of the circle. The circle circumference is (2π R).

$circle\ circumference = 2\pi\ r$

$\therefore\ total\ angle\ of\ a\ circle = 2\pi\ r / r = 2\pi$



Relation between the three systems:

$360^{o}\ 00`00`` = 400^{g}\ 00^{c}\ 00^{cc} = 2\pi$

$90^{o}\ 00`00`` = 100^{g}\ 00^{c}\ 00^{cc} = \pi/2$

Example:

Convert 15o 37` 14`` to other systems:

Solution A:

$15^{o}\ 37`\ 14`` = 15 + [37/60] + [14/(60*60)] = 15.6205^{o}$

$15.6205^{0} / 360^{0} = x / 400^{g} \Rightarrow x = 17.3561^{g} = 17^{g}\ 35^{c}\ 61^{cc}$

Solution B:

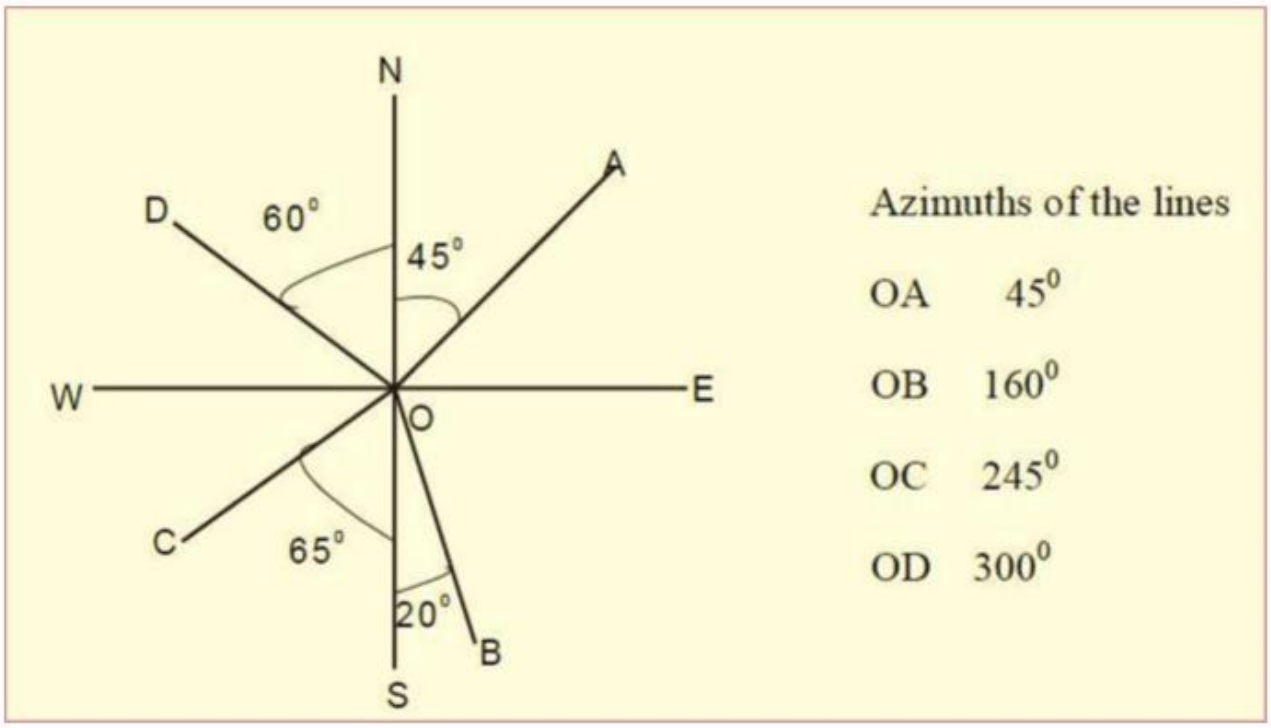
$15.6205^{0} / 360^{0} = x / 2\pi \Rightarrow x = 0.2726\ rad$

Note: Do not forget to change the system of your calculator while angle conversions.

Directions

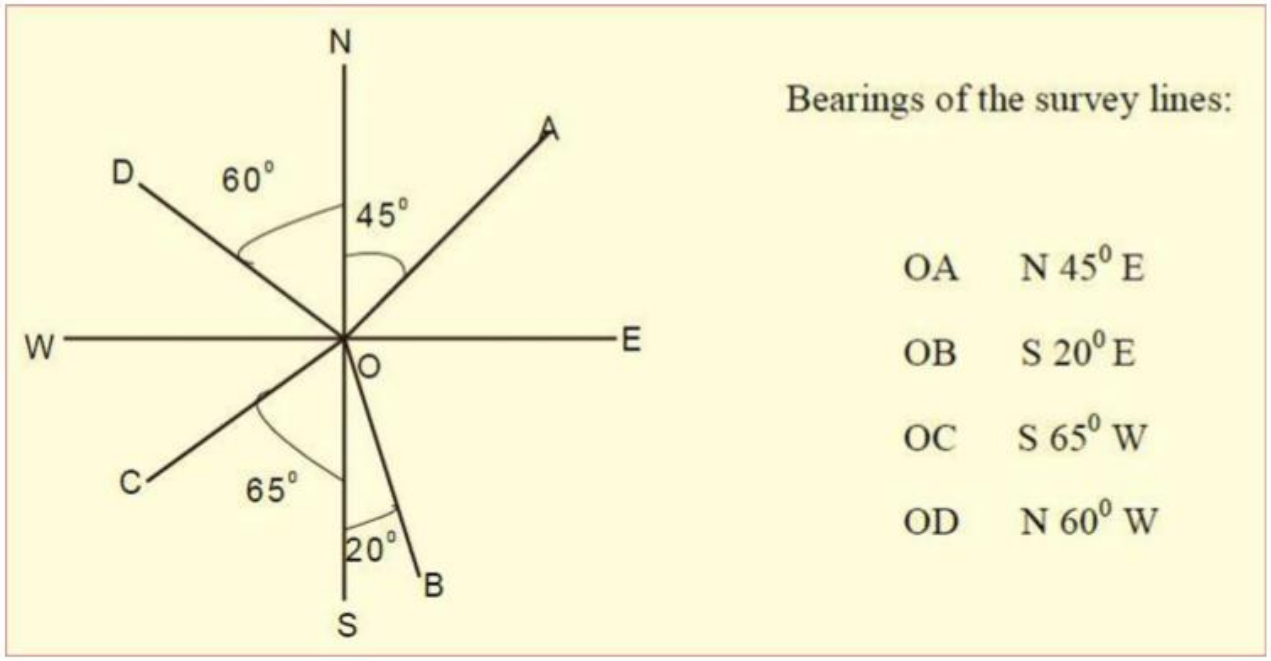
Azimuth (Whole circle):

An azimuth is a direction of a line given by an angle measured clockwise (usually) from the north to the survey lines. Azimuth range is between (0-360°). When the value of azimuth greater than (360°), it's reduced by (360º) before final listing



Bearing:

Is the direction of a line as given by accurate angle between the line and a reference line. The bearing angles which can be measured clockwise or counter clockwise from the north or south end of the survey lines, is always accompanied by letters that locate the quadrant in which line falls (NE, NW, SE, and SW).



Reverse Directions: Forward and back directions.

Forward Azimuth of OA = 45°

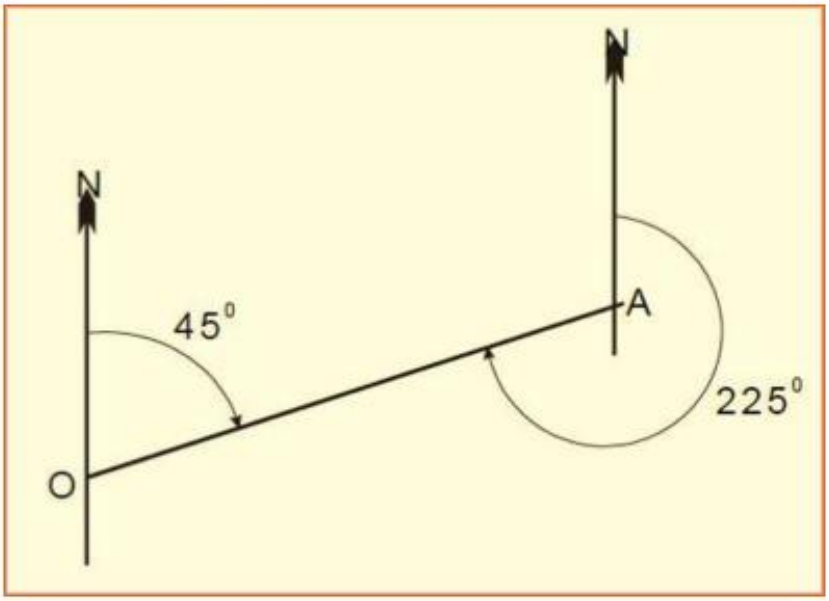
Back Azimuth of OA or Azimuth of AO = 225°

In general, the following relationships hold between forward and back azimuths. Back azimuth = forward azimuth±180°

(+) if forward azimuth < 180°

(-) if forward azimuth > 180°

For Bearings, the only change is (N to S), (S to N), (E to W) and (W to E).



Interior angles: are angles between adjacent lines of a closed polygon measured from the inside. The sum of interior angles of a closed polygon is equal to: (2n-4)*90, where n = number of sides of the polygon.

Azimuth computation:

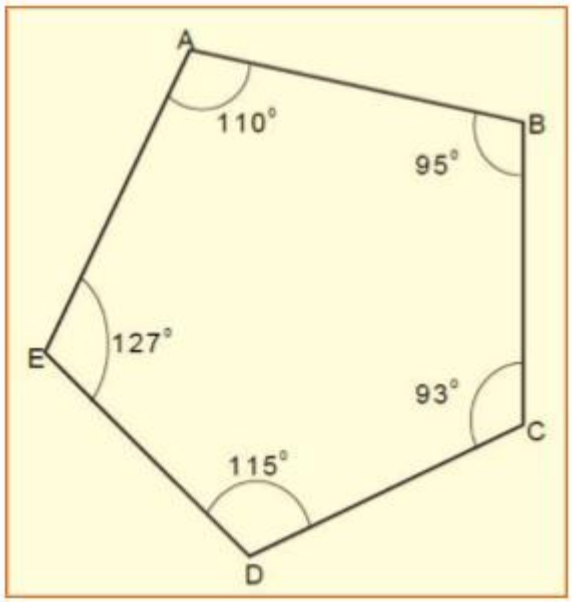
Azimuth for any line = Azimuth for previous line + Horizontal angle between both two lines (measured clockwise) ±180

(+) For smallest, and (–) for greatest

If the result is greater than 540º, added (-540º) to the result.

Example:

If Azimuth BC=180°, find the azimuth others:



Azimuth BC=180°

Azimuth CD=180°+(360°-93°)-180°=267°

Azimuth DE=267°+(360°-115°)-180°=332°

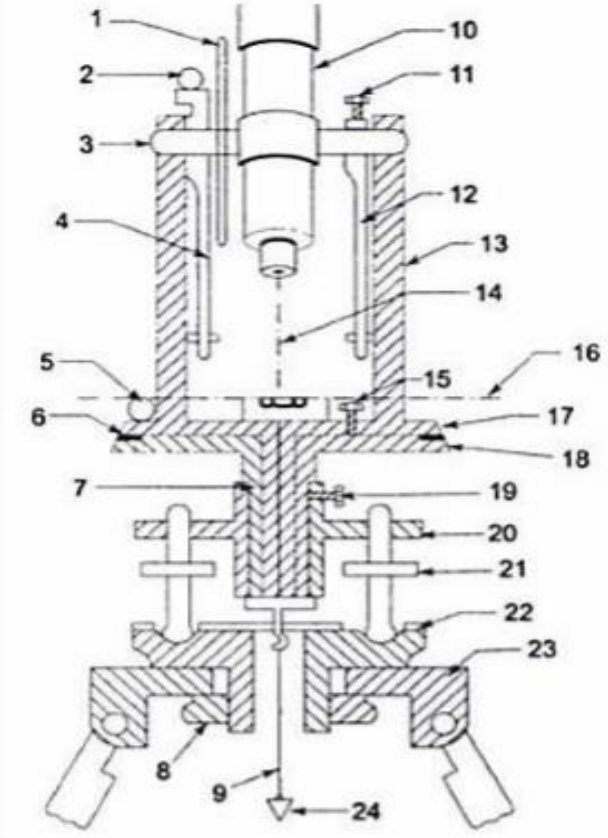
Azimuth EA=332°+(360°-127°)-540°=25°

Azimuth AB=25°+(360°-110°)-180°=95°

Azimuth BC=95°+(360°-95°)-180°=180°

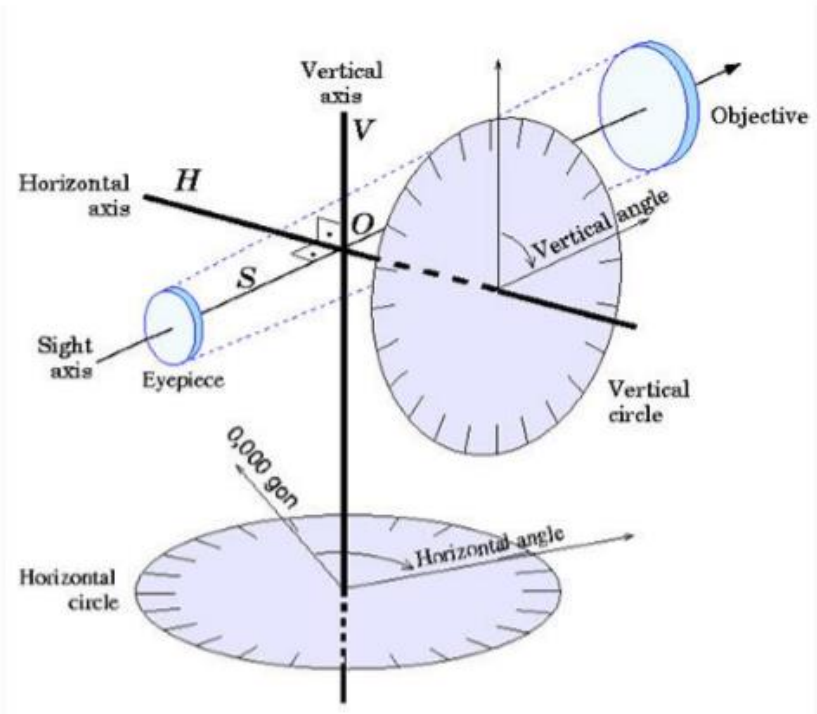
Details of a Theodolite

Parts of theodolite:



1. Vertical circle
2. Altitude bubble
3. Horizontal axes
4. Vernier arm
5. Plate bubble
6. Graduated arc
7. Levelling head
8. Clamping nut
9. Vertical axis
10. Telescope
11. Vertical circle clamping screw
12. Arm of the vertical circle clamp
13. Standard
14. Line of sight
15. Upper plate clamping screw
16. Axis of plate bubble
17. Upper plate
18. Lower plate
19. Lower plate clamping screw
20. Tribrach
21. Foot screw
22. Trivet
23. Tripod top
24. Plumb bob

Measurement with theodolite:



Setting up of Theodolite

1.Set up the tripod over the station mark with tripod head approximately in horizontal plane.

2.Remove the theodolite from its case and place it on the tripod head attached by bolt.

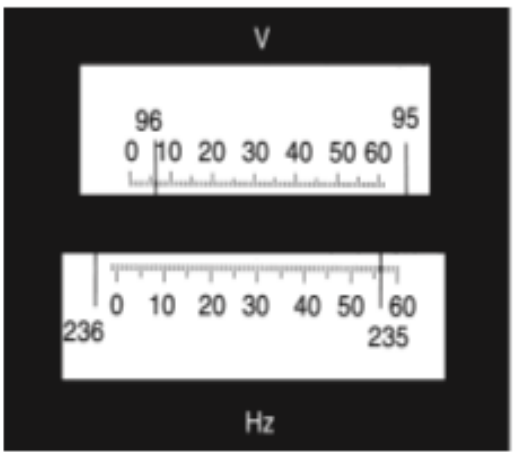
3. Attach the plum-bob if supplied and move the tripod as necessary until the bubble is approximately over the station mark. Push the legs well into the ground and tighten any tripod leg wing nuts.

4.Level up the instrument by its foot screws, exactly the same as what is done in level setting up.

5. Loosen the holding bolt and slide the theodolite with straight line movements until the plumb-bob exactly centered over the station mark, tighten the holding bolt again.

6.Check the levelling up again; the centered again, repeat both as needed.

7. Remove the telescope cap, place it in the pocket or case, eliminate eye piece parallax in usual way, open and adjust the mirror, focus the telescope.



Vertical 96°06′30″
Horizontal 235°56′30″