Surveying Positions with a Theodolite:

1- Face Left Position (F.L): This is the first and primary position of the device. In this position, the vertical circle is on the left side of the observer (left of the device's telescope).

2- Face Right Position (F.R): This is the second position of the device. In this position, the vertical circle is on the right side of the observer (right of the device's telescope). To take readings in this position, you rotate the telescope backward, then turn the device 180 degrees, and start measuring counterclockwise to observe the desired targets

Method of measuring horizontal angle

3- Average direction method

The direction resulting from the average value of the angle in the face left and face right positions .And it is determined according to the type of angle (horizontal or vertical), the angle extracted from the average is considered the correct one used in subsequent orientation operations.

"To calculate the average of the face left and face right positions and the horizontal angle between them, follow these steps:

1. Start by fixing the value of the direction (F.L) from the point where the device is installed towards the observed point.

2. After fixing the value of (F.L) from step 1, change the value of (F.R) as follows:

   - If the given value of (F.R) is less than 180 degrees, ⟶ F.R + 180

   - If the given value of (F.R) is greater than 180 degrees, ⟶ F.R - 180

3. Next, add the changed value of (F.R) to the constant value of (F.L) from step 1. Divide the sum by 2, and thus, the result of the division represents the averaged direction of the first direction (Mean).

4. Repeat the same steps above for each direction from the device station to the observed point.

5. The horizontal angle between two directions is the difference between the subsequent averaged direction and the previous averaged direction. Note that if the result of the subtraction is negative, add 360 to it to obtain the correct horizontal angle.

By following these steps, you can calculate the average of the face left and face right positions and the horizontal angle between them accurately.

Example / in surveying tasks, theodolite was used to measure horizontal angles, and the results were as follows

محطة الجهاز	النقطة المرصودة	قراءة الدائرة الأفقية	
		F.L	F.R
B	A	15° 19' 40"	195° 19' 20"
	C	120° 27' 55"	300° 28' 5"

Find the horizontal angel ABC

Solution:

BA

١. نثبت F.L   15° 19' 40"

٢. نغير F.R   195° 19' 20"

-180°
_____

15° 19' 20"

+15° 19' 40"

(30° 39' 00")/2

BA$_{mean}$ = 15° 19' 30"

BC

١. نثبت F.L   120° 27' 55"

٢. نغير F.R   300° 28' 5"

-180°
_____

120° 28' 5"

+120° 27' 55"

(240° 56' 00")/2

BC$_{mean}$ = 120° 28' 00"

⦠ ABC = 120° 28' 00" - 15° 19' 30" = 105° 8' 30"

محطة الجهاز	النقطة المرصودة	قراءة الدائرة الأفقية		Mean	Angle
		F.L	F.R		
B	A	15° 19' 40"	195° 19' 20"	15° 19' 30"	105° 08' 30"
	C	120° 27' 55"	300° 28' 5"	120° 28' 00"	

Example / in transvers work, theodolite was used to measure horizontal angles, and the results were as follows

محطة الجهاز	النقطة المرصودة	قراءة الدائرة الأفقية	
		F.L	F.R
B	A	00° 03' 20"	180° 03' 10"
	C	31° 25' 20"	211° 25' 40"
C	B	275° 10' 20"	95° 10' 12"
	D	45° 46' 10"	225° 46' 18"

Find the horizontal angel ABC and BCD

Solution:

محطة الجهاز	النقطة المرصودة	قراءة الدائرة الأفقية		Mean	Angle
		F.L	F.R		
B	A	00° 03' 20"	180° 03' 10"	00° 03' 15"	31° 22' 15"
	C	31° 25' 20"	211° 25' 40"	31° 25' 30"	
C	B	275° 10' 20"	95° 10' 12"	275° 10' 16"	130° 35' 58"
	D	45° 46' 10"	225° 46' 18"	45° 46' 14"	

Angle ABC = 31° 22' 15"

Angle BCD = 130° 35' 58"

2- Rpetition method

This method is employed when the theodolite features two vertical axes and is carried out as follows:

1. The theodolite is carefully set up over a specific ground point (O), and vertical adjustments are performed above this point and make the horizontal adjustments for the telescope device

2. The telescope is directed towards point A in a way that the horizontal circle is zeroed at this point

3. The telescope is opened, and the motion screw is released. The telescope is directed towards point B, and by reading the horizontal circle, we obtain the angle value AOB.

4. The telescope is re-directed towards point A (after retaining the reading taken at B using the "Hold" button), and the same steps as above from A to B are repeated, resulting in another reading, which is double the value of the first angle.

5. This process is repeated for a specified number of times (6 times), where readings are taken for both F.L and F.R (6 times each). The results are then divided by the number of repetitions to obtain the correct angle value from this repetition.

Example/ The angle AOC was measured using a theodolite with the repetition method, and the field results were as follows

Station	Repetition	observed point	F.L	F.R
O	1	A	00°00'00"	180°00'00"
		B	18°33'10"	198°33'20"
	2	A	18°33'15"	198°33'25"
		B	37° 6'30"	217°6'40"
	3	A	37° 6'35"	217°6'37"
		B	55°39'52"	235°39'56"
	4	A	55°39'56"	235°39'54"
		B	74°13' 8"	254°13'14"
		A	74°13' 6"	254°13'12"
		B	92°46'28"	272°46'30"
	6	A	92°46'29"	272°46'31"
		B	111°19 '47"	291°19'43"

It is required to calculate the exact value of angle AOB

Solution:

Station	repetition	observed point	F.L	F.R	mean	Angle
O	1	A	00°00'00"	180°00'00"	00°00'0"	18°33'15"
		B	18°33'10"	198°33'20"	18°33'15"	
	2	A	18°33'15"	198°33'25"	18°33'20"	18°33'15"
		B	37° 6'30"	217°6'40"	37° 6'35"	
	3	A	37° 6'35"	217°6'37"	37° 6'36"	18°33'18"
		B	55°39'52"	235°39'56"	55°39'54"	
	4	A	55°39'56"	235°39'54"	55°39'55"	18°33'10"
		B	74°13' 8"	254°13'14"	74°13'11"	
	5	A	74°13' 6"	254°13'12"	74°13' 9"	18°33'20"
		B	92°46'28"	272°46'30"	92°46'29"	
	6	A	92°46'29"	272°46'31"	92°46'30"	18°33'15"
		B	111°19 '47"	291°19'43"	111°19'45"	

AV of angle AOB $= \dfrac{sum\ of\ angles}{no\ of\ repetition}$

$$= \frac{18°33'15+18°33'15+18°33'18+18°33'10+18°33'20"+18°33'15"}{6}$$

$= 18°33'16"$

3- Direction method

This method is used when the theodolite has a single vertical axis. It is faster in practice and calculation compared to the previous method and is employed when a relatively large number of angles need to be measured. However, it is less accurate than the previous method, and any error in one angle will affect the subsequent angles, leading to error accumulation that can be corrected statistically.

The measurement of angles using this method is as follows:

1. Set up the theodolite over the observation point (M) and adjust the theodolite's vertical axis over this point. Ensure that the theodolite's base is horizontal and the telescope is level.

2. The zero reading is recorded on the horizontal protractor so that the device is in the F.L position. The telescope is directed to one of the most visible points because it will be observed twice. Let it be (A). Then the device is directed to B and the horizontal angle is read between the point directed at, B, and the point in the direction A. This angle is AMB.

3. Continue reading the directions as you move the telescope to other points (C, D, E) in a clockwise direction relative to the point (A).

4. Change the theodolite to the reversed position (F.R) and start by directing the telescope to point (A) in a counterclockwise direction. Observe the points in the opposite direction to the first round (counterclockwise) and record the angles in the table, from bottom to top (since you start from the point where you left off in the first round, F.L). Then, take the average for each direction as described earlier.

5. Calculate the angle between each consecutive pair of directions, ensuring that the sum of all angles adds up to 360 degrees. Any error is distributed among the angles to correct them.

Example/ The device was placed above point M and the following readings were recorded

theodolite location	observed point	F.L	F.R
M	A	00°00'00"	180°00'00"
	B	45°34'30"	225°34 '20"
	C	133°17'00"	313°3 '10"
	D	246°28'40"	66 ° 28'18"
	E	329°35'12"	149°35 '24"
	A	360°00 '00"	180°00 '00"

Calculate the average direction of each line and the horizontal angle and check the solution

Solution:

theodolite location	observed point	F.L	F.R	Mean	Angle
M	A	00°00'00"	180°00'00"	00 ° 00'00"	45°34'25"
	B	45°34'30"	225°34 '20"	45 ° 34'25"	
	C	133°17'00"	313°3 '10"	133°16 '35"	87°42'10"
	D	246°28'40"	66 ° 28'18"	246°28 '29"	113°11'54"
	E	329°35'12"	149°35 '24"	329°35 '18"	83°06'49"
	A	360°00 '00"	180°00 '00"	360°00 '00"	30°24'42"
					∑ = 360°