GEE 4812:
Principles of Geomatics

Angular Measurements

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- Unit of Measurement
- Face Left and Face Right Orientation
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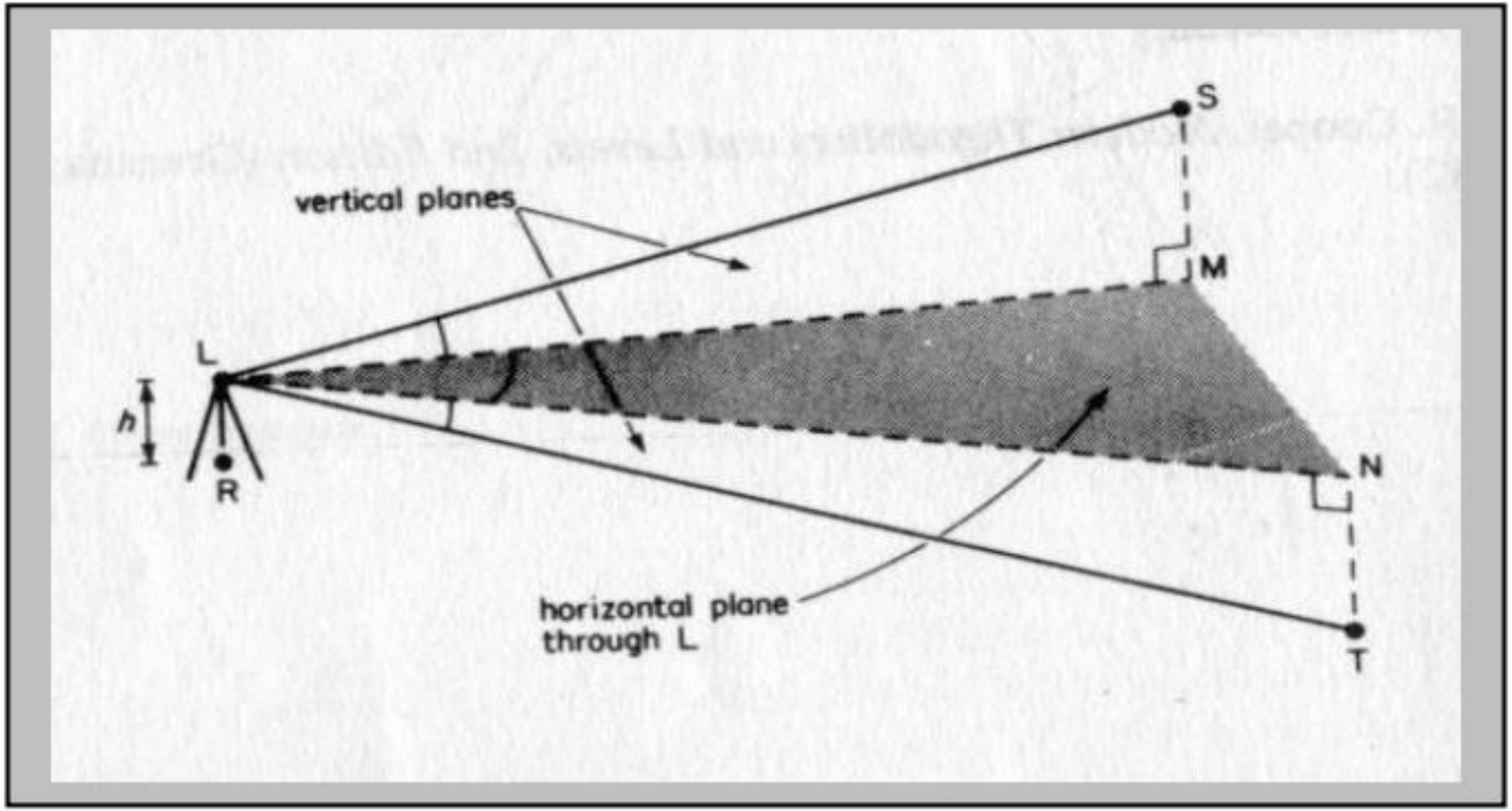
Angular Measurements

- Angles are one of the basic measurements in surveying.
- By angles, it is referred to both horizontal and vertical angles.
- The basic instrument is the theodolite.
- Although there are number of varieties produced by different manufacturers, all instruments have the same basic concepts arranged in the same geometric relationship.

Angular Measurements

- Theodolites are normally classified by the precision to which they resolve the angles and vary from say 0.1 seconds (0.1“) to 1 second (1“) and more.
- The choice of which depends on the accuracy specifications for the work to be done.
- At the moment there are latest electronic theodolites which measure the angles automatically as opposed to conventional ones.

Principle of Angle Measurement

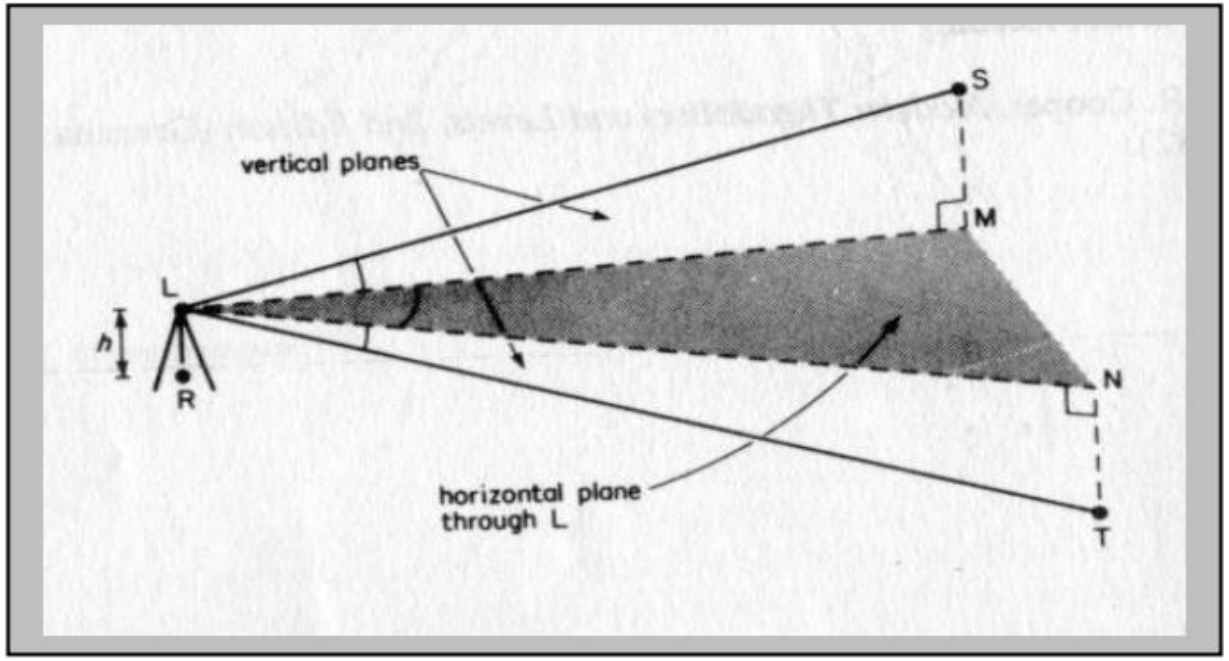


Principle of Angle Measurement

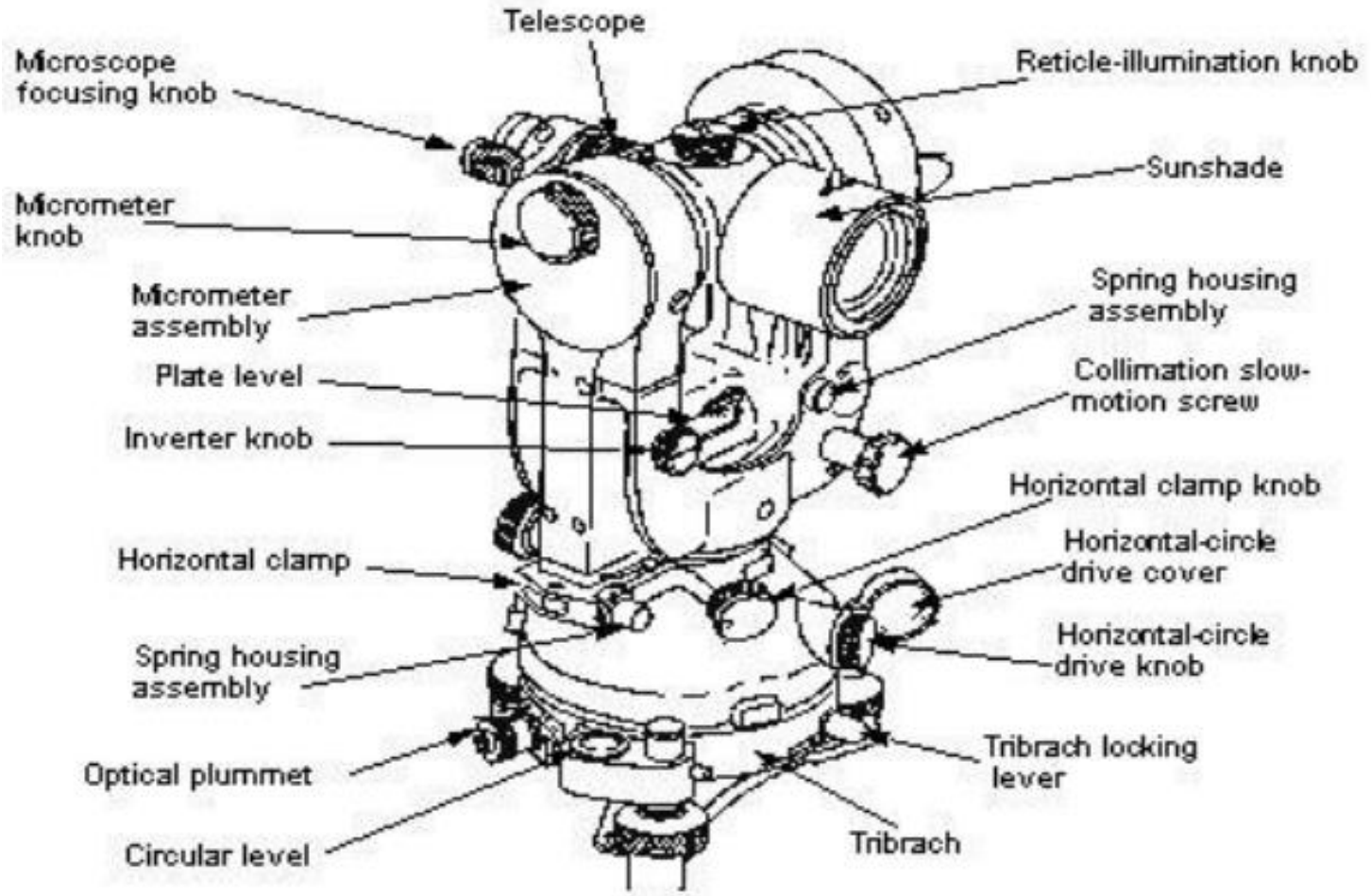
- The figure on the next page shows two points S and T and a theodolite set up on point R.
- The horizontal angle at L between S and T is angle MLN, where M and N are the vertical projections of S and T on to the horizontal plane through L.
- The vertical angles to S and T from L are angle SLM (and angle of elevation) and angle TLN (an angle of depression).

Principle of Angle Measurement

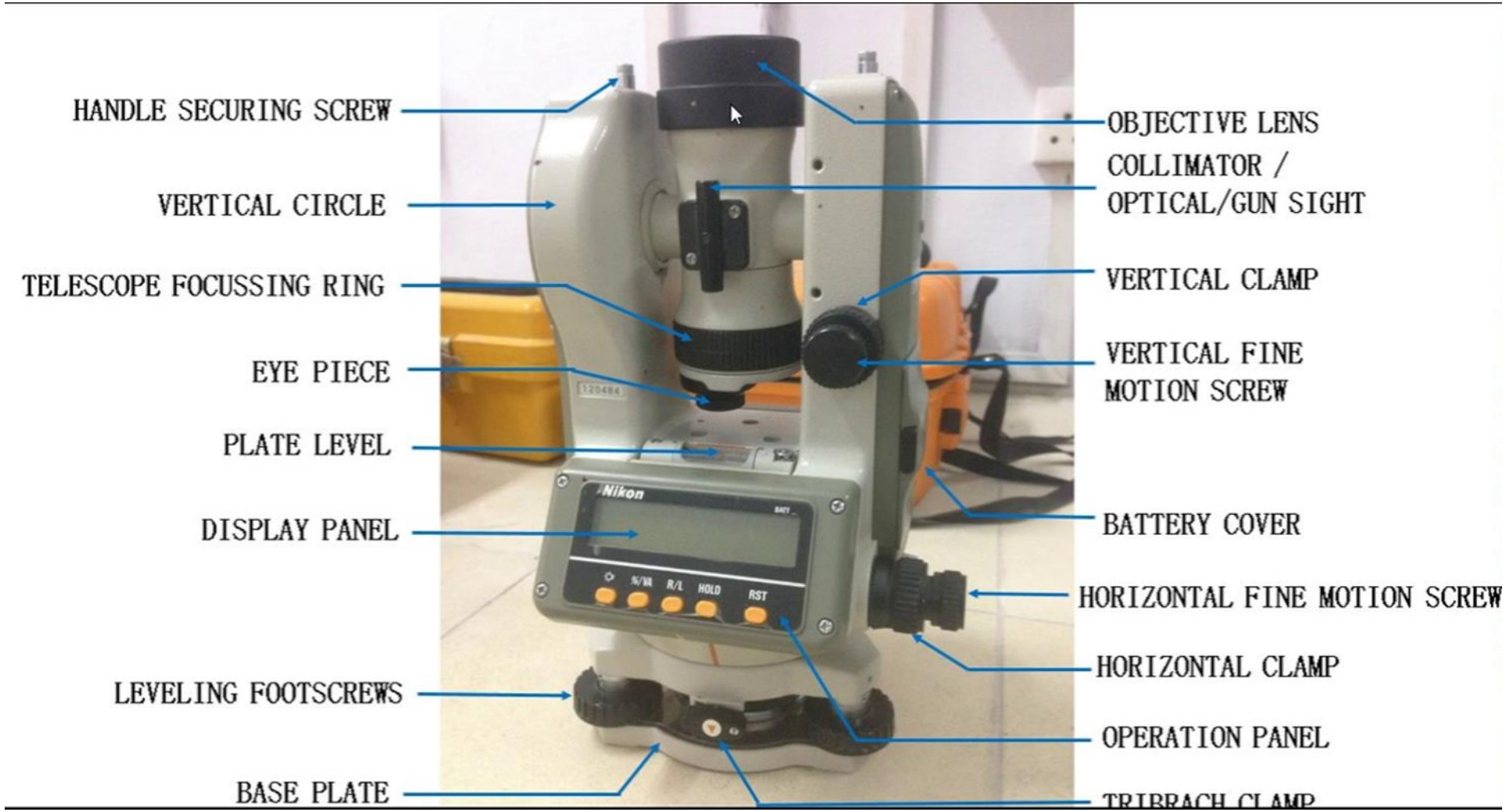
- In order to measure horizontal and vertical angles, the theodolite must be set over point R using a plumbing device and must be levelled to bring the angle reading systems of the theodolite into appropriate planes.



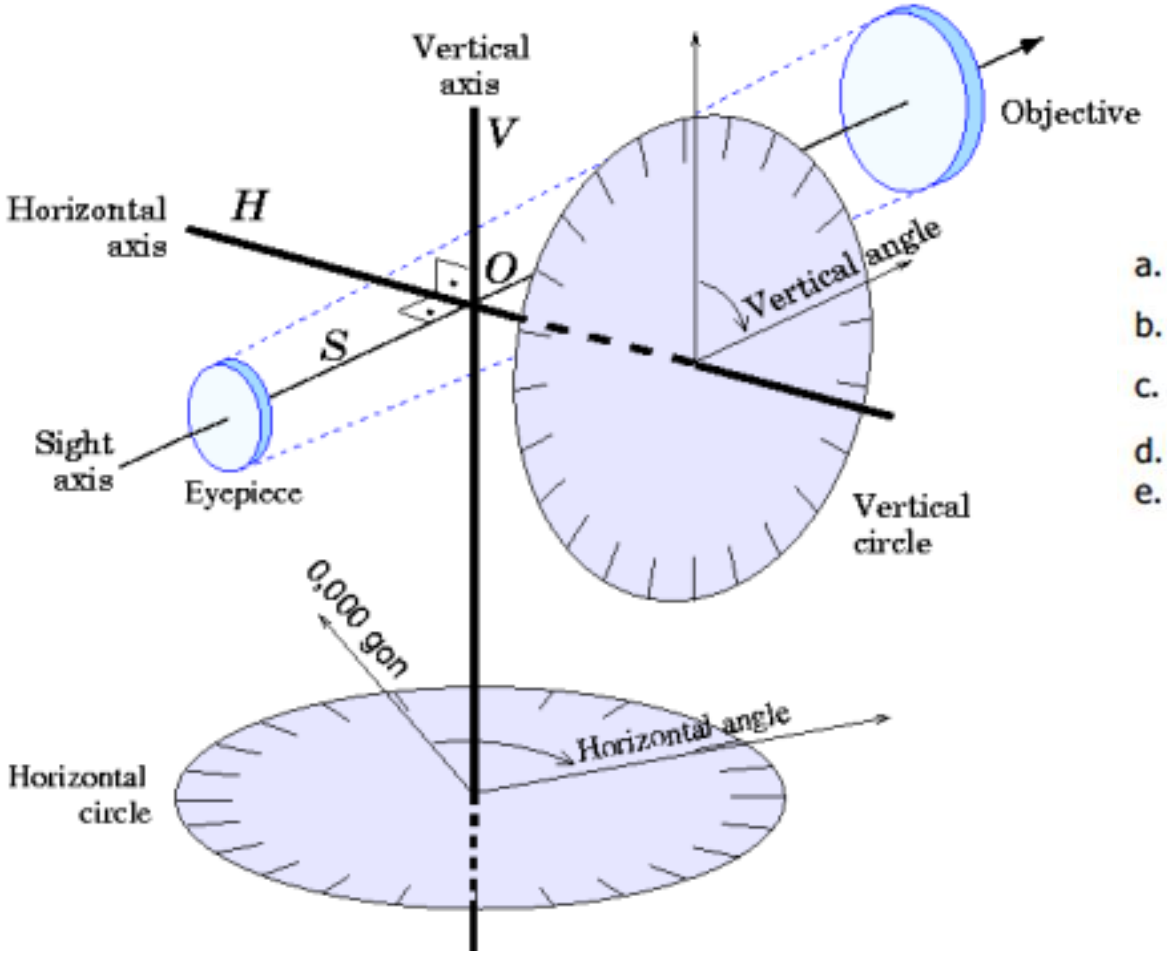
Features of the Theodolite



Features of the Theodolite



Features of the Theodolite



a. The Vertical axis, V
b. The Horizontal, Trunnion or Transit axis, T
c. The Line of Collimation axis, C
d. The Plate Level axis P, which is the tangent to the top of the plate level tube.
e. The line of Collimation of the optical plummet or the Optical Plummet axis, O

Unit of Measurement

- Angles are measured in Angles e.g 100.5025 degrees (decimal degrees).
- Usually presented in Sexagesimal Notation i.e degrees, minutes, seconds.

Degrees.Minutes.Seconds = ddd.mm.ss

$$100.5025\ degrees = 100°30'09''$$

Unit of Measurement

Vertical and Horizontal Angle readings

HORIZONTAL CIRCLE READING			
MAIN SCALE	182°	30′	
MICROMETER		2′	54″
TOTAL	182°	32′	54″

VERTICAL CIRCLE READING			
MAIN SCALE	36°	40′	
MICROMETER		5′	23″
TOTAL	36°	45′	23″

Analog Theodolite

Digital Theodolite

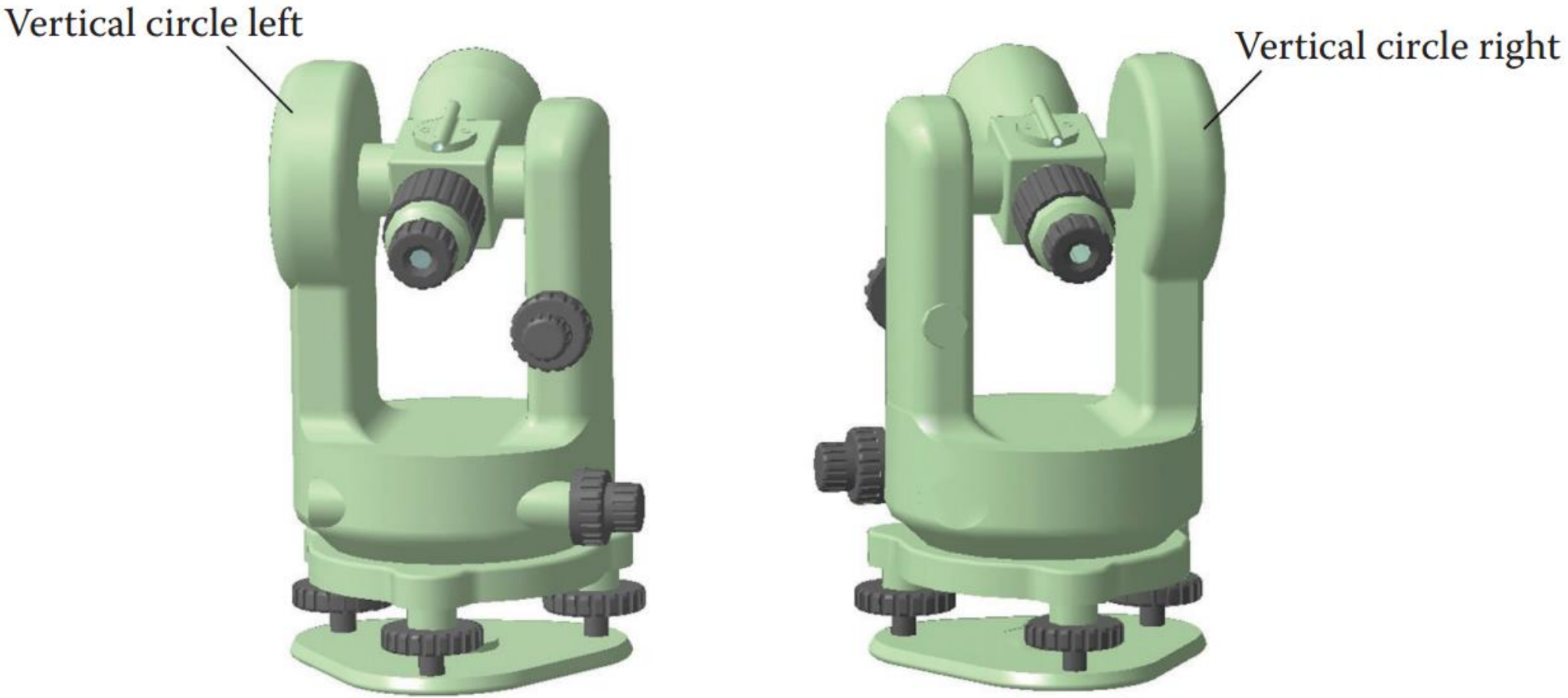
Field Procedures

- In some cases we want to have our angles with a relatively high order of accuracy, so that we must try to minimise the effects of certain systematic errors and of random errors as much as possible.
- In such cases we should adopt the following rules;
- Measure in both faces and use the values for calculation of the average.
- Several types of possible systematic errors are eliminated in this way.

Field Procedures

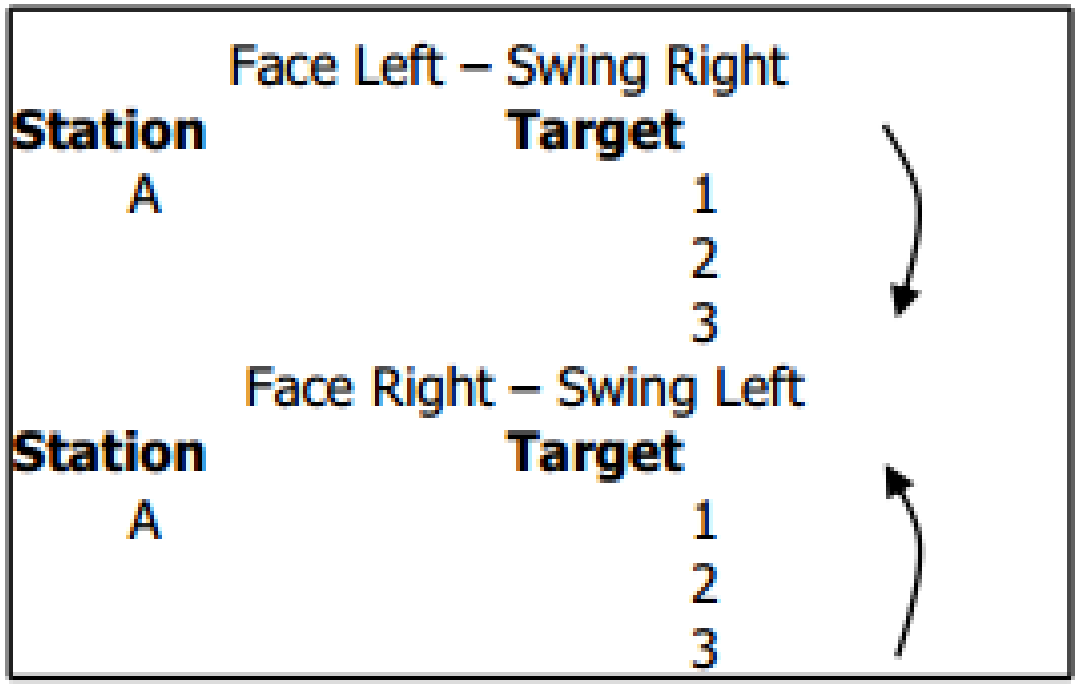
- Take more than one direction to each target point. This will reduce the effect of random errors.
- Spread the observations over the horizontal circle, i.e. use all parts of the circle. In this way any small residual graduation errors may be compensated.
- These rules are applied in the so-called Bessel-rounds. Each round consists of one set of Face Left and one set of the Face Right readings to the targets, transiting the instrument the instrument in between.

Face Left and Face Right Orientation

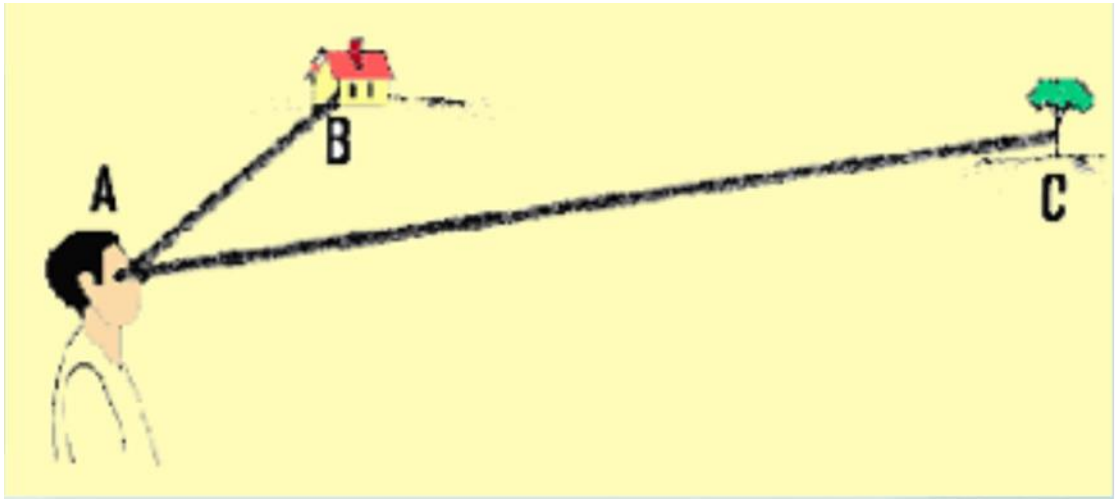


Face Left and Face Right Orientation

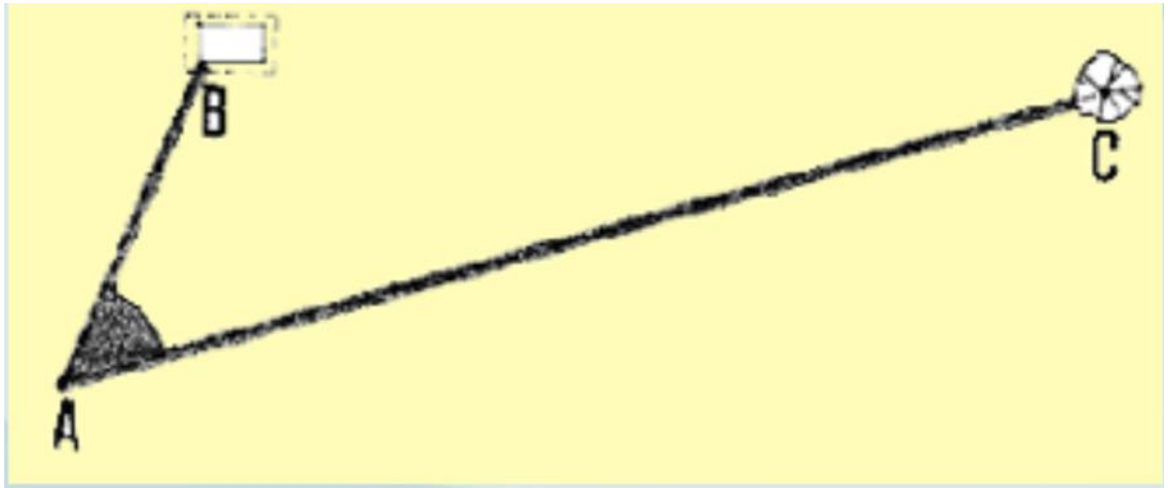
- When observing e.g. 3 targets from station point A, the sequence for one round is as follows:



Horizontal Angles



The lines of sight in angle BAC



Horizontal angle BAC

Horizontal Angles

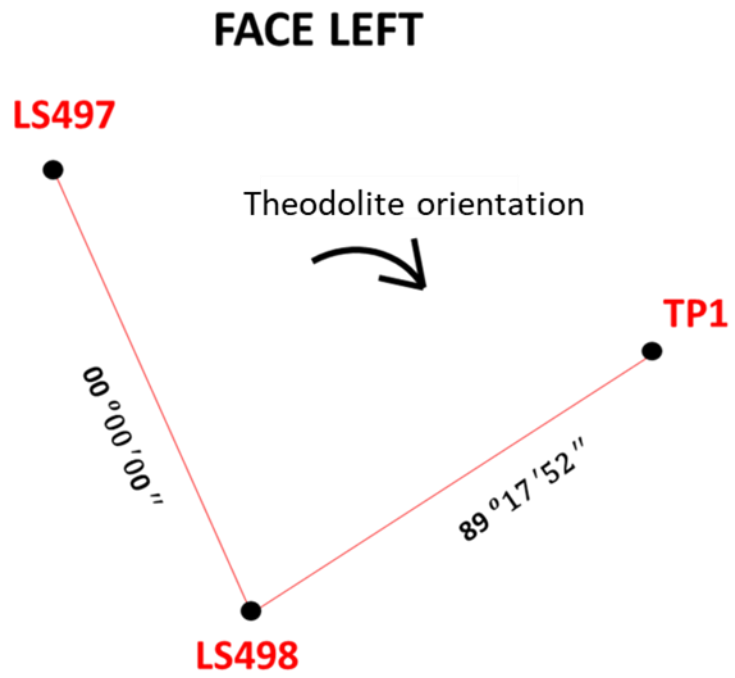
- The mean horizontal circle readings are obtained by averaging the FL and FR readings.

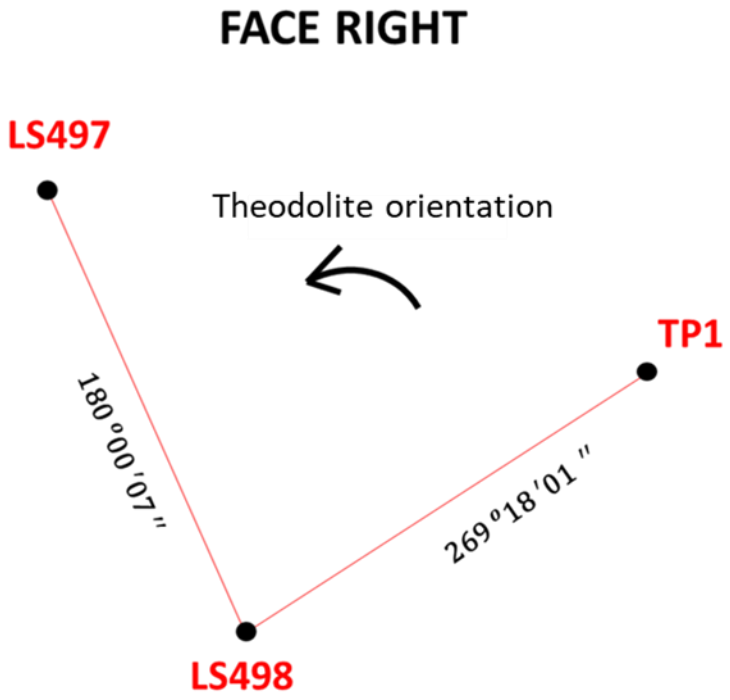
  To simplify these calculations, the degrees of the FL readings are carried through and only the minutes and the seconds values are averaged.

- The final horizontal angles are obtained by meaning the values obtained from each round.

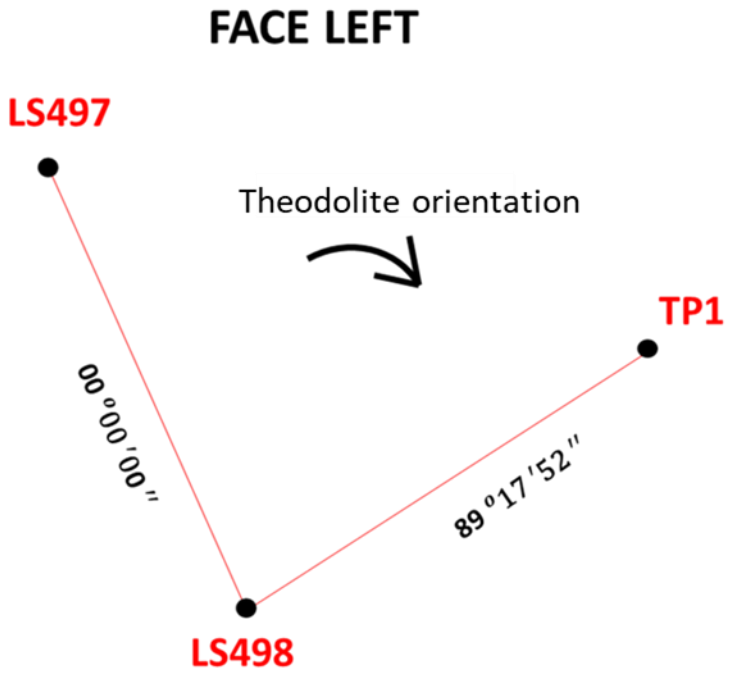
Horizontal Angles

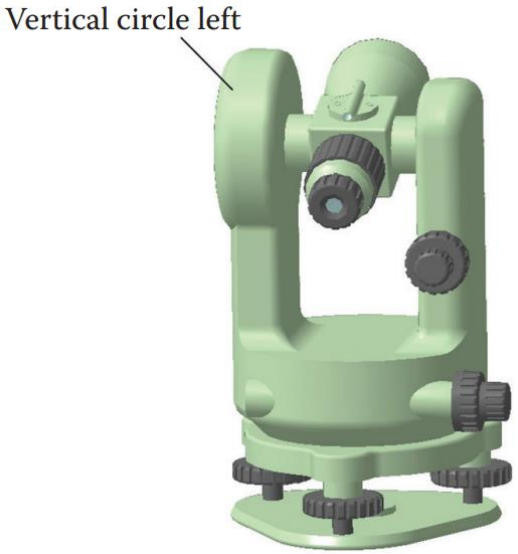
- Theodolite set up at LS498.





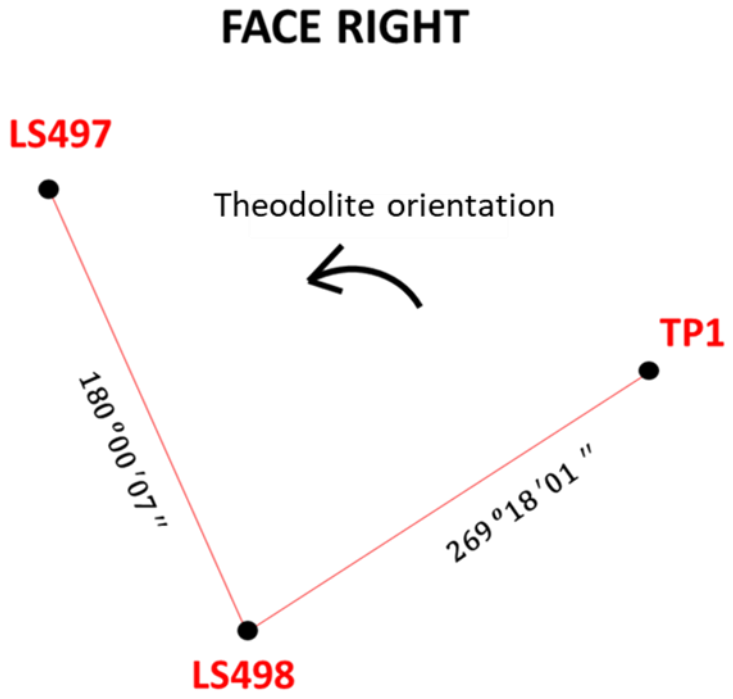
Horizontal Angles: Face Left Readings

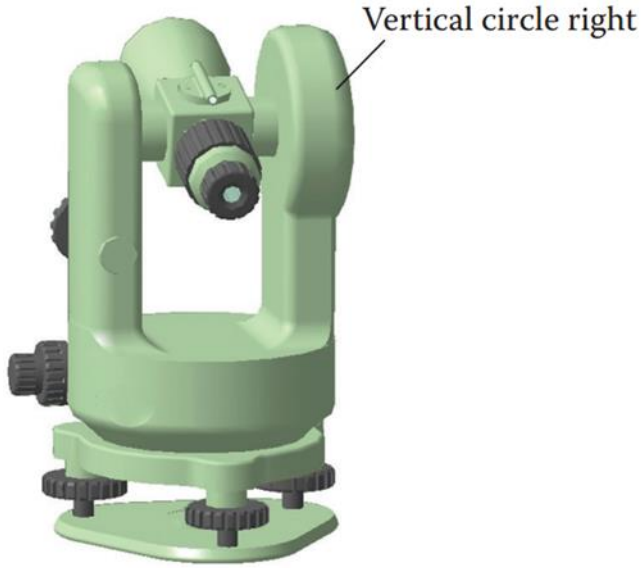




Stn	Object	Face Left			Face Right			Simple Mean			Reduced Mean		
		°	'	"	°	'	"	°	'	"	°	'	"
LS498	LS497	000	00	00									
	TP1	89	17	52									

Horizontal Angles: Face Right Readings





Stn	Object	Face Left			Face Right			Simple Mean			Reduced Mean		
		°	′	″	°	′	″	°	′	″	°	′	″
LS498	LS497	000	00	00	180	00	07						
	TP1	89	17	52	269	18	01						

Horizontal Angles: Simple Mean

- Adopt the Face Left degree value.
- Then find the average of the FL and FR minutes and seconds.

Stn	Object	Face Left			Face Right			Simple Mean			Reduced Mean		
		°	'	"	°	'	"	°	'	"	°	'	"
LS498	LS497	000	00	00	180	00	07	000	00	04			
	TP1	89	17	52	269	18	01	89	17	58			

Simple Mean = (FL+FR±180°)/2

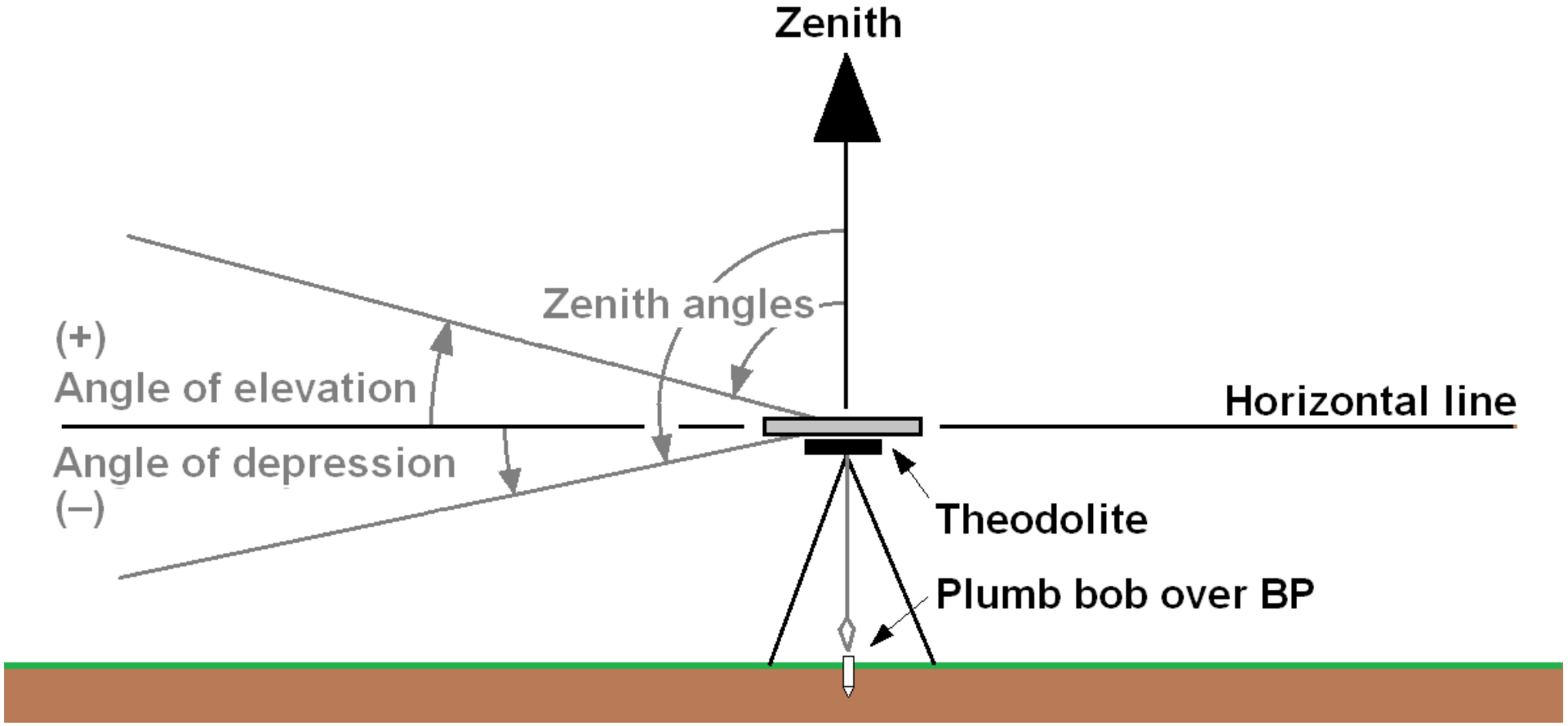
(+) if FL >180° or FR<180°
(-) if FL <180° or FR>180°

Horizontal Angles: Reduced Mean

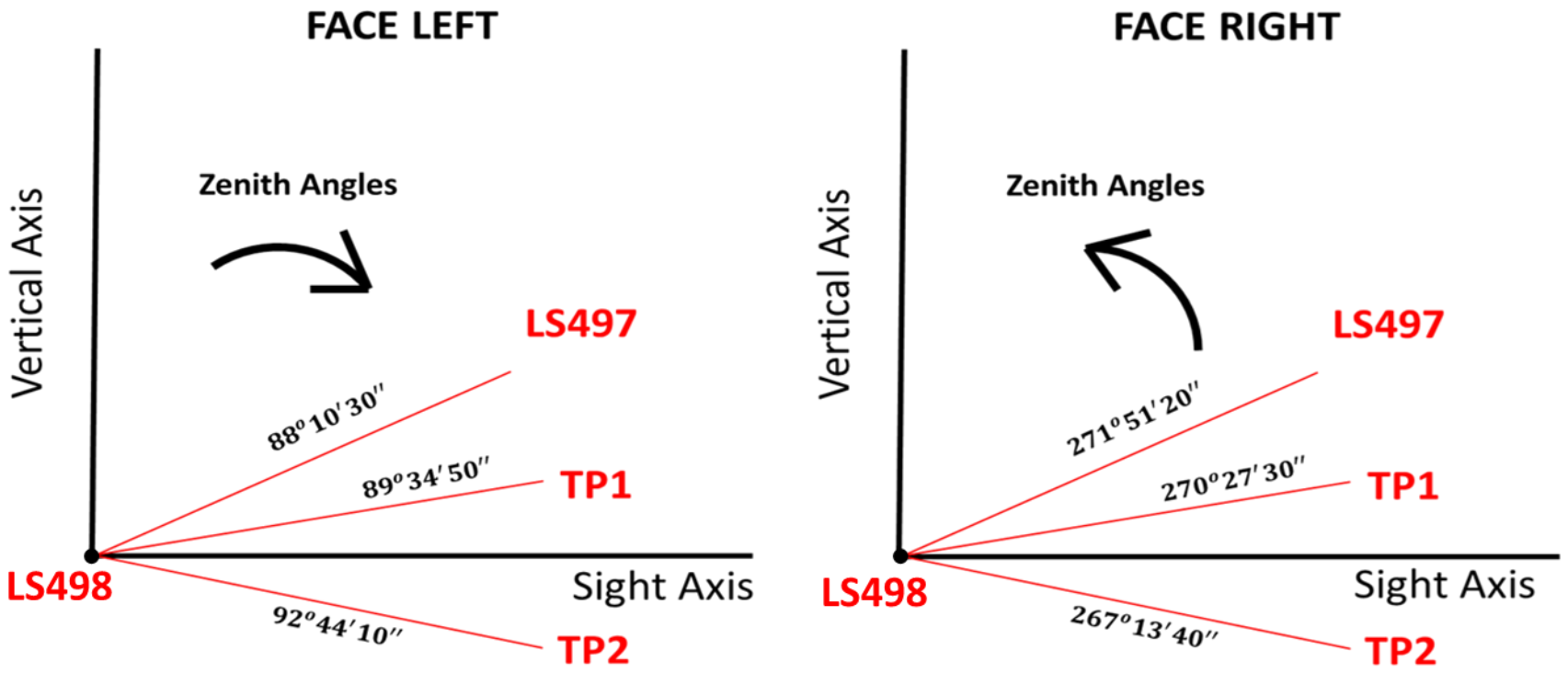
- Subtract the initial Simple Mean ($00°00'04''$) from the other Simple Means.
- The Reduced mean is the angle between lines LS498-LS497 and LS498-TP1.

Stn	Object	Face Left			Face Right			Simple Mean			Reduced Mean		
		°	'	"	°	'	"	°	'	"	°	'	"
LS498	LS497	000	00	00	180	00	07	000	00	04	000	00	00
	TP1	89	17	52	269	18	01	89	17	58	89	17	52

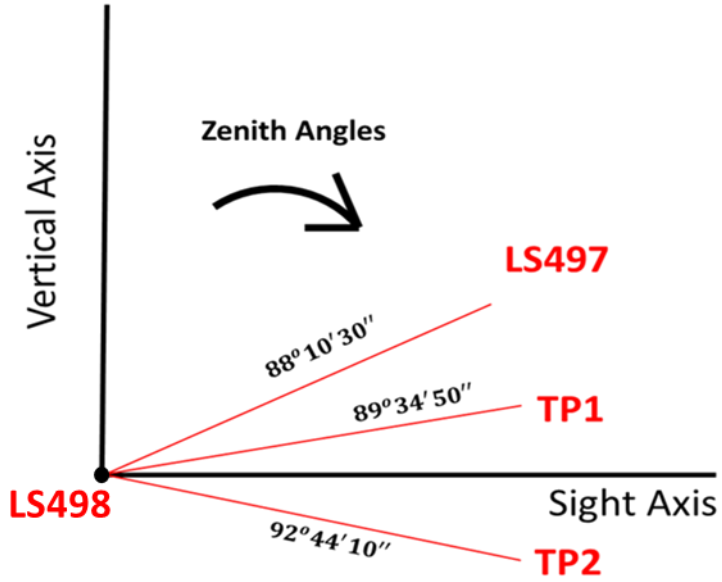
Vertical Angles



Vertical Angles

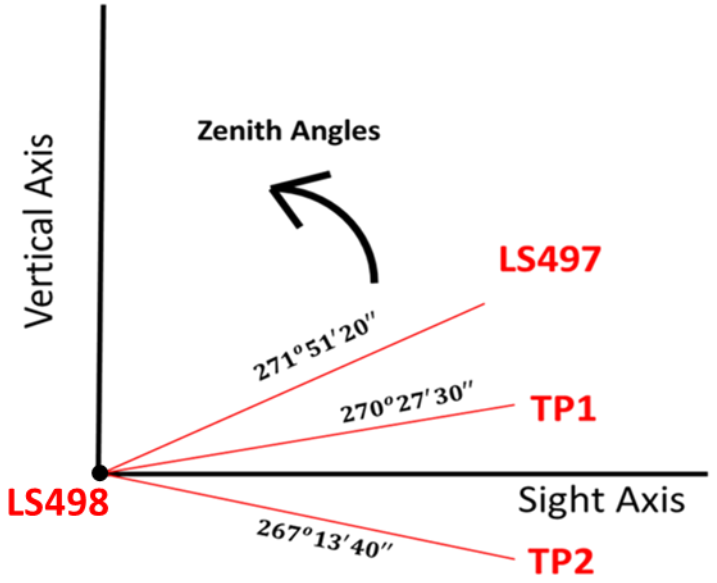


Vertical Angles: Face Left Readings



Stn	Object	Face Left			Face Right			Reduced Face Left			Reduced Face Right			Final Angle		
		°	′	″	°	′	″	°	′	″	°	′	″	°	′	″
LS498	LS497	88	10	30												
	TP1	89	17	52												
	TP2	92	44	10												

Vertical Angles: Face Right Readings



Stn	Object	Face Left			Face Right			Reduced Face Left			Reduced Face Right			Final Angle		
		°	′	″	°	′	″	°	′	″	°	′	″	°	′	″
LS498	LS497	88	10	30	271	51	20									
	TP1	89	17	52	270	27	30									
	TP2	92	44	10	267	13	40									

Vertical Angles: Reduced Face Left

$$Vertical\ Angle(FL) = 90° - Zenith\ Angle$$

Stn	Object	Face Left			Face Right			Reduced Face Left			Reduced Face Right			Final Angle		
		o	'	"	o	'	"	o	'	"	o	'	"	o	'	"
LS498	LS497	88	10	30	271	51	20	01	49	30						
	TP1	89	17	52	270	27	30	00	27	30						
	TP2	92	44	10	267	13	40	- 02	- 44	- 10						

Positive Angle = Angle of Elevation

Negative Angle = Angle of Depression

Vertical Angles: Reduced Face Right

$$Vertical\ Angle(FR) = Zenith\ Angle - 270°$$

Stn	Object	Face Left			Face Right			Reduced Face Left			Reduced Face Right			Final Angle		
		o	'	"	o	'	"	o	'	"	o	'	"	o	'	"
LS498	LS497	88	10	30	271	51	20	01	49	30	01	51	20			
	TP1	89	17	52	270	27	30	00	27	30	00	25	10			
	TP2	92	44	10	267	13	40	- 02	- 44	- 10	- 02	- 46	- 20			

Positive Angle = Angle of Elevation

Negative Angle = Angle of Depression

Vertical Angles: Final Angle

$$Final\ Angle = \frac{Reduced\ FL + Reduced\ FR}{2}$$

Stn	Object	Face Left			Face Right			Reduced Face Left			Reduced Face Right			Final Angle		
		o	'	"	o	'	"	o	'	"	o	'	"	o	'	"
LS498	LS497	88	10	30	271	51	20	01	49	30	01	51	20	01	50	25
	TP1	89	17	52	270	27	30	00	27	30	00	25	10	00	26	20
	TP2	92	44	10	267	13	40	- 02	- 44	- 10	- 02	- 46	- 20	- 02	- 45	- 15

Positive Angle = Angle of Elevation

Negative Angle = Angle of Depression

END