CE 260
SURVEYING

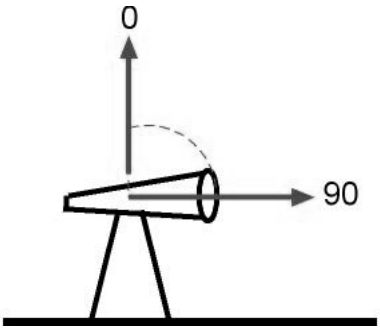
CHAPTER 5

THEODOLITES

- General Background:
- **Theodolites** or **Transits** are surveying instruments designed to precisely measure horizontal and vertical angles.

THEODOLITES

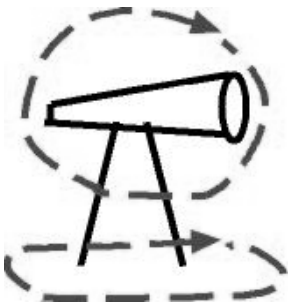
- They are used to establish straight and curved lines.
- To establish or measure distance (Stadia)
- To establish Elevation when used as a level. (When we set the vertical angle to 90°).



TRANSITS

They have:

- 4 screw level base.
- Metallic vertical and horizontal circles read with Vernier scale.
- Plumb Bob
- Low precision
- Old instrument. Not in use now.



THEODOLITES

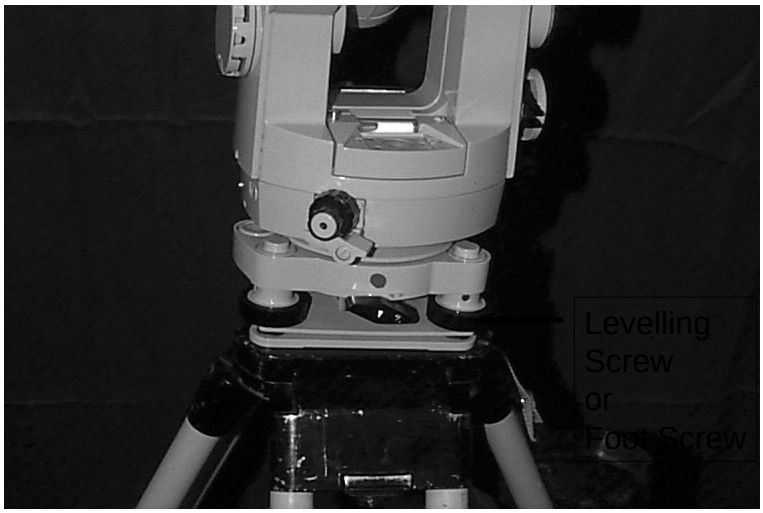
They have:

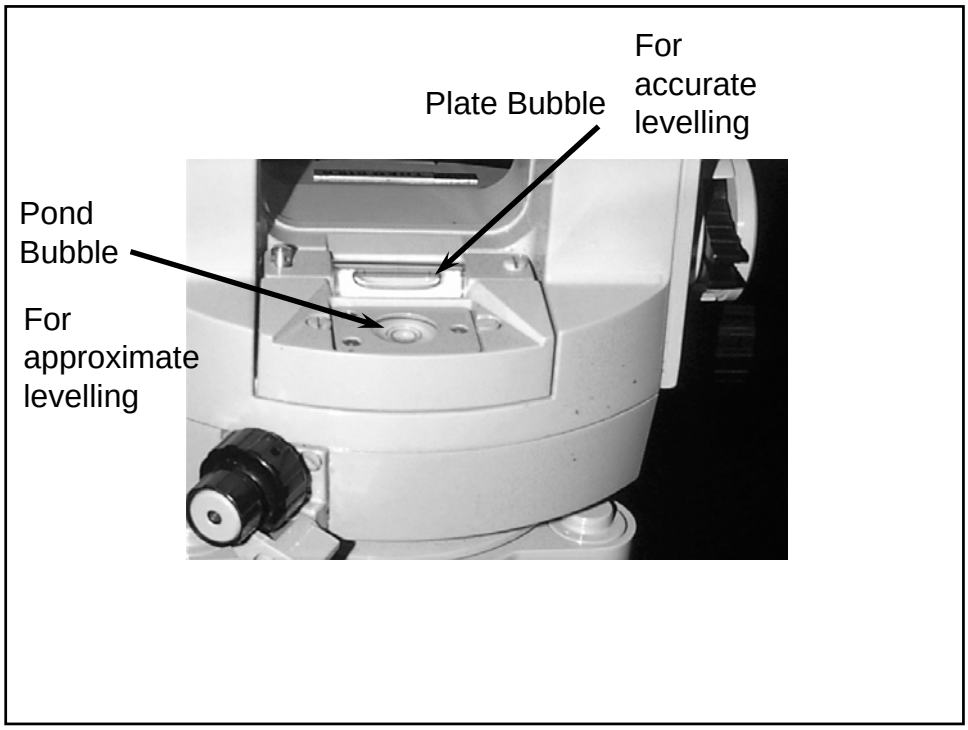
- 3 screw level base
- Glass horizontal and vertical circles, read directly or through micrometer.
- Right angle prism (optical plummet)
- High precision

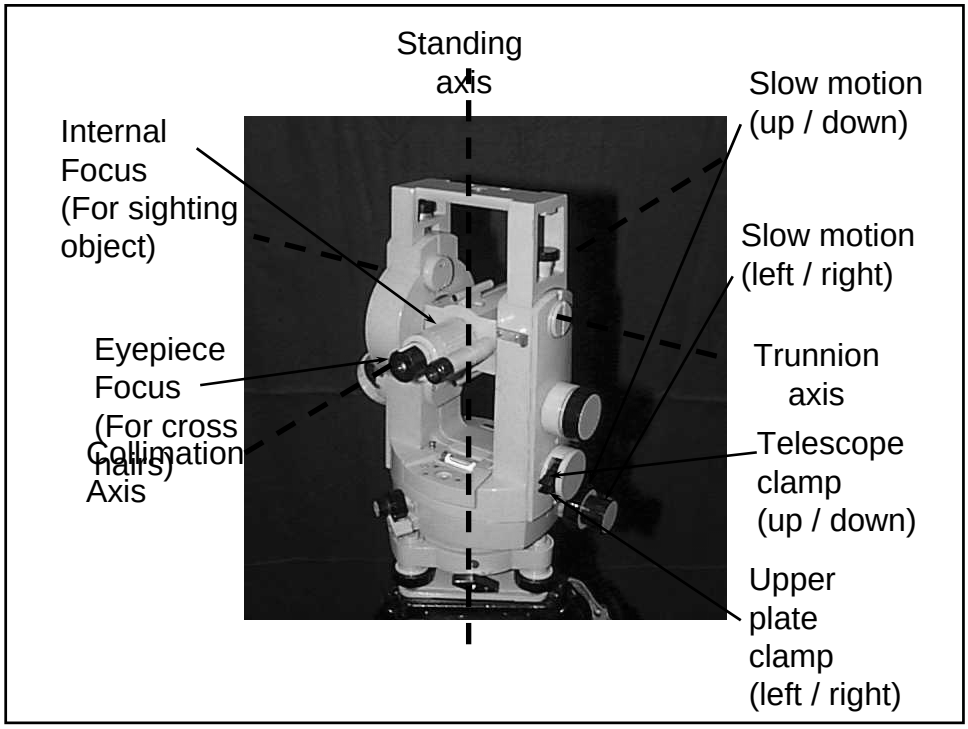
Hold Theodolite by handle

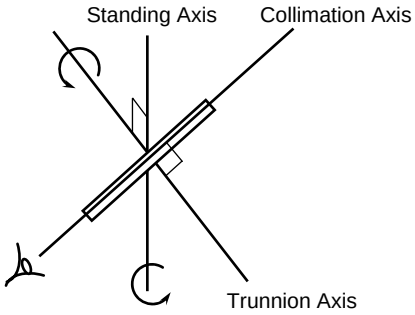
Attach to tripod head

Do not let go of handle until theodolite is attached to tripod.




For accurate levelling
Plate Bubble
Pond Bubble
For approximate levelling


Standing axis
Slow motion (up / down)
Internal Focus (For sighting object)
Slow motion (left / right)
Eyepiece Focus (For cross hairs)
Trunnion axis
Collimation Axis
Telescope clamp (up / down)
Upper plate clamp (left / right)

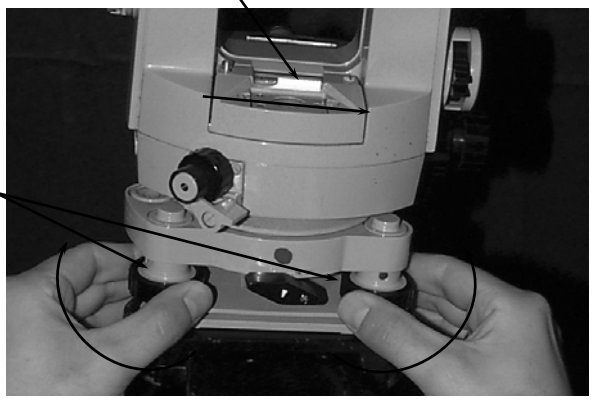


All three axes should be mutually at right angles

Plate Level Bubble Tube

Required to move the bubble to the right

Foot Screws

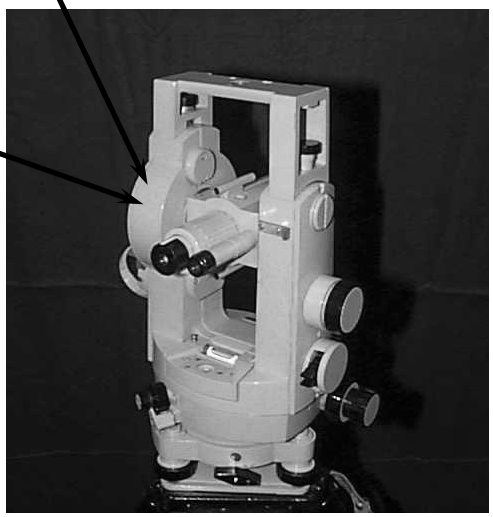


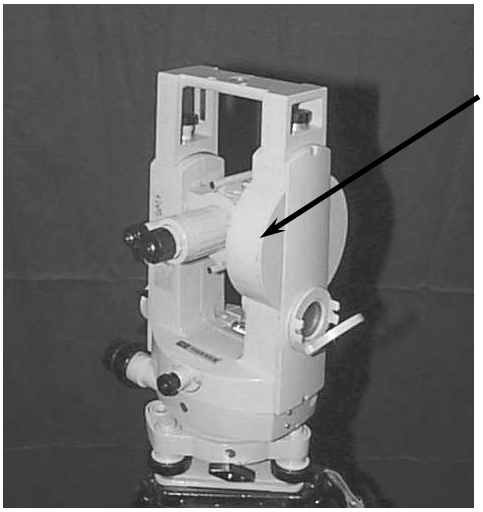
Bubble follows direction of left thumb

Both thumbs move in (or out)

Vertical Circle - (for vertical angles)

Face Left
F/L





Face Right
(F/R)

THEODOLITES SET-UP

1. Place the instrument over the point with the tripod plate as level as possible and with two tripod legs on the downhill side, if applicable.
2. Stand back a pace or two and see if the instrument appears to be over the station; if it does not, adjust the location and check again from a pace or two away.

THEODOLITES SET-UP

3. Move to a position 90° opposed to the original inspection location and repeat step 2.
4. Check that the station point can now be seen through the optical plummet (or that the laser plummet spot is reasonably close to the setup mark). Then push the tripod legs firmly by pressing down on the tripod shoe spurs.

THEODOLITES SET-UP

5. While looking through the optical plumb (or at the laser spot), manipulate the leveling screws (one, two or all the three at a time) until the cross hair (bull's-eye) of the optical plummet or the laser spot is directly on the station mark.
6. Level the theodolite circular bubble by adjusting the tripod legs up or down.

THEODOLITES SET-UP

7. Perform a check through the optical plummet or note the location of the laser spot to confirm that it is still quite being over the station mark.
8. Turn one (or more) leveling screws to be sure that the circular bubble is now exactly centered (if necessary).

THEODOLITES SET-UP

9. Loosen the tripod clamp bolt a bit and slide the instrument on the flat tripod top (if necessary) until the optical plummet or laser spot is exactly centered on the station mark. Retighten the tripod clamp bolt and reset the circular bubble, if necessary.

THEODOLITES SET-UP

10. The instrument can now be precisely leveled by centering the tubular bubble. Set the tubular bubble so that it is aligned in the same direction as two of the foot screws. Turn these two screws (together or independently) until the bubble is centered. Then turn the instrument 90°, at which point the tubular bubble will be aligned with the third leveling screw.

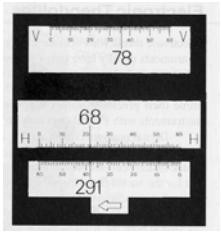
THEODOLITES SET-UP

10. Next, turn that third screw to center the bubble. The instrument now should be level, although it is always checked by turning the instrument through 180°.

ELECTRONIC THEODOLITE

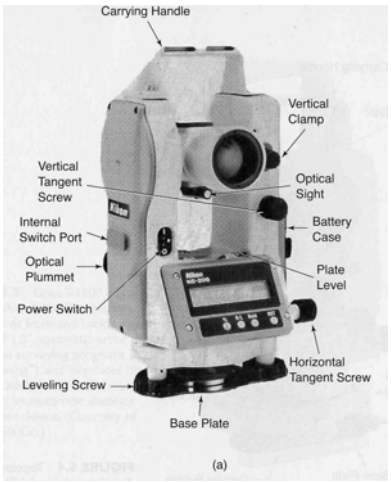
- Electronic read out 1” eliminate mistakes in reading the angles.
- Precision varies from 0.5” – 20”
- Zero is set by a button.
- Repeated angle averaging.
- Replacing optical theodolites (It is less expensive to purchase and maintain).

THEODOLITES



Top image shows the Electronic Theodolite. Bottom shows the Scale readings.

THEODOLITES



- ELECTRONIC THEODOLITE DETAILS

THEODOLITES

- OPERATION KEYS AND DISPLAYS

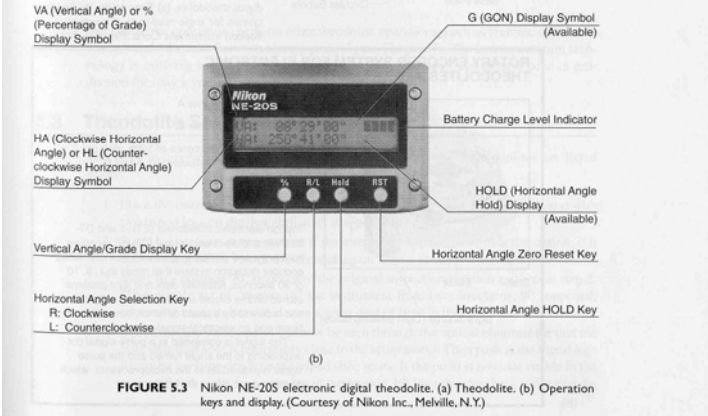
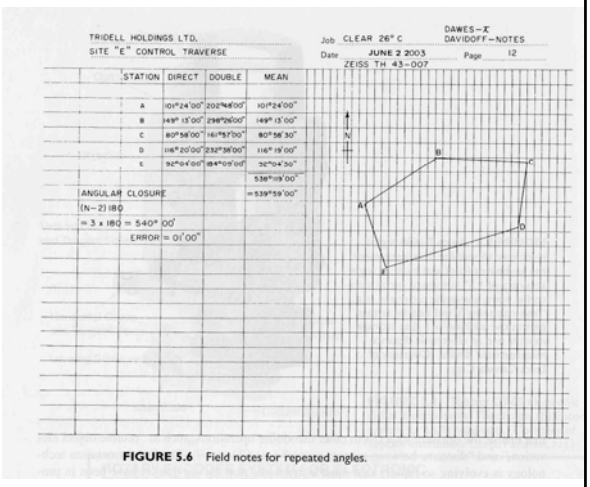


FIGURE 5.3 Nikon NE-20S electronic digital theodolite. (a) Theodolite. (b) Operation keys and display. (Courtesy of Nikon Inc., Melville, N.Y.)

THEODOLITES

- Field noted for repeated angles


TRIDELL HOLDINGS LTD.
SITE "E" CONTROL TRAVERSE

Job CLEAR 26° C
Date JUNE 2 2003
ZEISS TH 43-007
DAWES-X
DAVIDOFF-NOTES
Page 12

STATION	DIRECT	DOUBLE	MEAN
A	101°24'00"	202°48'00"	101°24'00"
B	149° 13'00"	298°26'00"	149° 13'00"
C	80°58'00"	161°57'00"	80°58'30"
D	116° 20'00"	232°38'00"	116° 19'00"
E	92°04'00"	184°09'00"	92°04'30"
			539°19'00"
ANGULAR CLOSURE			=539°59'00"
(N-2) 180			
= 3 x 180 = 540° 00'			
ERROR = 01'00"			

FIGURE 5.6 Field notes for repeated angles.

THEODOLITES

Repeating optical theodolite:

- Has 3 leveling screws
- Optical plummet, light weight, glass circle, micrometer (to read the angles).
- Most theodolites are equipped with compensating device (automatic horizontal).
- 90° or 270° vertical angle of horizon.

THEODOLITES

- Micrometer used to read vertical and horizontal angles.
- 2 independent motion (upper and lower).

THEODOLITES

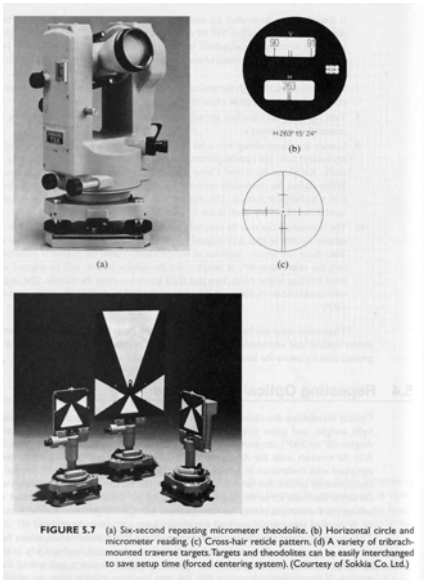


FIGURE 5.7 (a) Six-second repeating micrometer theodolite. (b) Horizontal circle and micrometer reading. (c) Cross-hair reticle pattern. (d) A variety of tribrach-mounted traverse targets. Targets and theodolites can be easily interchanged to save setup time (forced centering system). (Courtesy of Sokkia Co. Ltd.)

Angle Measurement with an Optical Theodolite

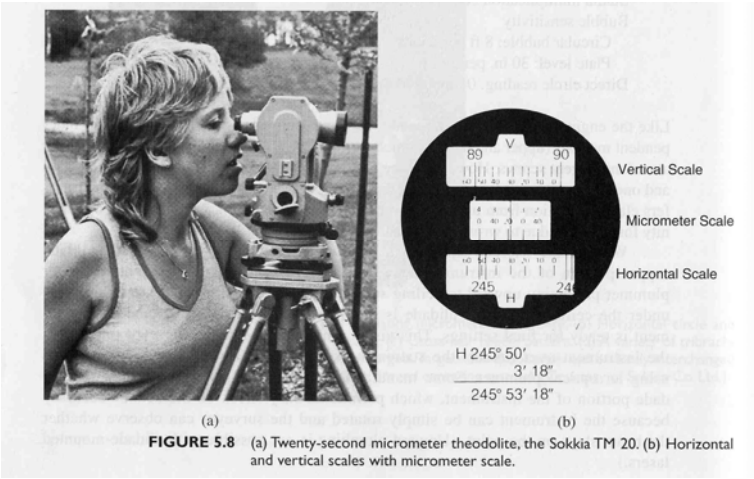


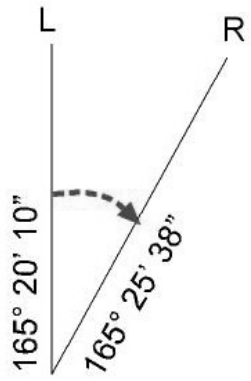
FIGURE 5.8 (a) Twenty-second micrometer theodolite, the Sokkia TM 20. (b) Horizontal and vertical scales with micrometer scale.

DIRECT OPTICAL THEODOLITE

- Has only one motion (upper).

<u>To find angle:</u>

- Read the initial direction (L target)
- Read the final direction (R target)
- Determine the difference between the two.



R 165° 25' 38"
L 165° 20' 10"
□0° 05' 28"

DIRECT OPTICAL THEODOLITE

- Direct optical theodolite generally is more precise. Some models can read directly 0.2" and estimate 0.1".
- Several sightings are required for precise work.
- Distribute initial reading around the circle to minimize the effect of circle graduation distribution, so initial reading read 0, 45,90,135,…

DIRECT OPTICAL THEODOLITE

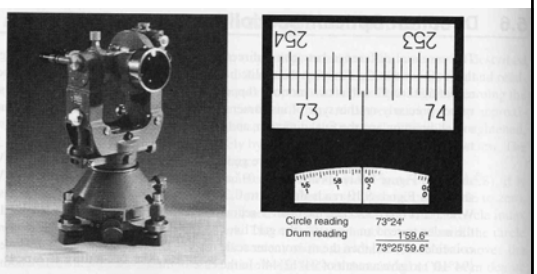


FIGURE 5.10 (a) Wild T-3 precise theodolite for first-order surveying. (b) Circle reading (least graduation is 4 minutes) and micrometer reading (least graduation is 0.2 seconds). (Courtesy of Leica Canada Co.) On the micrometer, a value of 01'59.6" can be read. The reading is, therefore, 73°25'59.6".

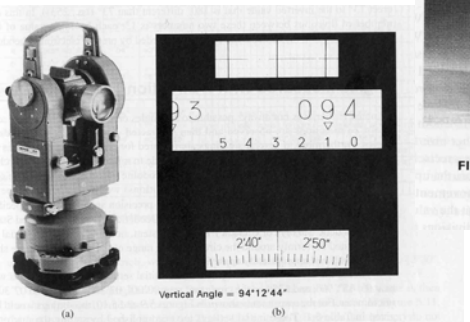


FIGURE 5.9 (a) Wild T-2, a 1-second optical direction theodolite. (b) Vertical circle reading. (Courtesy of Leica Canada Co.)

- Angles measured with a Direction Theodolite

Table 5.1 APPROXIMATE INITIAL SCALE SETTINGS FOR FOUR POSITIONS

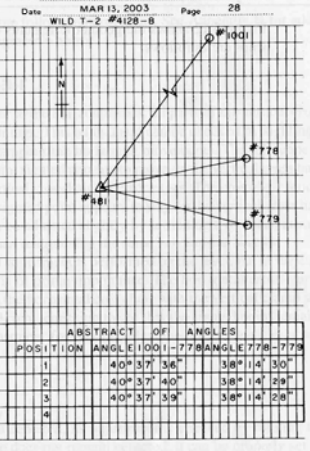
10-minute micrometer, Wild T-2	2-minute micrometer, Wild T-3
0°00'00"	0°00'00"
45°02'30"	45°00'30"
90°05'00"	90°01'00"
135°07'30"	135°01'30"

FOXLEA SUBDIVISION — DIRECTIONS FOR CONTROL EXTENSION

Job CLEAR, 17 °C — CRAWFORD — X, HABKIRK — NOTES
Date MAR 13, 2003 — Page 28
WILD T-2 #4128-8

X @ STATION #481

STATION SIGHTED	D/R	READING	MEAN D/R	REDUCED DIRECTION
POSITION 1				
1001	D	0° 00' 08"		
	R	180° 00' 12"	10"	0° 00' 00"
778	D	40° 37' 44"		
	R	220° 37' 47"	46"	40° 37' 36"
779	D	78° 52' 19"		
	R	258° 52' 13"	16"	78° 52' 06"
POSITION 2				
1001	D	45° 02' 22"		
	R	225° 02' 26"	24"	0° 00' 00"
778	D	85° 40' 02"		
	R	265° 40' 05"	04"	40° 37' 40"
779	D	123° 54' 30"		
	R	303° 54' 36"	33"	78° 52' 09"
POSITION 3				
1001	D	90° 05' 03"		
	R	270° 05' 07"	05"	0° 00' 00"
778	D	130° 42' 44"		
	R	310° 42' 45"	44"	40° 37' 39"
779	D	168° 57' 10"		
	R	348° 57' 14"	12"	78° 52' 07"
POSITION 4				
ETC.				



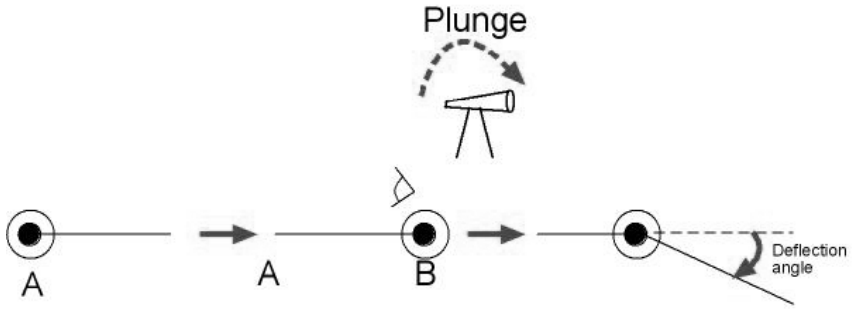
ABSTRACT OF ANGLES

POSITION	ANGLE 1001-778	ANGLE 778-779
1	40° 37' 36"	38° 14' 30"
2	40° 37' 40"	38° 14' 29"
3	40° 37' 39"	38° 14' 28"
4		

FIGURE 5.11 Field notes for directions.

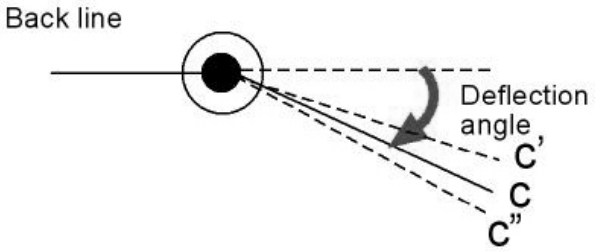
LAYING OFF ANGLES

- The angle is to be laid out no more precisely than the least count of the transit or theodolite.

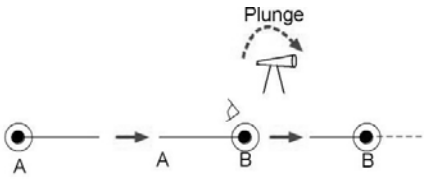


LAYING OFF ANGLES

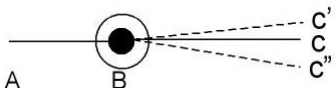
- Process: Lock angle, rotate theodolite, then open lock and measure again same angle. Should have double the first angle measurement.



PROLONGING A STRAIGHT LINE

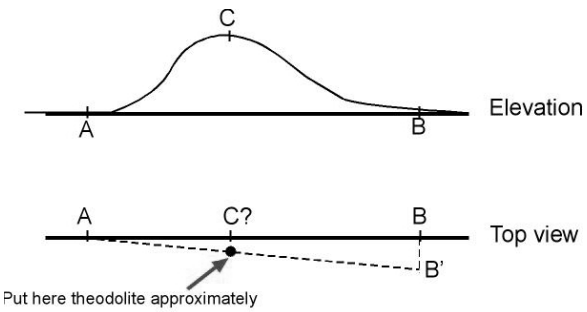


- Start by taking distance at A. Then go to B, rotate 180°, look back at A, plunge and make another line towards C.



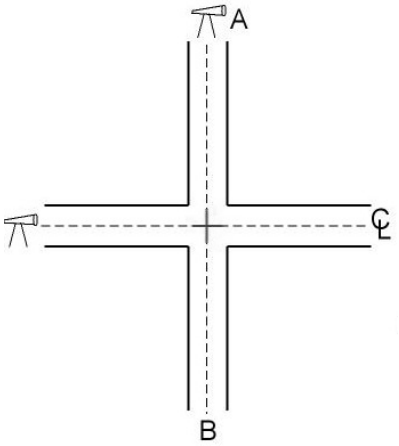
BUCKING IN (INTERLINGING)

- Read A, then plunge to B. If Distance between B and B' is 1 M, then you have to move 0.5 M to find C. then do the sighting again.

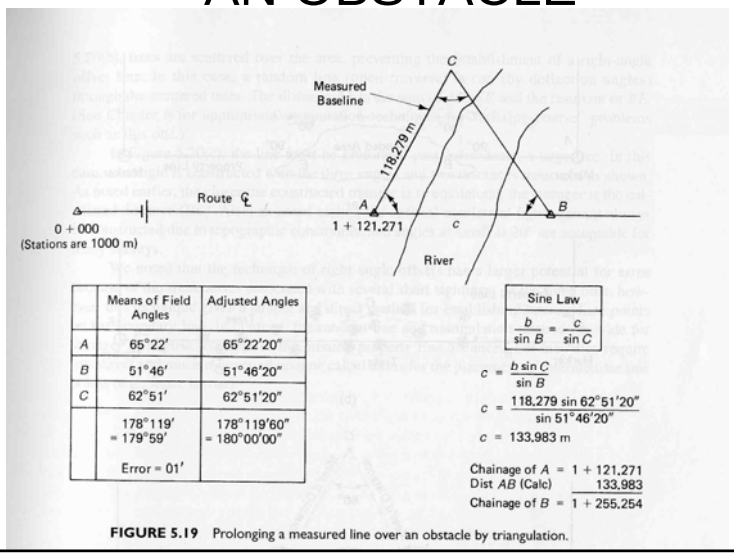


INTERSECTION OF 2 STRAIGHT LINES

- Put 2 strings between points and then get the intersection.



PROLONGING A MEASUREMENT LINE BY TRIANGULATION OVER AN OBSTACLE



	Means of Field Angles	Adjusted Angles
A	65°22′	65°22′20″
B	51°46′	51°46′20″
C	62°51′	62°51′20″
	178°119′ = 179°59′ Error = 01′	178°119′60″ = 180°00′00″

Sine Law

$$\frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c = \frac{b \sin C}{\sin B}$$

$$c = \frac{118.279 \sin 62°51′20″}{\sin 51°46′20″}$$

$$c = 133.983 \text{ m}$$

Chainage of A = 1 + 121.271
Dist AB (Calc) 133.983
Chainage of B = 1 + 255.254

FIGURE 5.19 Prolonging a measured line over an obstacle by triangulation.

PROLONGING A LINE PAST AN OBSTACLE

There are 3 methods for it:

1. Right-angle offset method.
2. Random-line method.
3. Triangulation method.

PROLONGING A LINE PAST AN OBSTACLE

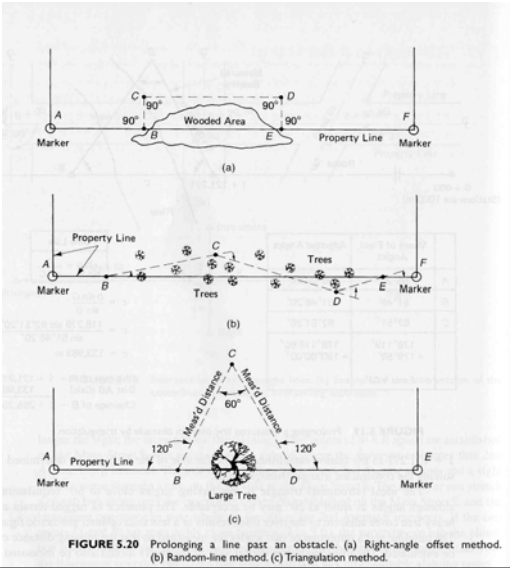


FIGURE 5.20 Prolonging a line past an obstacle. (a) Right-angle offset method. (b) Random-line method. (c) Triangulation method.

THE END OF CHAPTER 5

THANK YOU!