SURVEYING LAB - II MANUAL

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Experiment No.: 1

STUDY OF THEODOLITE

OBJECTIVE:

To study different parts of transit Theodolite and Temporary adjustments.

DEFINITON AND TERMS

VERTICAL AXIS:

It is the axis about which the telescope can be rotated in a horizontal plane.

HORIZONTAL AXIS:

It is the axis about which the telescope can be rotated in a vertical plane.

LINE OF COLLINATION:

It is the imaginary line joining the intersection of the cross hairs of the diaphragm to the optical center of the object glass and its continuation.

AXIS OF THE TELESCOPE:

It is the line joining the optical center of the object glass to the center of the eye-piece.

AXIS OF THE LEVEL TUBE:

It is the straight line tangential to the longitudinal curve of the level tube at the center of the tube.

CENTERING:

The process of setting the theodolite exactly over the station mark is known as centering.

TRANSITING:

It is the process of turning the telescope in vertical plane through 180º about the trunnion axis.

DESCRIPTION OF EQUIPMENT:

TELESCOPE:

It consists of eye-piece, object glass and focusing screw and it is used to sight the object.

VERTICAL CIRCLE:

It is used to measure vertical angles.

LEVELLING HEAD:

It consists of two parallel triangular plates called tribrach plates. Its uses are

1. To support the main part of the instrument.
2. To attach the theodolite to the tripod.

LOWER PLATE:

It consists of lower clamp screw and tangent screw.

UPPER PLATE:

The upper plate is attached to the inner axis and it carries two verniers. It consists an upper clamp screw and tangent screws. These screws are used to fix upper plate with lower plate accurately.

FOOT SCREWS:

These are used to level the instrument

PLUMB BOB:

It is used to center theodolite exactly over the ground station mark.

SWINGING THE TELESCOPE:

It means turning the telescope about its vertical axis in the horizontal plane. A swing is called right or left according as the telescope is rotated clockwise or counter clockwise.

FACE LEFT:

If face of the vertical circle is to the left side of the observer, then the observation of the angles taken is known as face left observation.

FACE RIGHT:

If the face of the vertical circle is to the right side of the observation, then the observation of the angles taken is known as face right observation.

CHANGING FACE:

It is an operation of bringing the face of the telescope from left to right and vice-versa.

TEMPORARY ADJUSTMENTS:

There are three temporary adjustments of a theodolite. These are

1. Setting up the theodolite over a station.
2. Leveling up.
3. Elimination of parallax.

SETTING UP:

It includes two operations

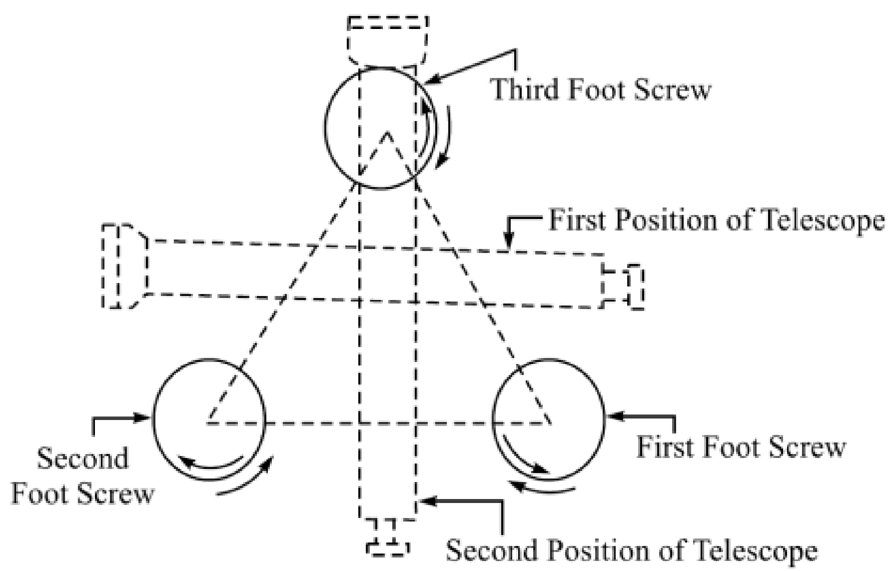
1. Centering a theodolite over a station: Done by means of plumb bob.
2. Approximately leveling it by tripod legs only: Done by moving tripod legs radially or circumferentially.

LEVELING UP:

Having centered and approximately leveled the instrument, accurate leveling is done with the help of foot screws with reference to the plate levels, so that the vertical axis shall be truly vertical.

To level the instrument the following operations have to be done.

1. Turn the upper plate until the longitudinal axis of the plate level is roughly parallel to a line joining any two of the leveling screws (A & B).



Levelling of Foot Screws

2. Hold these two leveling screws between the thumb and first finger of each hand uniformly so that the thumb moves either towards each other or away from each other until the bubble comes to the center.
3. Turn the upper plate through 90º i.e until the axes of the level passes over the position of the third leveling screw ‘C’.
4. Turn this leveling screw until the bubble comes to the center.

5. Rotate the upper plate through 90º to its original position fig(a) and repeat step(2) till the bubble comes to the center.

6. Turn back again through 90º and repeat step 4.

7. Repeat the steps 2 and 4 till the bubble is central in both the positions.

8. Now rotate the instrument through 180º. The bubble should be remaining in the center of its run, provided it is in correct adjustment. The vertical axis will then be truly vertical.

3. ELIMINATION OF PARALLAX:

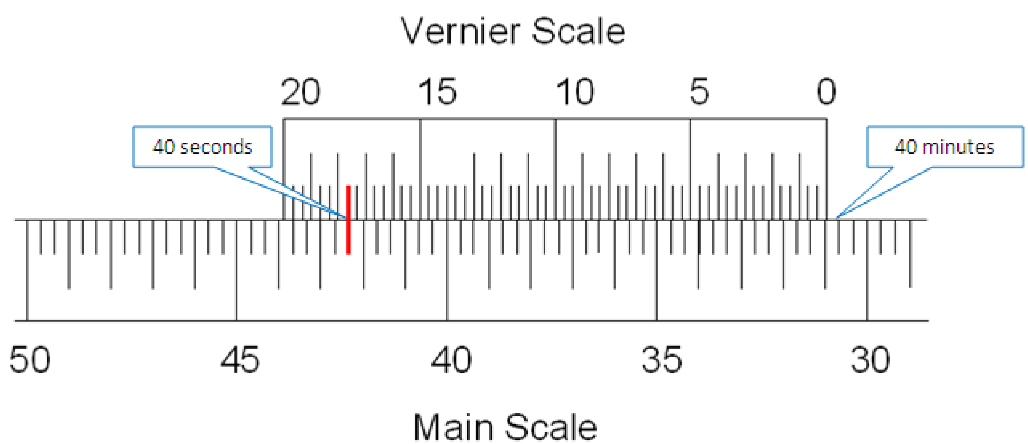
Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. Unless parallax is eliminated, accurate sighting is not possible. Parallax can be eliminated in two steps.

a. FOCUSSING THE EYE-PIECE:

Point the telescope to the sky or hold a piece of white paper in front of the telescope. Move the eyepiece in and out until a distant and sharp black image of the cross-hairs is seen.

b. FOCUSSING THE OBJECT:

Telescope is now turned towards object to be sighted and the focusing screw is turned until image appears clear and sharp.



	o	'	"
Main Scale	30	40	
Vernier Scale		17	40
Reading	**30**	**57**	**40**

Experiment No.: 2

MEASUREMENT OF HORIZONTAL ANGLE BY REPETITION METHOD

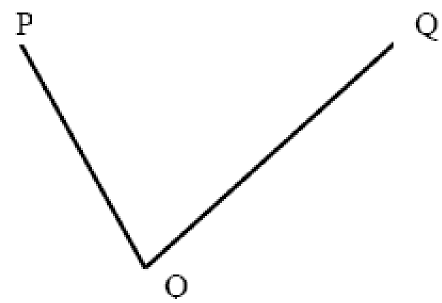
OBJECTIVE:

To measure a horizontal angle by repetition method.

THEORY: In this method, the angle is added several times mechanically and the value of the angle obtained by dividing the accumulated reading by the number of repetitions.

EQUIPMENTS USED:

- Transit Theodolite
- Tripod and
- Ranging rods



PROCEDURE:

1. Set up the instrument over ‘O’ and level it accurately.
2. With the help of upper clamp and tangent screw, set 0º reading on vernier ‘A’. Note the reading of vernier ‘B’.
3. Release the upper clamp and direct the telescope approximately towards the point ‘P’. Tighten the lower clamp and bisect point ‘P’ accurately by lower tangent screw.
4. Release the upper clamp and turn the instrument clock-wise towards Q. Clamp the upper clamp and bisect ‘Q’ accurately with the upper tangent screw. Note the readings of verniers ‘A’ and ‘B’ to get the values of the angle POQ.
5. Release the lower clamp and turn the telescope clockwise to sight P again. Bisect P by using the lower tangent screw.
6. Release the upper clamp, turn the telescope clockwise and sight Q. Bisect Q by using the upper tangent screw.

7. Repeat the process until the angle measured (required number of times is 3). The average angle with face left will be equal to final reading divided by three.

8. Change face and make three more repetitions as described above. Find the average angle with face right, by dividing the final reading by three.

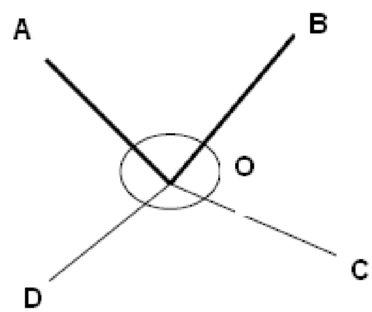
9. The average horizontal angle is then obtained by taking the average of the two angles with face left and face right.

Experiment No.: 3

MEASUREMENT OF HORIZONTAL ANGLE BY REITERATION METHOD

OBJECTIVE:

To measure horizontal angle by reiteration method.



EQUIPMENTS:

- Transit Theodolite
- Tripod and
- Ranging rods

PROCEDURE:

If it is required to measure angles AOB, BOC, and COD etc by reiteration method
The following steps are to be used.

1. Set the instrument over “O” and level it set the Vernier to zero and bisect point A accurately.
2. Loose the upper clamp and turn the Telescope clockwise to point B. Bisect B by using the upper tangent screw. Read both the Verniers, the mean of the Verniers will give the angles AOB.
3. Similarly, bisect successively C, D etc, thus closing the circle. Read both the Verniers at each bisection.
4. Finally sight to A the reading of the vernier should be the same as the original setting reading.

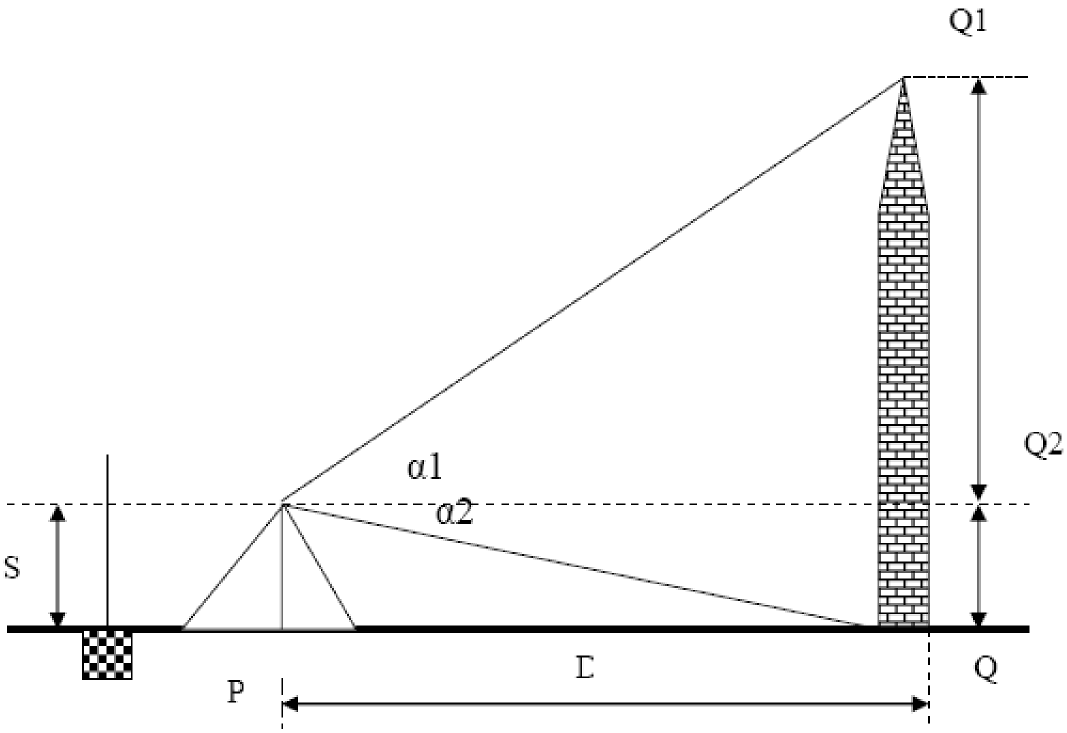
Repeat the steps 02 to 04 with other face i.e. face Right.

Experiment No.: 4 & 5

DETERMINING AN HEIGHT OF OBJECT BY MEASURING VERTICAL ANGLE

OBJECTIVE:

Determining a height of object by measuring vertical angle.



EQUIPMENTS:

1. Theodolite
2. Leveling Stop
3. Tape or Chain
4. Pegs
5. Plumb bob

PROCEDURE:

1. Setup the instrument at station P.
2. Perform all temporary adjustments.
3. Bring the line of collimation horizontal
4. Enter the initial readings in the tabular form.
5. Swing the telescope and take staff reading over the given B.M.
6. Swing the telescope towards the object.

7. Release the vertical clamp screw, sight the top of the object Q1, and clamp the vertical clamp screw.

8. Read C and D verniers and enter the readings.

9. Release the vertical clamp screw, sight the bottom of the object Q, and clamp the screw.

10. Read vernier readings and enter in the tabular form.

11. Measure the Horizontal distance between the instrument station and the object.

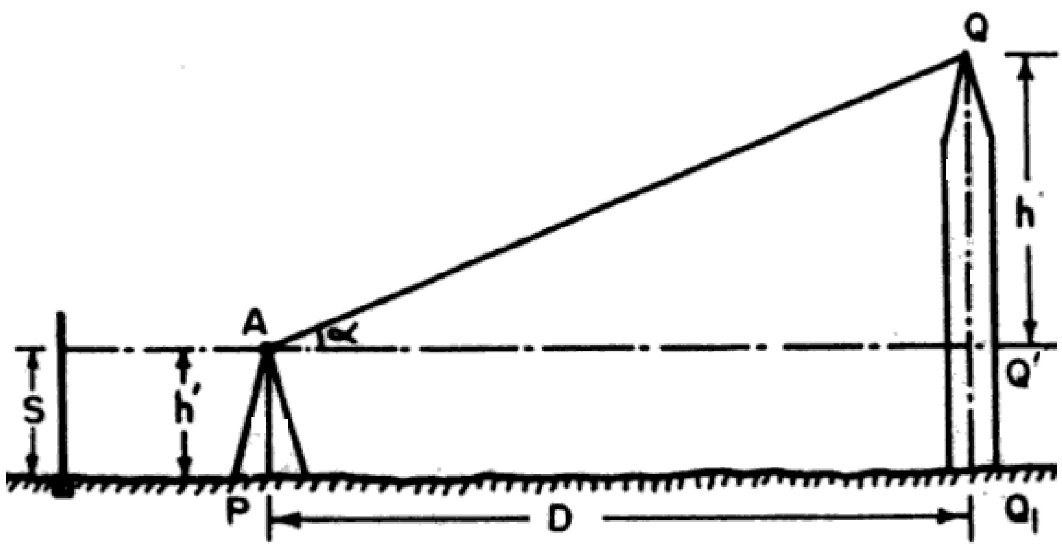
12. The above procedure will be repeated with the face right observation.

13. The average of the two observations by transiting the telescope taken with different faces will be vertical angle.

14. Calculate the height of the top point Q1 from horizontal line (h1) and height of the bottom point Q0 from horizontal line (h2) by using formula h = d tan α

Methods:

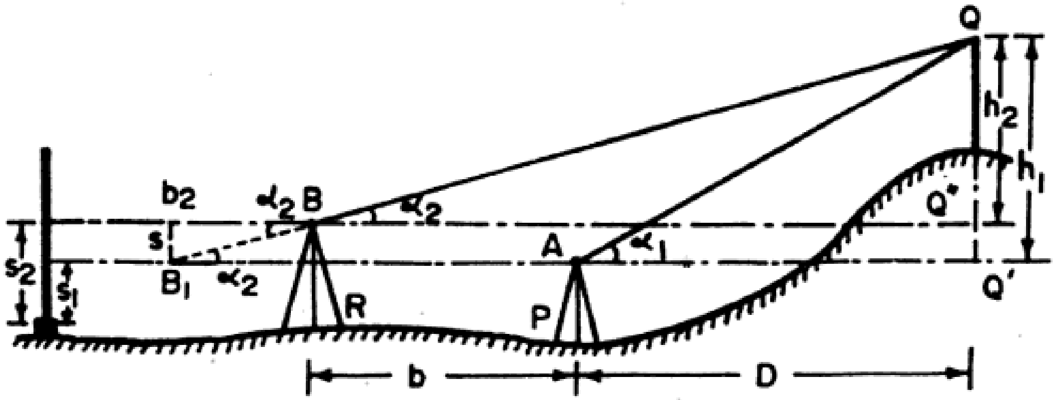
1. Measurement of Height of an object when base is accessible (on level ground)



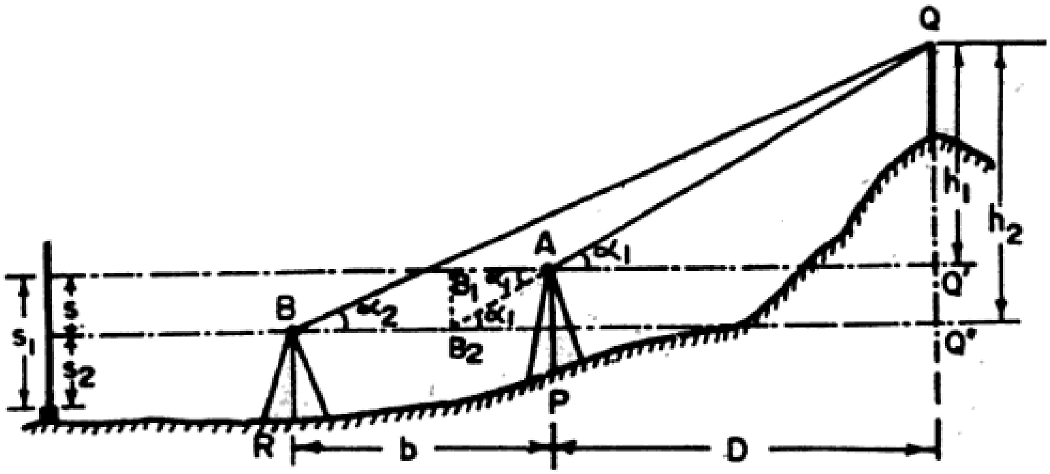
BASE ACCESSIBLE.

h = D tan α
Height of the object = s + h
R.L. of top of the object = R. L. of B.M. + s + h

2. Measurement of Height of an object when base is inaccessible



When P is Lower than R



When P is higher than R

$$D = \frac{(b \pm s \cot \alpha_2) \tan \alpha_2}{\tan \alpha_1 - \tan \alpha_2}$$

Use + sign with $s \cot \alpha_2$ when the instrument axis at A is lower and − sign when it is higher than at B.

$$\text{R.L. of } Q = \text{R.L. of B.M.} + S_1 + h_1$$

$$h_1 = D \tan \alpha_1$$

Experiment No.: 6

DETERMINATION OF CONSTANTS OF TACHEOMETER

OBJECTIVE

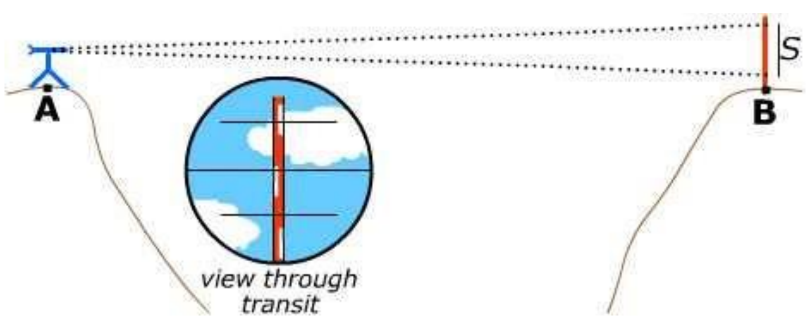
To determine the multiplying constant and additive constant of the given theodolite.

EQUIPMENTS

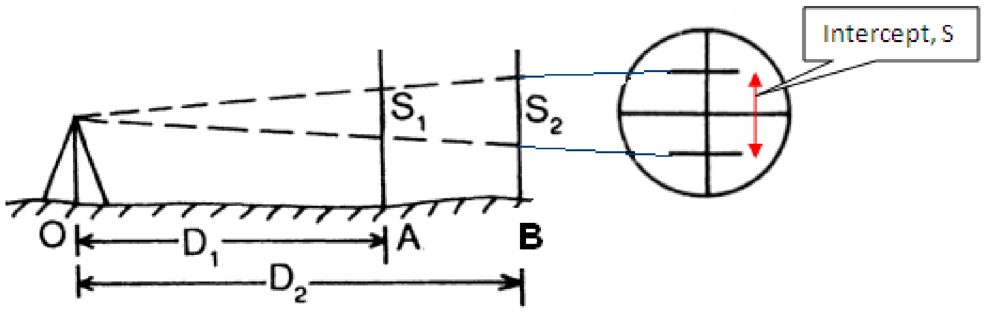
- Theodolite
- Ranging Rods
- Levelling Staff
- Tape

PROCEDURE

1. Stretch the chain in the field and drive pegs at 10m, 20m interval.
2. Set the theodolite at the zero and do the temporary adjustments.
3. Keep the staff on the pegs and observe the corresponding staff intercepts with horizontal site.
4. Substitute the values of distance (D) and staff intercept (s) for different points in the equation D = ks + C, where k & s are the tacheometric constants. k is the multiplying constant & C is the additive constant.
5. Solve the successive pairs of equations to get the value of k & C and find out the average of these values.



Measurement of Horizontal Distance



Instrument Station	Staff Station	Distance	Stadia Reading			Stadia Intercept (S)
			Top	Middle	Bottom	
O	A					
	B					

D = KS + C

$D_1 = K.S_1 + C$ □ 1

$D_2 = K.S_2 + C$ □ 2

Solve Two Equations & find K & C

RESULT:

Multiplying constant, K =

Additive constant, S =

Experiment No.: 7

MEASUREMENT OF HORIZONTAL DISTANCE & VERTICAL HEIGHTS USING TACHEOMETRIC SURVEYING

OBJECTIVE:

Determination of elevation of points by Tacheometric surveying

EQUIPMENT:

- Tacheometer with tripod,
- Tape,
- Leveling staff,
- Ranging rods

THEORY:

The Tacheometer is an instrument which is generally used to determine the horizontal as well as vertical distance . it can also be used to determine the elevation of various points which cannot be determine by ordinary leveling. When one of the sight is horizontal and staff held vertical then the RLs of staff station can be determined as we determine in ordinary leveling .But if the staff station is below or above the line of collimation then the elevation or depression of such point can be determined by calculating vertical distances from instrument axis to the central hair reading and taking the angle of elevation or depression made by line of sight to the instrument made by line of sight to the instrument axis.

Procedure:

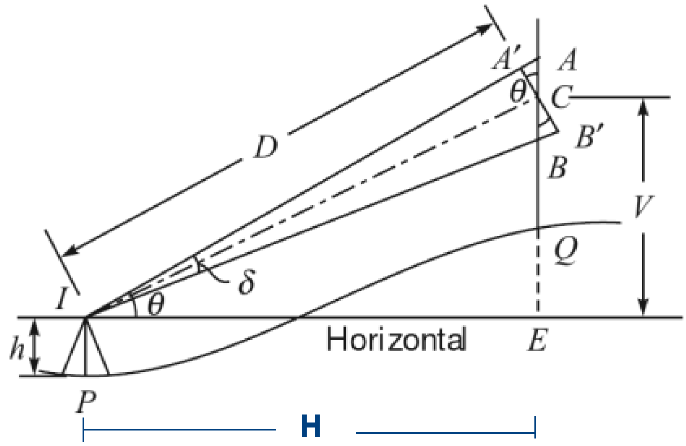
1) Set up the instrument in such a way that all the point should be visible from the instrument station.

2) Carryout the temporary adjustment and set vernier zero reading making line of sight horizontal.

3) Take the first staff reading on Benchmark and determine height of instrument.

4) Then sight the telescope towards the staff station whose R.Ls are to be calculated. Measure the angle on vernier if line of sight is inclined upward or downward and also note the three crosshair readings.

5) Determine the R.Ls of various points by calculating the vertical distance

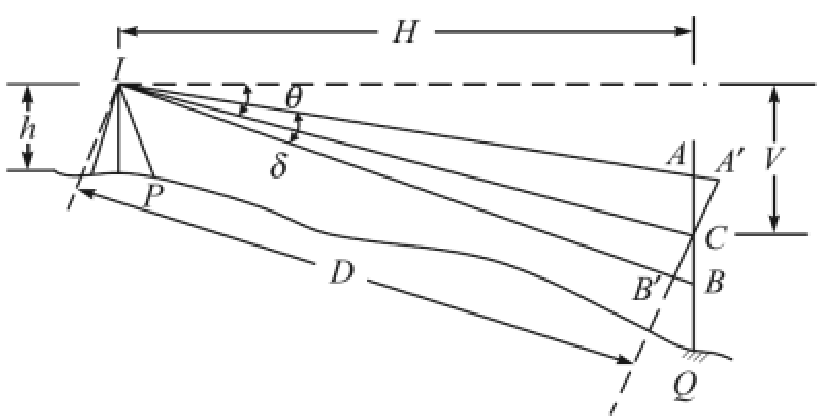


Inclined sight (elevation)

$$H = D\cos\theta = KS\cos^2\theta + C\cos\theta$$

$$V = \frac{1}{2}KS\sin 2\theta + C\sin\theta$$

$$\text{R.L. of } Q = \text{R.L. of } P + h + V - CQ$$



Inclined sight (depression).

$$D = KS\cos\theta + C$$

$$H = D\cos\theta = KS\cos^2\theta + C\cos\theta$$

$$V = D\sin\theta = KS\sin\theta\cos\theta + C\sin\theta$$

$$\text{R.L. of } Q = \text{R.L. of } P + h - V - CQ$$

Experiment No.: 8

SIMPLE CURVE SETTING
BY OFFSETS FROM LONG CHORD METHOD

OBJECTIVE:

To set out a simple curve by linear method (offsets from long chord method)

EQUIPMENT:

- Cross Staff,
- Arrows,
- Ranging rod
- Tape

THEORY:

Linear methods are used when:-

1. High degree of accuracy is not required
2. The curve is short

Linear methods for setting out curve include

1. **By ordinates or offsets from long chord.**
2. By offsets from tangents (T)
    a. Perpendicular offsets
    b. Radial offsets

ELEMENTS OF SIMPLE CIRCULAR CURVE

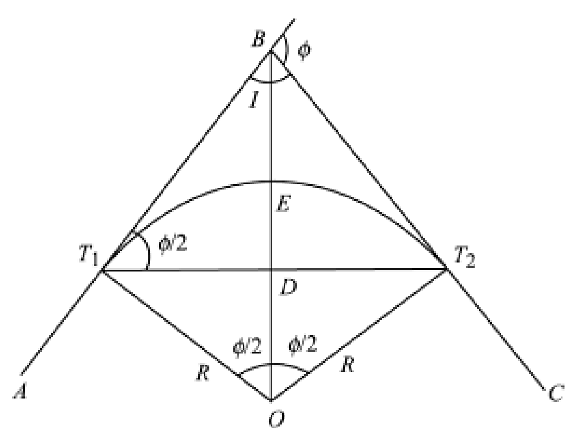


Fig. 10.10 Notations for Circular Curves

1. *AB* and *BC* are known as the *tangents* to the curve (Fig. 10.10).
2. *B* is known as the *point of intersection* or *vertex*.
3. The angle ϕ is known as the *angle of deflection*.
4. The angle I is called the *angle of intersection*.
5. Points T_1 and T_2 are known as *tangent points*.
6. Distances BT_1 and BT_2 are known as *tangent lengths*.
7. When the curve deflects to the right, it is called a *right-hand curve*, when it deflects to the left, it is said to be a *left-hand curve*.
8. *AB* is called the *rear tangent* and *BC*, the *forward tangent*.
9. The straight line T_1DT_2 is known as the *long chord*.
10. The curved line T_1ET_2 is said to be the *length of the curve*.
11. The mid-point E of the curve T_1ET_2 is known as the *apex* or *summit of the curve*.
12. The distance *BE* is known as the *apex distance* or *external distance*.
13. The distance *DE* is called the *versed sine* of the curve.
14. R is the *radius* of the curve.

Offsets or Ordinates from a Long Chord

Let *AB* and *BC* be two tangents meeting at a point *B*, with a deflection angle ϕ. The following data are calculated for setting out the curve (Fig. 10.11).

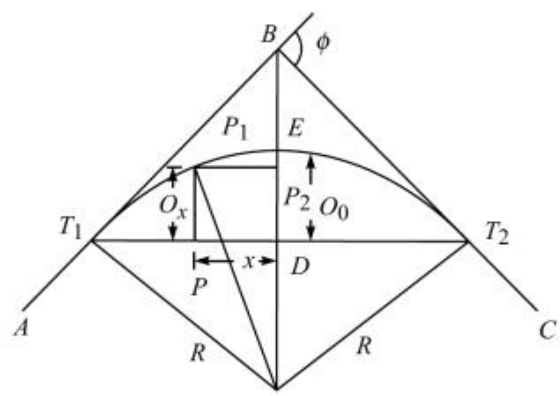


Fig. 10.11 Offsets from a Long Chord

1. The tangent length is calculated according to the formula; TL = $R \tan \phi/2$
2. Tangent points T_1 and T_2 are marked.
3. The length of the curve is calculated according to the formula:

$$\text{CL} = \frac{\pi R\phi^\circ}{180^\circ}$$

4. The chainages of T_1 and T_2 are found out.
5. The length of the long chord (L) is calculated from

$$L = 2R \sin \phi/2$$

6. The long chord is divided into two equal halves, the left half and the right half. Here the curve is symmetrical in both the halves.

7. The mid-ordinate O_0 is calculated as follows:
   (a) $O_0 = DE =$ versed sine of curve $= R(1 - \cos \phi/2)$ (10.3)
   (b) Again, $OF = R$ and $OD = R - O_0$

   From triangle OT_1D, $OT_1^2 = OD^2 + T_1D^2$

   or $$R^2 = (R - O_0)^2 + \left(\frac{L}{2}\right)^2$$

   or $$R - O_0 = \sqrt{R^2 - (L/2)^2}$$

   or $$O_0 = \sqrt{R^2 - (L/2)^2} \quad (10.4)$$

   Thus, the mid-ordinate O_0 can be calculated from Eq. (10.3) or (10.4).

8. Considering the left half of the long chord, the ordinates O_1, O_2, … are calculated at distances X_1, X_2,… taken from D towards the tangent point T_1.

   The formula for the calculation of ordinates is deduced as follows.

   Let P be a point at a distance x from D. Then PP_1 (O_x) is the required ordinate. A line P_1P_2 is drawn parallel to T_1T_2. From triangle OP_1P_2,

   $$OP_1^2 = OP_2^2 + P_1P_2^2$$

   or $$R^2 = \{(R - O_0) + O_x\}^2 + x^2 \qquad [\text{where, } OP_2 = (R - O_0) + O_x]$$

   or $$R - O_0 + O_x = \sqrt{R^2 - x^2}$$

   or $$O_x = \sqrt{R^2 - x^2} - (R - O_0) \quad (10.5)$$

9. The ordinates for the right half are similar to these obtained for the left half.

Experiment No.: 9

SETTING OUT OF SIMPLE CIRCULAR CURVE BY RANKINE METHOD

OBJECTIVE:

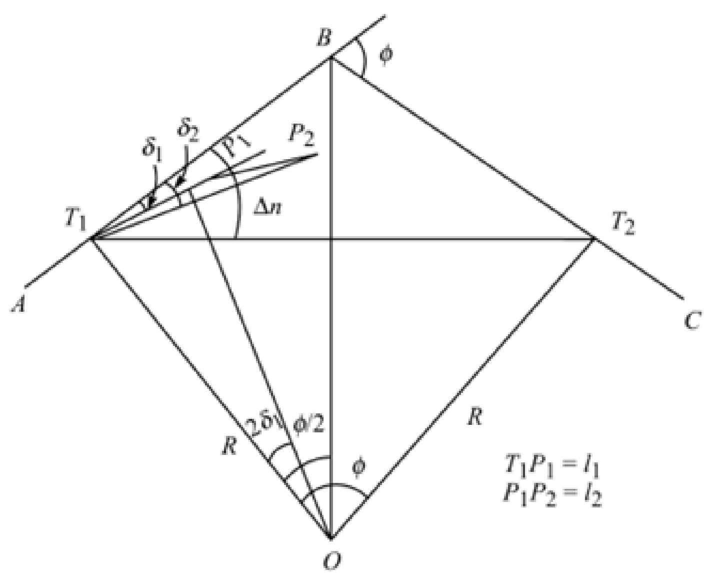
Setting out of simple circular curve by Rankine method of tangential angle.

EQUIPMENT:

- Theodolite with Tripod
- Ranging rods
- Arrows
- Tape

Horizontal Curve Setting by Ranking Method

Let AB and BC be two tangents intersecting at B, the deflection angle being ϕ (Fig. 10.18). The tangent length is calculated and tangent points T_1 and T_2 are marked.



Instrumental Method

Let P_1 = first point on the curve,

T_1P_1 = l_1 length of first chord (initial sub-chord)

δ_1 = deflection angle for first chord

R = radius of the curve

Δ_n = total deflection for the chords

Here, $\angle T_1OP_1 = 2 \times \angle BT_1P_1 = 2\delta_1$

Again,

$$\text{Chord } T_1P_1 \sim \text{Arc } T_1P_1$$

Now,

$$\frac{\angle T_1OP_1}{l_1} = \frac{360°}{2\pi R}$$

$$2\delta_1 = \frac{360° \times l_1}{2\pi R}$$

or

$$\delta_2 = \frac{360° \times l_1}{2 \times 2\pi R} \text{ degrees} = \frac{360 \times 60 \times l_1}{2 \times 2 \times \pi R} \text{ mins}$$

$$= \frac{1,718.9 \times l_1}{R} \text{ mins}$$

Similarly,

$$\delta_2 = \frac{1,718.9 \times l_2}{R} \text{ mins}$$

$$\delta_3 = \frac{1,718.9 \times l_3}{R} \text{ mins} \quad \text{and so on.}$$

Finally,

$$\delta_n = \frac{1,718.9 \times l_n}{R} \text{ mins}$$

Again, when degree of curve D is given,

$$\delta_1 = \frac{D \times l_1}{60} \text{ degrees}$$

$$\delta_2 = \frac{D \times l_2}{60} \text{ degrees} \quad \text{and so on.}$$

Finally,

$$\delta_n = \frac{D \times l_n}{60} \text{ degrees}$$

Arithmetical check: $\delta_1 + \delta_2 + \delta_3 + \ldots + \delta_n = \Delta_n = \phi/2$

PROCEDURE:

1. Set the theodolite at the point of curve T1.
2. With both the plates clamped to zero, direct the theodolite to bisect the point of intersection V. The line of sight is thus in the direction of the rear tangent.
3. Release the vernier plate and set angle 1 on the vernier .The line of sight is thus directed along chord T1A.
4. With zero end of tape pointed at T1 and arrow held at a distance T1A = c along it, swing the tape around T1 till the arrow is bisected by the cross hairs.
5. Thus the first point A is fixed.
6. Set the second deflection angle 2 on the vernier so that the line of sight is directed along T1B.
7. With the zero end of the tape pinned at A, and an arrow held at distance AB = C along it, swing the tape around A till the arrow is bisected by the cross hairs, thus fixing the point B.
8. Repeat steps 4 and 5 till last point is reached.

TOTAL STATION

1. PREPARATION

Precautions

1. Never point the instrument at the sun without a filter.

2. Never store the instrument in extreme temperatures and avoid sudden changes of temperature.

3. When not using the instrument, place it in the case to avoid shock, dust, and humidity.

4. If there is a great difference in temperature between the work site and the instrument storage location leave the instrument in the case until it adjusts to the temperature of the surrounding environment.

5. Please remove the battery for separate storage if the instrument is to be in storage for an extended time. The battery should be charged once a month during storage.

6. The instrument should be placed in its carrying case during transportation. It is recommended that the original packing case be used for cushioning during extended transportation.

7. Be sure to secure the instrument with one hand when mounting or removing from the tripod.

8. Clean exposed optical parts with degreased cotton or lens tissue only.

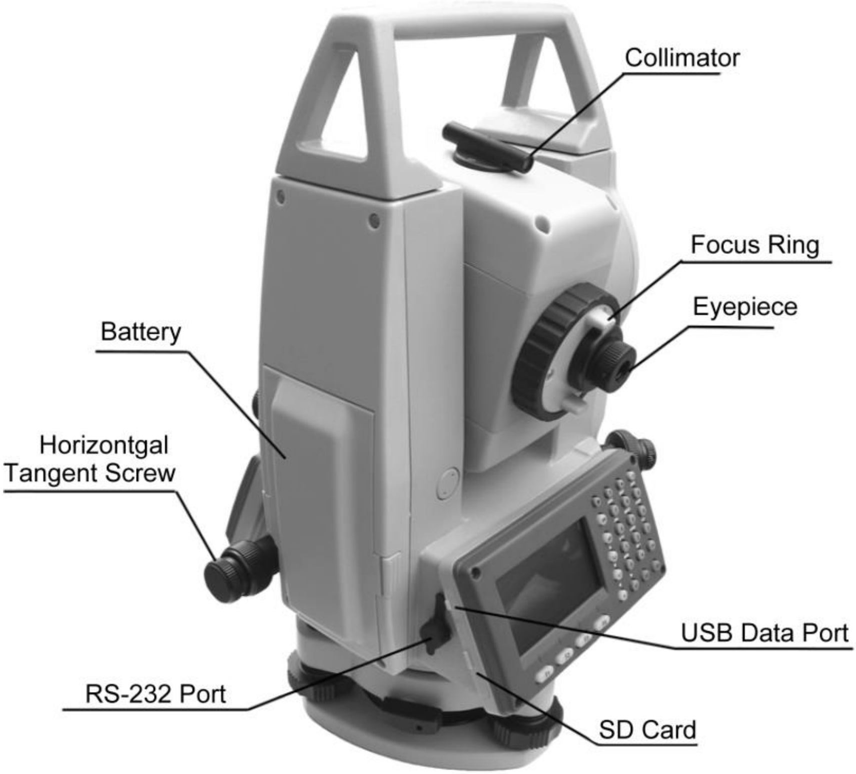
9. Clean the instrument's surface with a woolen cloth when finished with use. Dry it immediately if it gets wet.

10. Check the battery, functions, and indications of the instrument as well as its initial setting and correction parameters before operating.

11. Unless you are a maintenance specialist do not attempt to disassemble the instrument for any reason. Unauthorized disassembly of the instrument can result in a void warranty.

12. The total stations emit a laser during operation. DO NOT stare into the beam or laser source when instrument is operation.

Nomenclature


Collimator
Focus Ring
Eyepiece
Battery
Horizontgal
Tangent Screw
USB Data Port
RS-232 Port
SD Card

Unpacking and Storage of the Instrument

Unpacking of the Instrument

Place the case lightly with the cover upward, unlock the case and take out the instrument.

Storage of the Instrument

Replace the cover on the telescope lens, place the instrument into the case with the vertical clamp screw and circular vial upward (objective lens toward the tribrach), tighten the vertical clamp screw, close and lock the case.

Instrument Set Up

Mount the instrument onto the tripod and secure firmly. Level and center the instrument precisely to ensure the best performance. Use the tripod with a 5/8” tripod screw.

Operation Reference: Leveling and Centering the Instrument

1). Setting up the tripod

First extend the extension legs to suitable length and tighten the screws, firmly plant the tripod in the ground over the point of beginning.

2). Attaching the instrument to the tripod

Secure the instrument carefully on the tripod and slide the instrument by loosening the tripod mounting screw. If the optical plumb site is positioned over the center of the point tighten the mounting screw.

3). Roughly leveling the instrument by using the circular vial

Turn the leveling screw A and B to move the bubble in the circular vial, in which case the bubble is located on a line perpendicular to a line running through the centers of the two leveling screw being adjusted. Turn the leveling screw C to move the bubble to the center of the circular vial. Recheck the position of the instrument over the point and adjust if needed.

4). Leveling by using the plate vial

Rotate the instrument horizontally by loosening the Horizontal Clamp Screw and place the plate vial parallel with the line connecting leveling screws A and B, then bring the bubble to the center of the plate vial by turning the leveling screws A and B.

Rotate the instrument 90° (100g) around its vertical axis and turn the remaining leveling screw or leveling C to center the bubble once more.

Repeat the procedures for each 90 ° (100g) rotation of the instrument and check whether the bubble is correctly centered in all directions.

5). Centering by using the optical plummet(or laser plumment)

Adjust the eyepiece of the optical plummet telescope to your eyesight. Slide the instrument by loosening the tripod screw; place the point on the center mark of the optical plummet. Sliding the instrument carefully as to not rotate the axis will allow you to get the least dislocation of the bubble.(Place star-key after power on, then press F4(LASER)key, press F1(ON)key to turn on the laser plumment. Slide the instrument by loosening the tripod screw; Place laser facular on the occupied pointing, Sliding the instrument carefully as to not rotate the axis will allow you to get the least dislocation of the bubble. The last, press ESC key, and laser plummet turn off automatically.)

6). Complete leveling the instrument

Level the instrument precisely as in Step 4. Rotate the instrument and check to see that the bubble is in the center of the plate level regardless of the telescope direction then tighten the tripod screw firmly.

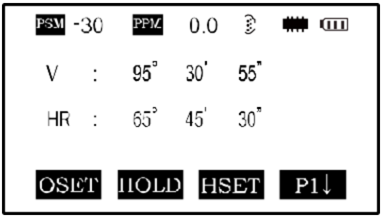
Battery Removal & Insertion - Information and Recharging

Battery removal & insertion

Insert the battery into the battery slot and push the battery until it clicks.

Press the right and left buttons of the battery compartment to remove the battery.

Battery information



 ------------- Indicates that battery is fully charged

 ------------- Indicates that the battery can only be used for about 1 hour.

Recharge the battery or prepare a recharged battery for use.

 ------------- Recharge the battery or prepare a recharged battery for use.

Note: The working time of the battery is determined by environment conditions, recharging time, and other factors.

Battery Recharging

Battery should be recharged only with the charger supplied with the instrument.

Remove the on-board battery from instrument as instructed and connect to the battery charger.

Battery Removal Caution

▲Before you take the battery out of the instrument, make sure that the power is turned off. Otherwise the instrument can be damaged.

Recharging Caution:

▲ The charger has built-in circuitry for protection from overcharging. However, do not leave the charger plugged into the power outlet after recharging is completed.

▲Be sure to recharge the battery at a temperature of 0℃～45℃, recharging may be abnormal beyond the specified temperature range.

▲When the indicator lamp does not light after connecting the battery and charger the battery or the charger may be damaged.

Storage Caution:

▲The rechargeable battery can be repeatedly recharged 300-500 times. Complete discharge of the battery may shorten its service life.

▲In order to get the maximum service life be sure to recharge the battery at least once a month.

Reflector Prisms

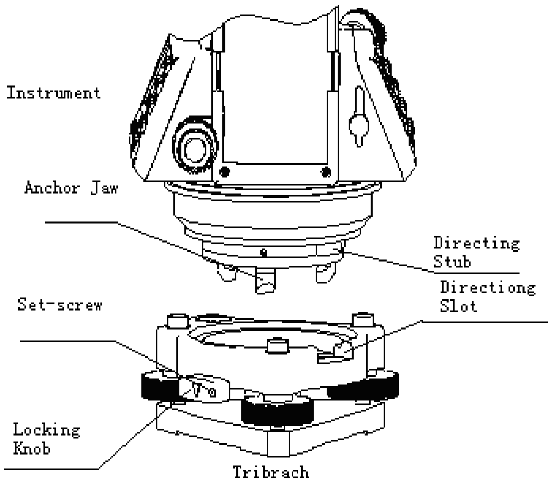
When doing distance measuring in prism mode a reflector prism needs to be placed as the target. Reflector systems can be single or multiple prisms which can be mounted with a tripod/tribrach system or mounted on a prism pole. Unique mini prism systems allow setups at corners that are hard to reach. Reflectorless targets extend the range of the instrument when used in reflectorless mode.

Illustrated are some prisms and a reflector compatible with instruments:

Mounting and Dismounting the Instrument from the Tribrach

Dismounting

When necessary the instrument can be dismounted from the tribrach. Loosen the tribrach locking screw in the locking knob with a screwdriver if necessary. Turn the locking knob 180 degreescounter-clockwise to disengage anchor jaws and remove the instrumentfrom the tribrach.



Mounting

Insert three anchor jaws into holes in tribrach and line up the directing stub on the instrument with the directing slot of the tribrach. Turn the locking knob 180 degrees clockwise and tighten the locking screw with a screwdriver.

Eyepiece Adjustment and Object Sighting

Method of Object Sighting (for reference)

Sight the telescope to the sky and rotate the eyepiece tube to make the reticule clear.

Collimate the target point with top of the triangle mark in the collimator. (keep a certain distance between eye and the collimator).

Make the target image clear with the telescope focusing screw.

If there is parallax when your eye moves up and down or left and right this indicates the diopter of the eyepiece lens or focus is not adjusted well and accuracy will be effected. You should readjust the eyepiece tube carefully to eliminate the parallax.

Turning the instrument On and Off

Power on

1. Be sure that the instrument is leveled.
2. Press and momentarily hold the power (POWER) key.
3. Rotate the EDM head in an upwards direction to initialize.
4. To turn OFF press and hold the power key until instrument powers down.

Be sure there is sufficient battery power. If 'Battery Empty' is shown on the display, the battery should be recharged or replaced.

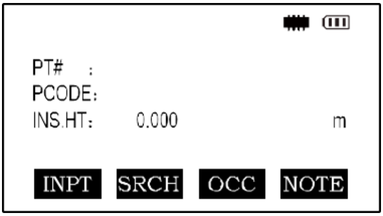
*** DO NOT remove the battery during measuring, otherwise the data will be lost and the instrument could be harmed!! ***

How To Enter Alphanumeric Characters

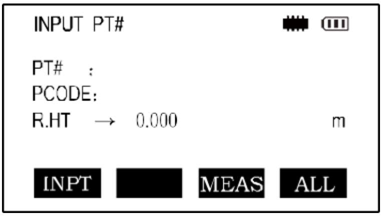
*How to select an item

[Example 1] Select INS.HT (instrument height) in the data collection mode (first press the MENU button then F1:DATA COLLECT and then select the data file desired. Press F2 to list, the arrow keys to choose and then F4 to select). Press F1 again for OCC.PT# INPUT.

The arrow (→) indicates an item to enter. Press [▲] [▼] key to move the arrow line up or down



Press [▼] move->R..HT



Press F1 INPUT then 1 to input “1”

Press . to input “. ”

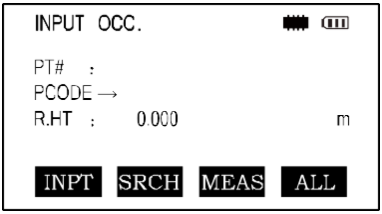
Press 5 to input “5 ”, press ENT

Then R. HT =1.5 m

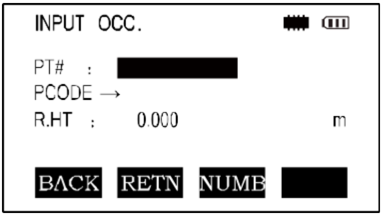
*How to enter characters

[Example 2] Input the code "ABC1" of instrument point in Data Collection Mode.

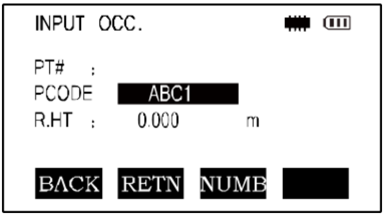
1. Move the arrow to PCODE using the [▲]or [▼]key



2. Press F1 (input) key



3. Press F1 key once



Press [7] key once for "A"

Press [7] key twice for "B"

Press [7] key three times for "C"

Press [1] key once for "1" (*Press F3 to switch to NUMB mode first)

Press enter key to finish input

2. FUNCTION KEY AND DISPLAY

Operating Key

Keys	Names	Function
ANG	Angle meas. key	Angle measurement mode
	Distance meas. key	Distance measurement mode
	Coordinate meas. key	Coordinate measurement mode (▲Up)
S.O	Layout key	Layout measurement mode (▼ Down)
K1	Quick key1	User-defined quick key 1(◀Left)
K2	Quick key 2	User-defined quick key 2(▶Right)
ESC	Escape key	Return to the measurement mode or previous layer mode.
ENT	Enter key	Press after confirmation of inputting values
M	Menu key	Switches menu mode and normal mode
T	Shift key	Shift distance measuring key
★	Star key	Press once to adjust contrast or twice for illumination of keypad
⏻	Power key	On / Off key press and hold
F1- F4	Soft key (Function	Responds to the message displayed

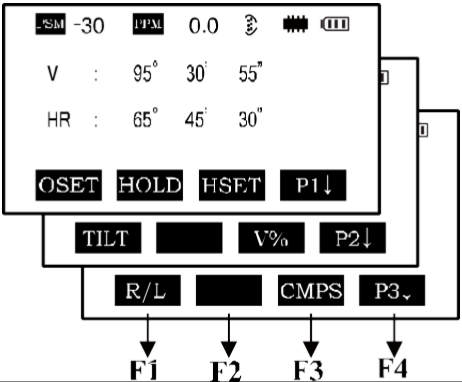
	key)	
0 – 9	Number key	Input numbers
—	Minus key	Input minus sign, displays electronic bubble
.	Point key	On / Off laser pointing function

Display marks:

Display	Content
V	Vertical angle
V%	Vertical angle as a percentage (Gradient display)
HR	Horizontal angle (right)
HL	Horizontal angle (left)
HD	Horizontal distance
VD	Elevation difference
SD	Slope distance
N	North coordinate
E	East coordinate
Z	Z or elevation coordinate
*	EDM working
m/ft	Switches units between meters and feet
m	Meter unit
S/A	Sets temperature, air pressure, prism constant
PSM	Prism constant (unit:mm)
PPM	Atmospheric correction

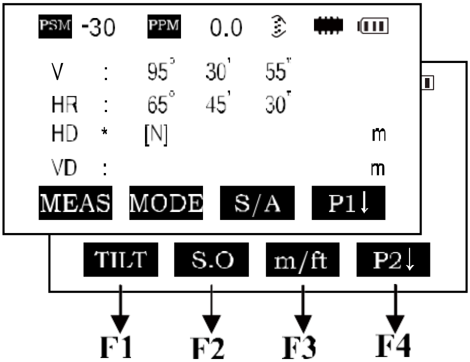
Function Key

Angle measurement mode (three-page menu)



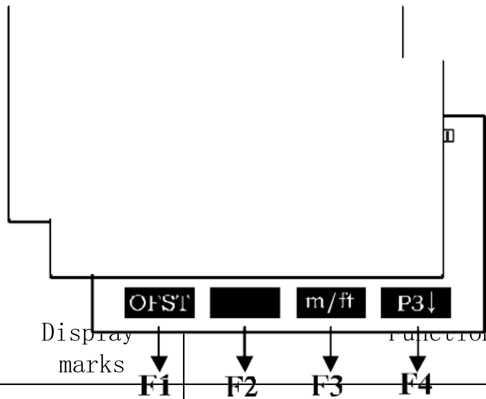
Page	Keys	Display marks	Function
P1	F1	OSET	Horizontal angle is set to 0° 0′ 0″
	F2	HOLD	Hold the horizontal angle
	F3	HSET	Set a required horizontal angle by entering numbers
	F4	P1↓	Scroll to the next page (P2)
P2	F1	TILT	Tilt correction screen. If the correction is turned on the display will show the tilt correction value.
	F2		
	F3	V%	Vertical angle percent grade (%) mode
	F4	P2↓	Scroll to the next page (P3)
P3	F1	R/L	Switches Right/Left rotation of horizontal angle
	F2		
	F3	CMPS	Switches vertical angle "0" position
	F4	P3↓	Scroll to the next page (P1)

Distance measurement mode (two-page menu)



Page	Keys	Display marks	Function
P1	F1	MEAS	Begin measuring
	F2	MODE	Sets measuring mode, Fine/--/Tracking
	F3	S/A	Sets temperature, air pressure, prism constant
	F4	P1↓	Scroll to the next page (P2)
P2	F1	OFSET	Selects Off-set measurement mode
	F2	S. O.	Selects Stake Out measurement mode
	F3	m / ft	Switches units between meters and feet
	F4	P2↓	Scroll to the next page (P1)

Coordinate measurement mode（three-page menu）



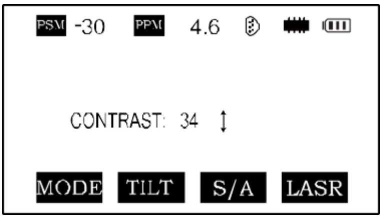
Page	Keys	Display marks	Function
P1	F1	MEAS	Start measuring
	F2	MODE	Sets a measuring mode, Fine/Tracking
	F3	S/A	Sets temperature, air pressure, prism constant
	F4	P1↓	The function of soft keys is shown on next page (P2)
P2	F1	R.HT	Sets prism height
	F2	INSHT	Sets instrument height
	F3	OCC	Sets instrument coordinate.
	F4	P2↓	Shows the function of soft keys on page 3

P3	F1	OFSET	Off-set measurement mode
	F2	BACKSIGHT	Setting a direction angle for backsight orientation
	F3	m / ft	Switches meter and feet unit.
	F4	P3↓	Shows the function of soft keys on page1

star-key mode

The total station(non-reflectorless):

Press the star key , following is displayed:



1. Contrat adjustment: After pressing star key, adjust the display contrast by pressing [▲] or [▼] key.

2. Illumination: After pressing star key, select [Illumination] by pressing F1(LAMP) key or press star key.

3. Tilt: After pressing star key, select [tilt] by pressing F2 (TILT) key, and select ON or OFF by pressing F1 or F3 key, press F4 (ENT) key.

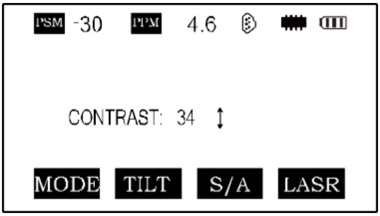
4. S/A: After pressing star key, select [S/A] by pressing F3 (S/A) key, then you can set Prism contrast, air pressure and temperature.

5. Laser plumment: If total station has this function, after pressing star key, select [laser] by pressing F4 (LASR) key, and select ON or OFF by pressing F1 or F2 key.

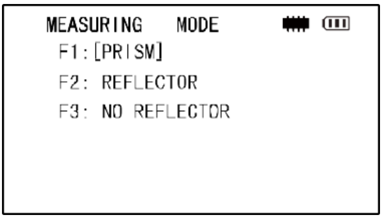
*In some interface, you can turn on or turn off panel backlight by press star key directly.

The total station(reflectorless):

Press the star key , following is displayed:



1. Mode: Press the F1 (mode) key, the following is displayed :



You can select the type of measure mode by pressing the F1—F3 keys.

2. You can turn on the lamp by pressing the star key once more or

by pressing twice from any menu.

Dot-key Mode

The total station can function as a laser pointer

The laser pointer can be turned on or off by pressing the (.) dot key.

1. INITIAL SETTINGS

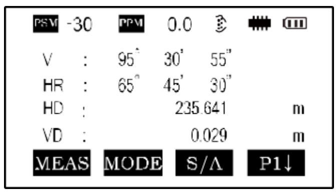
The series total station can be reset to the instruments original factory settings.

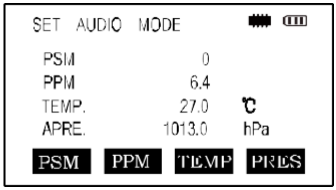
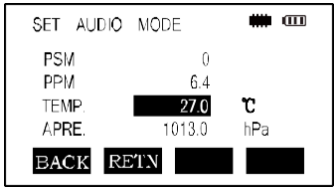
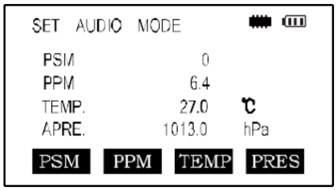
See Section 11 "Basic Settings"

Setting the Temperature and Atmospheric Pressure

Measure the surrounding temperature and air pressure in advance.

Example: temperature +25°, air pressure 1017.5 hPa

Procedure	Operation	Operating procedure	Display
		Enter the Distance Measurement Mode	

	F3	Press F3 to enter the S/A screen	
Temp. Settings	F3	Press F3 to enter temperature section, enter the correct temperature, press the ENT key to set	
Atms. Pressure	F2	Press F2 key and enter the air pressure, press the ENT key to confirm	
Remarks	Temperature operating range: -30° ～+60℃ or -22～+140 ℉ Air pressure: 560～1066 hPa or 420～800 mmHg or 16.5～31.5 inHg If the atmospheric correction value calculated from the temperature and air pressure exceeds the range of ±999.9PPM, the operation will return to step 4 automatically, and you should enter the data again.		

Setting of the Atmospheric Correction

The infrared emitted by the Total Station varies with the air temperature and pressure. Once the atmospheric correction value is set the instrument will correct the distance measuring result automatically.

Air pressure: 1013hPa

Temperature: 20℃

The calculation of atmospheric correction :

$\Delta S = 273.8 - 0.2900\,P / (1 + 0.00366T)$ (ppm)

ΔS: Correction Coefficient (Unit ppm)

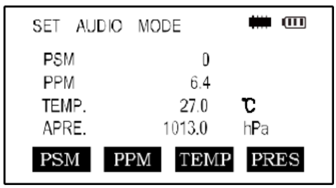
P: Air Pressure (Unit : hPa If the unit is mmHg , please convert using

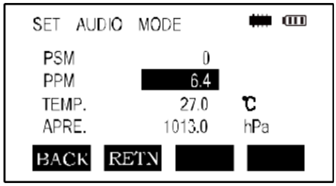
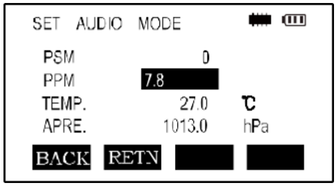
1hPa = 0.75mmHg

T: temperature (unit℃)

Direct Setting Method of Atmosphere Correction Value

After measuring the temperature and air pressure the atmosphere correction value can be obtained from an atmospheric correction chart or correction formula (PPM).

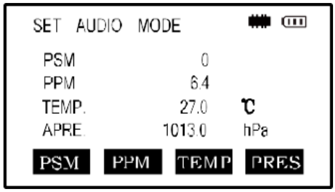
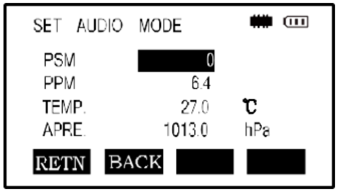
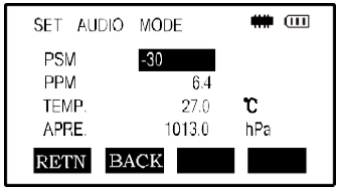
Procedure	Operation	Operation Procedure	Display
	F3	Press F3 Key in distance measurement or coordinate measurement mode	

	F2	Press F2 [ppm] key, which shows the current setting value	
	Enter value	Enter atmospheric correction and press ENT	
*1）See 2.10“How to Enter Alphanumeric Characters” Input range：-999. 9PPM to +999. 9 Step length: 0 .1PPM *2）If Temperature and Atmospheric Pressure are reset, the PPM will be recalculated automatically.			

Setting of the Prism Constant

In the factory the prism constant for the total station is set at -30mm. If the constant of the prism used is not -30mm, you must change this setting. Once the prism constant is set it will become the new default value until changed.

Procedure	Operation	Operation Procedure	Display

	F3	Press F3 (S/A) Key in Distance Measurement Mode or Coord. Measurement Mode.	
②	F1	② Press F1 (PRISM) key	
③	Enter data	Press F1 (INPUT) key to enter the Prism Constant correction value. *1, press F4 to confirm and return to the Setting Mode.	
Input range: -99. 9mm to +99. 9mm Step length 0. 1mm			

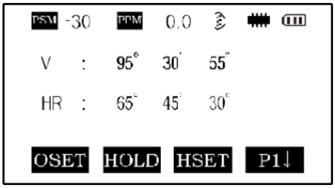
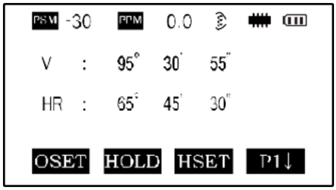
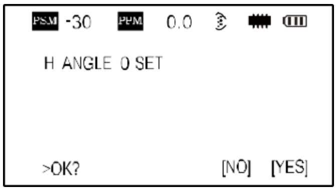
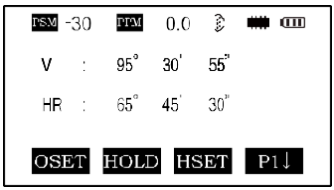
*The total station in reflectorless measuring mode sets the prism constant to 0 automatically.

2. ANGLE MEASUREMENT

Measuring Horizontal Angle Right and Vertical

Angles

Make sure the angle measurement mode is selected.

Operation procedure	Operation	Display
①Collimate the first target (A)	Collimate A	
To set horizontal angle of target A at 0° 00' 00" press the F1 (OSET) key and then press the F4 (YES) key	F1 F4	 
③Collimate the second target (B) The required V/H angle to target B will be displayed	Collimate B	

Note : The horizon angle will be saved when the instrument is powered off and displayed when powered on.

Reference: How to Collimate

Point the telescope toward a light surface or sky. Turn the diopter ring and adjust the diopter so that the cross hairs are clearly observed.

Aim the target at the peak of the triangle mark of the sighting collimator. Allow a certain space between the sighting collimator and yourself for collimating.

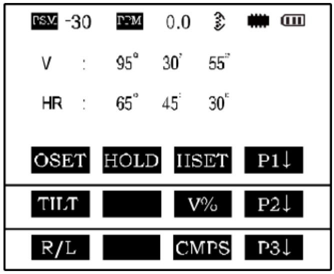
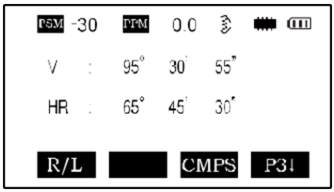
Focus the target with the focusing knob.

If parallax is created between the cross hairs and the target when viewing vertically or horizontally while looking into the telescope, focusing is incorrect or diopter adjustment is poor.

This adversely affects precision in measurement please eliminate the parallax by carefully focusing and using the diopter adjustment.

Switching Horizontal Angle Right/Left

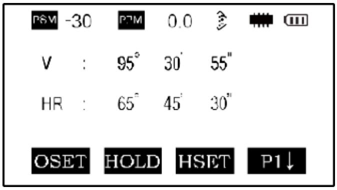
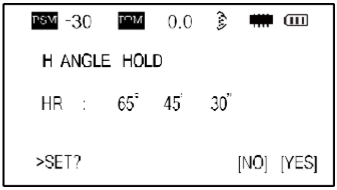
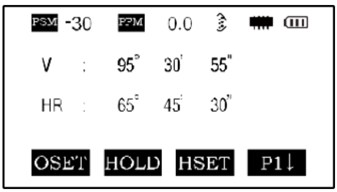
Make sure the angle measurement mode is selected.

Operation procedure	Operation	Display
Press the F4 Key twice to get the menu to page 3. (P3)	F4 twice	
Press the F1 (R/L) key. The Horizontal Right angle mode (HR) Switches to Horizontal Left mode (HL)	F1	
Measure as HL mode		
*Each time the F2 (R/L) key is pressed the HR/HL mode switches		

Setting of the Horizontal Angle

Setting by Holding the Angle

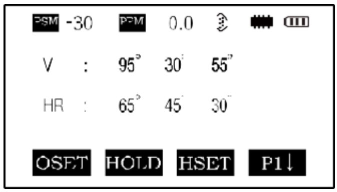
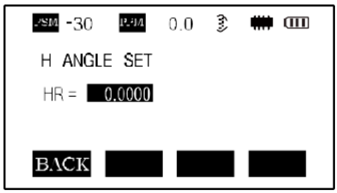
Make sure the angle measurement mode is selected.

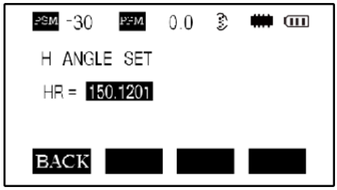
Operation procedure	Operation	Display
① Set the required horizontal angle using the horizontal tangent screw	Display angle	
②Press the F2 (HOLD)key	F2	
③Collimate the target	Collimate	
④Press the F4 (YES) key to finish holding the horizontal angle, the display turns back to the normal angle measurement mode	F4	

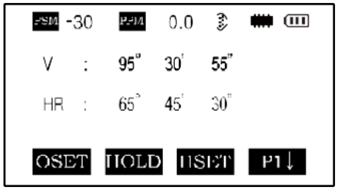
*To return to the previous mode, press the ESC key.

Setting the Horizontal Angle from the Keypad

Make sure the angle measurement mode is selected.

Operation procedure	Operation	Display
①Collimate the target	Collimate	
②Press the [F3] (HSET) key	[F3]	

<table>
<tr>
<td>③ Input the required horizontal angle by using the keys, for example: 150.10.20, inputs 150°10′ 20″ .
Press ENT
Carry on normal measurement after entering the required horizontal angle</td>
<td>150.10.20
ENT</td>
<td>


</td>
</tr>
</table>

3. DISTANCE MEASUREMENT

When setting the atmospheric correction obtain the correction value by measuring the temperature and pressure.

Setting of the Atmospheric Correction

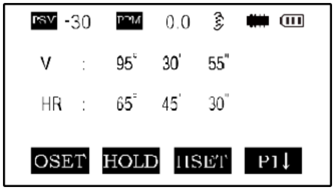
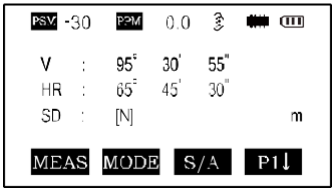
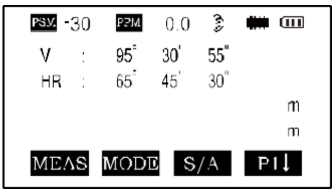
When setting the atmospheric correction obtain the correction value by measuring the temperature and pressure. Refer to Section 3.2 “Setting of the Atmospheric Correction”.

Setting of the Correction for Prism Constant

The instrument is preset for a Prism Constant value of -30mm at the factory. If the prism is of another constant the instrument needs to be updated with this constant. Refer to Chapter 3.3 "Setting of the Prism Constant". The updated value is kept in the instrument memory after the power is shut off.

Distance Measurement (Continuous Measurement)

Make sure the angle measurement mode is selected.

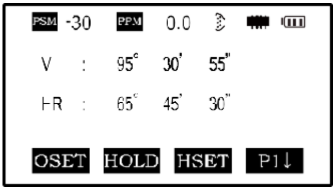
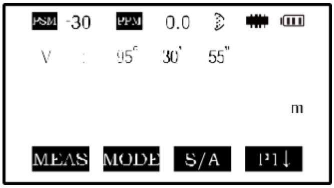
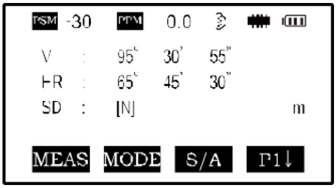
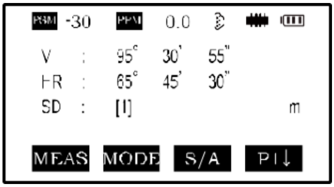
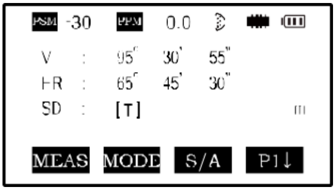
Operation procedure	Operation	Display
Collimate the center of prism *1	Collimate	
distance measurement starts *2 *3;		
③ The measured distances are shown (*4,*7) By key again th to ho (HR), vertical (V) angle, vertical distance (VD) and slope distance (SD)		

*1) The total station prism mode collimate center of prism when measuring;
2) When EDM is working, the "" mark appears in the display. The total stations will display "weak signal" when measuring if the signal is weak.
*3) To change the mode from Fine to Tracking, refer to section 5.4 "Fine mode / Tracking Mode". To set the distance measurement on when the instrument is powered up, refer to Chapter 11 " Basic Settings".
*4) The distance unit indicator "m" (for meter) or "ft" (for feet) appears and disappears alternatively with a buzzer sounding at every renewal of distance data.
5) Measurement may repeat automatically in the instrument if the result is affected by external factors.
*6) To return to the angle measuring angle mode from the distance-measuring mode, press the [ANG] key.
*7)It is possible to choose the display order (HR,HD,VD) or (V, HR,SD) for initial measuring mode. Refer to Chapter 11 "Basic Settings".

Changing the Distance Measurement Mode (Repeat Measurement / Single Measurement/ Track Measurement)

Make sure the angle measurement mode is selected.

Operation procedure	Operation	Display

Collimate the center of the prism	Collimate	
 key , Continu Measurement begins *1;		
Press the F2 (MODE) key to switch between Repeat Measurement, Single Measurement and Tracking Measurement. [N], [1], [T]	F2 F1	

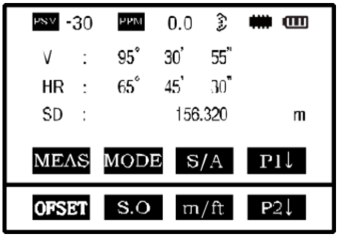
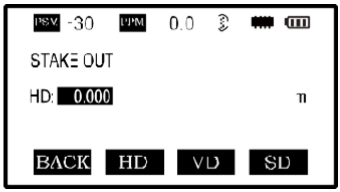
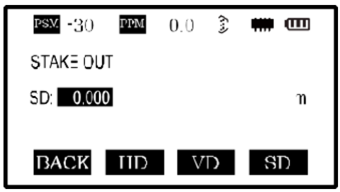
*1 It is possible to set the measurement mode for N-times measuring mode or continuous measurement mode when the power is turned on. Refer to Chapter 11 "Basic Settings".

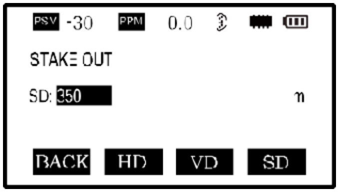
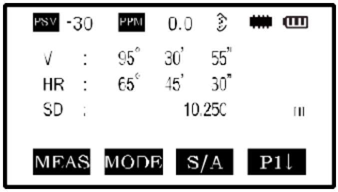
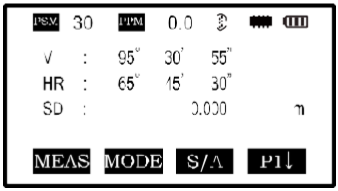
Stake Out (S.O.)

The difference between the measured distance and the input stake out distance is displayed.

Measured distance - Stake out distance = Displayed value

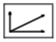
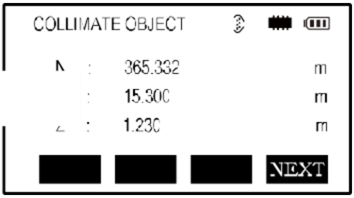
In a stake out operation you can select either horizontal distance (HD), relative elevation (VD), and slope distance (SD.)

Operation procedure	Operation	Display
Press the F4(↓) key in the distance measuring mode to menu P2	F4	
Press the F2 (S.O) key The data previously set is shown	F2	
Select the measuring mode by pressing the F2 to F4 keys. F2:HD, F3:VD, F4:SD	F1	

Enter the distance 350 , press F4	Enter 350 F4	
Collimate the target (Prism), measurement starts. The difference between the measured distance and the stake out distance is displayed.	Collimate Prism	
Move the target until the difference becomes 0.		
To return to normal distance measurement mode, stake out distance to “0” or switch to other measurement mode.		

Offset Measurement

There are four offset measurement modes:

To show the coordinate of po: key. *1*2		

*1) To return to procedure 5, press F4 (NEXT) key

*2) To escape the measuring, press ESC key, the display returns to the previous mode.

4. COORDINATE MEASUREMENT

Execution of Coordinate Measurement

Measure the coordinates by entering the instrument height and prism height, coordinates of unknown Point will be measured directly.

* When setting coordinate values of occupied point, see Section "Setting Coordinate Values of Occupied Station Point".

* When setting the instrument height and prism height, see Section "Setting Height of the Instrument" and 6.4 "Setting Height of Target (prism Height)".

* To set backsight, determine the backsight azimuth or check the known azimuth, coordinate and distance.

The coordinates of the unknown point are calculated as shown below and displayed:

Coordinates of occupied point: (N0, E0, Z0)

Instrument height :INS.HT

Prism height: R.HT

Vertical distance (Relative elevation): Z (VD)

Coordinates of the center of the prism, originated from the center point of the instrument: (n, e, z)

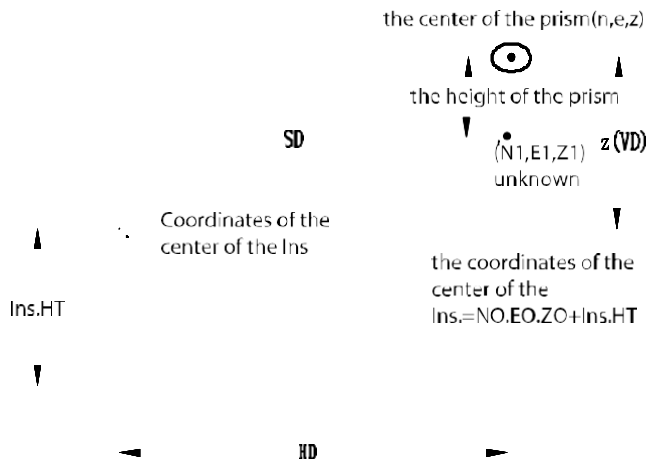
Coordinates of unknown point: (N1, E1, Z1)

N1=N0+n

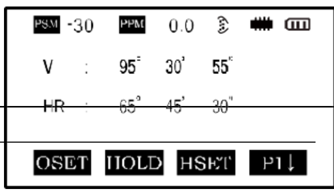
E1=E0+e

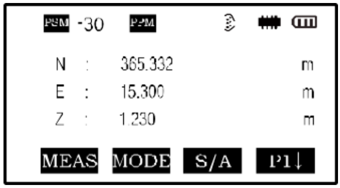
Z1=Z0+INS.HT+Z－R.HT

Center point of the instrument (N0, E0, Z0+INS.HT)



When doing coordinate measurement coordinates of occupied point, the instrument height, the prism height and back sight azimuth should be set.

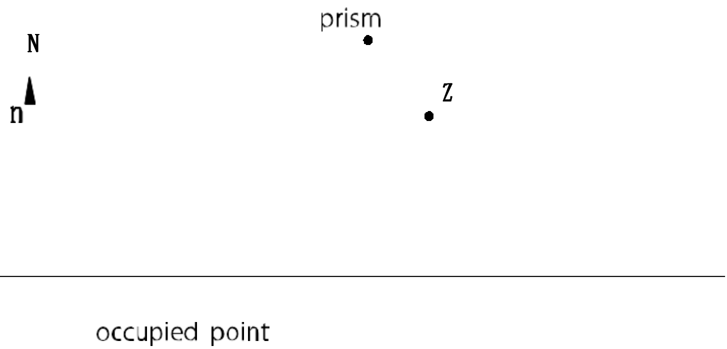
Operation procedure	Operation	Display
Set the direction angle of known	Set	

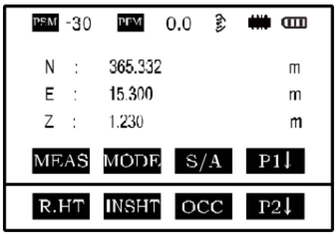
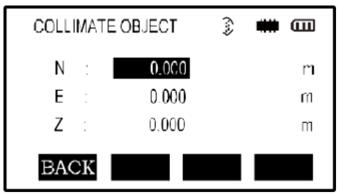
point A *1)	direction angle	
Collimate target prism B, key	Collimate target prism	
*1Refer to Section 4.3 "Setting of Horizontal Angle". In case the coordinate of instrument point is not entered, (0,0,0) will be used as the default for the instrument point. The prism height will be calculated as 0 when the prism height is not set.		

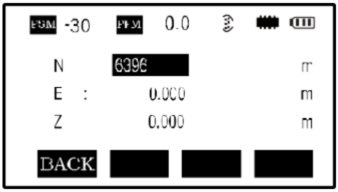
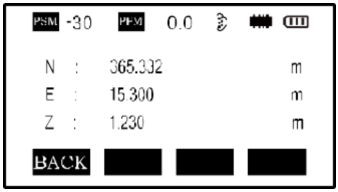
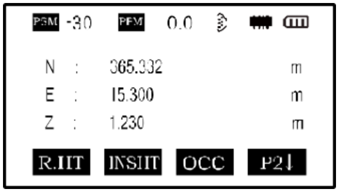
Setting Coordinate Values of Occupied Point

Set the coordinates of the instrument (occupied point) according to known values and the instrument automatically converts and displays the unknown point (prism point) coordinates following the observation.

The instrument retains the coordinates of the occupied point after turning the power off.



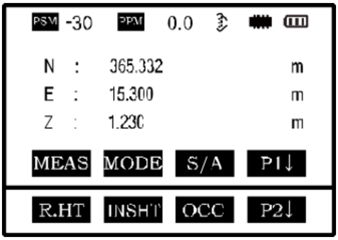
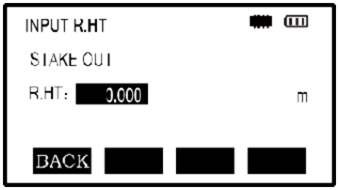
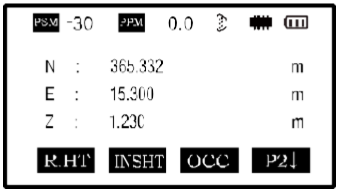
<table>
<tr><th>Operation procedure</th><th>Operation</th><th>Display</th></tr>
<tr><td>Press the [F4] (P1↓) key from the coordinate measurement mode to get the function on menu P2.</td><td>[F4]</td><td>
</td></tr>
<tr><td>Press the [F3] (OCC) key</td><td>[F3]</td><td>
</td></tr>
</table>

③Enter N coordinate value	Enter data ENT	
④Enter E and Z coordinate values in the same manner. After entering the values, the display returns to the coordinate measuring display menu.	Enter data ENT	 
Input range: -999999.999m/ft ≤ N、E、Z ≤ +999999.999m/ft		

Setting Height of the Instrument

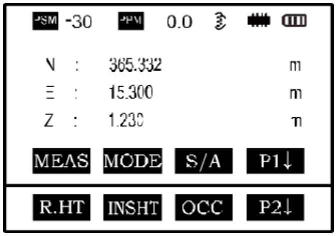
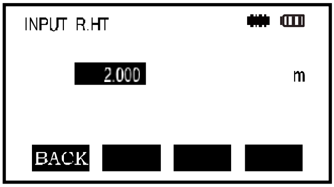
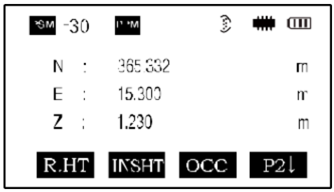
The instrument height value will be retained after the instrument is powered off.

Operation procedure	Operation	Display

Press the F4 (P1↓) key from the coordinate measurement mode to access the P2 menu screen.	F4	
② Press the F2 (I.HT) key, The current value is displayed.	F2	
Enter the instrument height and press the ENT key to get to the coordinate measuring display	Enter the I.H. ENT	
Input range: —999.999≤INS.HT≤+999.999m		

Setting Height of Target (Prism Height)

This mode can be used to obtain z coordinate values. The target height value will be retained after the instrument is powered off.

Operation procedure	Operation	Display
Press the F4 (P1↓) key from the coordinate measurement mode to access the P2 menu screen.	F4	
②Press the F1 (R.HT) key The current value is displayed.	F1	
Enter the prism height, then press the ENT key to get to the coordinate measuring display	Enter the prism height ENT	
Input range: —999.999m≤prism height≤+999.999m/ft		

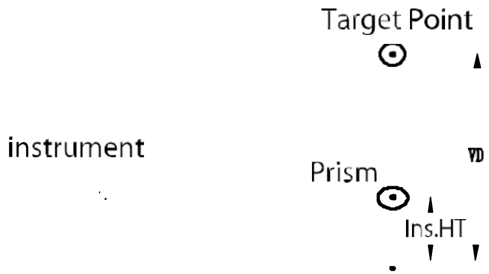
5. SURVEYING PROGRAM

Surveying Program Mode (programs)

By pressing the menu key M , the instrument will be in Menu Mode.

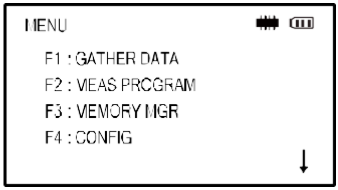
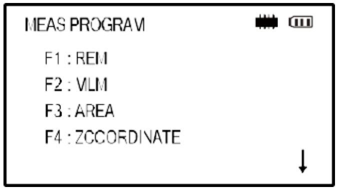
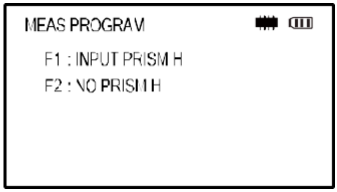
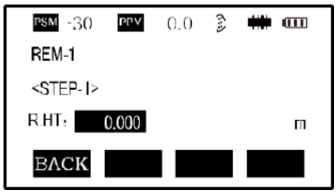
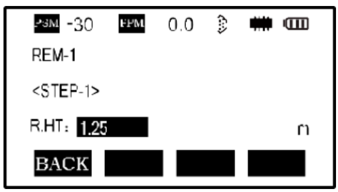
Remote Elevation Measurement (REM)

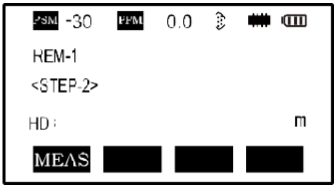
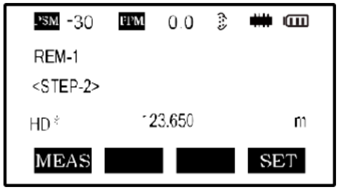
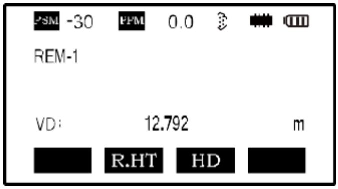
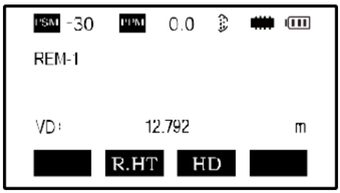
To obtain elevation of the point at which setting the target prism is not possible, place the prism at any point on the vertical line from the target then carry out REM procedure as follows.



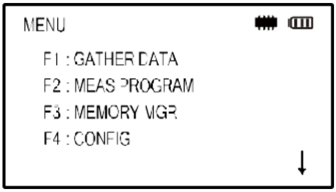
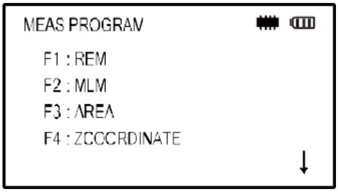
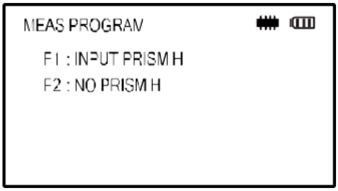
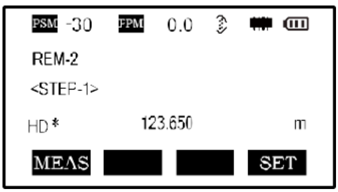
1) With prism height (h) input

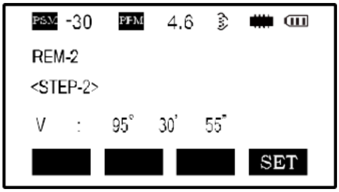
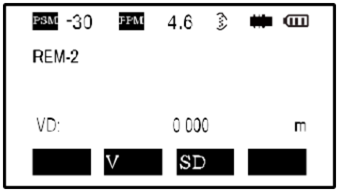
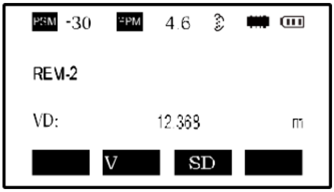
Operation procedure	Operation	Display

Press the M Key	M	
Press the F2 key , enter MEAS PROGRAM. menu	F2	
③Press the F1 (REM) key	F1	
④Press the F1 key	F1	
⑤Enter prism height (1.3 is an example in meters)	F1 Enter prism height 1.3 F4	

⑥Collimate prism	Collimate Prism	
⑦Press the F1 (MEAS) key, measurement starts. Horizontal distance (HD) between the instrument and prism will be shown.	F1	
⑧Press the F4 (SET) The prism position will be decided.	F4	
⑨ Collimate target K. Vertical distance (VD) will be shown.	Collimate K	
To return to procedure 5, press F2 (R.HT) key. To return to procedure 6, press F3 (HD) key. To return to PROGRAMS Menu, press the ESC key.		

2) Without prism height input

Operation procedure	Operation	Display
Press the [M] menu key	[M]	
Press the [F2] key, enter the measure programs menu.	[F2]	
③Press the [F1] (REM) Key.	[F1]	
④ Press the [F2] key to select the mode without prism height.	[F2]	
Collimate prism, press the [F1] (MEAS) key. Measuring starts. Horizontal distance (HD) between the instrument and target will	Collimate target	

be shown..		
⑥Press the F4 (SET) The target position will be decided.	F4	
Collimate ground point G , press the F4 (SET) key. The position of point G will be decided	F4	
Collimate target K Vertical distance (VD) will be shown	Collimat e K	
To return to procedure 5, press the F3 (HD) key. To return to procedure 6, press the F2 (V) key. To return to PROGRAMS Menu, press the ESC key.		

Missing Line Measurement (MLM)

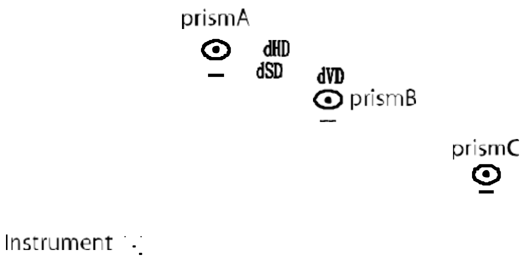
Measurement for horizontal distance (dHD) , slope distance (dVD),elevation (dVR) and horizontal bearing (HR) between two target prisms.

It is possible to enter the coordinate value directly or calculate from coordinate data file.

MLM Mode has two modes:

1. MLM-1 (A-B, A-C): Measurement A-B, A-C, A-D

2. MLM-2 (A-B, B-C): Measurement A-B, B-C, C-D

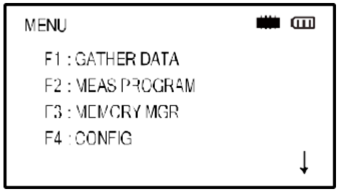
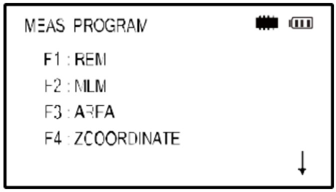
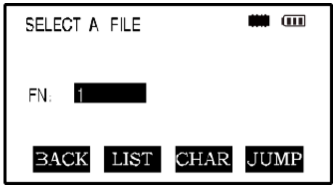
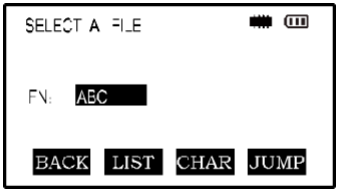
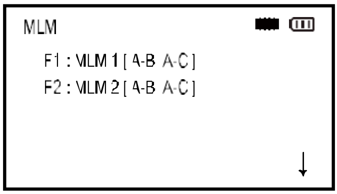


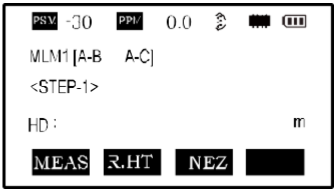
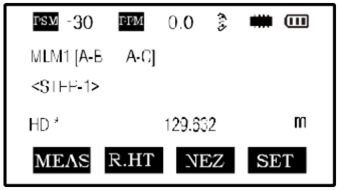
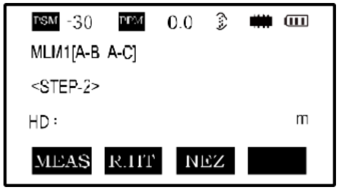
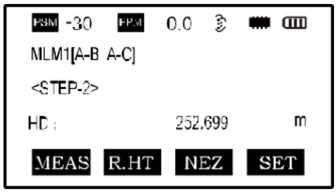
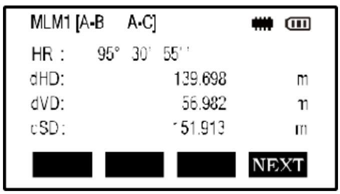
It is necessary to set the direction angle of the instrument.

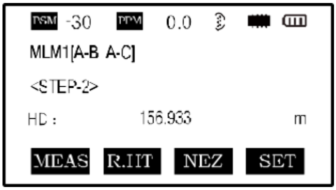
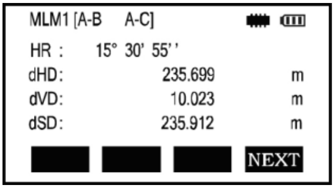
[Example] MLM-1 (A-B, A-C)

Procedure of MLM-2 (A-B, B-C) mode is completely the same as that of MLM-1 mode.

Operation procedure	Operation	Display

①Press the M menu key	M	
②Press the F2 key, enter MEAS PROGRAMS	F2	
③Press the F2 (MLM) key	F2	
④Enter file name	Enter file name	
⑤Press ENT key.	ENT	

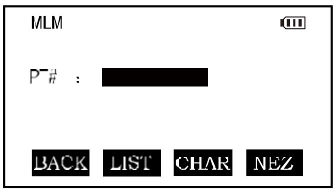
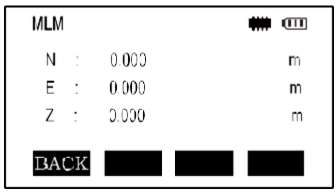
<table>
<tr><td>⑥Press the F1 key</td><td>F1</td><td>
</td></tr>
<tr><td>⑦Collimate prism A, and press the F1 (MEAS) key. Horizontal distance (HD) between the instrument and target A will be shown.</td><td>Collimate A
F1</td><td>
</td></tr>
<tr><td>⑧Press the F4 (SET) key
The position of the target is confirmed.</td><td>F4</td><td>
</td></tr>
<tr><td>⑨ Collimate prism B and press the F1 (MEAS) key. Horizontal distance (HD) between the instrument and target B will be shown..</td><td>Collimate B
F1</td><td>
</td></tr>
<tr><td>⑩Press the F4 (SET) key
The horizontal distance(dHD) and relative elevation (dVD) between target A and B.</td><td>F4</td><td>
</td></tr>
</table>

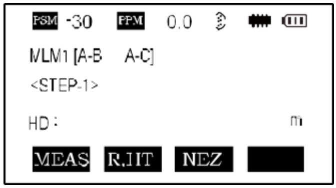
⑾To measure the distance between points A and C, press the F4 (NEXT) key*1)	F4	
⑿ Collimate point C (target C) and press the F1 (MEAS) key. Horizontal distance (HD) between the instrument and target C will be shown.	Collimate C F1	
⒀Press the F4 (SET) key. The horizontal distance (dHD) and relative elevation (dvD) between taget A and C will be shown	F4	
⒁To measure the distance between points A and D, repeat procedure 12 to 14 *		
*To return to Previous mode , press the ESC key.		

HOW TO USE COORDINATE DATA

It is possible to input coordinate values directly or calculate from a coordinate data file.

[Example] Input the data (NEZ) directly:

Operation procedure	Operation	Display
①Press the F3(NEZ) key	F3	 
② Press the F4(coordinate) key	F4	

③Enter coordinate, press ENT key to get to the second point.	ENT	

*To return to PROGRAMS Menu, press the ESC key.

Area Calculation

This mode calculates the area of an enclosed figure.

There are two area calculation methods as follows:

1) Area calculation from Coordinate data file

2) Area calculation from measured data

Note:

Area is not calculated correctly if observed lines cross each other.

It is not possible to calculate area from a mix of coordinate file data and measured data.

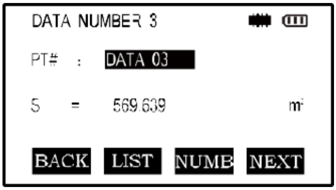
The number of points used for calculation is not limited.

The area to be calculated shall not exceed 200000 sqm. (approx. 49 acres)

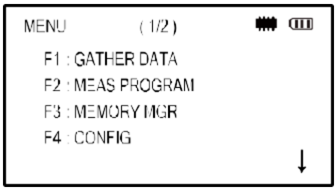
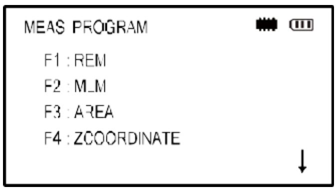
1) Area calculation from Coordinate data file

Operation procedure	Operation	Display

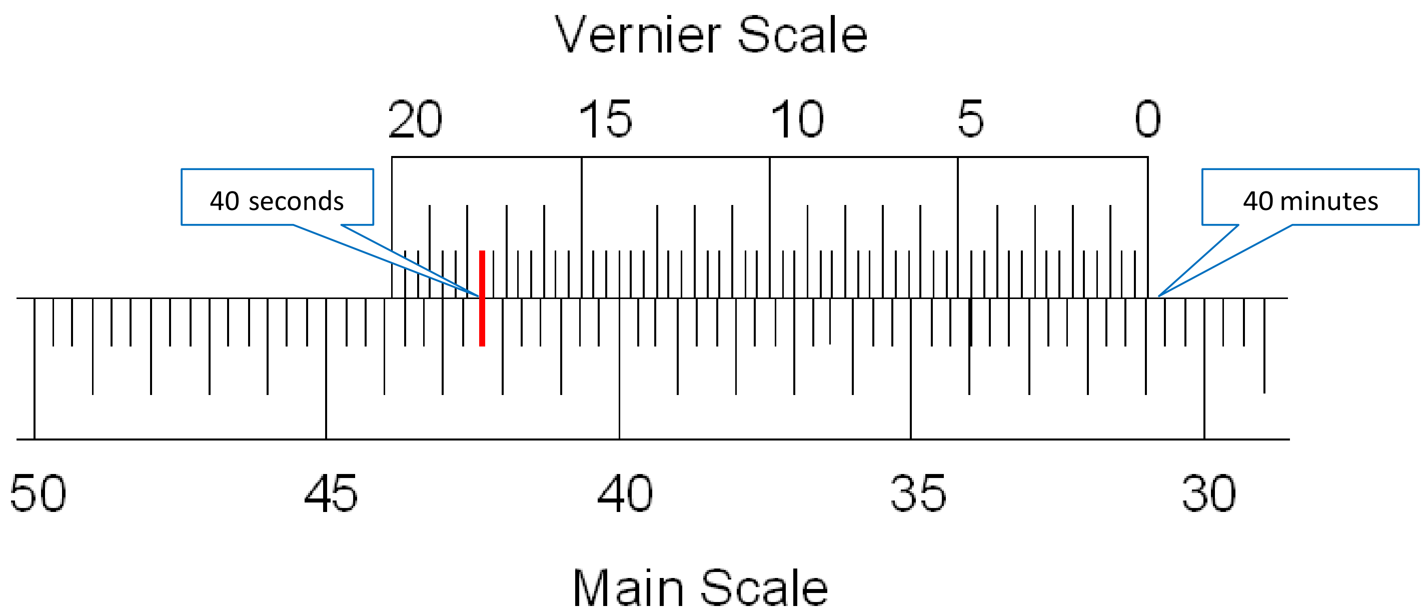
①Press M menu key	M	MENU (1/2) F1 : GATHER DATA F2 : MEAS PROGRAM F3 : MEMORY MGR F4 : CONFIG ↓
②Press the F2 key, enter the Measurement Program.	F2	MEAS PROGRAM F1 : REM F2 : MLM F3 : AREA F4 : ZCOORDINATE ↓
③Press F3 (AREA) key	F3	AREA MEASURE F1 : FILE DATA F2 : MEASURE
Press F1 (FILE DATA) key	F1	SELECT A FILE FN: BACK LIST NUMB
Enter file name or press F2 for LIST. Press ENT key, Initial display will be shown .	Enter File name ENT	DATA NUMBER 1 PT# : DATA 01 S = m^2 BACK LIST NUMB NEXT
⑥Press F4 (NEXT) key The top of the file data (DATA-01) will be set and the second point number	F4	DATA NUMBER 2 PT# : DATA 02 S = m^2 BACK LIST NUMB NEXT

will be shown.		
Repeat pressing [F4] (NEXT) key to set required number of the points. When 3 points are set, the area surrounded by the points is calculated and the result will be shown.	[F4]	
* To set the required point number, press [F1] (PT#) key. * To show the list of the coordinate data in the file, press [F2] (LIST) key.		

2) Area calculation from measured data

Operation procedure	Operation	Display
①Press [M] menu key	[M]	
②Press the [F2] key, enter the Measurement Program.	[F2]	

③Press F3 (AREA) key	F3	AREA MEASURE F1 : FILE DATA F2 : MEASURE
Press the F2 (MEASUREMENT) key	F2	PSM -30 PPM 0.0 DATA NUM 0 S = m² MEAS
Collimate a target or prism and press the F1 (MEAS) key. Measuring starts *	Collimate Prism F1	PSM -30 PPM 0.0 N : 365.332 m E : 15.300 m Z : 1.230 m MEAS YES
Press the F4 key to affirm	F4	PSM -30 PPM 0.0 DATA NUM 1 S = m² MEAS
⑦ Collimate a next prism and press F1 (MEAS) key. When 3 points are set, the area surrounded by the points is calculated and the result will be shown.	Collimate F1	PSM -30 PPM 0.0 DATA NUM 3 S = 125.693 m² MEAS
*1 Measurement is N-time measurement mode.		



	o	’	”
Main Scale	30	40	
Vernier Scale		17	40
Reading	**30**	**57**	**40**

Theodolite Surveying

Measuring Horizontal Distance using **Repetition Method**

Instrument at	Sighted To	Angle	Scale - A			Scale - B		Mean Reading			Angle		
			°	′	″	′	″	°	′	″	°	′	″
Face Left													
O	P	POQ	0	0	0	0	0	0	0	0			
	Q												
O	P	POQ											
	Q												
O	P	POQ											
	Q												
Face Right													
O	P	POQ	0	0	0	0	0	0	0	0			
	Q												
O	P	POQ											
	Q												
O	P	POQ											
	Q												
										Average Angle			

Theodolite Surveying

Measuring Horizontal Distance using **Reiteration Method**

Instrument at	Sighted To	Angle	Scale - A			Scale - B		Mean Reading			Angle		
			°	′	″	′	″	°	′	″	°	′	″
Face Left													
O	A		0	0	0	0	0	0	0	0			
	B	AOB											
	C	BOC											
	D	COD											
	A	DOA											
Face Right													
O	A		0	0	0	0	0	0	0	0			
	B	AOB											
	C	BOC											
	D	COD											
	A	DOA											

Result:

Angle	Face Left			Face Right			Average		
	°	′	″	°	′	″	°	′	″
AOB									
BOC									
COD									
DOA									

Theodolite Surveying

Measurement of Height of an object when base is accessible

Instrument at	Reading on B.M.	Face	Sighted To	Angle	Scale - C			Scale - D		Angle			Average Angle		
					°	′	″	′	″	°	′	″	°	′	″
P		Face Left	Q	α_1											
		Face Right	Q	α_1											

Measurement of Height of an object when base is inaccessible

Instrument at	Reading on B.M.	Face	Sighted To	Angle	Scale - C			Scale - D		Angle			Average Angle		
					°	′	″	′	″	°	′	″	°	′	″
P		Face Left	Q	α_1											
		Face Right	Q	α_1											
R		Face Left	Q	α_2											
		Face Right	Q	α_2											

SURVEYING LAB II

VIVA VOCE

Theodolite

1. What is Theodolite?
2. Uses of Theodolite?
3. Types of Theodolite?
4. What are major components of Theodolite?
5. What is Line of Collimation?
6. What is Transiting?
7. What is Swinging of Telescope?
8. What are Face Left and Face Right?
9. What are temporary adjustments?
10. What is Parallax? How do you eliminate Parallax?
11. What is the least count of Theodolite?
12. What is the difference between Dumpy Level and Theodolite?
13. What is deflection angle? How do you measure with Theodolite?
14. List out various methods of measurement of Horizontal Angle?
15. What is Trigonometric Leveling
16. List out various problems encountered in Trigonometric Leveling?
17. Say true or false: The maximum angle that can be measured with the vertical circle is 180^{o}.
18. What do you mean by “Staff held normal”?
19. What is the difference between fixed hair method and movable hair method?
20. What is the difference between staff intercept and stadia intercept?
21. What is tacheometry?
22. What are Tacheometric constants?
23. What is anallactic lens? Why it is used?
24. For finding the elevation of an inaccessible object, which survey will you recommend?

Curves

25. Types of Horizontal Curves?
26. Elements of Simple Circular Curve?
27. List out various methods used in Curve Setting?
28. What is the degree of curve?
29. What is the name for starting point of a curve?

30. What is the name for ending point of a curve?
31. What is difference between sub-chord and normal chord?
32. What do you mean by back tangent?
33. Which method is simple – Rankine's method or Double theodolite method? Justify.

Total Station

34. What is Total Station?
35. Major components of Total Station?
36. Uses of Total Station?
37. What is the Least of Count of Total Station?
38. Nowadays targets are not necessary for doing surveying. Is it true?