DEPARTMENT OF CIVIL ENGINEERING

Land Survey Practice-II

Lab Manual

(FOR 6TH SEMESTER CIVIL ENGINEERING STUDENTS UNDER
SCTE&VT,ODISHA,BHUBANESWAR)

JHARSUGUDA ENGINEERING SCHOOL,JHARSUGUDA

Department of Civil Engineering

VISION

To produce competent and capable Civil Engineering students by imparting excellent quality and skill based technical education, moral values and ethics for serving the society.

MISSION

- To provide knowledge of various Civil Engineering aspects and skill based practices with modern technique and methods in collaboration with industry by providing state-of-the-art lab facilities pertaining to the curriculum on par with the best to make future Civil Engineers.
- To inculcate ethical values & professionalism among the students.
- To promote the spirit of enquiry, innovation, life skills and to encourage entrepreneurship.

Non - stadia systems

This method of surveying is primarily based on principles of trigonometry and thus telescopes without stadia diaphragm are used. This system comprises of two methods:

(i) Tangential method and (ii) Subtense bar method.

Fixed-hair method or Stadia method

It is the most prevalent method for tacheometric surveying. In this method, the telescope of the theodolite is equipped with two additional cross hairs, one above and the other below the main horizontal hair at equal distance. These additional cross hairs are known as stadia hairs. This is also known as tacheometer.

Principle of Stadia method

(Figure 23.1) A tacheometer is temporarily adjusted on the station P with horizontal line of sight. Let a and b be the lower and the upper stadia hairs of the instrument and their actual vertical separation be designated as i. Let f be the focal length of the objective lens of the tacheometer and c be horizontal distance between the optical centre of the objective lens and the vertical axis of the instrument. Let the objective lens is focused to a staff held vertically at Q, say at horizontal distance D from the instrument station.

By the laws of optics, the images of readings at A and B of the staff will appear along the stadia hairs at a and b respectively. Let the staff interval i.e., the difference between the readings at A and B be designated by s. Similar triangle between the object and image will form with vertex at the focus of the objective lens (F). Let the horizontal distance of the staff from F be d. Then, from the similar Δs ABF and a' b' F,

$$\frac{AB}{d} = \frac{a'b'}{f}$$

$$\text{Or, } d = \frac{AB}{a'b'} \times f = \frac{s}{i} \times f$$

$$\therefore d = \frac{f}{i} \cdot s$$

as a' b' = ab = i. The ratio (f / i) is a constant for a particular instrument and is known as stadia interval factor, also instrument constant. It is denoted by K and thus

$d = K.s$ ---------------------------- Equation (23.1)

The horizontal distance (D) between the center of the instrument and the station point (Q) at which the staff is held is d + f + c. If C is substituted for (f + c), then the horizontal distance D from the center of the instrument to the staff is given by the equation

$D = Ks + C$ ---------------------------- Equation (23.2)

The distance C is called the stadia constant. Equation (23.2) is known as the stadia equation for a line of sight perpendicular to the staff intercept.

Determination of Tacheometric Constants

The stadia interval factor (K) and the stadia constant (C) are known as tacheometric constants.

Before using a tacheometer for surveying work it is required to determine these constants. These can be computed from field observation by adopting following procedure.

Step 1 : Set up the tacheometer at any station say P on a flat ground.

Step 2 : Select another point say Q about 200 m away. Measure the distance between P and Q accurately with a precise tape. Then, drive pegs at a uniform interval, say 50 m, along PQ. Mark the peg points as 1, 2, 3 and last peg-4 at station Q

Step 3 : Keep the staff on the peg-1, and obtain the staff intercept say s_1 .

Step 4 : Likewise, obtain the staff intercepts say s_2, when the staff is kept at the peg-2,

Step 5 : Form the simultaneous equations, using Equation (23-2)

$D_1 = K.s_1 + C$ -------------(i)

and $D_2 = K.s_2 + C$ -------------(ii)

Solving Equations (i) and (ii), determine the values of K and C say K_1 and C_1 .

Step 6 : Form another set of observations to the pegs 3 & 4, Simultaneous equations can be obtained from the staff intercepts s_3 and s_4 at the peg-3 and point Q respectively. Solving those equations determine the values of K and C again say K_2 and C_2.

Step 7 : The average of the values obtained in steps (5) and (6), provide the tacheometric constants K and C of the instrument.

Anallactic Lens

It is a special convex lens, fitted in between the object glass and eyepiece, at a fixed distance from the object glass, inside the telescope of a tacheometer. The function of the anallactic lens is to reduce the stadia constant to zero. Thus when tacheometer is fitted with anallactic lens, the distance measured between instrument station and staff position (for line of sight perpendicular to the staff intercept) becomes directly proportional to the staff intercept. Anallactic lens is provided in external focusing type telescopes only.

Inclined Stadia Measurements

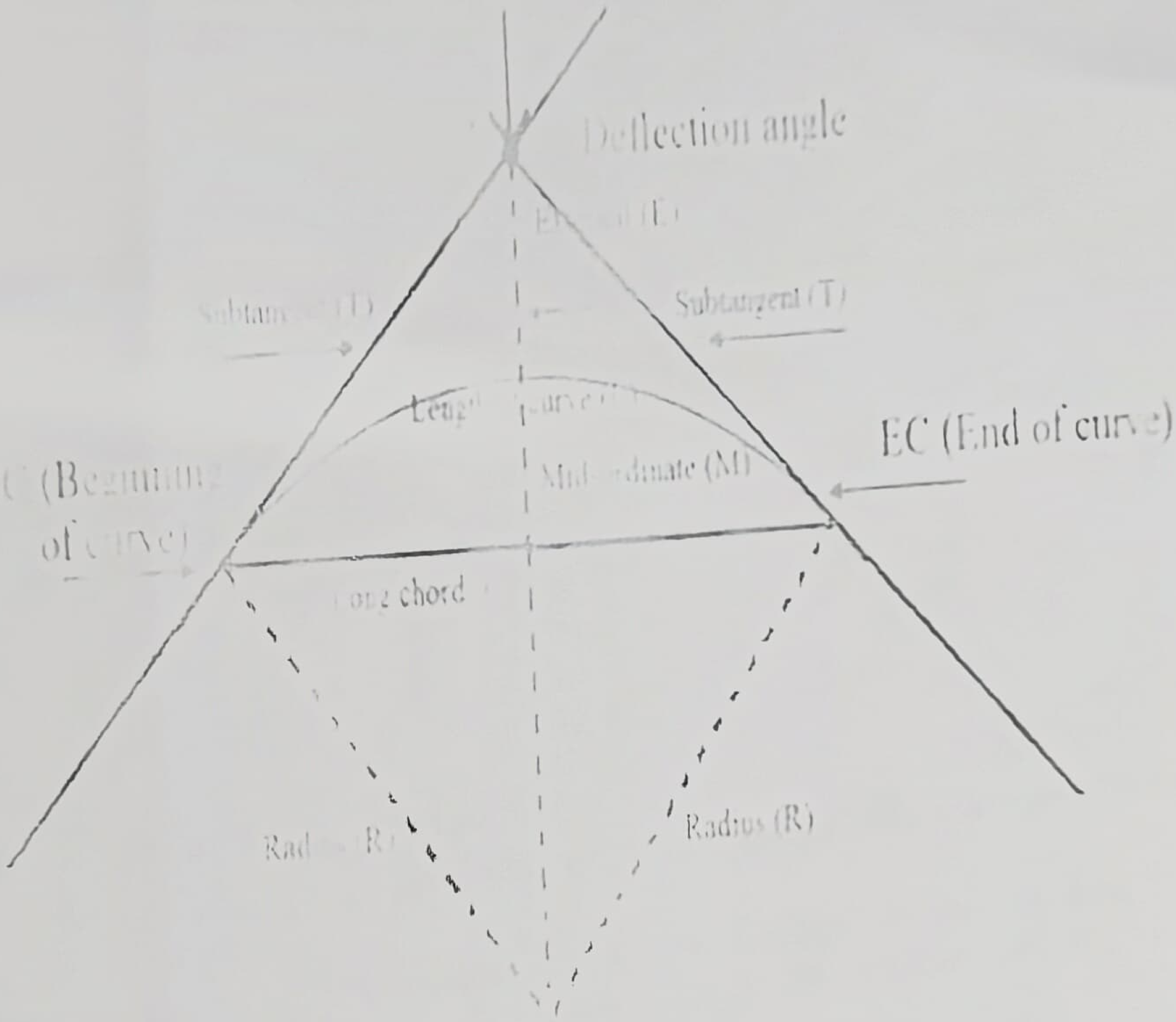
It is usual that the line of sight of the tacheometer is inclined to the horizontal. Thus, it is frequently required to reduce the inclined observations into horizontal distance and difference in elevation.

Let us consider a tacheometer (having constants K and C) is temporarily adjusted on a station, say P (Figure 23.2). The instrument is sighted to a staff held vertically, say at Q. Thus, it is required to find the horizontal distance PP' (= H) and the difference in elevation P'Q. Let A, R and B be the staff points whose images are formed respectively at the upper, middle and lower cross hairs of the tacheometer. The line of sight, corresponding to the middle cross hair, is inclined at an angle of elevation θ and thus, the staff with a line perpendicular to the line of sight. Therefore A'B' = AB cos θ = s cos θ where s is the staff intercept AB. The distance D (= OR) is C + K. scos θ (from Equation 23.2). But the distance OO_1 is the horizontal distance H, which equals OR cos θ. Therefore the horizontal distance H is given by the equation.

$H = (Ks \cos\theta + C) \cos\theta$

Or $H = Ks \cos^2\theta + C \cos\theta$ ---------------------- Equation (23.3)

in which K is the stadia interval factor (f/i), s is the stadia interval, C is the stadia constant (f + c), and θ is the vertical angle of the line of sight read on the vertical circle of the transit.



Simple curve

Simple curves Types of curves in surveying

Compound curve

This is a curve that is comprised of a series of two or more simple curves of different radius turning in the same general direction. This type of curve is used to avoid cutting or filling. They become advantages when a road has to be placed to fit ground, like a layout between a river and a cliff, when the bend has to follow a specified path.

1.5. SETTING OUT SIMPLE CURVES

The methods of setting out curves can be mainly divided into two heads depending upon instruments used :

(1) *Linear methods*. In the linear methods, only a chain or tape is used. Linear methods are used when (*a*) a high degree of accuracy is not required, (*b*) the curve is short.

(2) *Angular methods*. In angular method, an instrument such as a theodolite is used with or without a chain (or tape).

Before a curve is set out, it is essential to locate the tangents, points of intersection (P.I.), point of the curve (P.C.) and point of tangency (P.T.).

Location of tangent. Before setting out the curve, the surveyor is always supplied with a working plan upon which the general alignment of tangent is known in relation to the traverse controlling the survey of that area. Knowing offsets to certain points on both the tangents, the tangents can be staked on the ground by the tape measurements. The tangents may then be set out by theodolite by trial and error so that they pass through the marks as nearly as possible. The total deflection angle (Δ) can then be measured by setting the theodolite on the P.I.

Location of tangent points. After having located the P.I. and measured Δ, the tangent length (T) can be calculated from equation 1.5. *i.e.*,

$$T = R \tan \frac{\Delta}{2}$$

The point T_1 (Fig. 1.2) can be located by measuring back a distance $VT_1 = T$ on the rear tangent.

Similarly, the point T_2 can be located by measuring a distance $VT_2 = T$ on the forward tangent.

Knowing the chainage of P.I., the chainage of point T_1 can be known by subtracting the tangent length from it. The length of the curve is then added to the chainage of T_1 to get the chainage of T_2. The tangent points must be located with greater precision.

Peg Interval. For the ease in calculations and setting out, it is essential that the pegs on the curve are at regular interval from the begining to the end. Such interval is known as *peg interval* and the chord joining two such adjacent pegs is known as the *full chord or normal chord.* The length of the normal chord is generally taken equal to 100 ft in English units or 20 metres, in metric units, so that angle subtended by the normal chord at the centre is equal to the degree of the curve. The stations having the chainages in the multiples of chain lengths are known as *full stations.* Except by chance, the tangent points will not be full stations (*i.e.*, their chainages will not be multiples of full chains). The distance between the point T_1 and the first peg will be less than the length of the normal chord so that the first peg may be a full station. Thus, the first chord joining the point of curve T_1 to the first peg will be a *sub chord.* Similarly, the last chord, joining the last peg on the curve and the tangent point T_2 will be a sub-chord. All other intermediate chords will be normal chords or units chords. Thus, if the chainage of T_1 is n chains + m links, the first chord length will be the remaining portion of the chain length *i.e.*, $(100 - m)$ links. Similarly, if the chainage of T_2 is n' chains + m' links, the last chord length will be m' links.

The length of the normal or unit chord should be so selected that there is no appreciable difference between the length of the chord and the arc. If the length of the chord is not greater than one-tenth of the radius, it will give sufficiently accurate results, the error being 8 mm in 20 m. For more accurate results, the length of normal chord should be limited to 1/20 of the radius so that the error is only 2 mm in 20 m.

Linear methods of Setting Out

Following are some of the linear methods for setting out simple circular curves :

(1) By ordinates or offsets from the long chord.

(2) By successive bisection of arcs.

(3) By offsets from the tangents.

(4) By offsets from chords produced (or by deflection distances).

Location of tangent points. If an angle measuring instrument is not available, the following procedure may be adopted for the location of tangent points (Fig. 1.4) :

(1) Produce two straights to meet at V.

(2) Select two inter-visible points E and G on the two straights, equidistant from V. VE and VG should be as long as possible.

(3) Join EG, measure it and bisect it at F. Join VF and measure it.

From similar triangles, VEF and VT_1O we have

$$\frac{VT_1}{OT_1} = \frac{VF}{EF}$$

$$\therefore \quad VT_1 = T = \frac{VF}{EF} \cdot OT_1 = \frac{VF}{EF} \cdot R$$

Thus, the tangent poins T_1 and T_2 can be located by measuring VT_1 and VT_2 each equal to T along the straights.

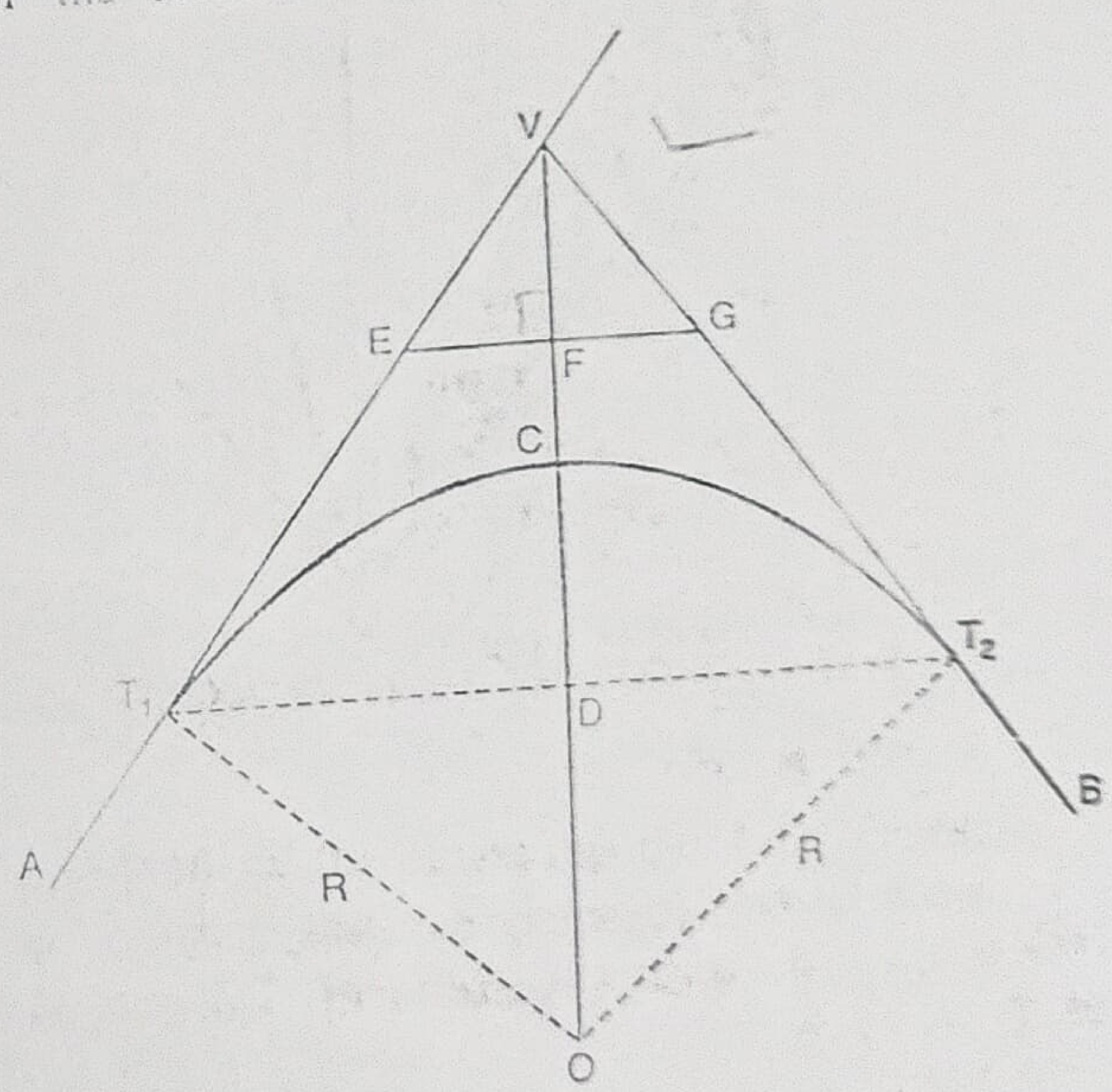


FIG. 1.4. LOCATION OF TANGENT POINTS.

1.6. BY ORDINATES FROM THE LONG CHORD : (Fig. 1.5)

Let

R = Radius of the curve.

O_0 = Mid-ordinate.

O_x = Ordinate at distance x from the mid-point of the chord.

T_1 and T_2 = Tangent points.

L = Length of the long chord actually measured on the ground.

Bisect the long chord at point D.

From triangle OT_1D,

$$OT_1^2 = T_1D^2 + DO^2$$

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

or

$$(R - O_0) = \sqrt{R^2 - \text{[illegible]}}$$

2. Join T_1C and T_2C and bisect them at D_1 and D_2 respectively. At D_1 and D_2, set out perpendicular offsets $C_1D_1 = C_2D_2 = R\left(1 - \cos\frac{\Delta}{4}\right)$ to get points C_1 and C_2 on the curve.

3. By the successive bisection of these chords, more points may be obtained.

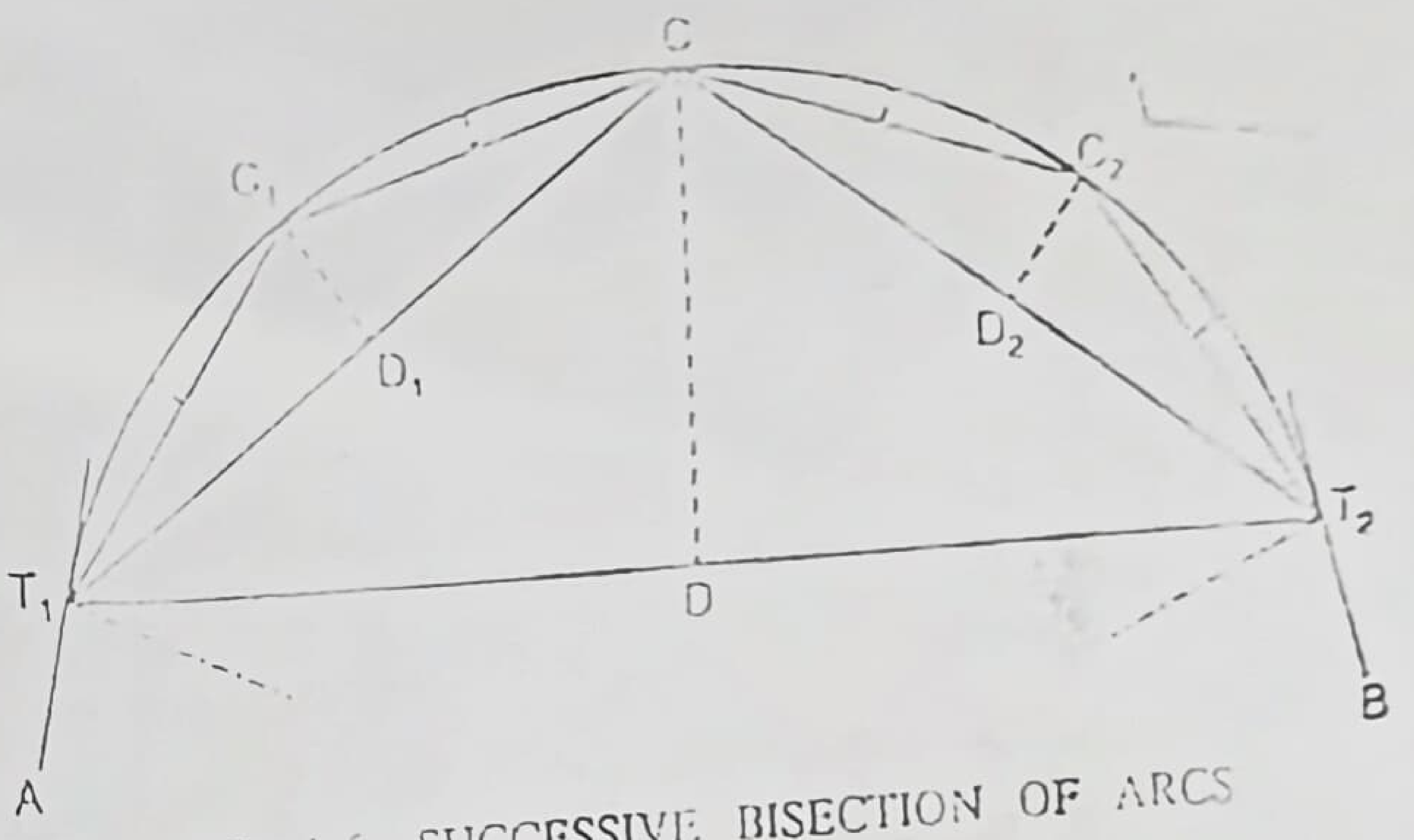


FIG. 1.6. SUCCESSIVE BISECTION OF ARCS

1.8. BY OFFSETS FROM THE TANGENTS

If the deflection angle and the radius of curvature are both small, the curves can be set out by offsets from the tangent. The offsets from the tangents can be of two types:

(i) Radial offsets (ii) Perpendicular offsets.

(i) Radial Offsets (Fig. 1.7)

Let O_x = Radial offset DE at any distance x along the tangent

$$T_1D = x$$

From triangle T_1DO,

$$DO^2 = T_1O^2 + T_1D^2$$

or $$(DE + EO)^2 = T_1O^2 + T_1D^2$$

or $$(O_x + R)^2 = R^2 + x^2$$

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

....(exact) ..(1.12)

In order to get an approximate expression for O_x, expand $\sqrt{R^2 + x^2}$. Thus,

$$O_x = R\left[1 + \frac{x^2}{2R^2} - \frac{x^4}{8R^4} + \ldots\right] - R$$

Neglecting the other terms except the first two, we get

$$O_x = R + \frac{x^2}{2R} - R$$

$$O_x = \frac{x^2}{2R} \quad \text{...(approx.)}$$

...(1.12 (a))

When the radius is large, the above approximate expression can also be obtained as under

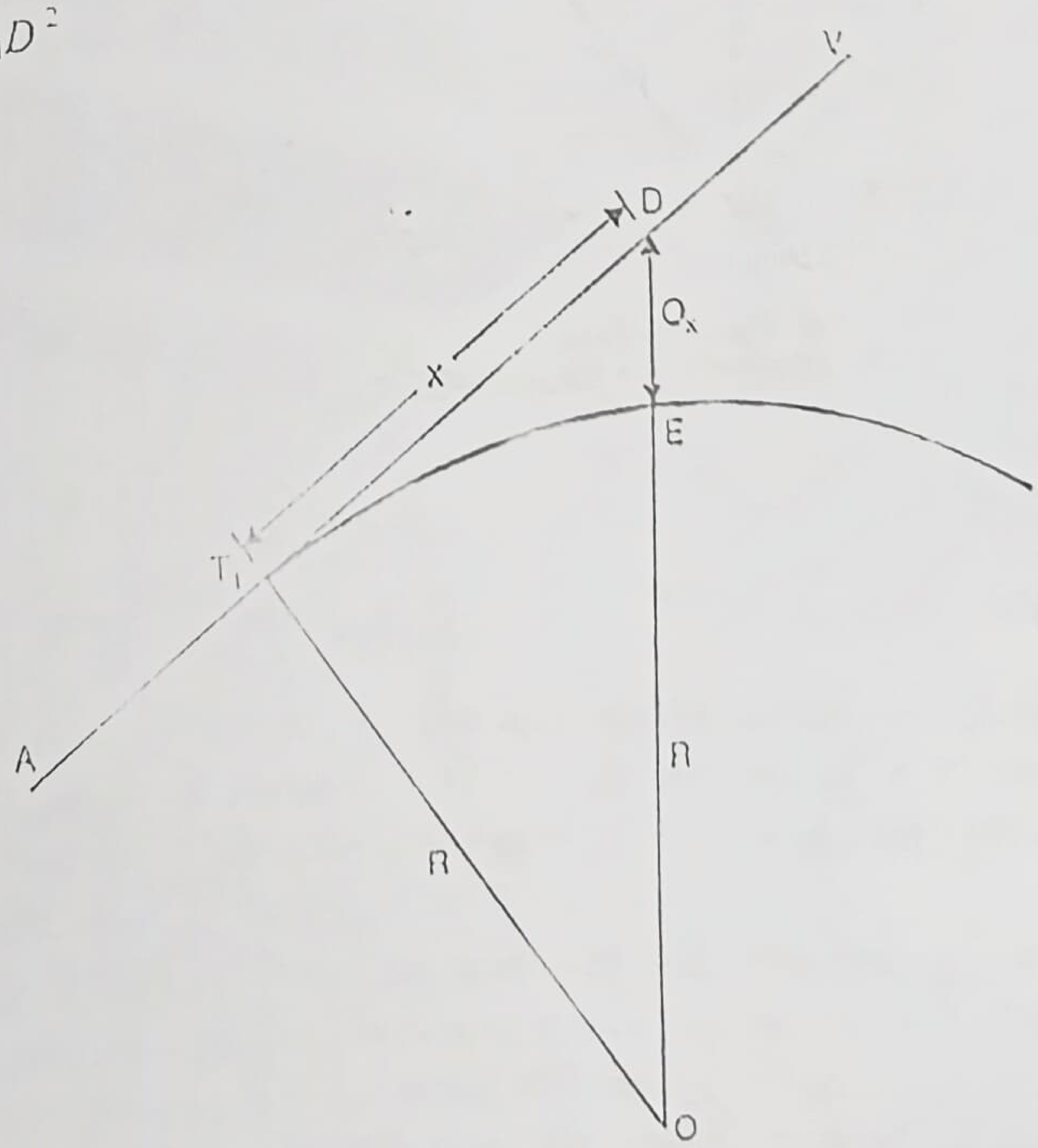


FIG. 1.7 SETTING OUT BY RADIAL OFFSETS.

or $O_o = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$ ...(1.9)

In order to calculate the ordinate O_x to any point E, draw the line EE_1 parallel to the long chord T_1T_2. Join EO to cut the long chord in G.

Then $O_x = EF = E_1D$

$= E_1O - DO$

$= \sqrt{(E_1O)^2 - (EE_1)^2} - (CO - CD)$

$= \sqrt{R^2 - x^2} - (R - O_o)$ ...(exact) ...(1.10)

To set out the curve, the long chord is divided into an even number of equal parts. Offsets calculated from equation 1.10 are then set out at each of these points.

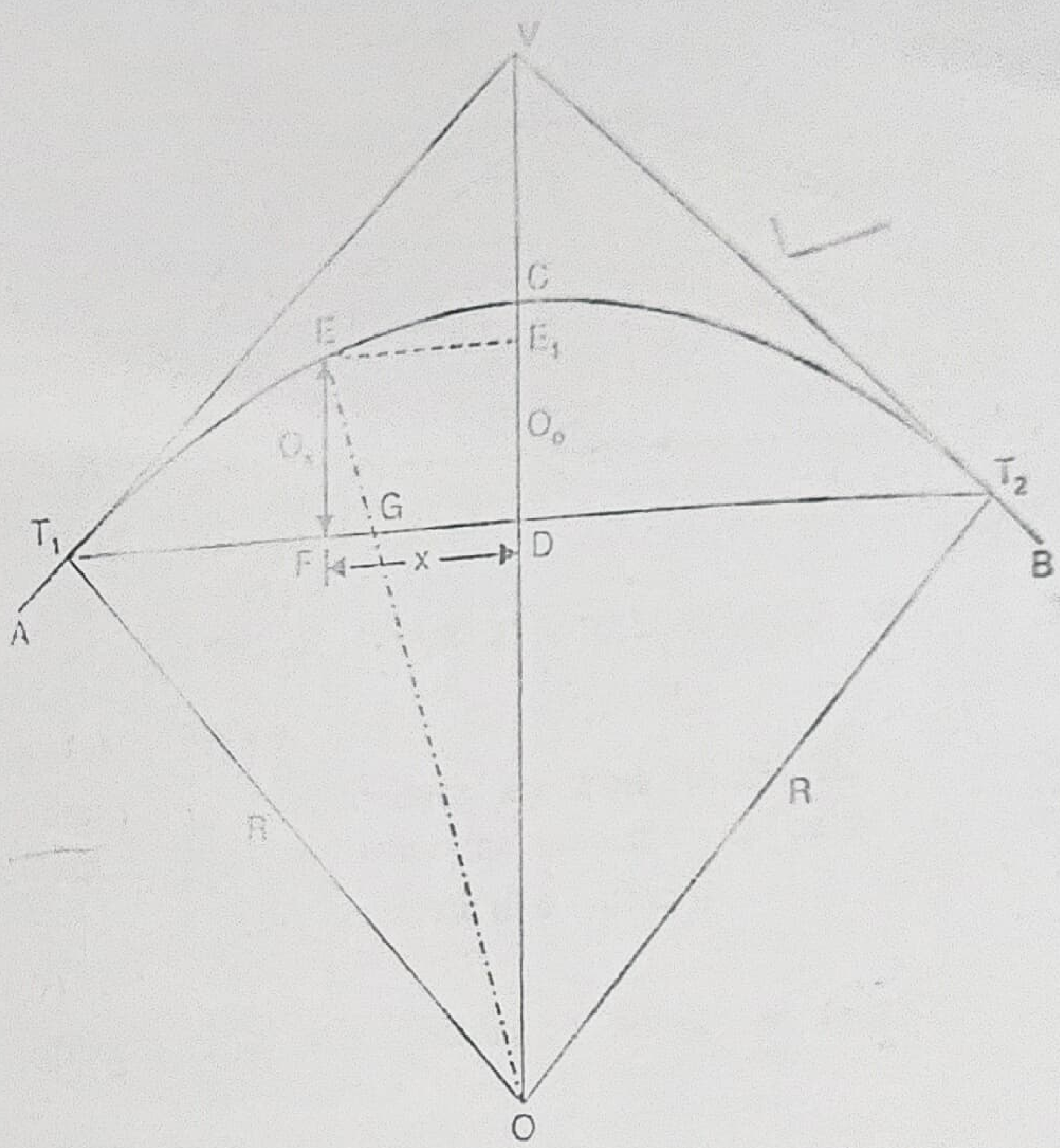


FIG. 1.5. BY ORDINATES FROM THE LONG CHORD.

Approximate Method

If the radius of the curve is large as compared to the length of the long chord, the offsets may be approximately calculated by assuming that the perpendicular ordinate EF (*i.e.* O_x) is approximately equal to the radial ordinate EG. Then taking $T_1F = x$ measured from T_1 we have

$$EG \times 2R = T_1F \times FT_2$$

or

$$O_x \times 2R = x\,(L - x)$$

$$O_x = \frac{x\,(L - x)}{2R} \quad \text{...(approx).} \qquad \text{...(1.11)}$$

It should be clearly noted that the distance x in this method is measured from the tangent point T_1, while it is measured from the mid-point of the chord in the previous case (equation 1.10).

1.7. BY SUCCESSIVE BISECTION OF ARCS OR CHORDS

Procedure (Fig. 1.6)

1. Join the tangent points T_1, T_2 and bisect the long chord at D. Erect the perpendicular DC and make it equal to the *versed sine* of the curve. Thus,

$$CD = R\left(1 - \cos\frac{\Delta}{2}\right) = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$T_1D^2 = DE(2R + DE)$$

or $$x^2 = O_x(2R + O_x)$$

Neglecting O_x in comparison to $2R$, we get

$$O_x = \frac{x^2}{2R} \quad \text{...(approximate)}$$

(iii) Perpendicular Offsets (Fig. 1.8)

Let: $DE = O_x$ = Offset perpendicular to the tangent

$T_1D = x$, measured along the tangent

Draw EE_1 parallel to the tangent.

From triangle EE_1O, we have

$$E_1O^2 = EO^2 - E_1E^2$$

or $$(T_1O - T_1E_1)^2 = EO^2 - E_1E^2$$

or $$(R - O_x)^2 = R^2 - x^2$$

From which, $O_x = R - \sqrt{R^2 - x^2}$ ...(exact) ...(1.13)

The corresponding approximate expression for O_x may be obtained by expanding the term $\sqrt{R^2 - x^2}$. Thus,

$$O_x = R - R\left(1 - \frac{x^2}{2R^2} - \frac{x^4}{8R^4} \cdots\cdots\right)$$

Neglecting the other terms except the first two of the expansion

$$O_x = R - R + \frac{x^2}{2R}$$

or $$O_x = \frac{x^2}{2R} \quad \text{...[1.13 (a)]}$$

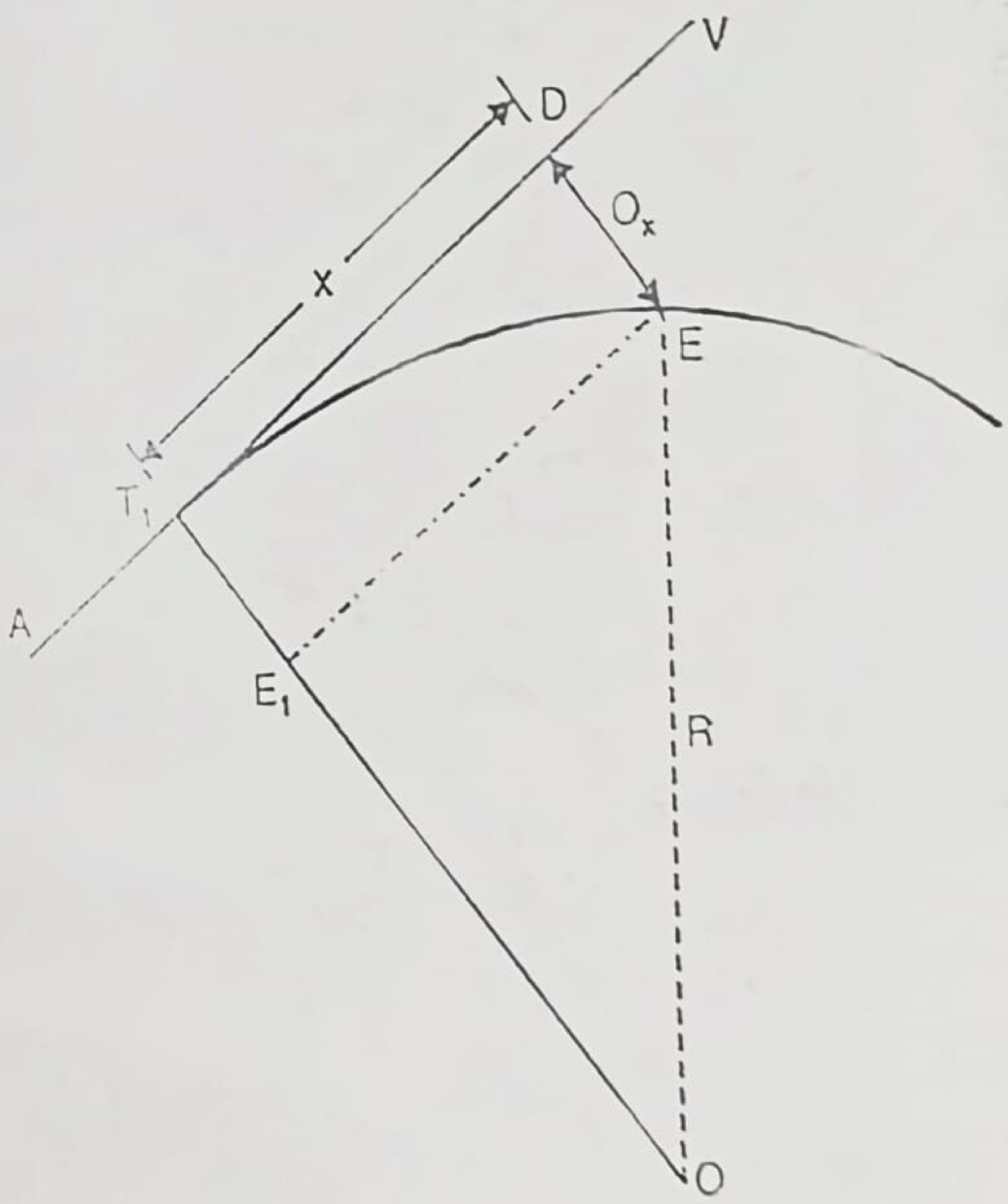


FIG. 1.8. SETTING OUT BY PERPENDICULAR OFFSETS

It should be noted that if the curve is set out by the approximate expression given above, the points on the curve will lie on a parabola and not on the arc of a circle. However, if the versed sine of the curve is less than one-eighth of its chord, the curve approximates very closely to a circle.

To set out the curve, distances x_1, x_2, x_3,....etc., are measured from the first tangent point along the tangent and the perpendicular offsets calculated above are erected with the help of an optical square at the corresponding points. When the distace x increases, the offsets become too large to set out accurately. In that case, the central position of the curve may be set out from a third tangent drawn through the apex of the curve.

The method is useful for small curves only.

1.9. BY DEFLECTION DISTANCES (OR OFFSETS FROM THE CHORDS PRODUCED)

The method is very much useful for long curves and is generally used on highway curves when a theodolite is not available.

Let T_1A = T_1A = initial sub-chord C_1

A, B, D etc. = points on the curve

$AB = C_2$

$BD = C_3$ etc.

T_1V = Rear Tangent

$\angle VT_1A = \delta$ = deflection angle of the first chord

$A_1A = O_1$ = first offset

$B_1B = O_2$ = second offset

$D_1D = O_3$ = third offset, etc.

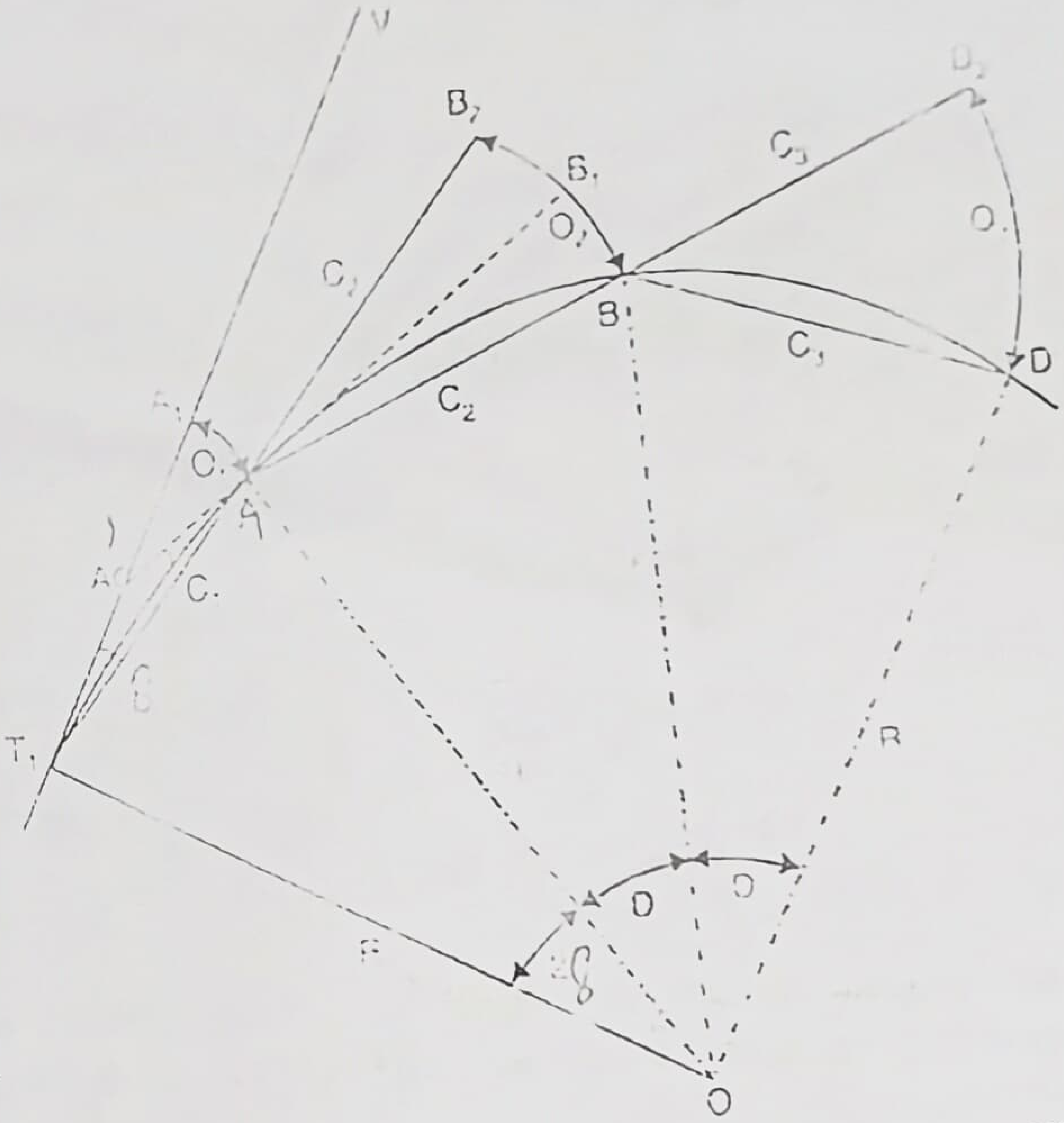


FIG. 1.9. SETTING OUT THE CURVE BY DEFLECTION DISTANCES.

Now arc $A_1A = O_1 = T_1A \cdot \delta$ ...(i)

Since T_1V is the tangent to the circle at T_1

$$\angle T_1OA = 2\angle A_1T_1A = 2\delta$$

Arc $$T_1A = R \cdot 2\delta$$

$$\delta = \frac{T_1A}{2R}$$ ...(ii)

Substituting the value of δ in (i), we get

$$\text{Arc } A_1A = O_1 = T_1A \cdot \frac{T_1A}{2R} = \frac{T_1A^2}{2R}$$

Taking arc T_1A = chord T_1A (very nearly), we get

$$O_1 = \frac{C_1^2}{2R}$$ ...[1.14 (a)]

In order to obtain the value of the second offset O_2 for getting the point B on the curve, draw a tangent AB_1 to the curve at A to cut the rear tangent in A'. Join T_1A and prolong it to a point B_2 such that $AB_2 = AB = C_2$ = length of the second chord. Then $O_2 = B_2B$ ...(iii)

As from equation 1.14 (a), the offset B_1B from the tangent AB_1 is given by

$$B_1B = \frac{C_2^2}{2R}$$

Again, $\angle B_2AB_1 = \angle A'AT_1$ being opposite angles.

Since T_1A' and $A'A$ are both tangents, they are equal in length.

$$\angle A'T_1A = \delta = \angle A'AT_1$$

$$\therefore \angle B_2AB_1 = \angle A'AT_1 = \delta$$

$$\text{arc } B_2B_1 = AB_2 \cdot \delta = C_2 \cdot \delta$$

Substituting the value of δ from (iii), we get

$$B_2B_1 = C_2 \cdot \frac{T_1A}{2R} = \frac{C_2 \cdot C_1}{2R} \quad ...(iv)$$

$$\text{arc } B_2B = B_2B_1 + B_1B$$

or

$$O_2 = \frac{C_2C_1}{2R} + \frac{C_2^2}{2R} = \frac{C_2}{2R}(C_1 + C_2) \quad ...[1.14\ (b)]$$

Similarly, the third offset $O_3 = D_2D$ is given by

$$O_3 = \frac{C_3}{2R}(C_2 + C_3)$$

The last or nth offset is given by

$$O_n = \frac{C_n}{2R}(C_{n-1} + C_n) \quad ...[1.14\ (c)]$$

Generally, the first chord is a sub-chord, say of length c, and the intermediate chords are normal chords, say of length C. In that case, the above formulae reduce to

$$O_1 = \frac{c^2}{R}$$

and

$$O_2 = \frac{C}{2R}(c + C) \quad ...[1.14\ (d)]$$

$$O_3 = O_4 = ... O_{n-1} = \frac{C}{2R}(2C) = \frac{C^2}{R} \quad ...[1.14\ (e)]$$

and

$$O_n = \frac{c'}{2R}(C + c') \quad ...[1.14\ (f)]$$

where c' is the last sub-chord.

Procedure for Setting Out the Curve

(1) Locate the tangent points T_1 and T_2 and find out their chainages as explained earlier. Calculate the length (c) of the first sub-chord so that the first peg is the full station.

(2) With zero mark at T_1, spread the chain (or tape) along the first tangent to point A_1 on it such that $T_1A_1 = c$ = length of the first sub-chord.

(3) With T_1 as centre and T_1A_1 as radius, swing the chain such that the arc A_1A = calculated offset O_1. Fix the point A on the curve.

(4) Spread the chain along T_1A and pull it straight in this direction to point B_2 such that the zero of the chain is at A and the distance $AB_2 = C$ = length of the normal chord.

(5) With zero of the chain centred at A and AB_2 as radius, swing the chain to a point B such that $B_2B = O_2$ = length of the second offset. Fix the point B on the curve.

...pread the chain along AB and repeat the steps (4) and (5) till the point of ...) is reached. All intermediate offsets will be equal to $\frac{C^2}{R}$, while the last offset will be equal to $\frac{c}{2R}(C + c)$.

The last point so fixed must coincide with the point of tangency (T_2) fixed originally by measurements from the vertex. If the discrepancy (sometimes called as the closing error) is more, the curve should be re-set. If the error is less, it should be distributed to all the points by moving them sideways by an amount proportional to the square of their distance from the point T_1.

The method is mostly used in road surveys and is very satisfactory, specially when a theodolite is not available. However, it has a great defect in that the error in fixing points is carried forward.

INSTRUMENTAL METHODS

The following are instrumental methods commonly used for setting out a circular curve :

(1) Rankine's method of tangential (or deflection) angle.

(2) Two theodolite method.

(3) Tacheometric method.

1.10. RANKINE'S METHOD OF TANGENTIAL (OR DEFLECTION) ANGLES

A deflection angle to any point on the curve is the angle at P.C. between the back tangent and the chord from P.C. to that point.

Rankine's method is based on the principle that the deflection angle to any point on a circular curve is measured by one-half the angle subtended by the arc from P.C. to that point. It is assumed that the length of the arc is approximately equal to its chord.

Let us first derive expression for the tangential angles.

Let T_1V = Rear tangent

T_1 = Point to curve (P.C.)

$\delta_1, \delta_2, \delta_3$ = The tangential angles or the angles which each of the successive chords T_1A, AB, BC etc. makes with the respective tangents to the curve at T_1, A, B etc.

$\Delta_1, \Delta_2, \Delta_3 ...$ = Total tangential angles or the deflection angles to the points A, B, C etc.

C_1, C_2, C_3 = Lengths of the chords T_1A, AB, BC...

T_1A = Tangent to the curve at A.

From the property of a circle,

$$\angle VT_1A = \frac{1}{2}\angle T_1OA$$

or $$\angle T_1OA = 2\angle VT_1A = 2\delta_1$$

Now $\frac{\angle T_1OA}{C} = \frac{360°}{2\pi R}$

or $\angle T_1OA = 2\delta = \frac{180° C}{\pi R}$

From which $\delta = \frac{90 C}{\pi R}$ degrees

$= \frac{90 \times 60}{\pi} \frac{C}{R} = 1718.9 \frac{C}{R}$ minutes.

Similarly,

$\delta_2 = 1718.9 \frac{C_2}{R}$; $\delta_n = 1718.9 \frac{C_n}{R}$.

or, in general,

$\delta = 1718.9 \frac{C}{R}$ minutes ...(1.15)

where C is the length of the chord.

For the first chord T_1A, the deflection angle = its tangential angle

or $\Delta_1 = \delta_1$ ...(1)

For the second point B, let the deflection angle be = Δ_2.

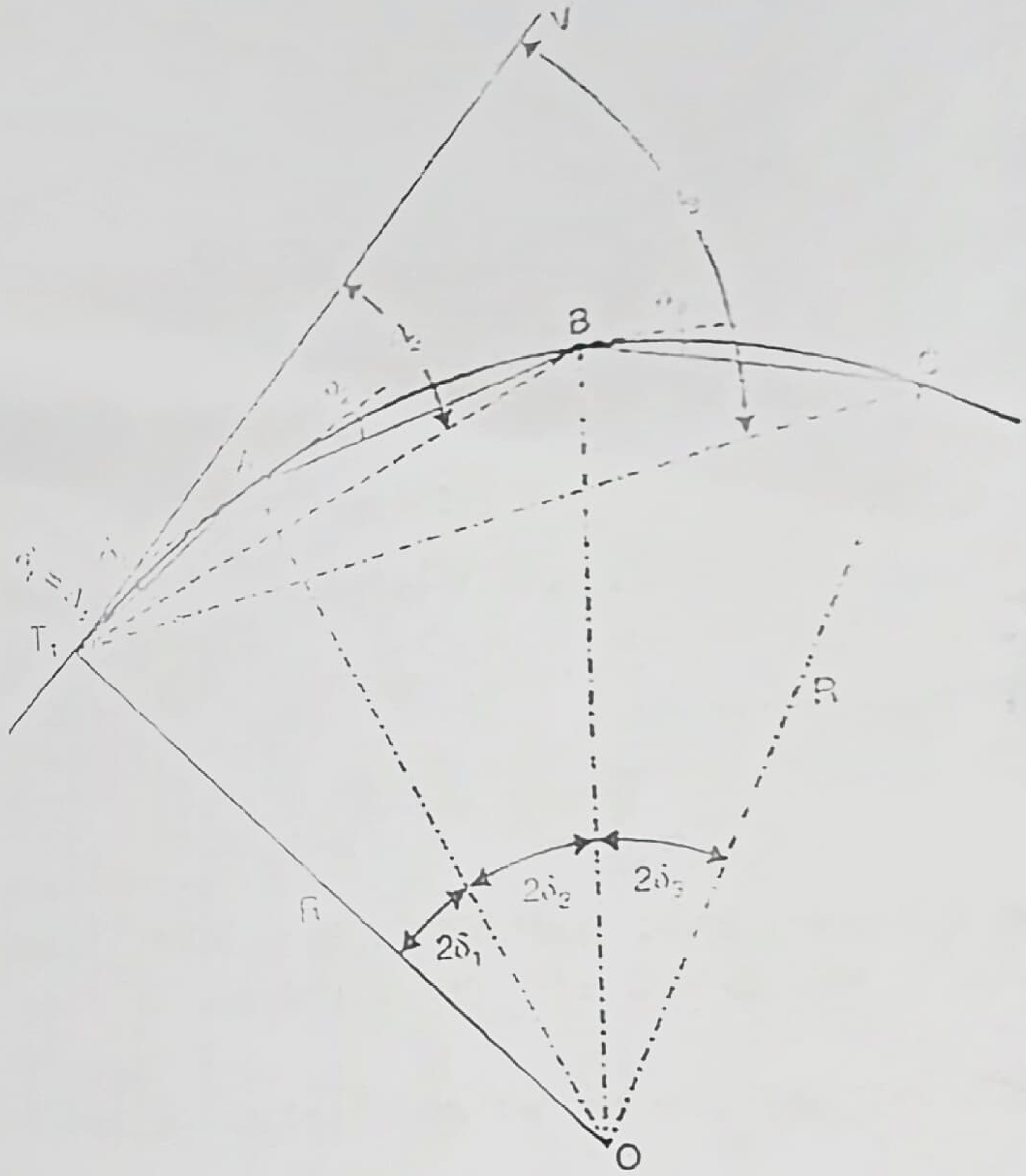


FIG. 1.10. RANKINE'S METHOD OF TANGENTIAL ANGLES.

Since δ_2 = tangential angle for the chord AB,

$\angle AOB = 2\delta_2$

$\angle AT_1B$ = Half the angle subtended by AB at the centre = δ_2

Now $\Delta_2 = \angle VT_1B = \angle A_1T_1A + \angle AT_1B$

$= \delta_1 + \delta_2 = \Delta_1 + \delta_2$ ...(2)

or Similarly, $\Delta_3 = \delta_1 + \delta_2 + \delta_3 = \Delta_2 + \delta_3$ ...(3)

and $\Delta_n = \delta_1 + \delta_2 + \ldots \delta_n = \Delta_{n-1} + \delta_n$ (1.16)

Hence, the deflection angle for any chord is equal to the deflection angle for the previous chord plus the tangential angle for that chord.

Check : Deflection angle of the long chord, *i.e.*,

$\angle VT_1T_2 = \Delta_n = \frac{\Delta}{2}$ where Δ is the intersection angle or the external deflection angle for the curve.

If the degree of the curve is equal to D for a 20 m chord,

$\delta_1 = \delta_2 = \ldots = \delta_{n-1} = \frac{1}{2} D$

Similarly, if c and c' are the first and the last sub-chords

$\delta_1 = \frac{c}{20} \cdot \frac{D}{2} = \frac{cD}{40}$, where c is metres ; $\delta_n = \frac{c'}{20} \cdot \frac{D}{2} = \frac{c'D}{40}$

$$\Delta_1 = \delta_1 = \frac{cD}{40}$$

$$\Delta_2 = \Delta_1 + \delta_2 = \frac{cD}{40} + \frac{1}{2}D$$

$$\Delta_3 = \Delta_2 + \delta_3 = \frac{cD}{40} + \frac{1}{2}D + \frac{1}{2}D = \frac{cD}{40} + D$$

$$\Delta_n = \Delta_{n-1} + \delta_n = \frac{cD}{40} + (n-2)\frac{D}{2} + \frac{c'D}{40}$$

Similarly, if the degree of the curve is equal to D for a 100 ft chord,

$$\delta_1 = \frac{c \times D}{200}, \qquad \delta_2 = \delta_3 = \ldots \delta_{n-1} = \frac{D}{2}$$

$$\delta_n = \frac{c'D}{200}.$$

Procedure for Setting out the Curve

(1) Set the theodolite at the point of curve (T_1). With both 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.

(2) Release the vernier plate and set angle Δ_1 on the vernier. The line of sight is thus directed along chord T_1A.

(3) With the zero end of the tape pointed at T_1 and an arrow held at a distance $T_1A = c$ along it, swing the tape around T_1 till the arrow is bisected by the cross-hairs. Thus, the first point A is fixed.

(4) Set the second deflection angle Δ_2 on the vernier so that the line of sight is directed along T_1B.

(5) 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.

(6) Repeat steps (4) and (5) till the last point T_2 is reached.

Check : The last point so located must coincide with the point of tangency (T_2) fixed independently by measurements from the point of intersection. If the discrepancy is small, last few pegs may be adjusted. If it is more, the whole curve should be reset.

In the case of the left hand curve, each of the calculated values of the deflection angle (i.e. Δ_1, Δ_2 etc.) should be subtracted from 360°. The angles so obtained are to be set on the vernier of theodolite for setting out the curve.

In the above method, three men are required : the surveyor to operate the theodolite, and two chainmen to measure the chord lengths with chain or tape. This method is most frequently used for setting out circular curves of large radius and of considerable length.

Field Notes

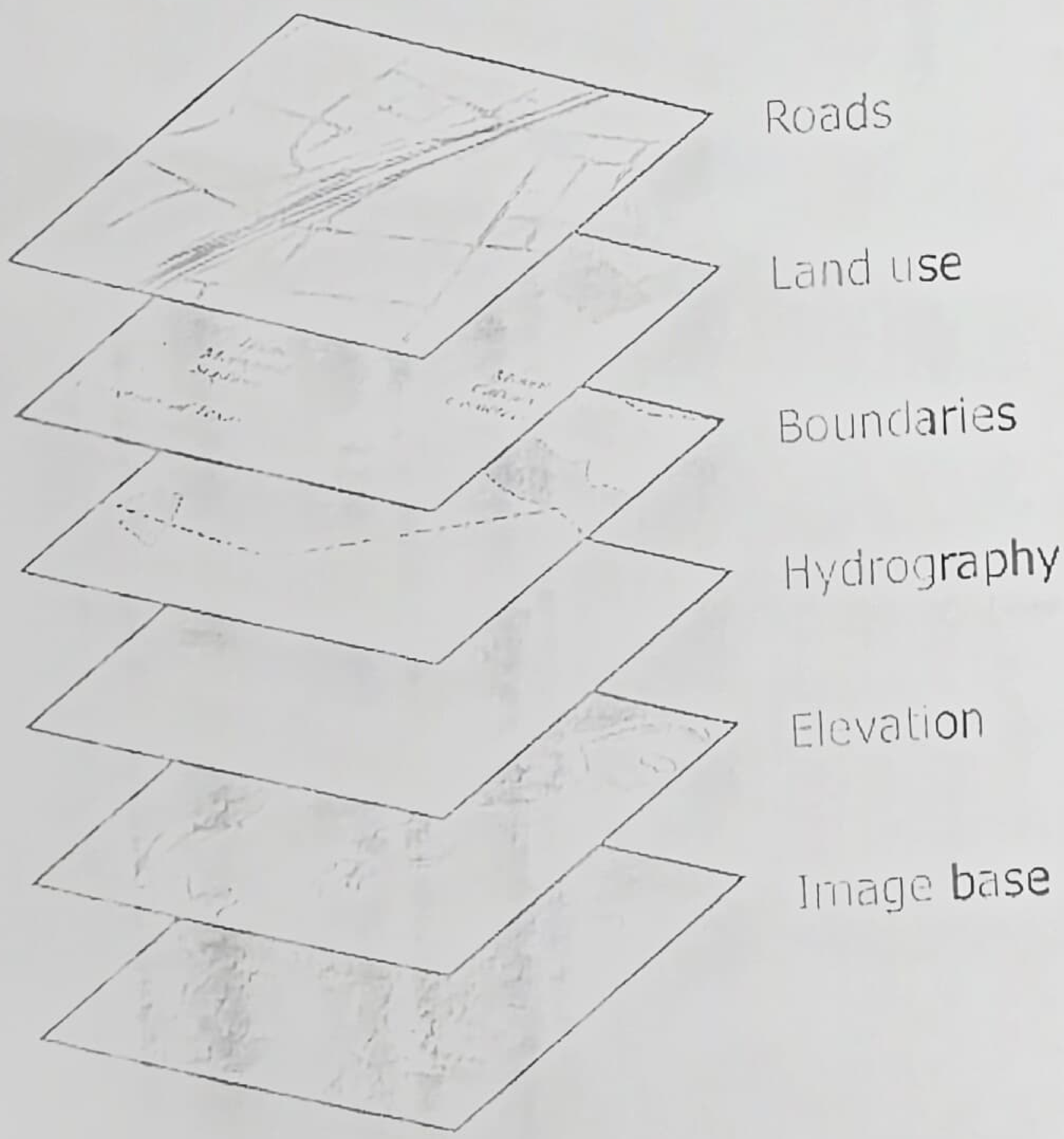
The record of deflection angles for various points is usually kept in the following form (next page) :

Maps

A map is a collection of map elements laid out and organized on a page. Common map elements include the map frame with map layers, a scale bar, north arrow, title, descriptive text, and a symbol legend.

The primary map element is the map frame, and it provides the principal display of geographic information. Within the map frame, geographical entities are presented as a series of map layers that cover a given map extent—for example, map layers such as roads, rivers, place names, buildings, political boundaries, surface elevation, and satellite imagery.

The following graphic illustrates how geographical elements are portrayed in maps through a series of map layers. Map symbols and text are used to describe the individual geographic elements.



Map layers are thematic representations of geographic information, such as transportation, water, and elevation. Map layers help convey information through:

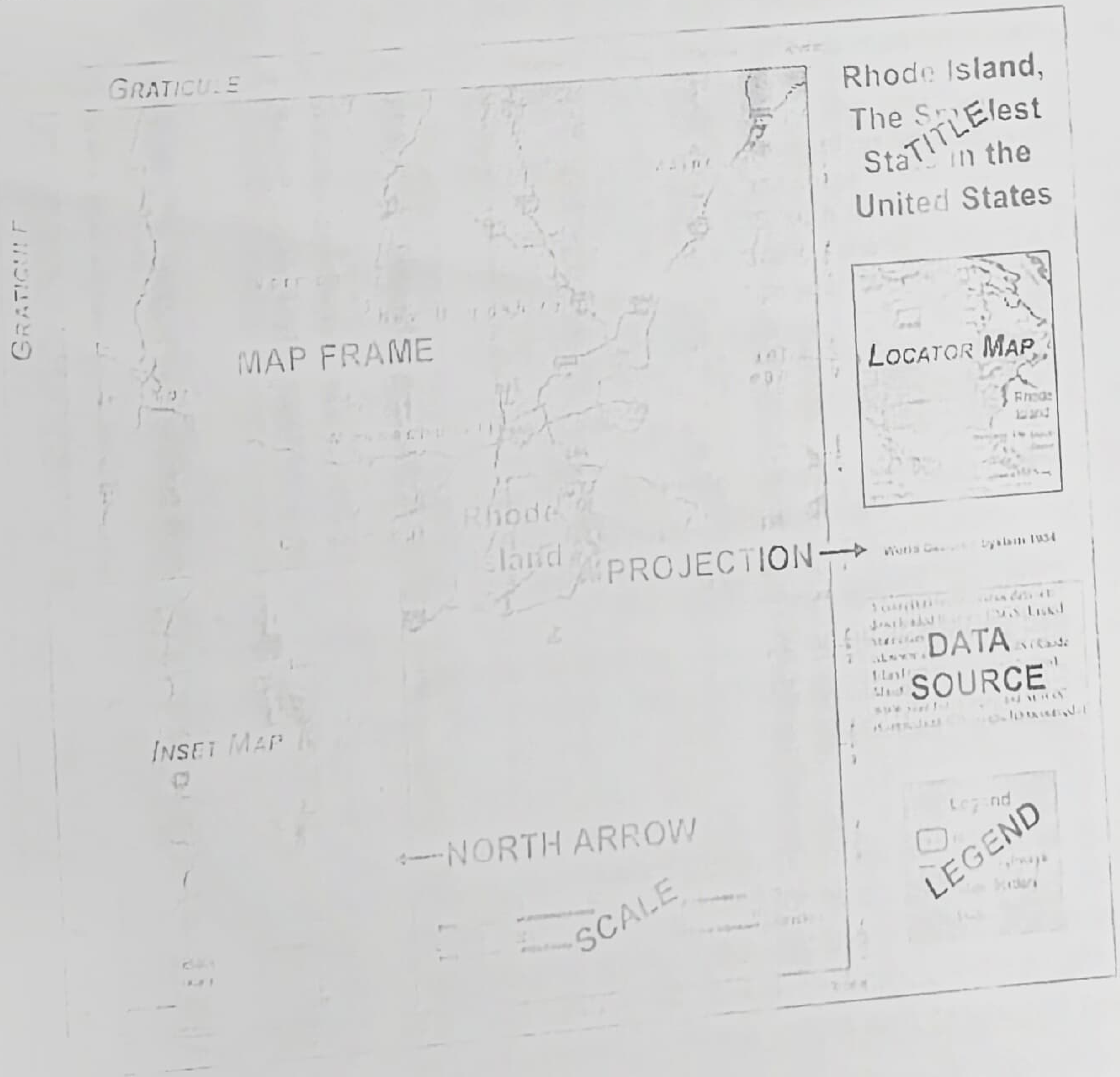
- Discrete features such as collections of points, lines, and polygons
- Map symbols, colors, and labels that help to describe the objects in the map

- Aerial photography or satellite imagery that covers the map extent
- Continuous surfaces such as elevation which can be represented in a number of ways—for example, as a collection of contour lines and elevation points or as shaded relief

Map Layout and composition

Along with the map frame, a map presents an integrated series of map elements laid out and arranged on a page. Common map elements include a north arrow, a scale bar, a symbol legend, and other graphical elements. These elements aid in map reading and interpretation.

The map layout below illustrates how map elements are arranged on a page.



Often, maps include additional elements such as graphs, charts, pictures, and text that help to communicate additional critical information.

Spatial relationships in a map

Maps help convey geographic relationships that can be interpreted and analyzed by map readers. Relationships that are based on location are referred to as spatial relationships. Here are some examples.

Political Maps

"Political maps" are among the most widely used reference maps. They are mounted on the walls of classrooms throughout the world. They show the geographic boundaries between governmental units such as countries, states, and counties. They show roads, cities and major water features such as oceans, rivers and lakes.

Political maps help people understand the geography of the world. They are usually the first type of map that students are introduced to in school. They are also known as "reference maps" because people refer to them again and again as they have questions.

Political maps are often printed on paper or another physical medium, but they can also be produced in digital form, suitable for viewing online. Every day millions of people visit search engines to find political reference maps. Some of the most popular searches are for "united states map", "world map", "europe map", and "florida map".

Thousands of different political reference maps have been prepared to show the current geography of the United States. There are maps of the entire nation, maps for each of the 50 states, maps of the 3142 counties (parishes in Louisiana, and boroughs in Alaska) that make up the states. Most counties, boroughs and parishes are further subdivided into even smaller political units. An incredible number of political maps have been prepared just to display the geography of the United States.

The maps most commonly seen in classrooms and offices are political maps of the world, countries and continents. They are often annotated with push pins, sticky notes, photographs, marker flags and string to show the travels of a family, locations of a business, or other locations and activities worthy of display.

Physical Maps

Physical maps are designed to show the natural landscape features of Earth. They are best known for showing topography, either by colors or as shaded relief. Physical maps often have a green to brown to gray color scheme for showing the elevation of the land. Darker greens are used for near-sea-level elevations, with the color grading into tans and browns as elevations increase. The color gradient often terminates in shades of gray for the highest elevations.

Rivers, lakes, seas and oceans are usually shown in blue, often with a light blue color for the most shallow areas and darkening in a gradient or by intervals for areas of deeper water. Glaciers and ice caps are shown in white colors.

Physical maps usually show the most important political boundaries, such as state and country boundaries. Major cities and major roads are often shown. This cultural information is not the focus of a physical map, but it is often included for geographic reference and to increase the utility of the map for many users.

- Which geographic features connect to others (for example, Water Street connects with 18th Ave.)
- Which geographic features are *adjacent* (contiguous) to others (for example, The city park is adjacent to the university
- Which geographic features are *contained within* an area (for example, The building footprints are contained within the parcel boundary.)
- Which geographic features *overlap* (for example, The railway crosses the freeway.)
- Which geographic features are near others (proximity) (for example, The Courthouse is near the State Capitol.)
- The feature geometry *is equal to* another feature (for example, The city park is equal to the historic site polygon).
- The *difference* in elevation of geographic features (for example, The State Capitol is uphill from the water.)The feature is *along* another feature (for example, The bus route follows along the street network.).

Within a map, such relationships are not explicitly represented. Instead, as the map reader, you interpret relationships and derive information from the relative position and shape of the map elements, such as the streets, contours, buildings, lakes, railways, and other features. In a GIS, such relationships can be modeled by applying rich data types and behaviors (for example, topologies and networks) and by applying a comprehensive set of spatial operators to the geographic objects (such as buffer and polygon overlay).

Classification of Maps

Millions of unique maps are in use throughout the world. Most of these maps can be placed into one of two groups: 1) reference maps; and, 2) thematic maps.

Reference maps show the location of geographic boundaries, physical features of Earth, or cultural features such as places, cities, and roads. **Political maps**, **physical maps**, **road maps**, **topographic maps**, **time zone maps**, **geologic maps**, and **zip code maps** are all examples of reference maps. A variety of reference maps have been created for almost every country of the world.

Thematic maps show the variation of a topic (the theme) across a geographic area. **Weather maps** showing daily high temperatures across the United States are familiar examples of a thematic map. They are made by starting with a reference map of the United States. Then temperature data is plotted atop of the reference map using colors to communicate the temperature forecast. **Income maps** and **resource maps** are other types of thematic maps.

In the sections of this article below, you will find several examples of commonly used reference maps and thematic maps.

Areas on the map where the brown contour lines are close together have steep slopes. Areas where the contour lines are spaced far apart have gentler slopes.

Topographic Maps

Topographic maps are reference maps that show the shape of Earth's surface. They usually do this with lines of equal elevation known as "contour lines", but elevation can also be shown using **colors** (second map), **color gradients**, **shaded relief** and a number of other methods.

Topographic maps are frequently used by hunters, hikers, skiers, and others seeking outdoor recreation. They are also essential tools of the trade for geologists, surveyors, engineers, construction workers, landscape planners, architects, biologists and many other professions - especially people in the military.

Topographic maps also show other important natural features such as lakes, rivers and streams. Their locations are determined by topography, making them important natural elements of topographic maps.

Important cultural features are also shown on topographic maps. These include roads, trails, buildings, place names, bench marks, cemeteries, churches, schools and much more. A standardized set of special symbols has been developed for this use.

Topographic maps have traditionally been printed on large sheets of paper with their four boundaries being lines of longitude and latitude. The **United States Geological Survey** is the most widely known organization for producing them. They produce a series of 7.5-minute topographic maps covering most areas of the United States (a 7.5-minute map shows an area that is 7.5 minutes of longitude by 7.5 minutes of latitude). These maps and maps of many other scales are available from USGS in both print and digital form.

Commercial publishers of topographic maps include the **DeLorme Atlas** (paper maps in books with state-wide coverage) and **MyTopo** (a source of digital and paper maps in traditional topographic and topophoto formats - we are affiliates of **MyTopo** and receive a commission on referred sales).

Weather Maps

People use an incredible number of weather maps. They are used to show predicted temperatures, predicted precipitation, storm warnings of various kinds, wind speed and direction, chance of precipitation, type of precipitation, snow accumulation, frost prediction and many other aspects of weather.

All of these weather maps are continuously updated to communicate the most current information. They are the world's most frequently consulted thematic maps. Weather maps are presented in newspapers, television programs and especially on websites. Delivering weather maps on websites and through web apps gives people around the world instant access to weather information.

Road, Street and Highway Maps

The digital mapping revolution caused an explosion of map creation in the 1990s. In 1996, **MapQuest**, the first popular online mapping service, allowed anyone with internet access the ability to create customized maps of almost any location in the United States.

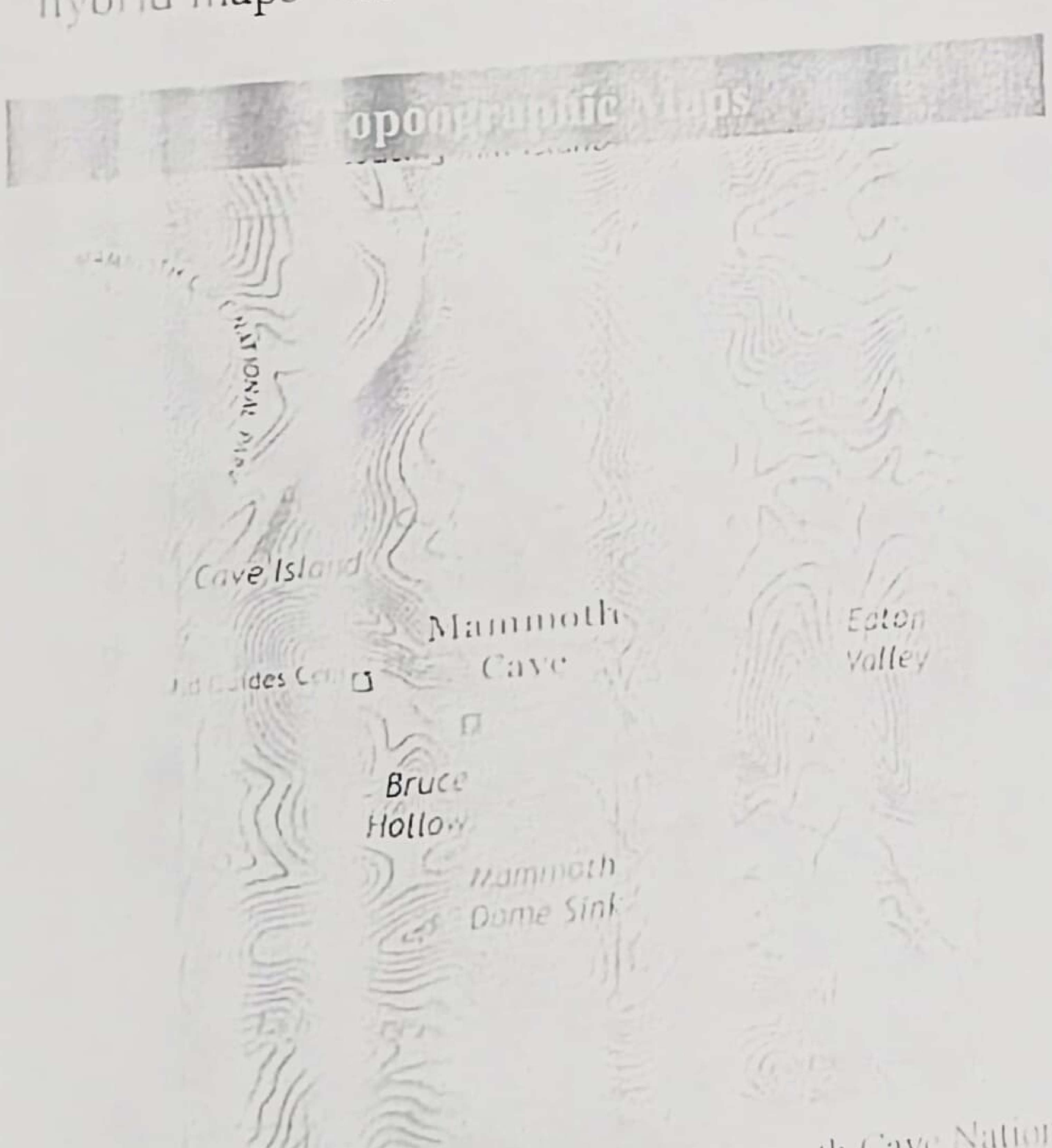
Within a few months, millions of people had become "cartographers". They were soon producing more unique maps in a single day than had been created during the entire history of paper cartography!

Today, **Google Maps** is the world's most popular online mapping system. In addition to maps, the service also provides travel route directions. It can create directions for people who are driving, taking public transportation, walking, cycling or taking a plane.

Billions of unique maps, millions of travel routes, and millions of street views are created each day with Google Maps. It is the first place millions of people go to plan any type of travel.

Google has another product named "**Google Earth**" that allows people to view streets, roads and satellite images within a single interface. Google Earth is a free download - the software installs on your computer and fetches the image directly from the Google Earth server.

Finally, for people who want printed maps, the **DeLorme Atlas & Gazetteer** is a series of books that contain state-wide map coverage for individual states (or-pairs of small adjacent states). The maps present a combination of road, topography, cultural and recreational information. These "hybrid maps" are a favorite of people who work and play outdoors in rural areas.

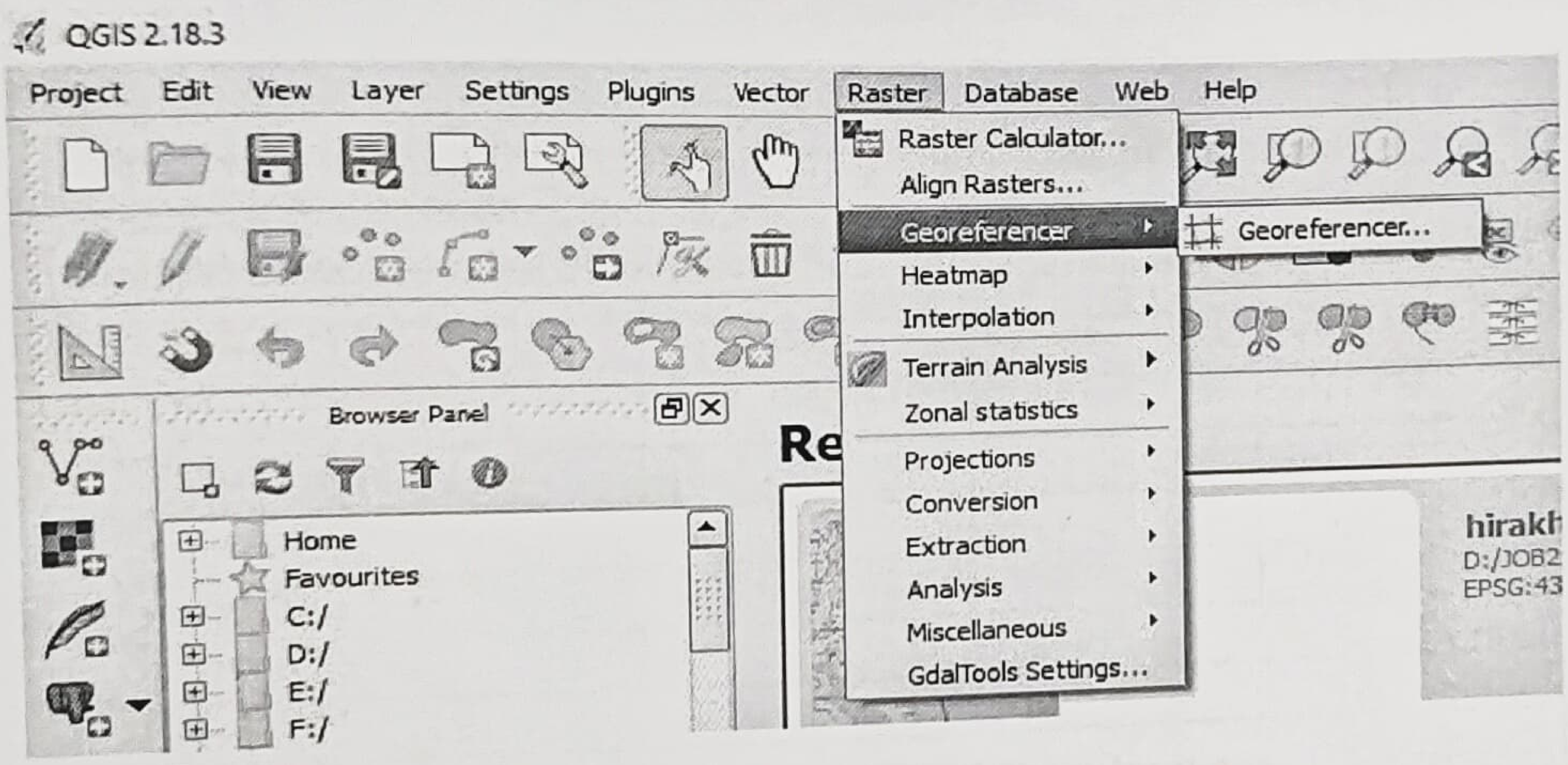


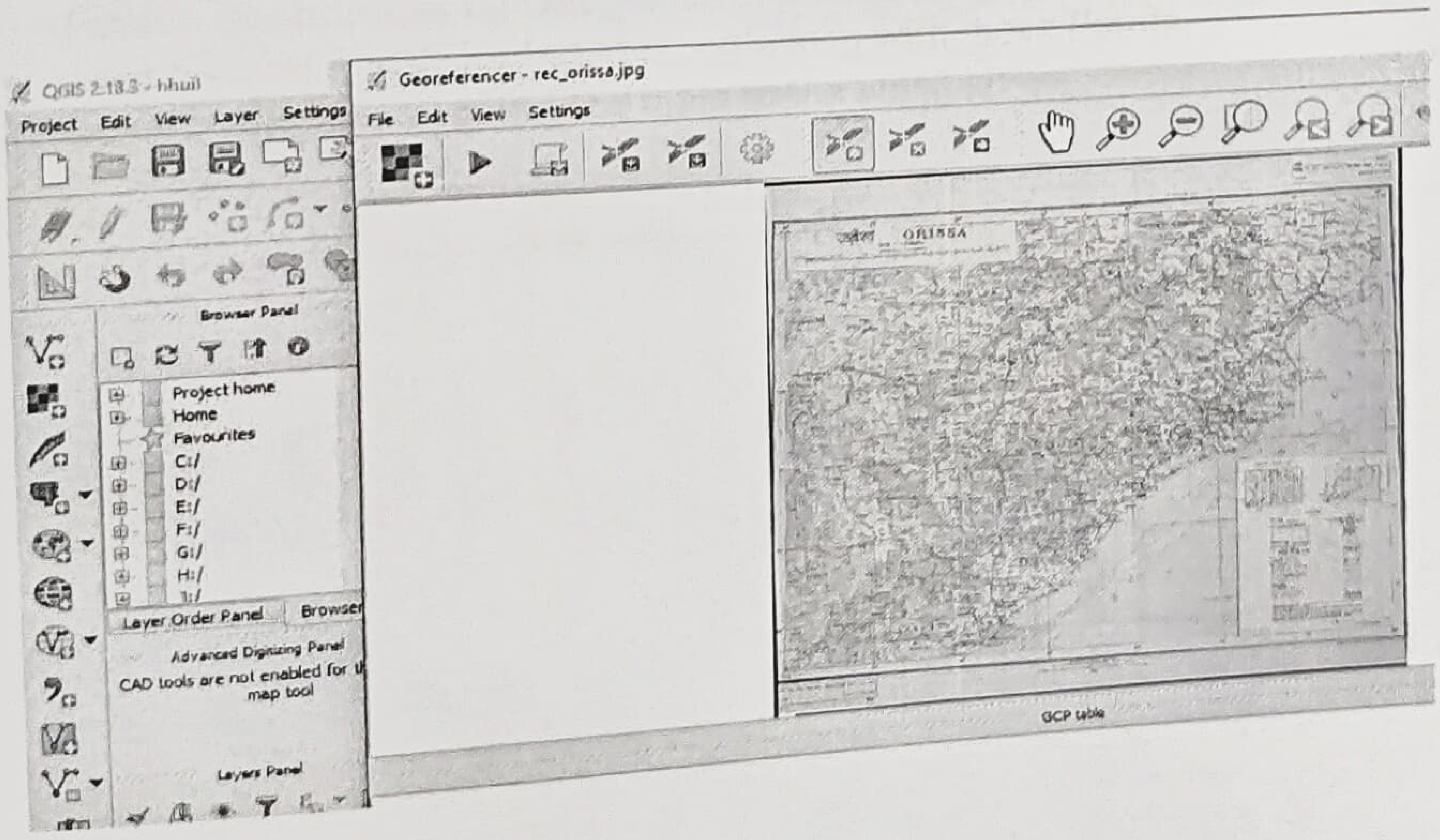
Topographic Map of an area within Mammoth Cave National Park, Kentucky. This map shows Earth's topography using brown contour lines with a contour interval of 20 feet. Roads, place names, streams and other features are also shown.

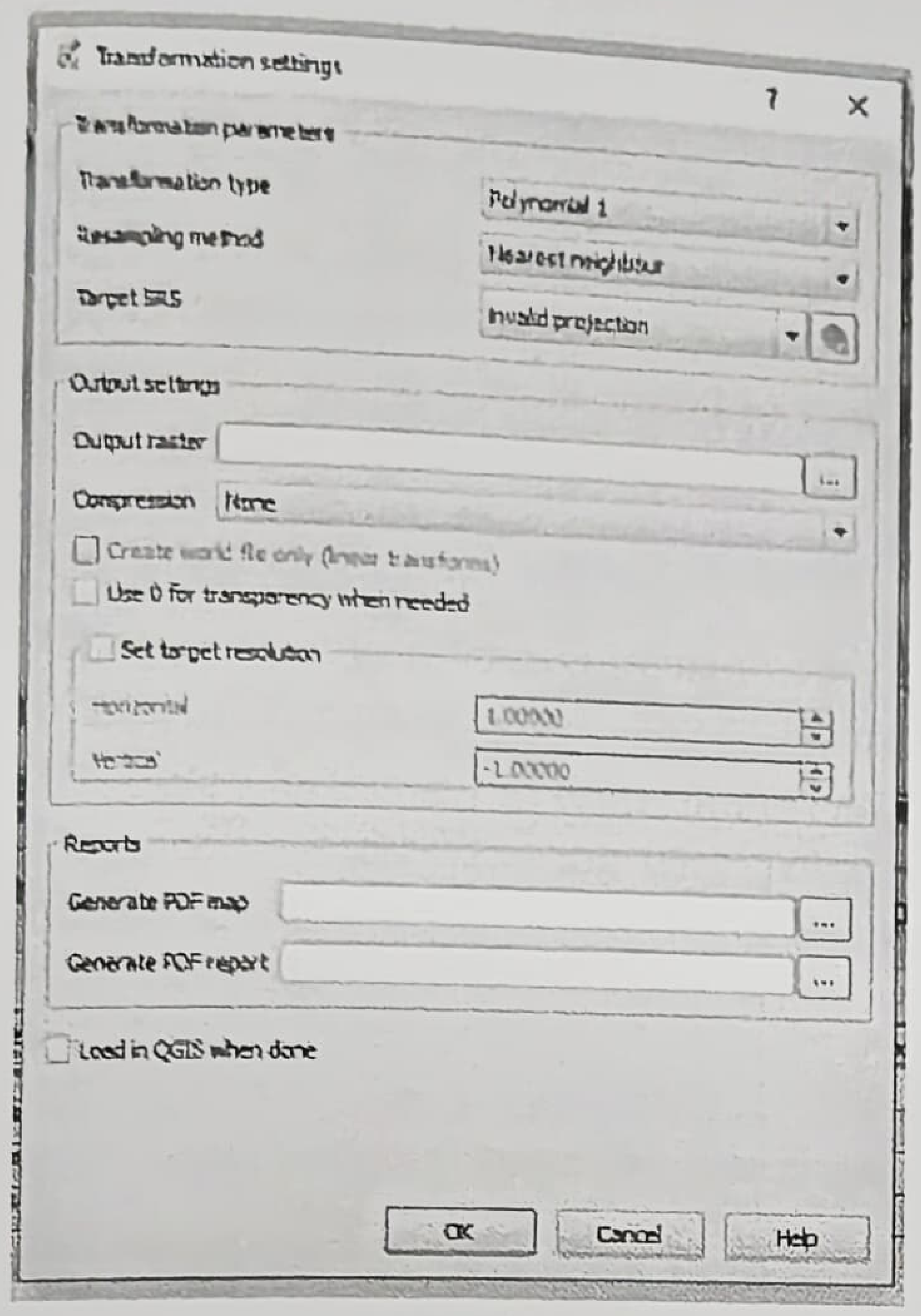
9.0 HANDS ON IN QGIS

Georeferencing

- Open QGIS
- Go to Layer Menu
- Add Raster Layer
- Open Odisha.jpg file provided to you
- Now Odisha raster image will be displayed in view area
- Then Go to Raster Menu
- Select Georeferencer
- A new Georeferencer Window will open
- In this window, Go to Open Raster (top left most button)
- The Odisha map (raster will be added to this window)
- Go to Add GCP point button
- Then add GCP points at the known coordinate locations on this Odisha map and input the longitude (X) and latitude (Y) values for at least four such known locations
- Once done with, then Click on Start Georeferencing Button on the top 2nd left in button bar
- A Dialog Box will appear and enter the output raster file (Odisha_Geo) name and click OK
- The output Georeferenced raster map of Odisha i.e. Odisha_Geo.jpg will be added to view







-Start Georeferencing of Odisha Map
-In the Georeferenced Odisha Map, Find the coordinates of Bhubaneswar, Sambalpur, Raurkela, Puri, Baleswar
- Find the distances of all other places from Bhubaneswar and prepare a table.

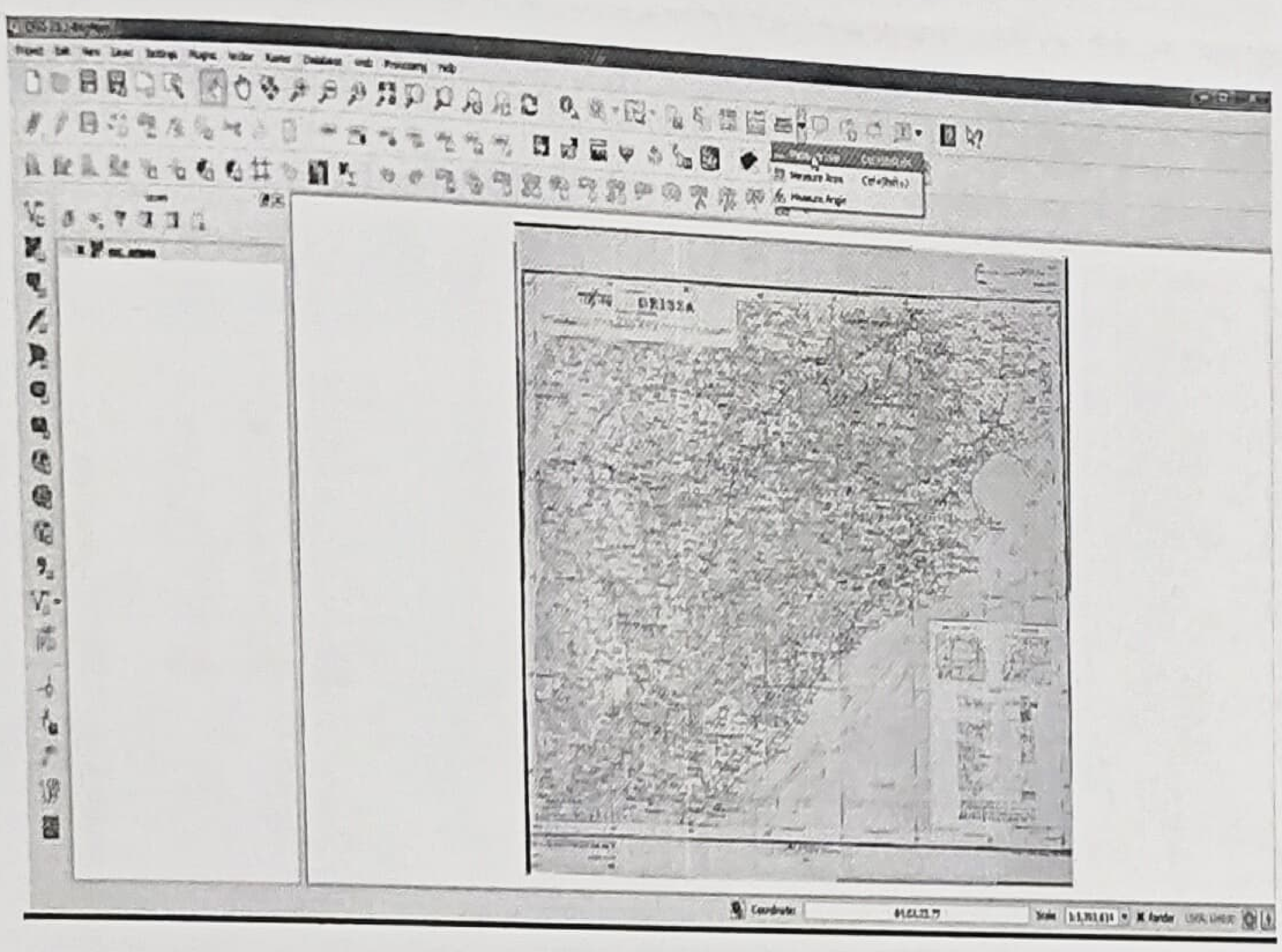
Sl	Place	Longitude	Lattitude	Distance from Bhubaneswar
1	Bhubaneswar			
2	Sambalpur			
3	Raurkela			
6	Puri			
7	Baleswar			

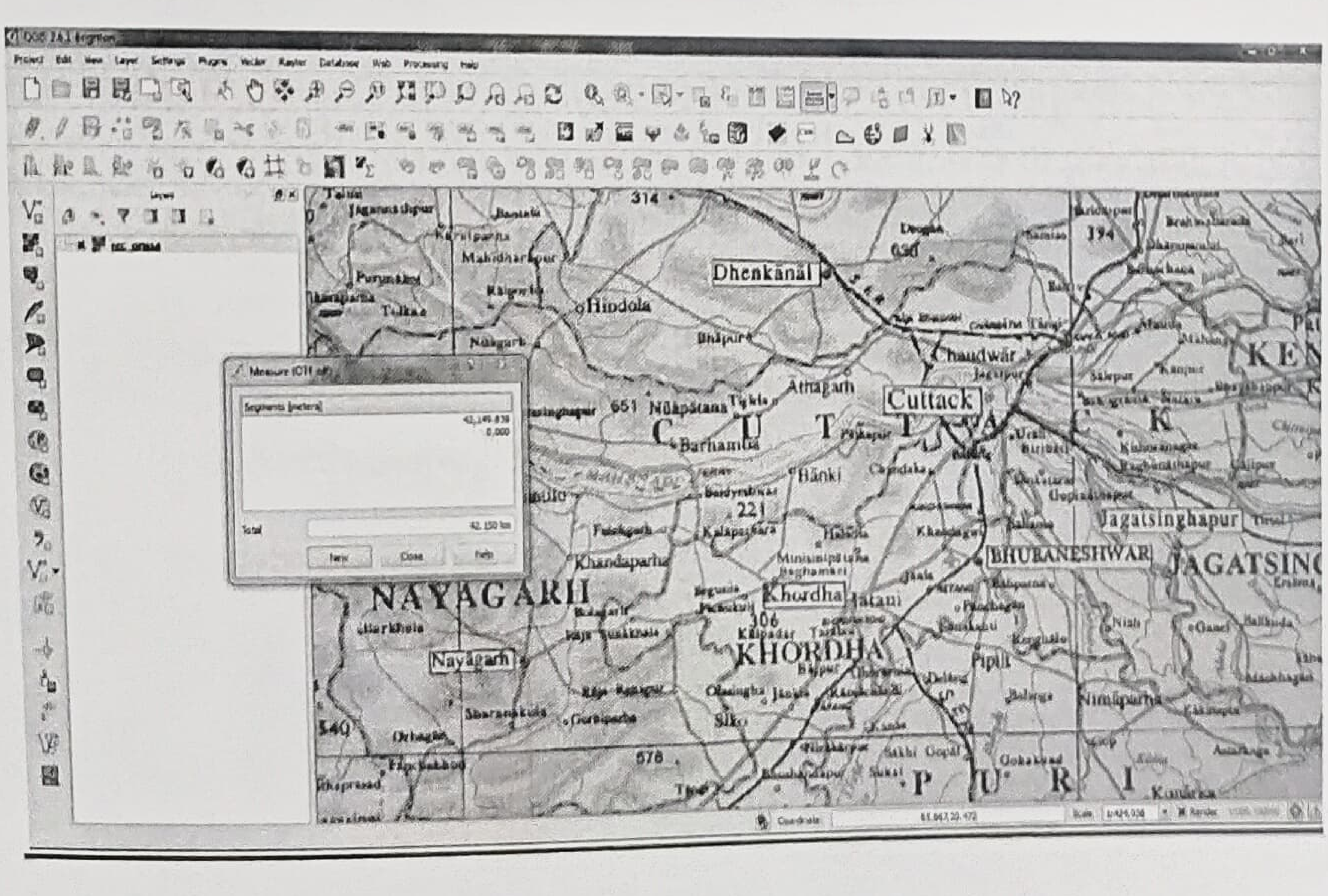
-Put the Coordinates on Google Earth and Check these locations.
-Take a screenshot/clipping of Google map with these Points.
-Send the google map and the table to the email id:

lusinayak28591@gmail.com

Distance Measurement

- Open QGIS
- Go to Layer Menu
- Add Raster Layer
- Open Odisha.jpg file provided to you
- Now Odisha raster image will be displayed in view area
- Then Go to Toolbar
- Select Measurement Toolbar
- Choose what you want a measure: a distance (Measure Line), a surface area (Measure Area) or an angel (Measure Angle). The Measure window will open
- Put your Cursor in the map image and click on the starting point
- Draw a line: left Clicking will create a node and right clicking will mark the end point. At Area you can create a multiple angled shape. In the measure window you can read the distance. Click on close in the Measure window (otherwise the line, area or angle will stay in the map image





Point Layer Creation for Towns on Odisha Map

- Open QGIS

- Go to Layer Menu

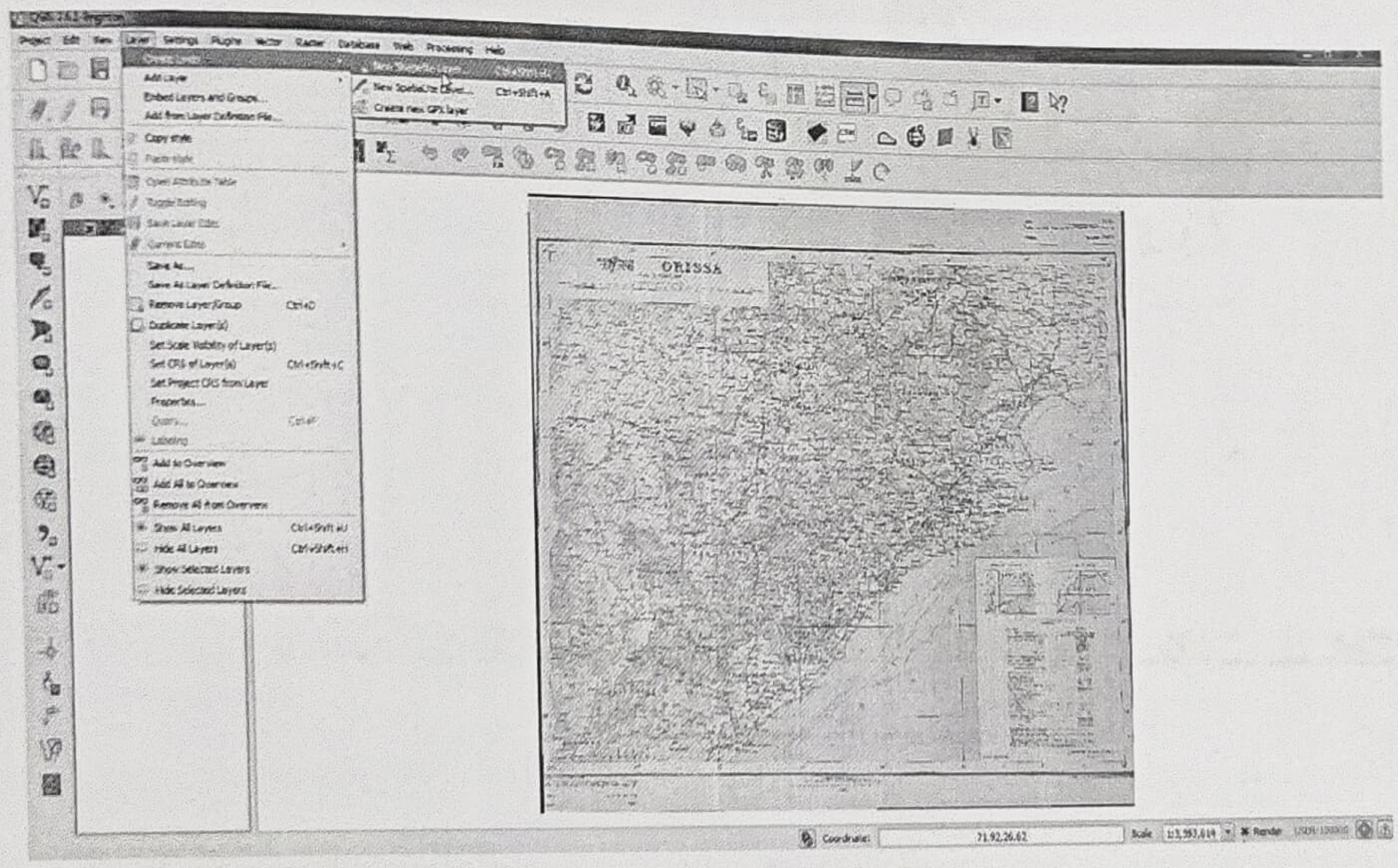
- Select *Layer > New > New Shape file Layer* to create the new empty layer for your vector feature

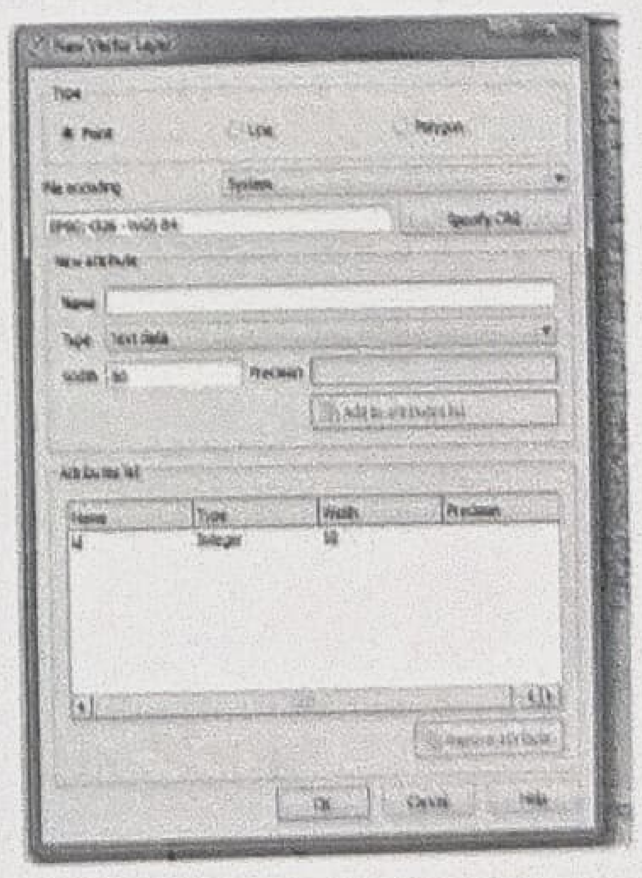
- You will be prompted to confirm the Coordinate Reference System for the layer. By default, the Coordinate Reference System for the project is used

-Click on the *Capture Points* button

-Click points at your chosen location, and choose a name for each point feature

-Click on *Toggle editing* to save the vector point layer

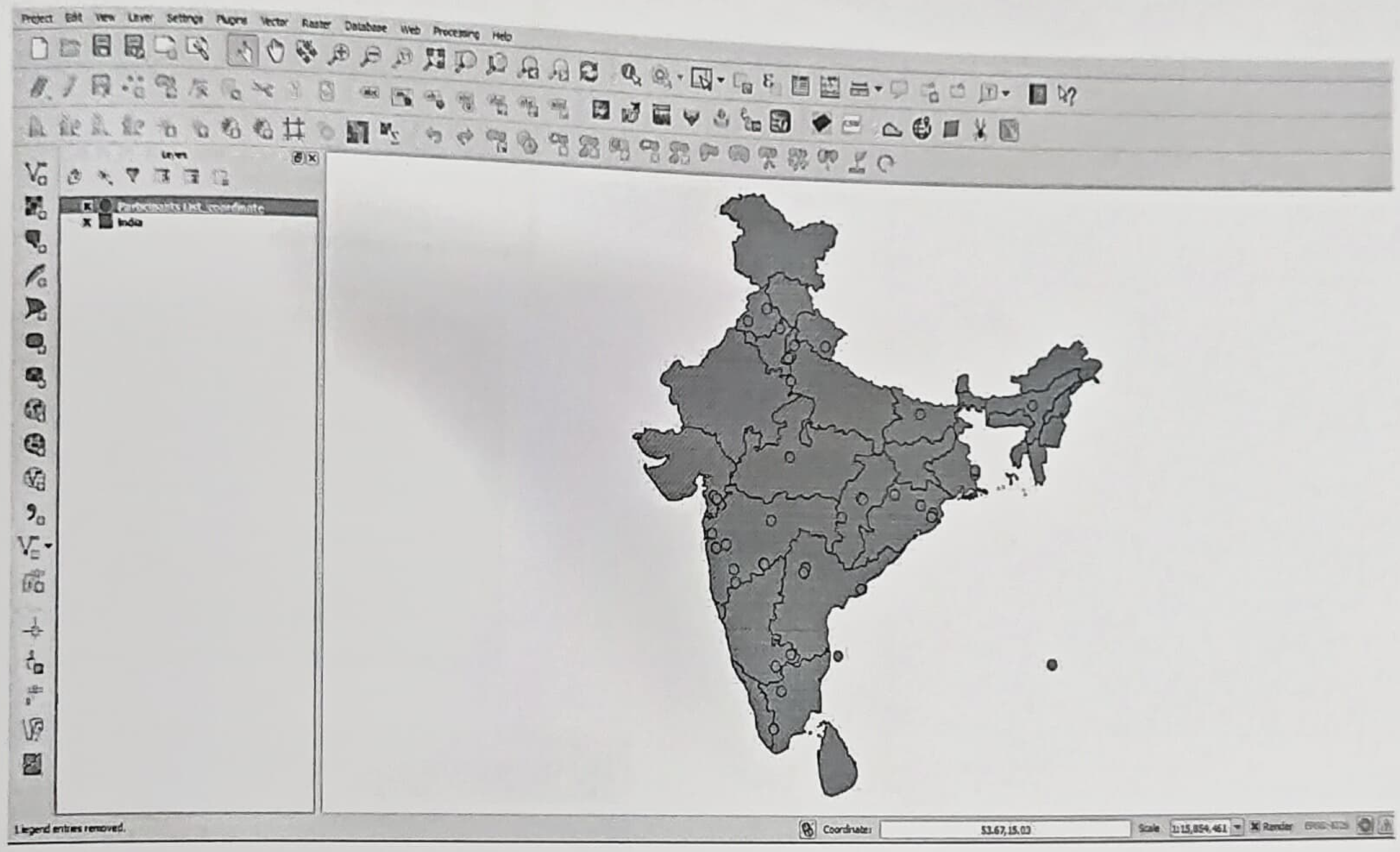




- The **Type of feature** you are tracing - point, line or polygon
- The **Name of the Attribute** you are tracing
- The **Type** of the Attribute - eg. Text, Whole Number
- The **Width** of the field for the Attribute. Select *Add to Attribute list*
- The **Shapefile Name** to save the layer as

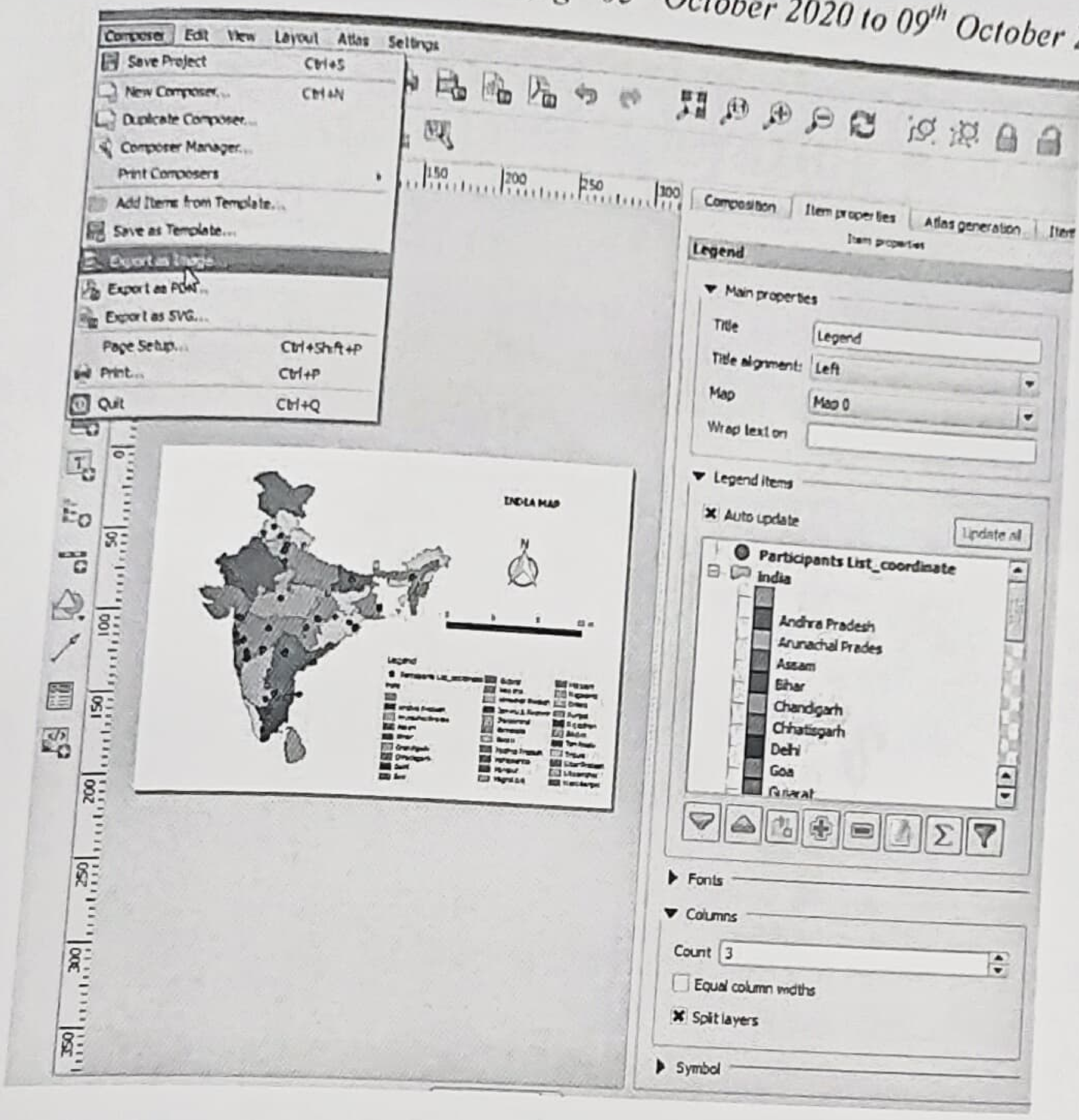
Point Layer Creation from Excel file of Coordinates of Participants

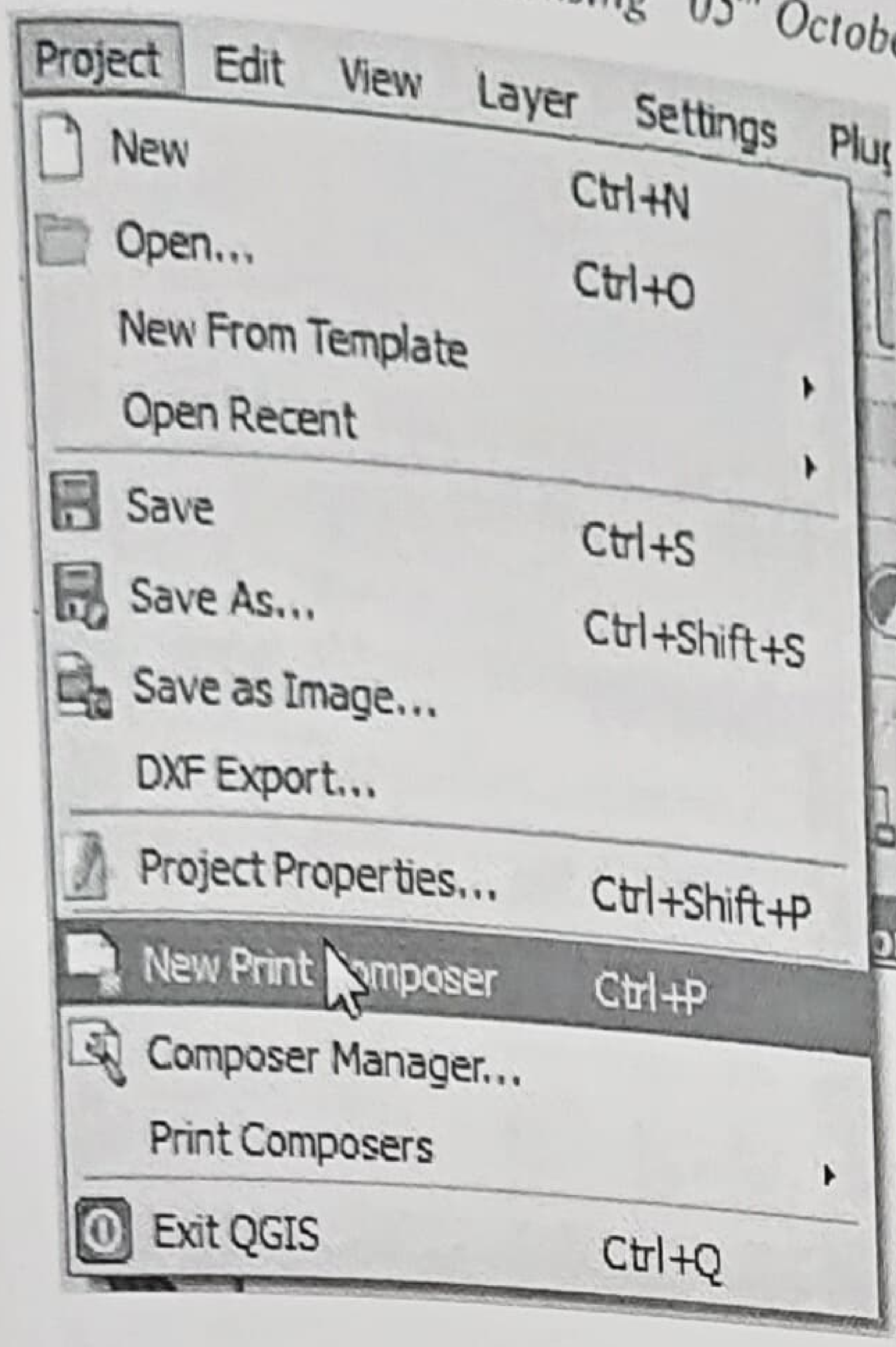
- Open Excel File
- Go to office Button
- Then Save as your File Format in Text (Tab Delimited) > Then Save
- Open QGIS
- Go to Layer Menu > Add Layer > Add Delimited Text Layer > Then Browse > Add Your Text Layer
- Then File Format Select In (Custom delimiters)
-"X" field is Longitude and "Y" Field is Latitude > Then OK.

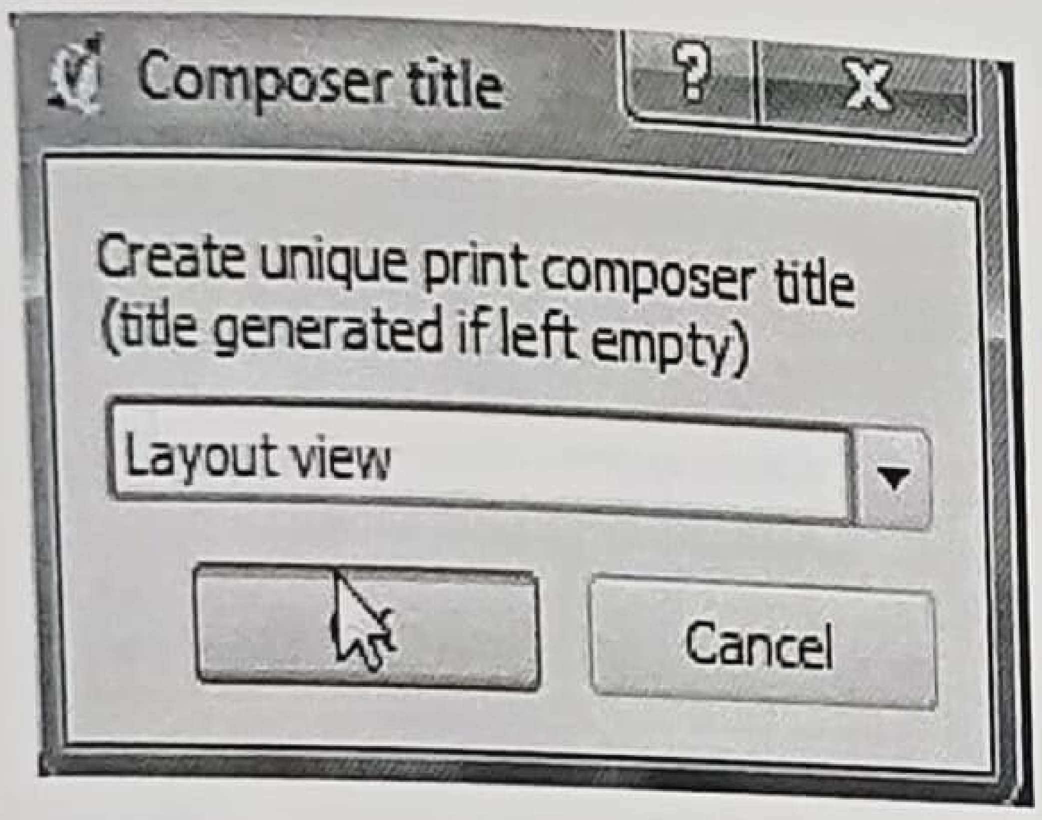


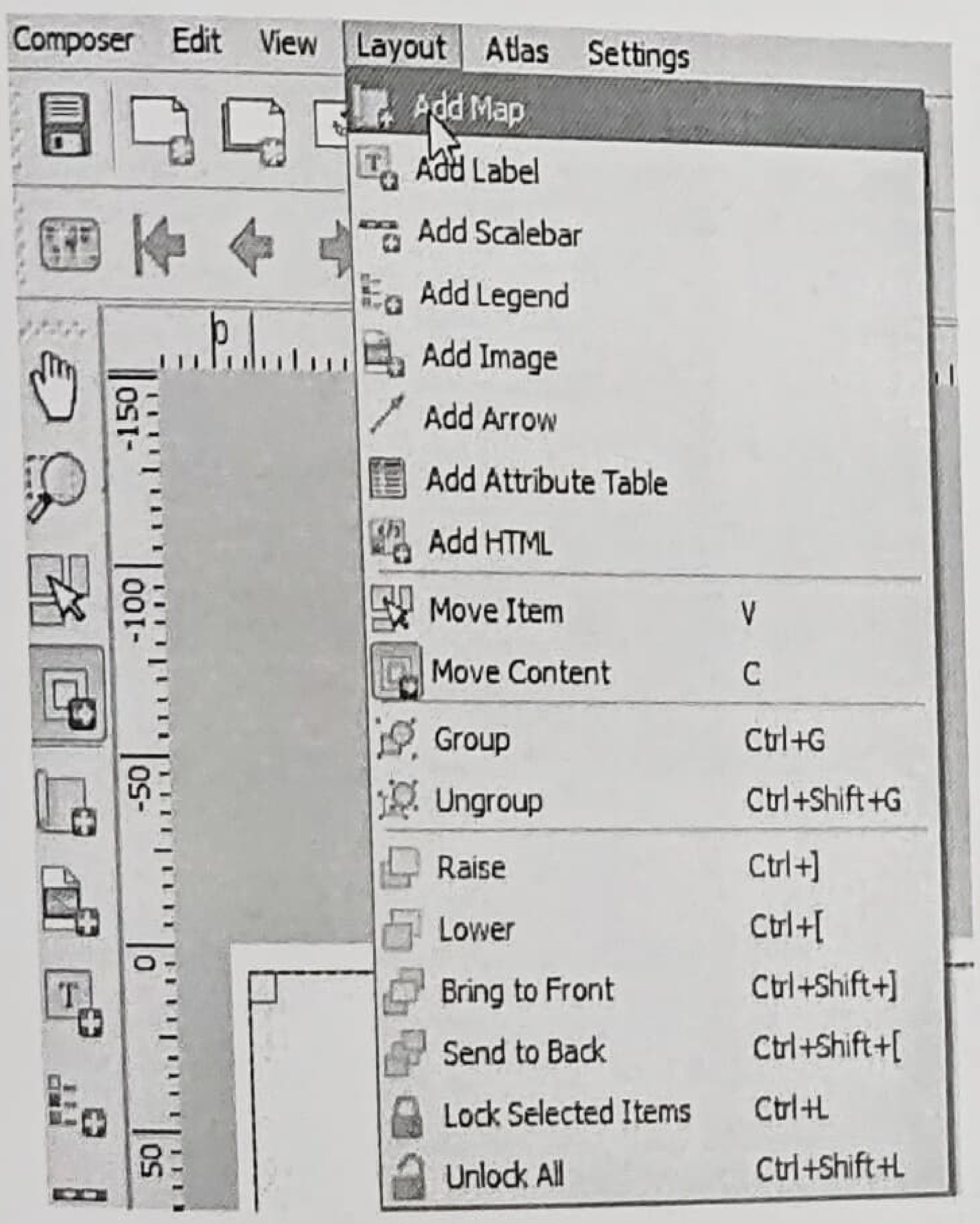
Map Layout Composition

- Open QGIS
- Go to Project Menu
- Then Select "New Print Composer" > Add Composer title > Then OK
- Select Your Layout Menu > Add Map
- Once the Add Map button is active, hold the left mouse button and drag a rectangle where you want to insert the map.
- Let us adjust the zoom level for the given map. Click on the Item Properties tab and enter 15000000 for Scale value.
- Add Label > Enter Your Title Name
-Add Image > Click on Item Properties tab and enter Search directories > Select your North Arrow > Then Add
- Then Add Scale bar
- Add Legend
- Then Go to Composer Menu > Export as Image


Composer
Edit
View
Layout
Atlas
Settings
Save Project
Ctrl+S
New Composer...
Ctrl+N
Duplicate Composer...
Composer Manager...
Print Composers
Add Items from Template...
Save as Template...
Export as Image...
Export as PDF...
Export as SVG...
Page Setup...
Ctrl+Shift+P
Print...
Ctrl+P
Quit
Ctrl+Q
Composition
Item properties
Atlas generation
Legend
Main properties
Title
Legend
Title alignment:
Left
Map
Map 0
Wrap text on
Legend items
Auto update
Update all
Participants List_coordinate
India
Andhra Pradesh
Arunachal Prades
Assam
Bihar
Chandigarh
Chhatisgarh
Delhi
Goa
Fonts
Columns
Count
3
Equal column widths
Split layers
Symbol
INDIA MAP


Project
Edit
View
Layer
Settings
New Ctrl+N
Open... Ctrl+O
New From Template
Open Recent
Save Ctrl+S
Save As... Ctrl+Shift+S
Save as Image...
DXF Export...
Project Properties... Ctrl+Shift+P
New Print Composer Ctrl+P
Composer Manager...
Print Composers
Exit QGIS Ctrl+Q

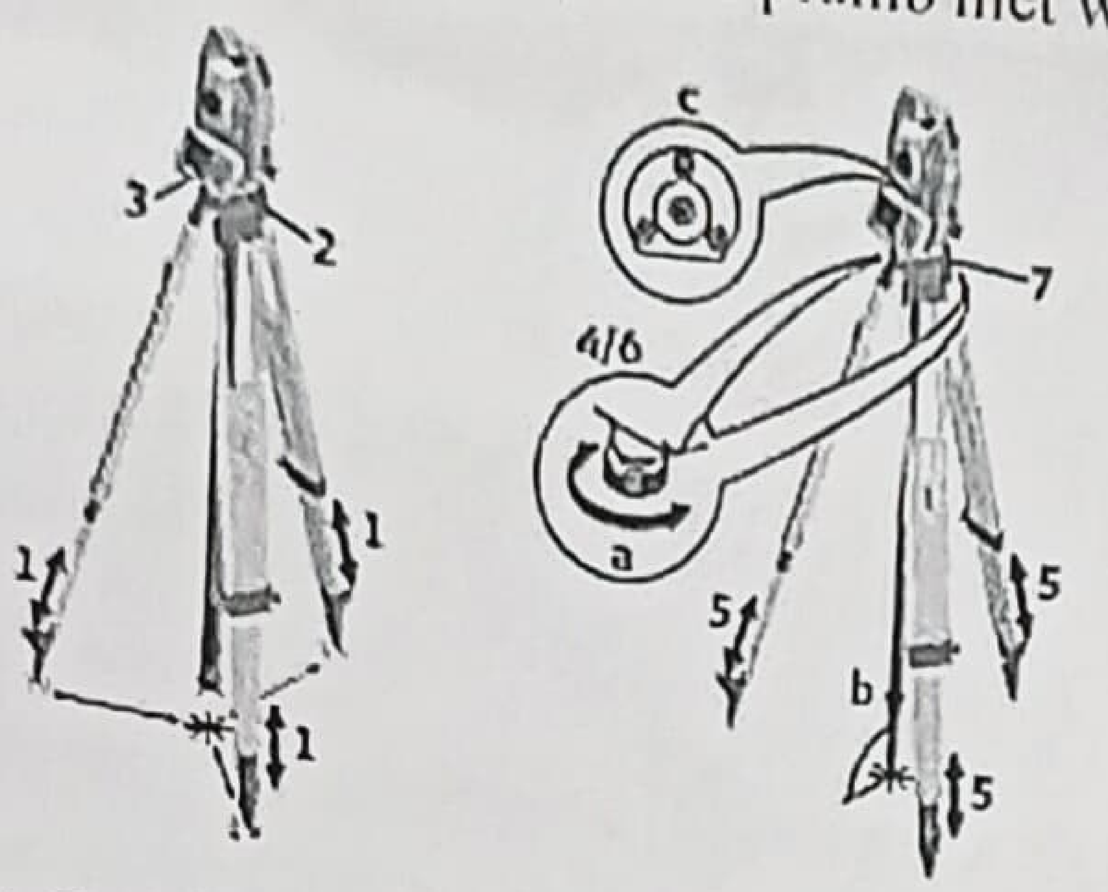

Composer title
Create unique print composer title
(title generated if left empty)
Layout view
Cancel


Composer
Edit
View
Layout
Atlas
Settings
Add Map
Add Label
Add Scalebar
Add Legend
Add Image
Add Arrow
Add Attribute Table
Add HTML
Move Item V
Move Content C
Group Ctrl+G
Ungroup Ctrl+Shift+G
Raise Ctrl+]
Lower Ctrl+[
Bring to Front Ctrl+Shift+]
Send to Back Ctrl+Shift+[
Lock Selected Items Ctrl+L
Unlock All Ctrl+Shift+L

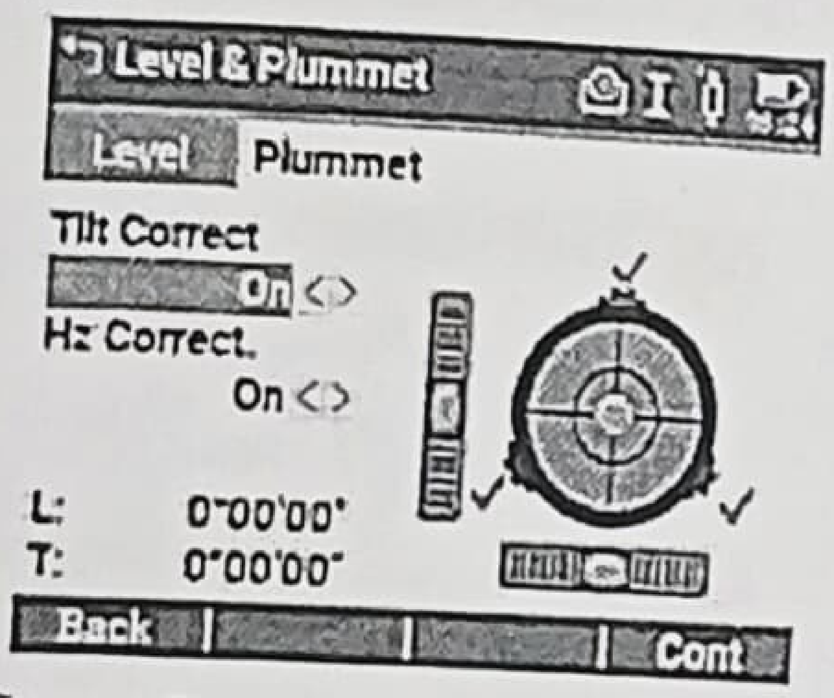
Standard operating procedures of TS07

- **Steps for Centering and Leveling:**

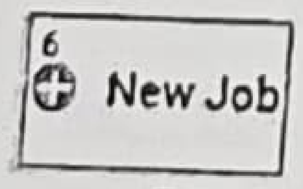
- Press ● Button
- Do the centering by laser plumb met with the help of legs.



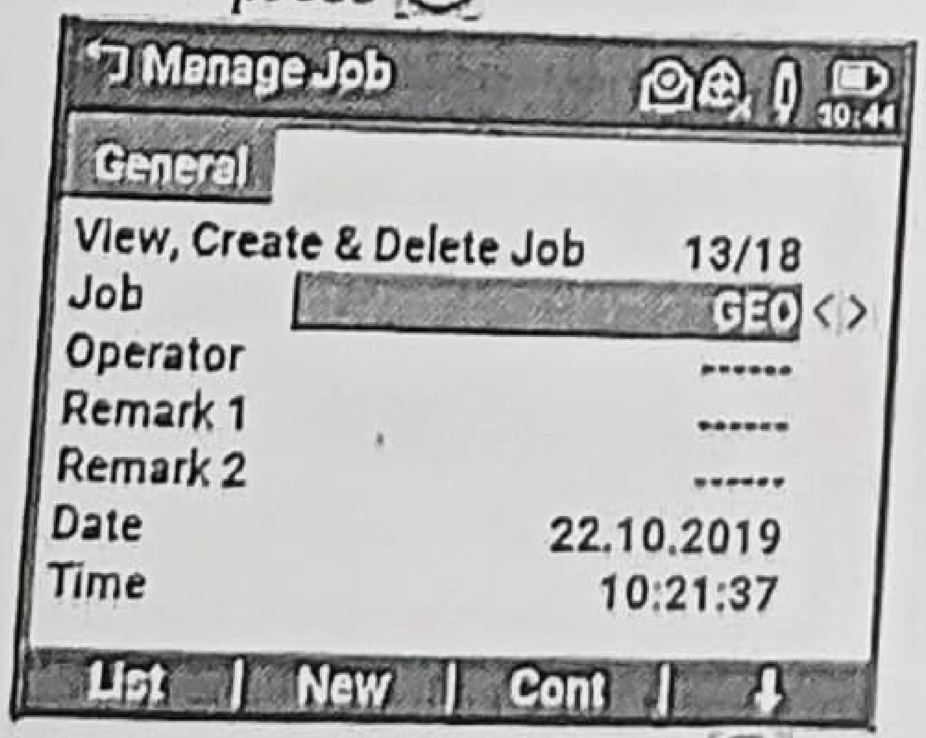
- Adjust the display tilt bubble by the Stand's Legs & foot screw after leveling press 'Cont.' F4



- **Steps for making a new job:**

- Go to 

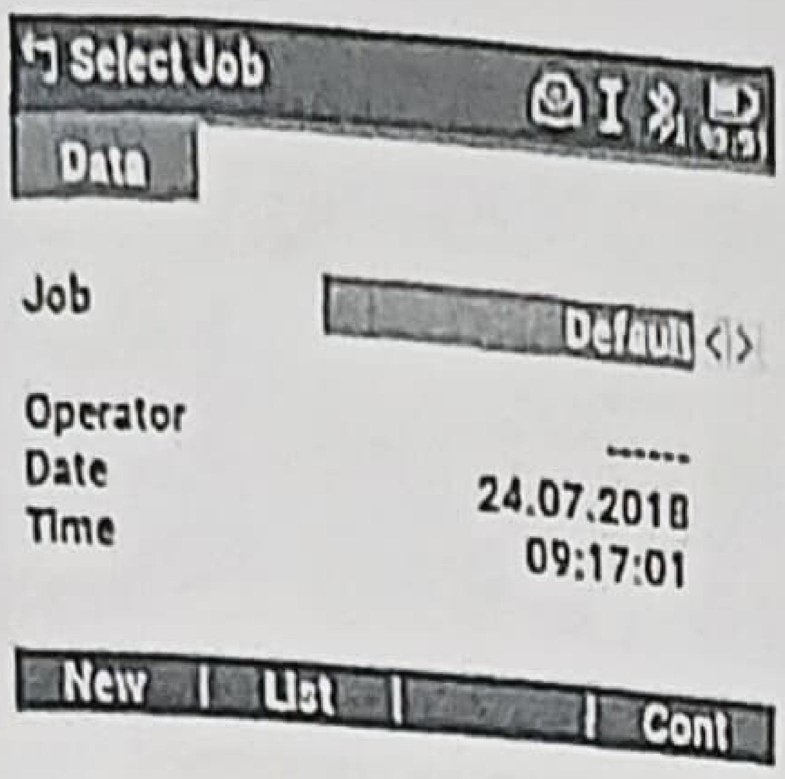
- Then press OK



- Put job name and press OK then 'Cont.' again 'Cont.'

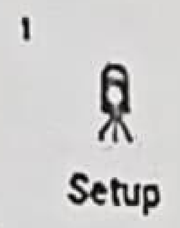
- **Steps for select old job or delete a job:**

- Go to 'Manage' by pressing Page key
- Go to Job then press OK
- Now you can select your job from 'List' F1 or you can delete your job by pressing F4 and F1

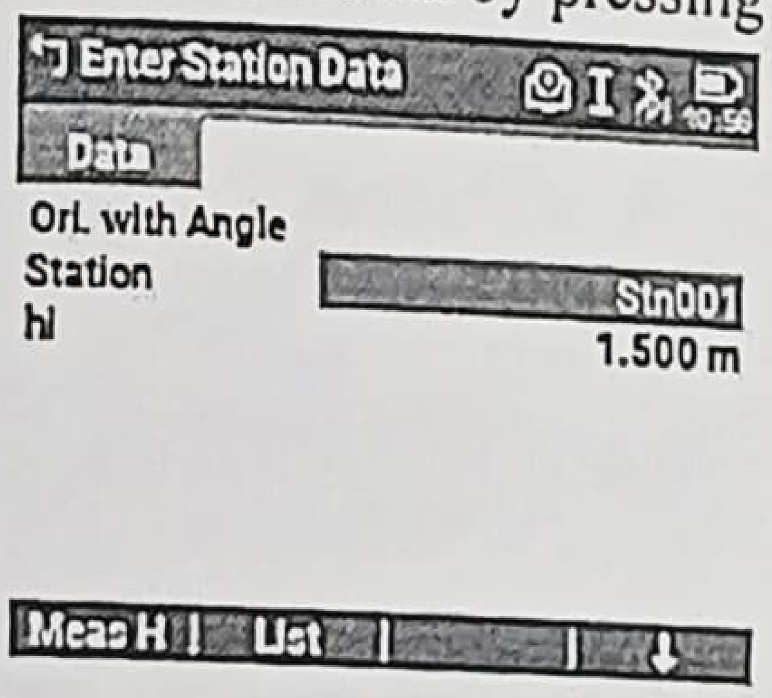


➢ After your selection press (OK)

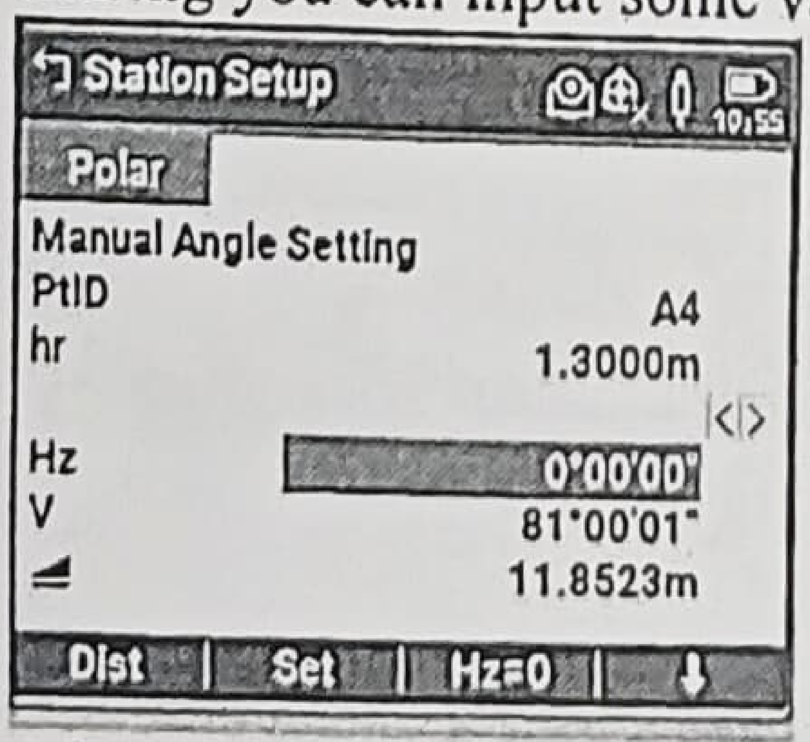
➢ **<u>Steps for Station Orientation:</u>**
➢ **<u>Orientation with Angle:</u>**



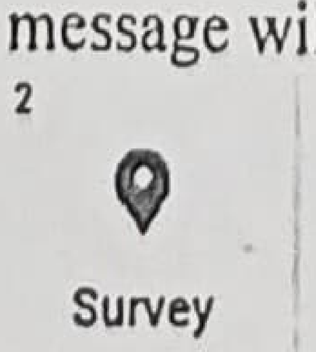
➢ Go to ______ then press (OK) then press 'Cont.' [F4]
➢ Select the Orientation Method 'Ori with Angle' – 'Press 'Cont.' [F4]
➢ Feed station data by pressing [F4] go to New [F1] then press 'Cont.' [F4]



➢ Put the Instrument Height then press (OK) then press [F3]
➢ Bisect your BS (Back sight) point or north
➢ Change Station ID then put HR (Range Pole Height) then put Code (BSP) Set the H Angele 0by pressing 'Hz=0' [F3] Then Press 'Dist.' [F1] then Press 'SET' [F2] for putting compass bearing you can input some value in 'HZ'



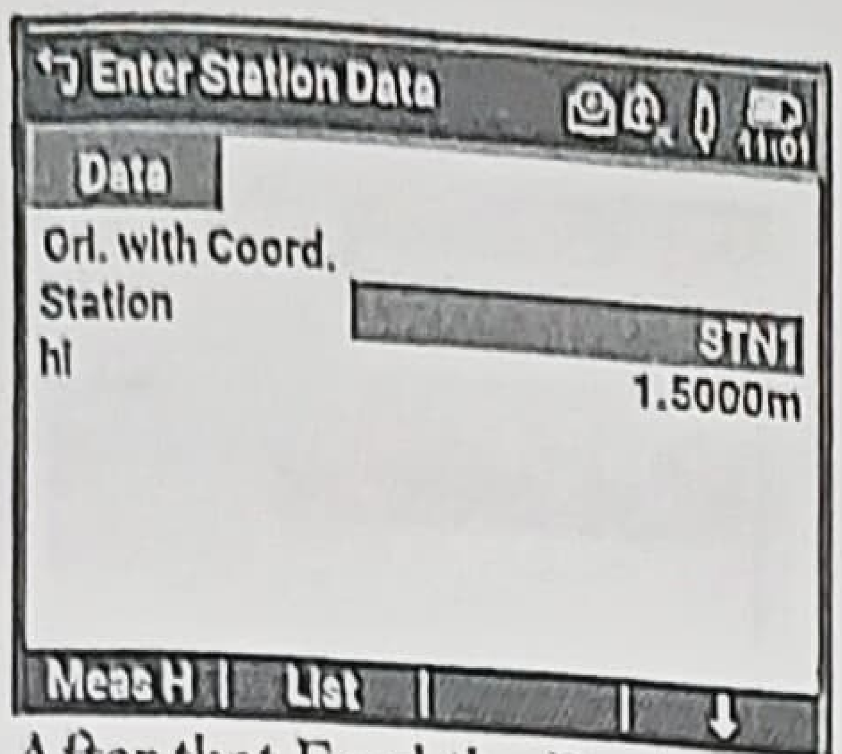
➢ After that one message will be display that your Orientation has been done successfully.



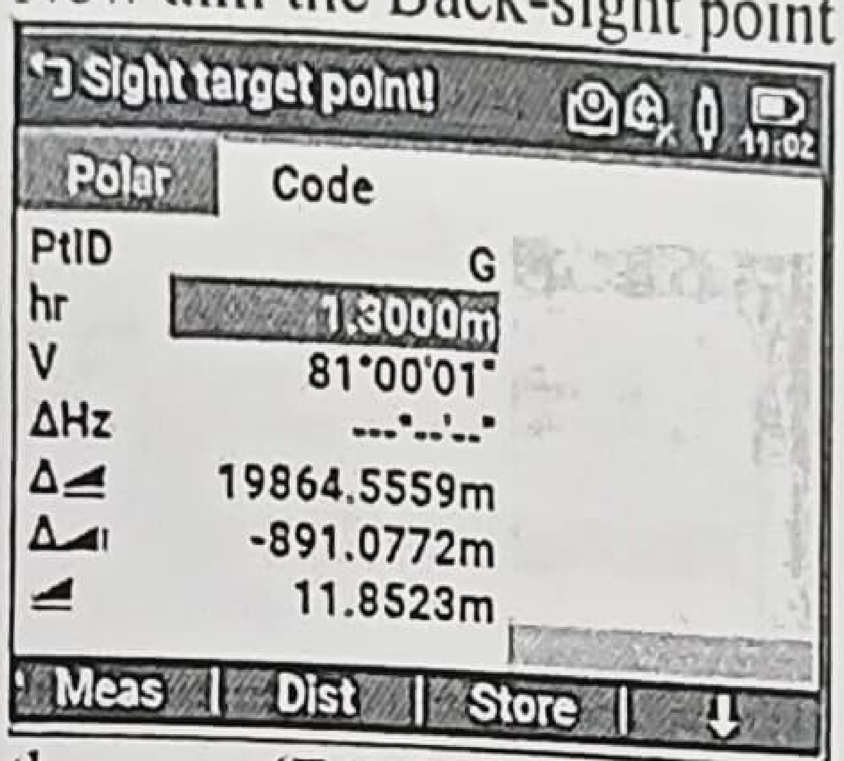
➢ Now come to then (OK) you can continue your measurement

<u>Orientation with Coordinate:</u>

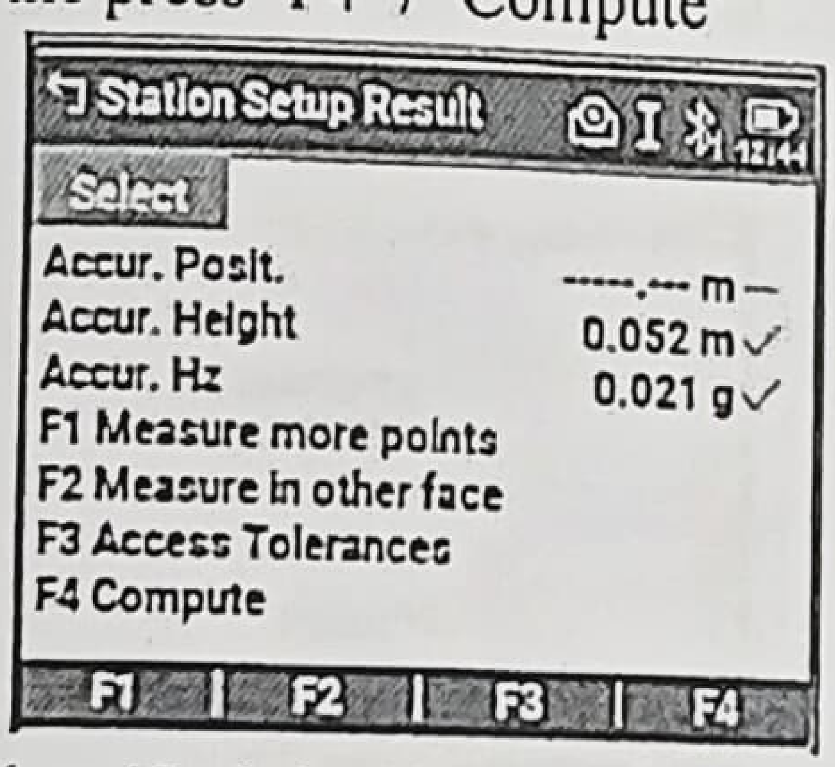
➢ If you have some known Back sight value, you can Go to 'Ori with Coord' then press 'Cont.' put the station point value and 'Hi' then press 'Cont.'



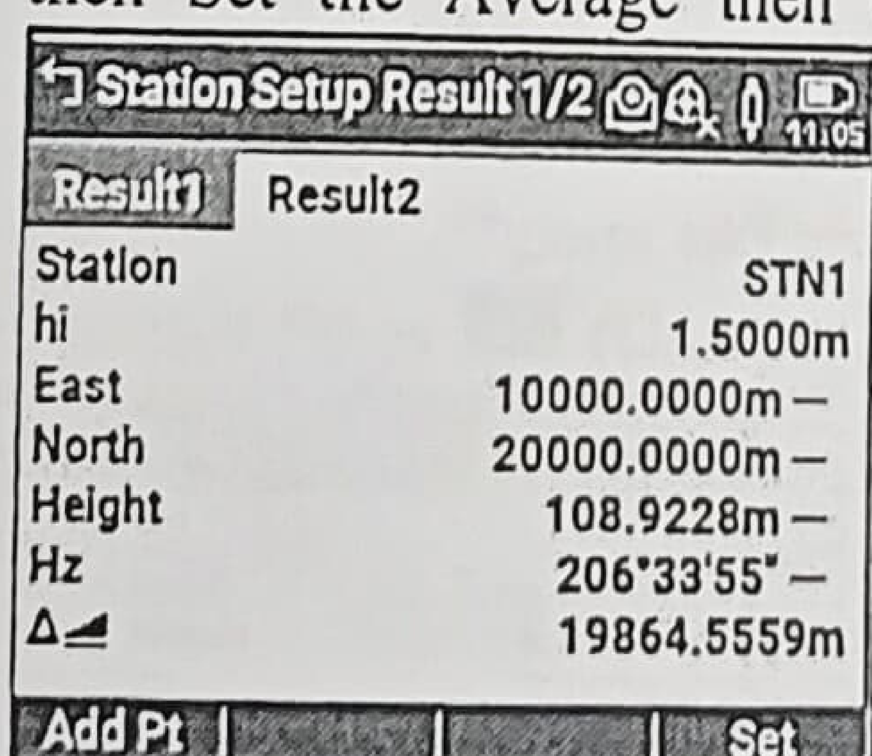
- After that Feed the Back-sight Value then press 'Cont.'
- Now aim the Back-sight point press 'Dist.' and 'Store'



- the press 'F4' / 'Compute'



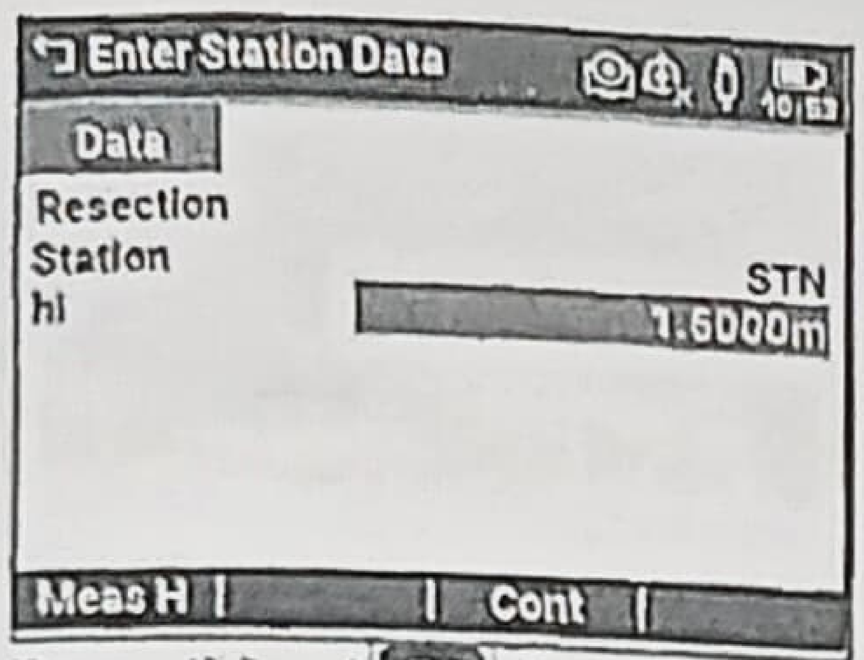
- then 'Set' the 'Average' then 'Cont.'



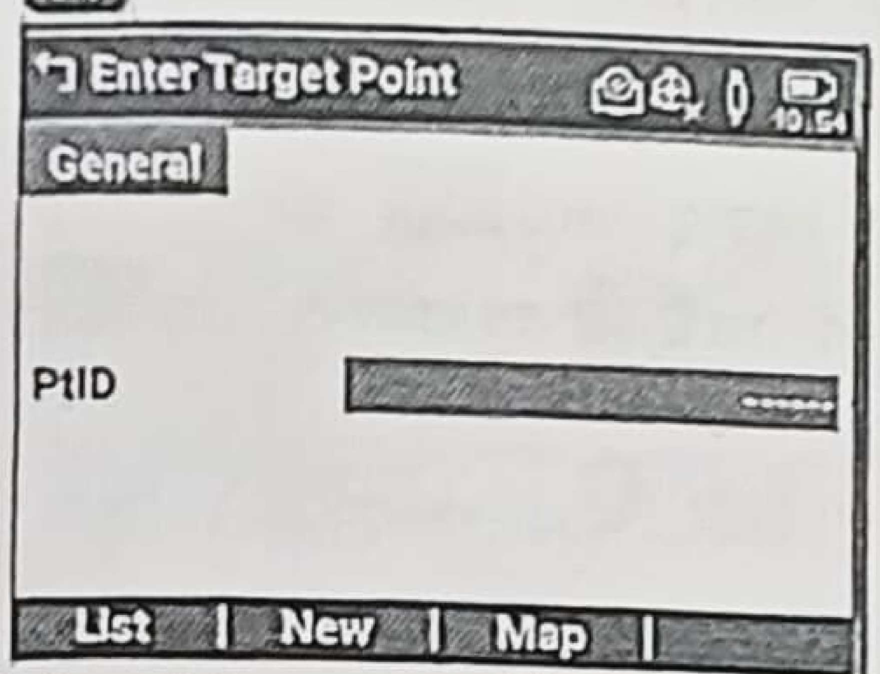
- Now come to 2 Survey then OK you can continue your measurement

Resection or Free Station:

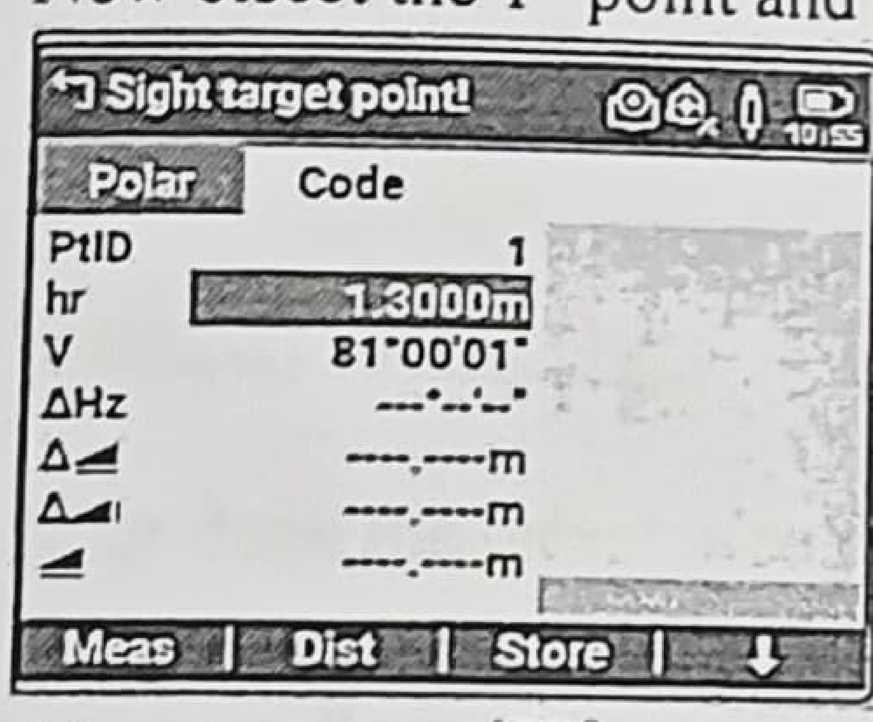
- This program is used to calculate the coordinates of unknown station point with respect to 2 known points:
- Put your TS on any un known point
- Go to 1 Setup then press OK then press 'Cont.' F4
- Select 'Resection' then press 'Cont.'
- Put your Station point Id (STN) and Height of Instrument then press 'Cont.'



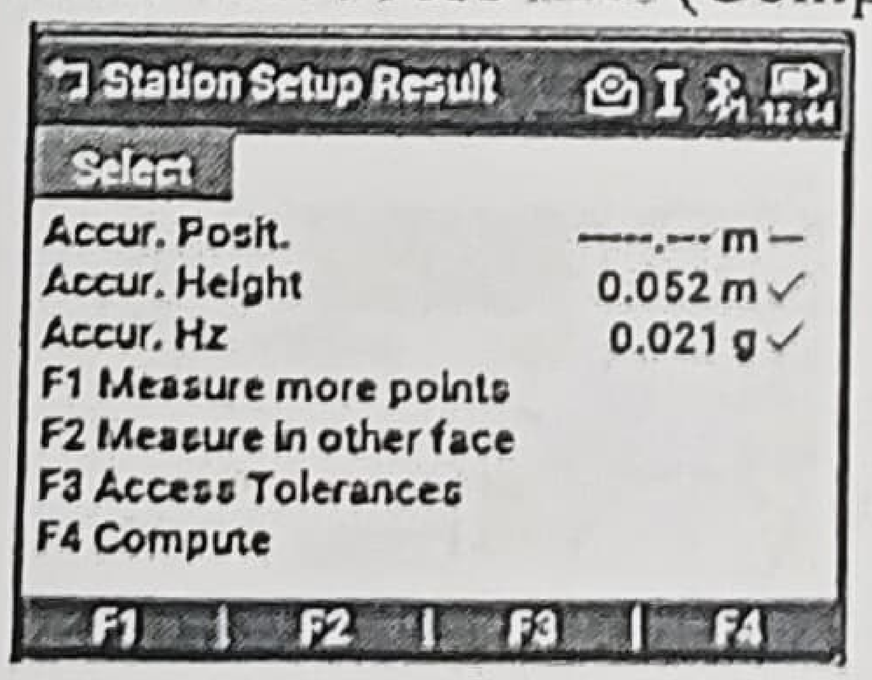
- Press 'New' [F2] feed the 1st station data which you are going to measure then press 'Cont.' [F4]



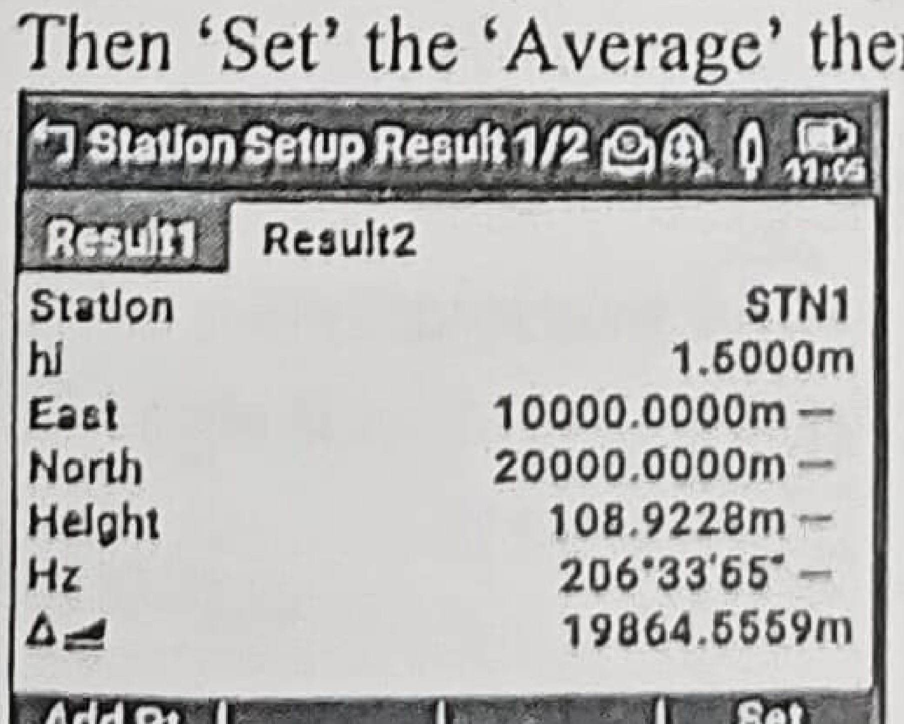
- Now bisect the 1st point and press 'Dist.' [F2] then press 'Store' [F3]



- After that press [F1] (Measure More Points) then Press 'New' [F2] feed the 2nd station data which you are going to measure then press 'Cont.' [F4]
- Now bisect the 2nd point and press 'Dist.' [F2] then press 'Store' [F3]
- After that Press [F4] (Compute)



- Then 'Set' the 'Average' then 'Cont.'



2

- Now come to 

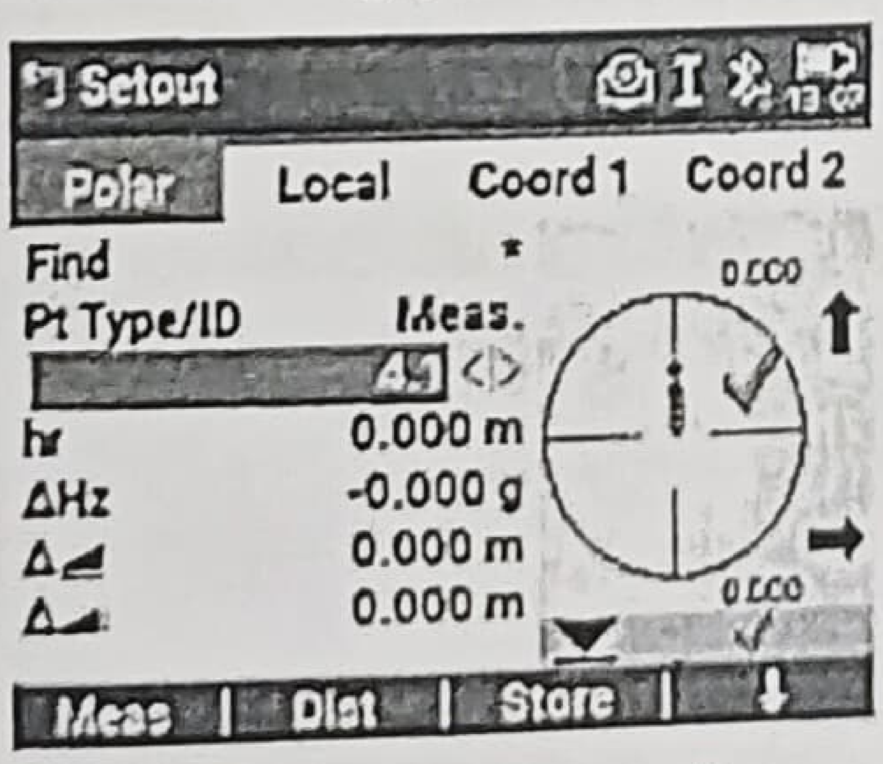
then [OK] you can continue your measurement

Shifting of Station:

- Place the Instrument in New Place of Known Co-ordinate & point no. (written in handbook)
- Go to Setup ______ then Press (OK) then Press 'Cont.' [F4]
- Select the Orientation Method then 'Ori with Coord' then press 'Cont.' [F4] put the station point value and 'Hi' then press (OK) after that Feed the Station Value then press 'Cont.' [F4] then press 'Cont.' [F3] then put the Back sight point id or you can select from 'List' [F1] 'New' [F2] 'Map' [F3] then press 'Cont.' [F4] then aim the Back sight point press 'Dist.' [F2] and 'Store' [F3] then press 'Compute' [F4] then press 'Set' [F4] then you can select 'Old' [F2] or 'Average' [F3] or 'New' [F4]
- Now come to Survey then (OK) you can continue your measurement

Stakeout or Set Out:

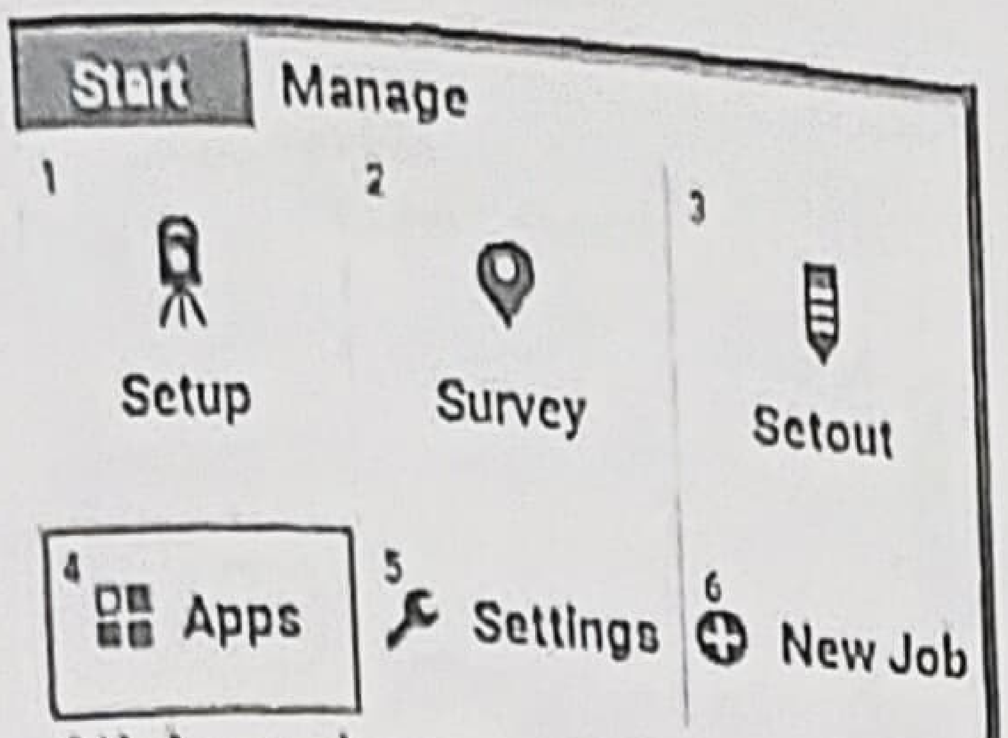
- After done the orientation of your Total Station
- Go to Setout then press (OK)
- Press 'Cont.' [F4]
- Then Press [F4] then press 'New' [F2]
- Feed Staking point data then Press 'Cont.' [F4]



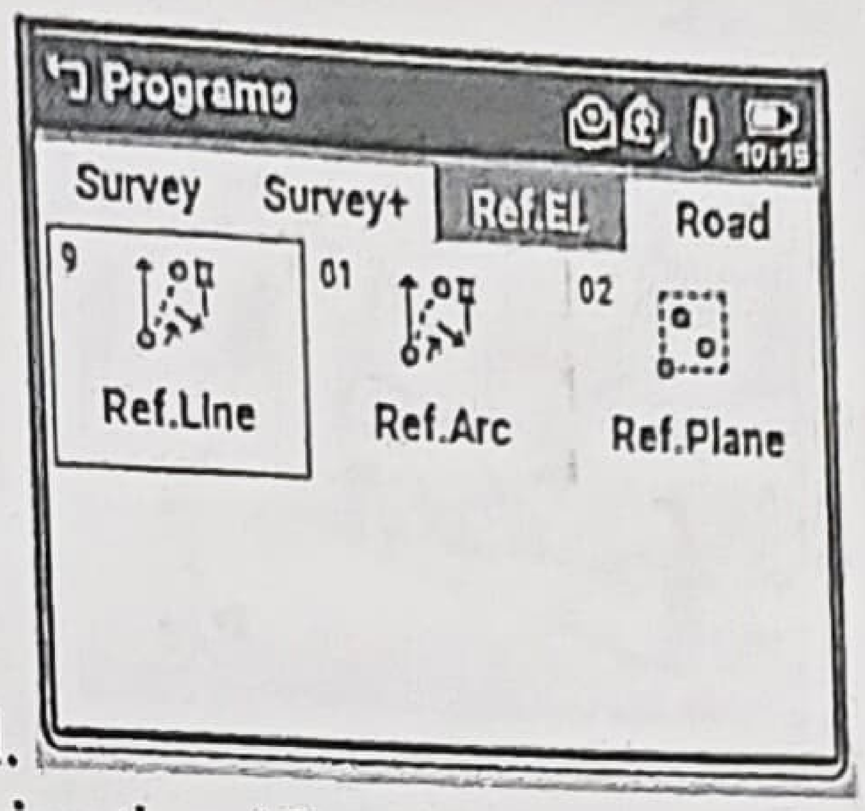
- Take a measurement of any point by pressing 'Dist.' [F2]. After that Rotate your TS on Hz 0° angle then move your prism into line of sight then 'Dist.' [F2] and 'Store' [F3]

Reference Line:

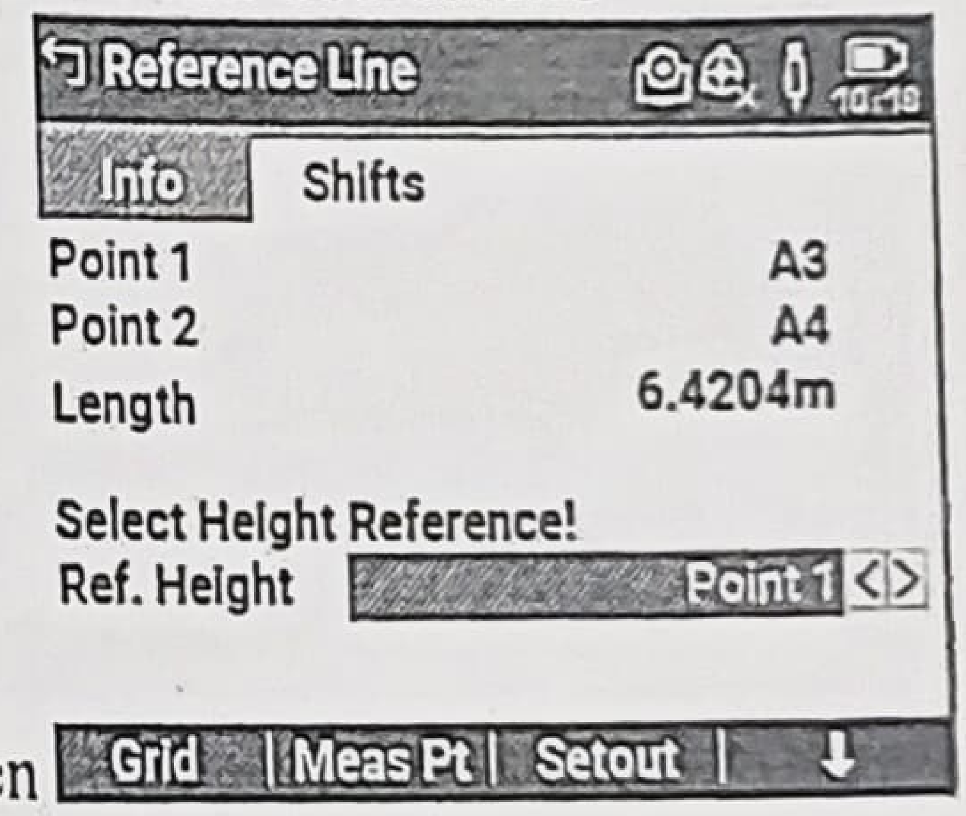
- After Orientation of your instrument just came to home Screen



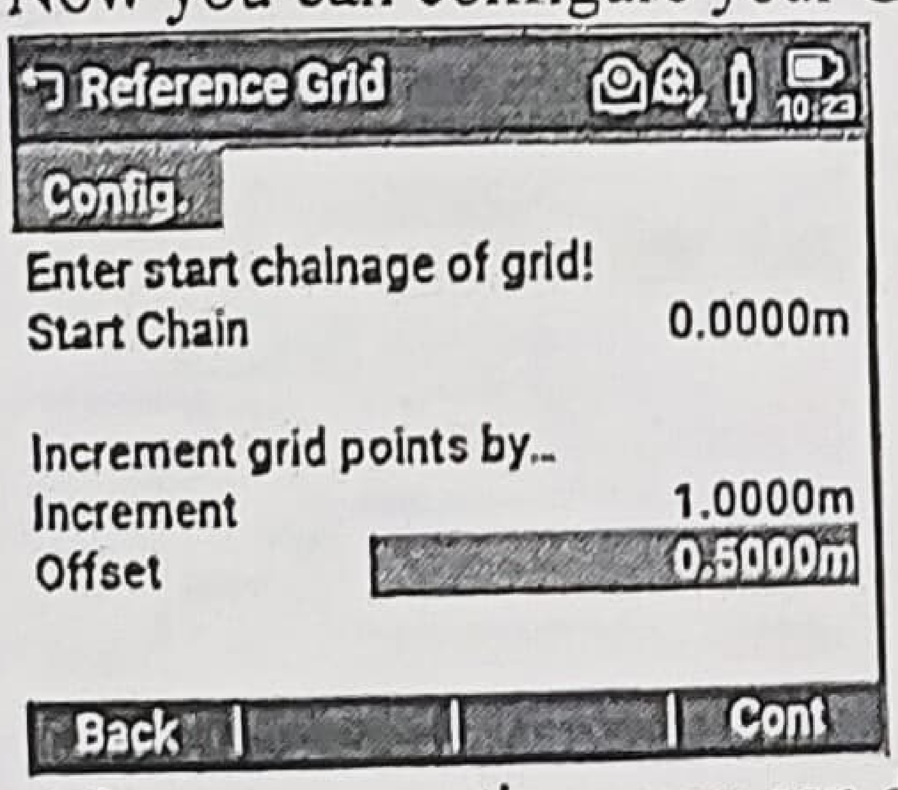
- Click on Apps



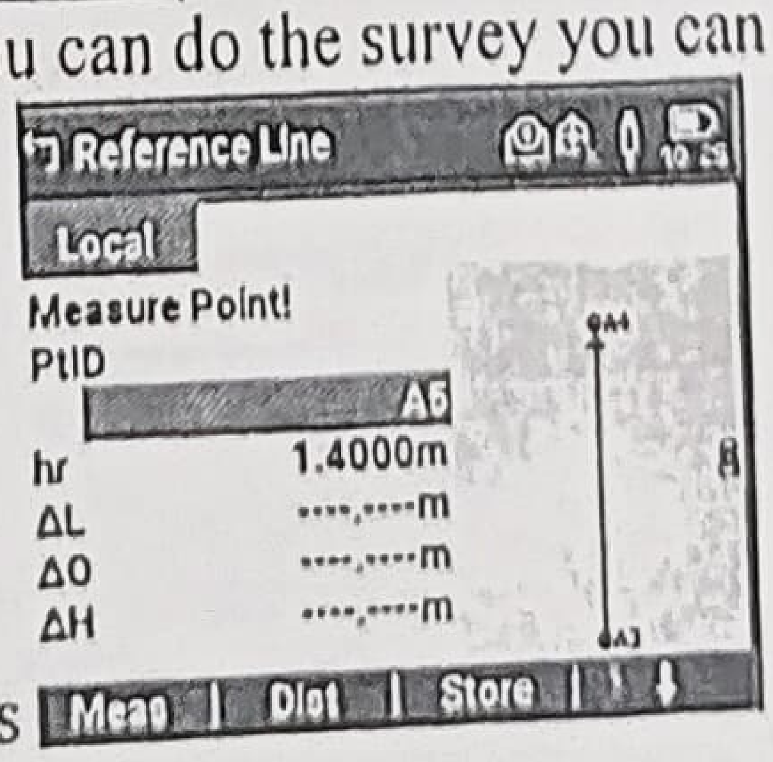
- Now click on Ref. El.
- Then Click on Ref. Line then 'Cont.'
- Now Measure or Input 1st and 2nd Reference Point Coordinates



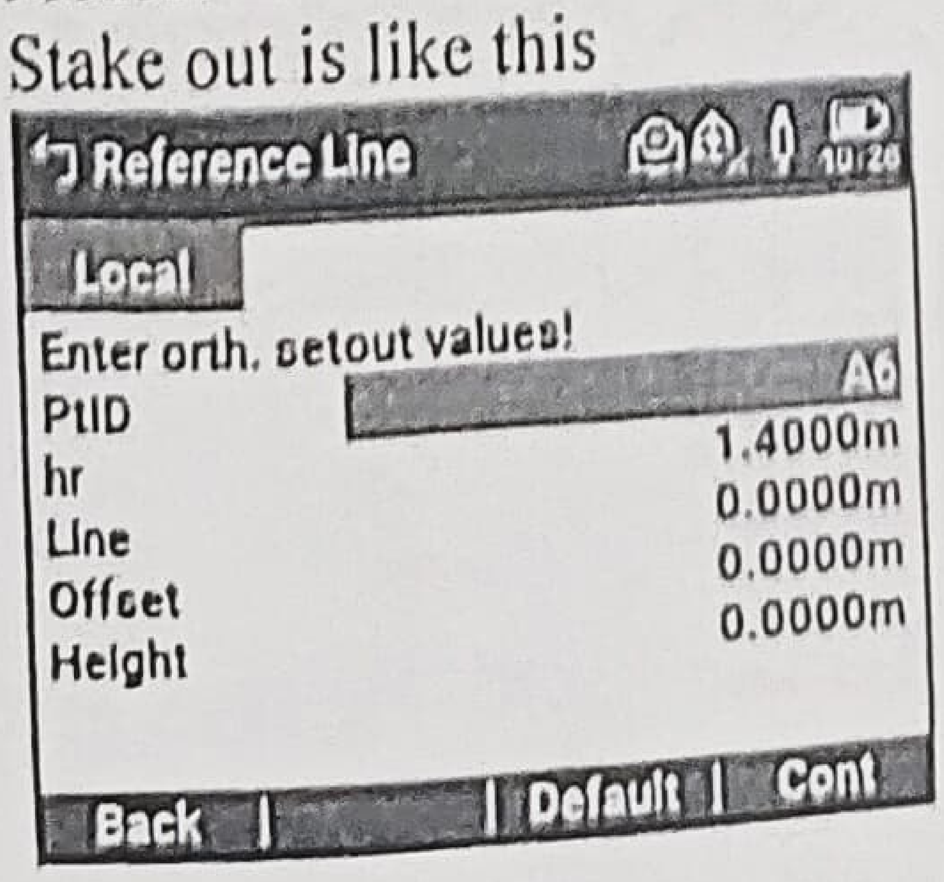
- After measuring you will find this screen
- Now you can configure your Grid by click on Grid



- After press continue you can do the survey you can also change the Chain edge and offset

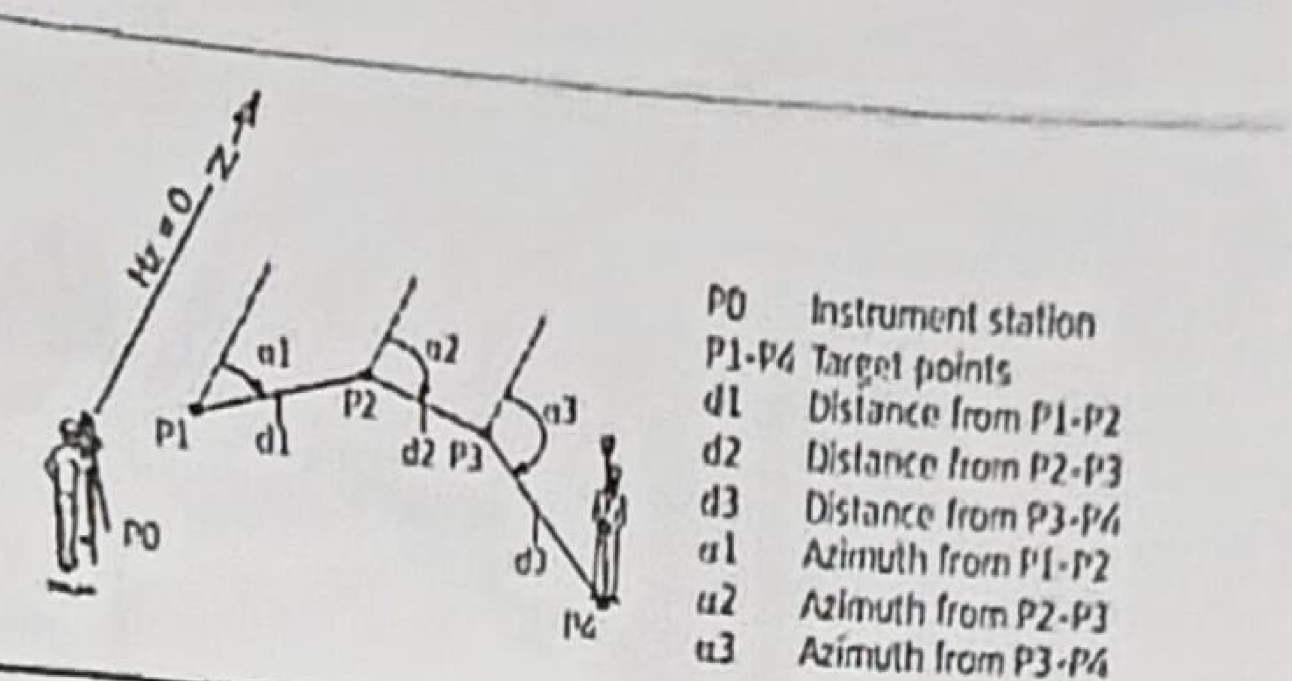


- Measure Point like this
- Stake out is like this

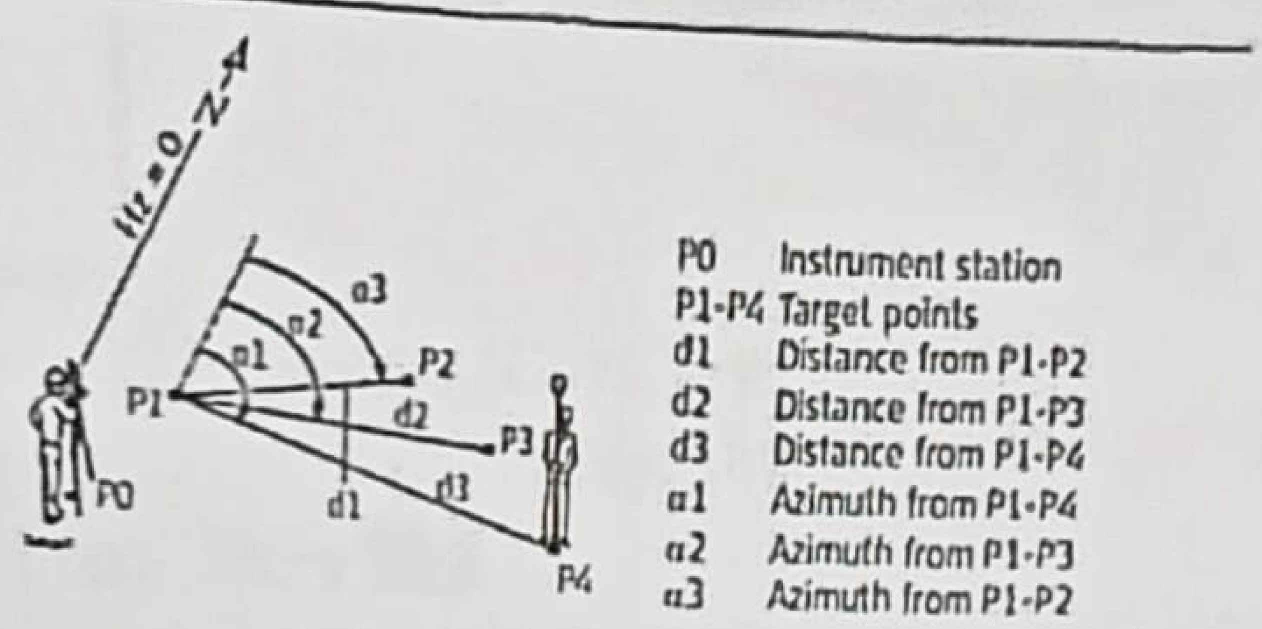


Tie Dist:

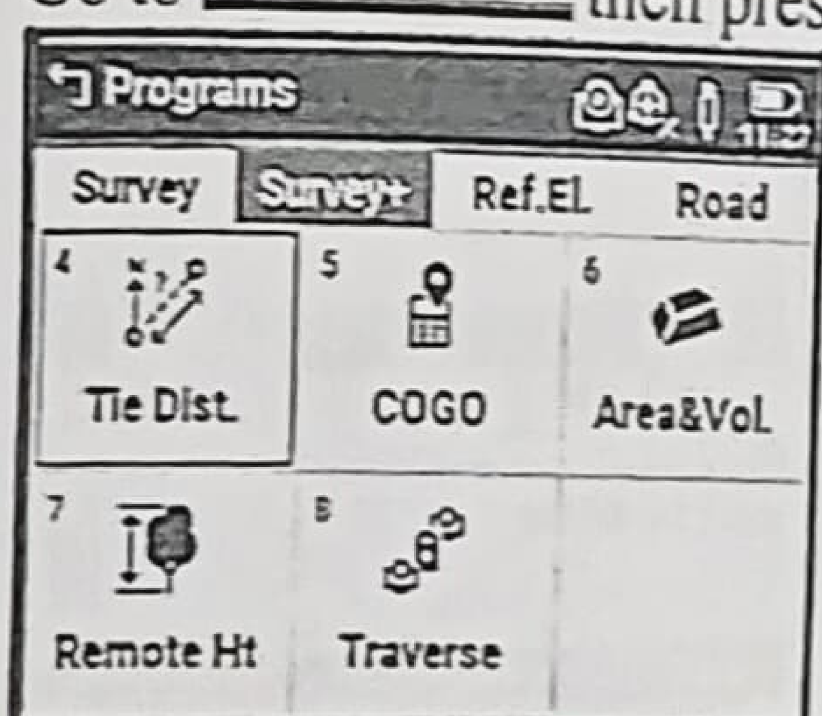
Polygonal method



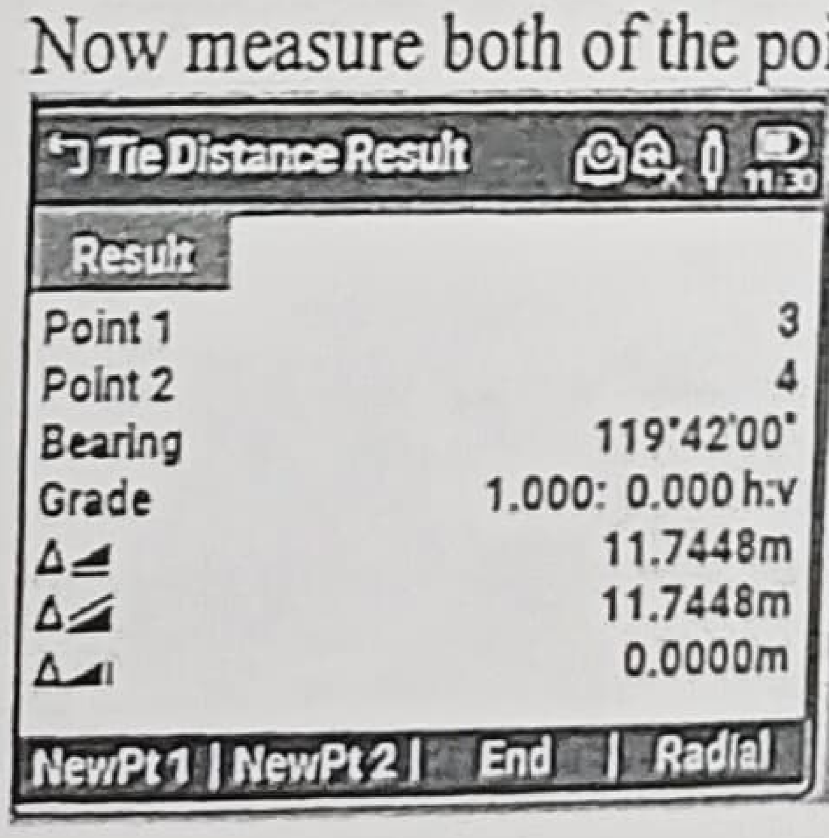
Radial method



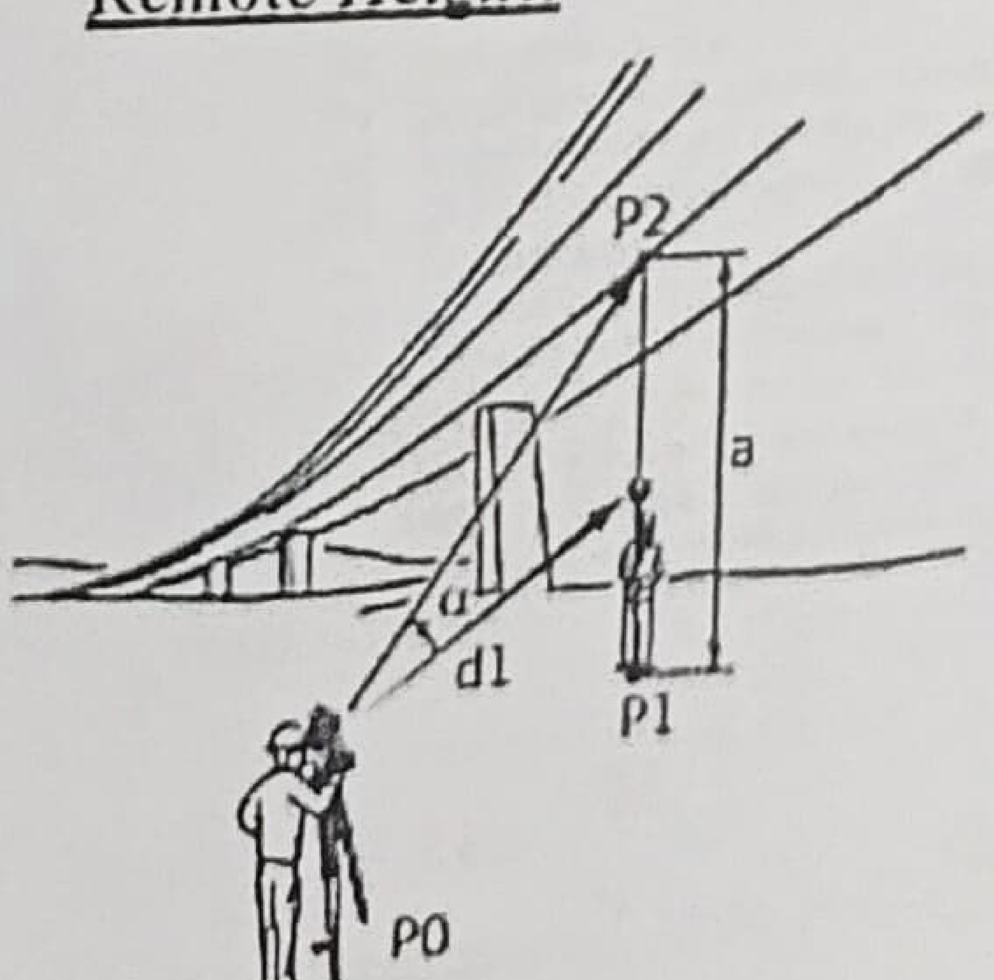
- Go to 4 Apps then press then press 'Page'

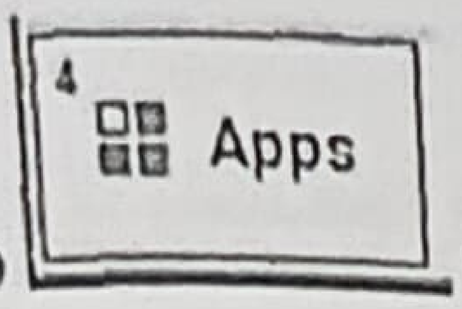


- Go to 'Tie Dist.' then press then press 'Cont.'
- Then choose the method 'Polygonal' then press 'Cont.'
- Now measure both of the points and store it you can see the Result

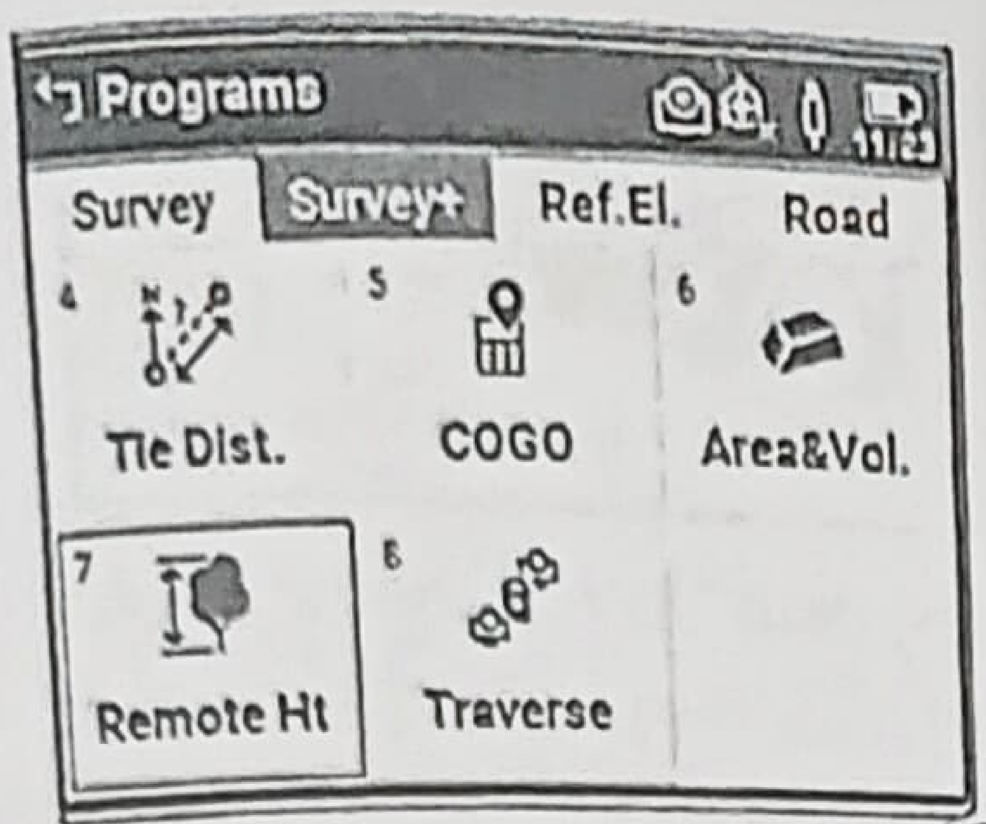


Remote Height:

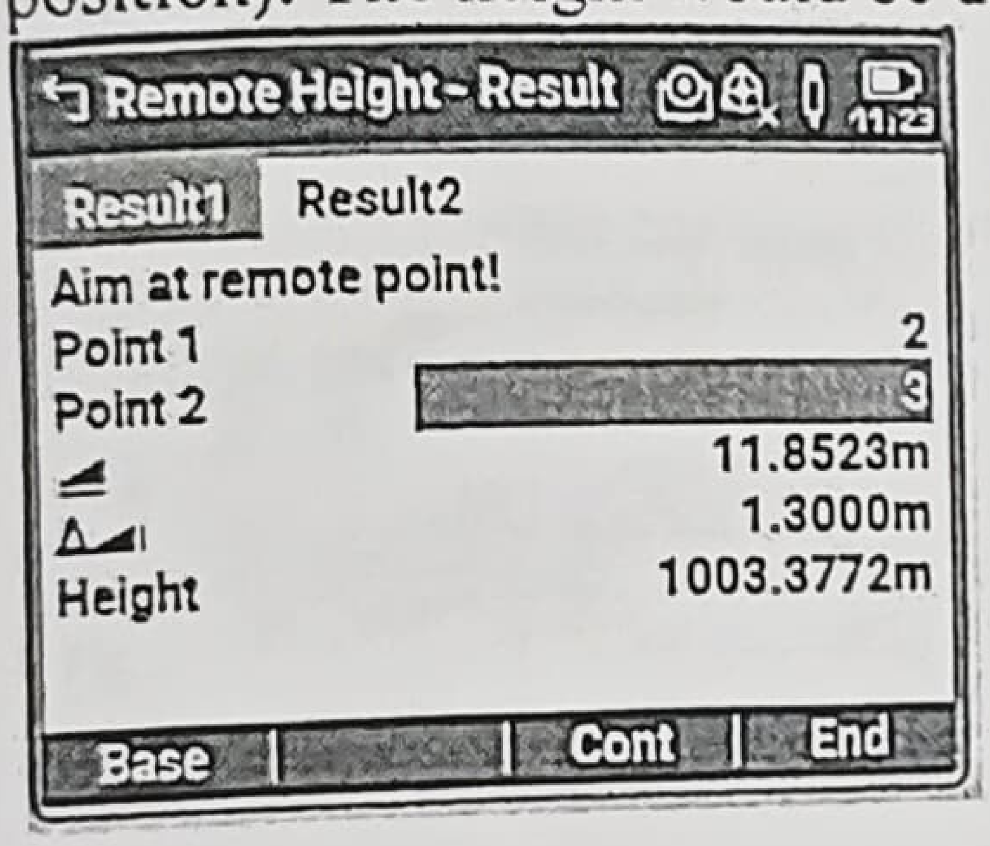


- Go to 

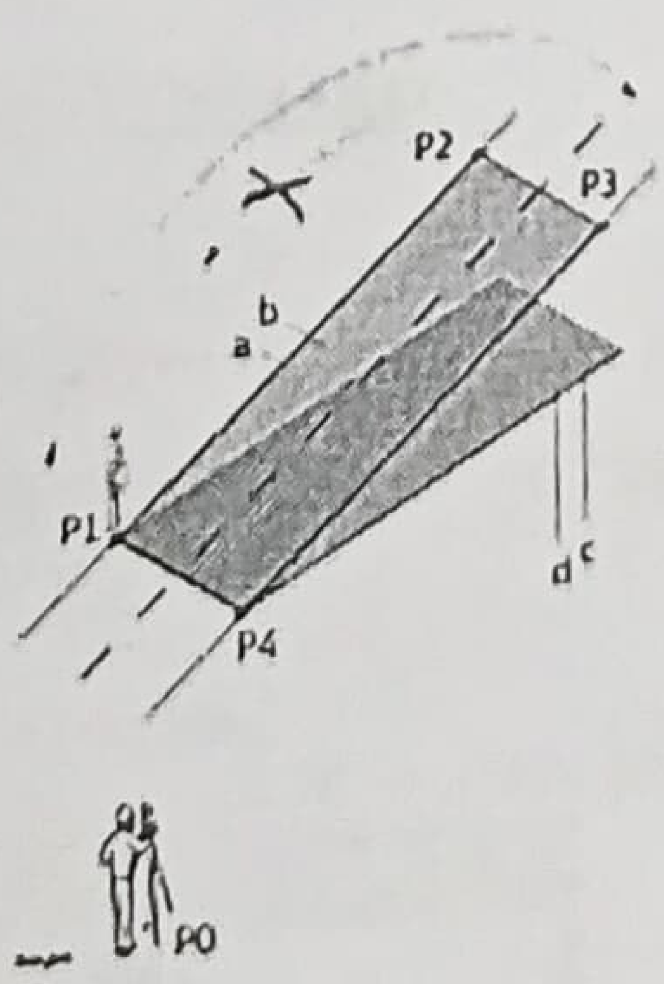
then press (OK) then press 'Page' [Page]



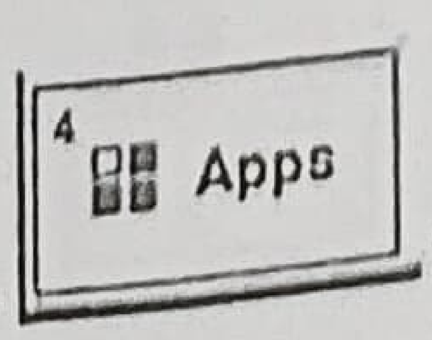
- Go to 'Remote ht' then press (OK) then press 'Cont.' [F4]
- Now aim the bottom point of object or prism feed the 'Prism Height' then measured by pressing 'Dist.' [F2] then press 'Store' [F3]
- Now bisect your desired point by rotted telescope vertically (Horizontal should be Same position). The height would be displayed on the screen.



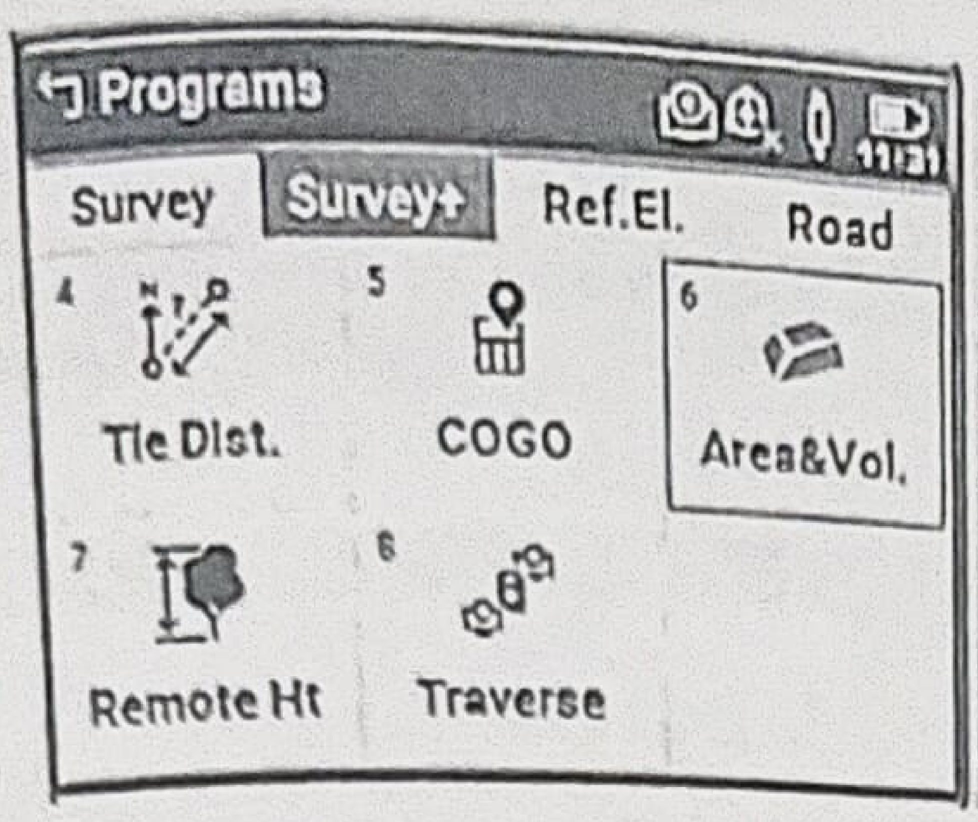
Area Calculation:



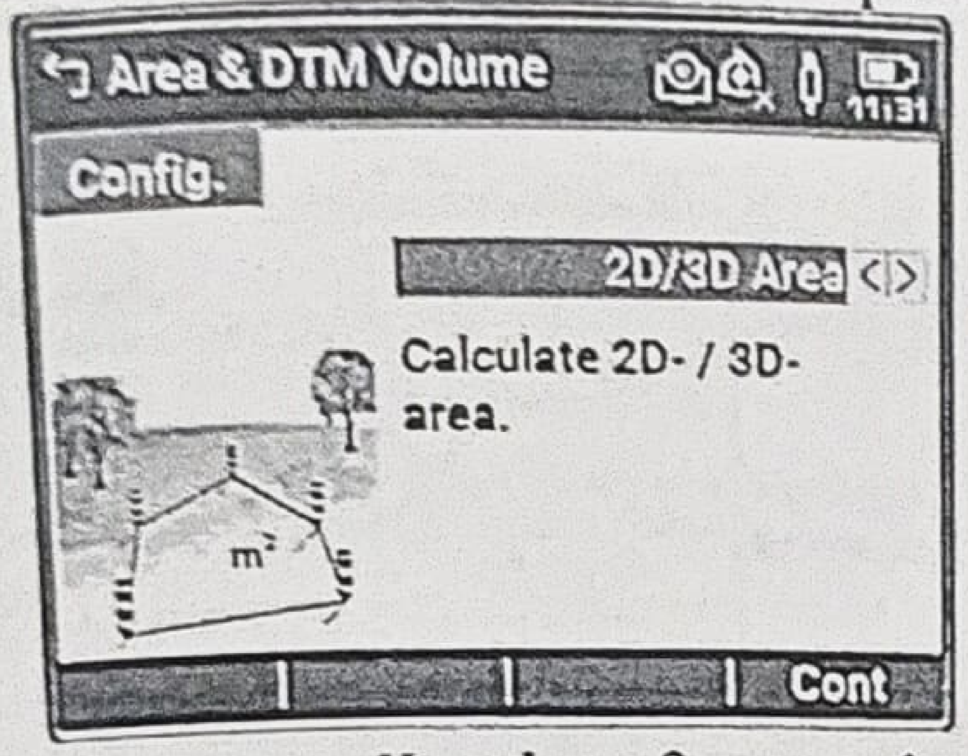
P0 Instrument station
P1 Target point which defines the sloped reference plane
P2 Target point which defines the sloped reference plane
P3 Target point which defines the sloped reference plane
P4 Target point
a Perimeter (3D), polygonal length from the start point to the current measured point of the area (3D)
b Area (3D), projected onto the sloped reference plane
c Perimeter (2D), polygonal length from the start point to the current measured point of the area (2D)
d Area (2D), projected onto the horizontal plane

- Go to 

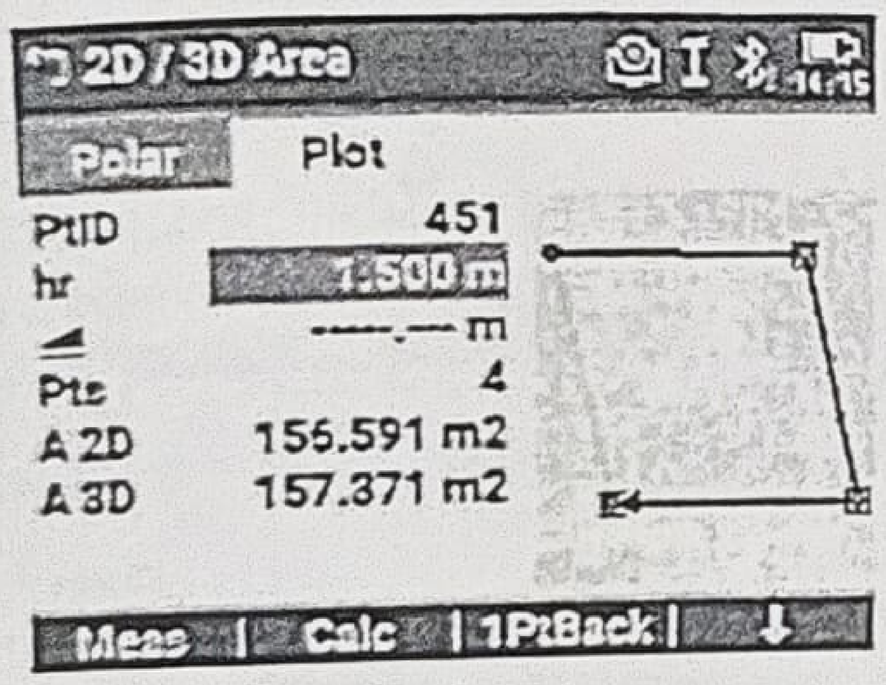
then press (OK) then press 'Page' [Page]



-
- Go to 'Area & Vol' then press OK then press 'Cont.' F4
- Select '2D/3D Area' then press 'Cont.' F4

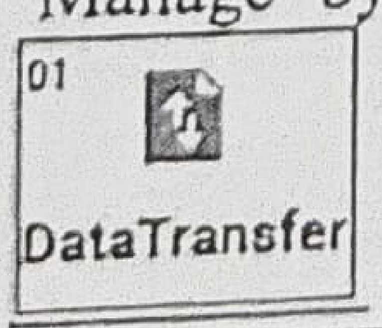


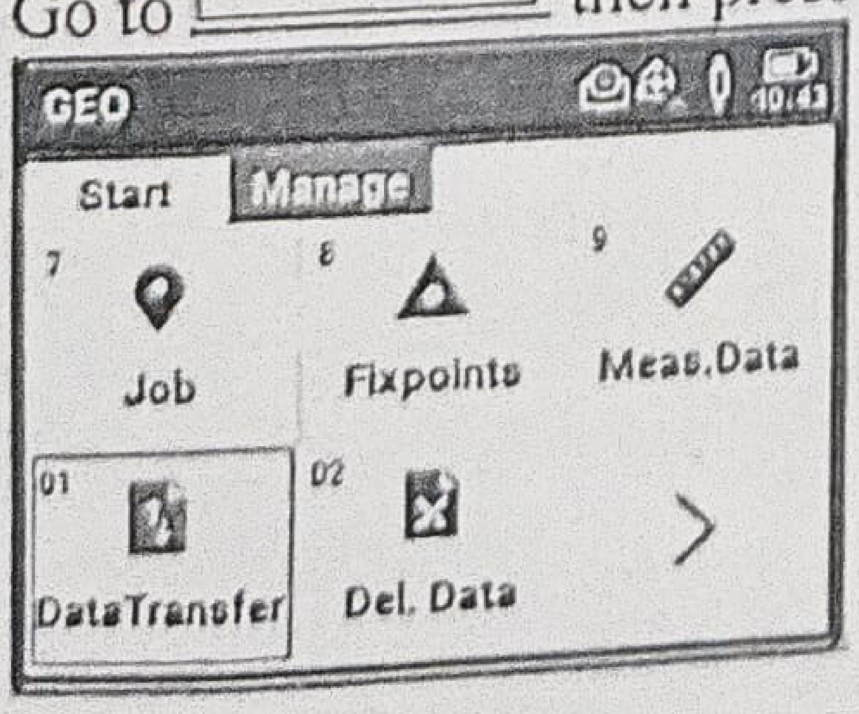
- Measure all points for area by Pressing 'Meas' F1 then press 'Calc' F2

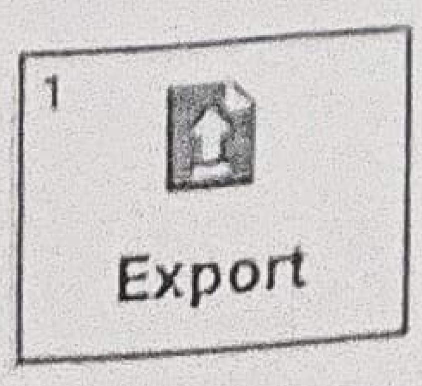


- You Can see the Area

- <u>**DATA DOWNLOAD**</u>

- Put a Pen Drive in your Total Station
- Go to 'Manage' by pressing Page key
- Go to  then press OK

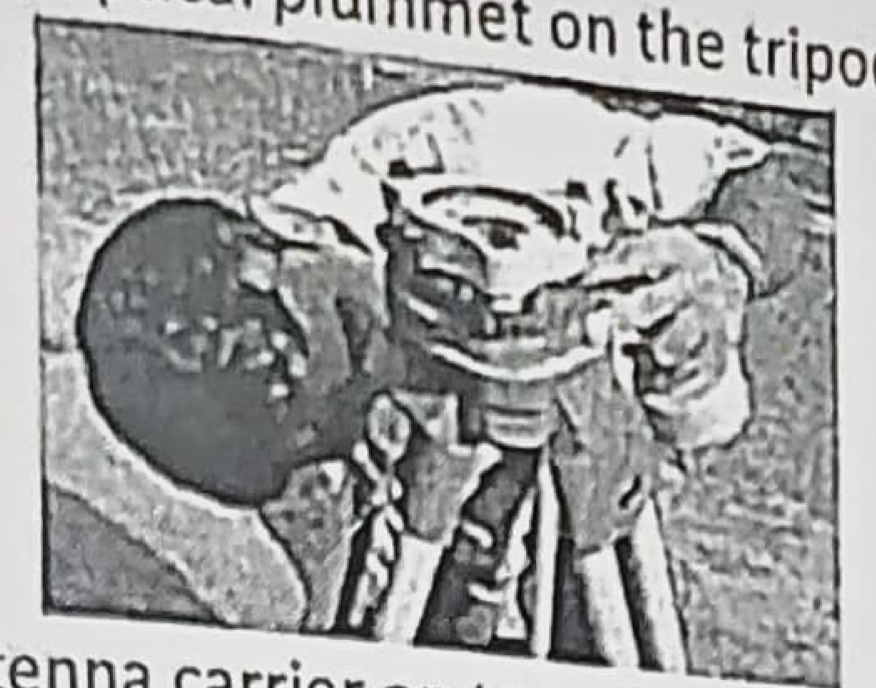


- Go to  then press

Steps of operation of GS16, CS20 DGPS in Post processing mode

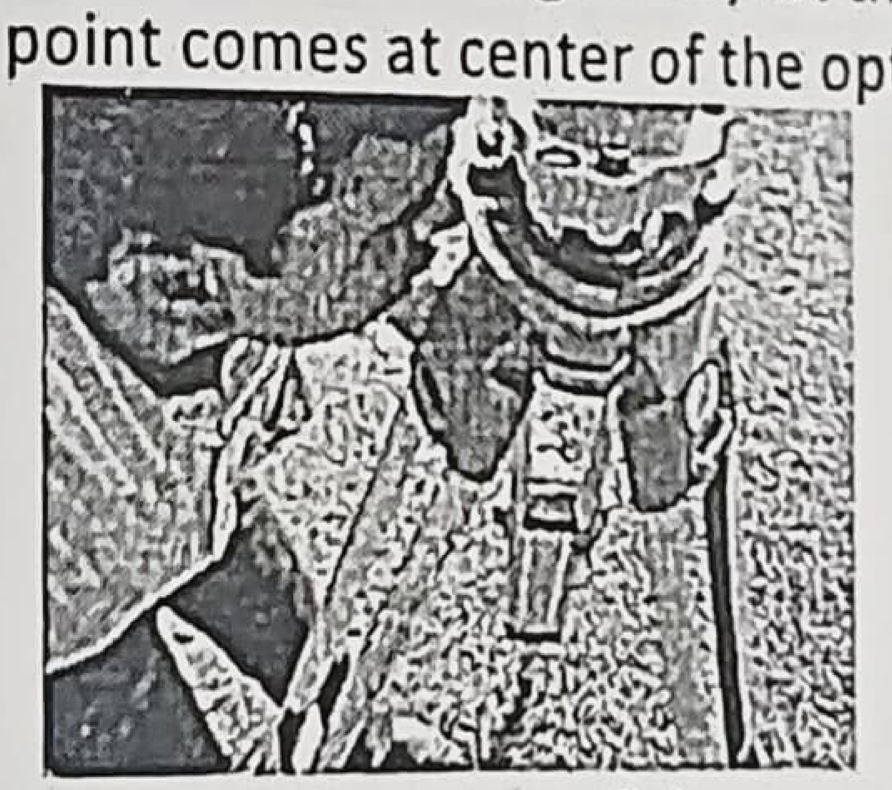
Steps of Setup of Base at point

- Mark the point on ground with a fine dot surrounded by a circle with acrylic paint
- Put the tripod approximately on top of the point
- Attach the Tribrach with optical plummet on the tripod as fig 1



- Attach the GRT146 Antenna carrier on top of the Tribrach and lock it as in fig 2

- Look through the optical plummet, focus it and focus the reticule, so that both the reticule and the ground point are seen distinctively
- By keeping one leg of the tripod fixed on ground, lift the other two legs and move the tripod gently in the hz plane until the ground point comes at center of the optical plummet view as in fig 3

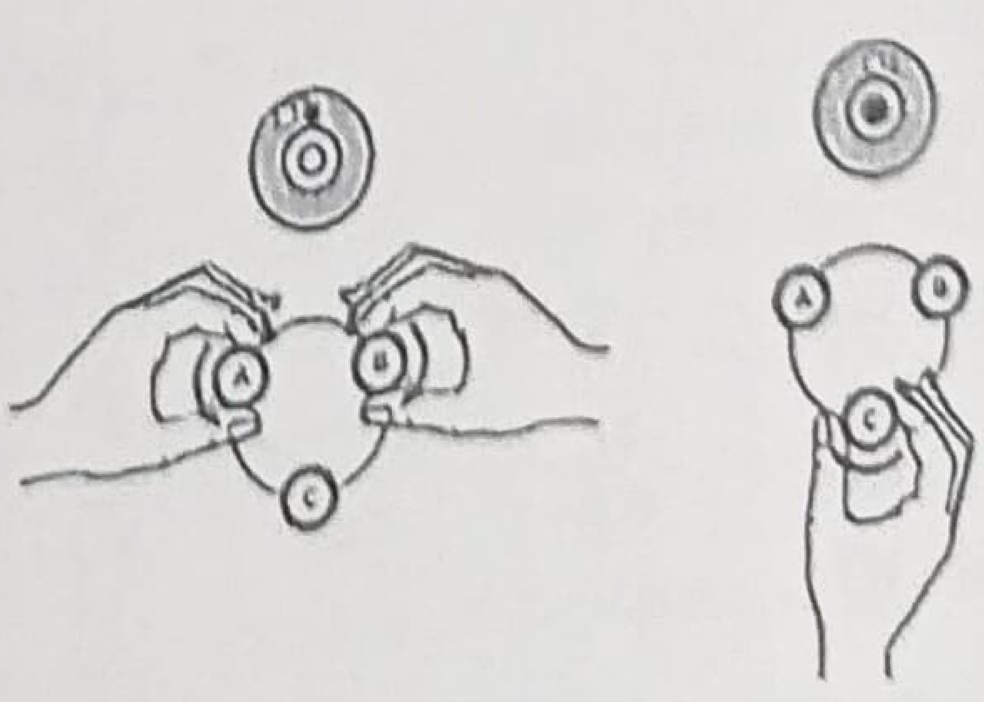


This makes the center of Tribrach vertically on top of the ground point but it should be properly leveled in all 360 degrees as well which can be done either by moving the 3 foot screws of the Tribrach but with this plummet center shifts

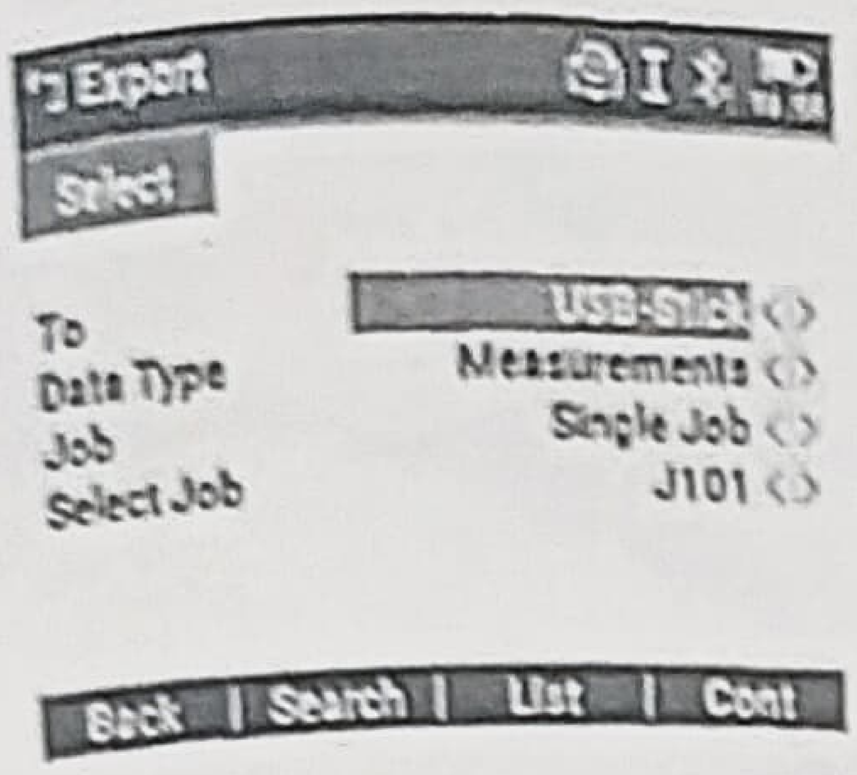
We recommend leveling by adjusting the heights of each telescopic legs of Tripod and this does not shift the plummet centre

Keep one foot on the base plate of a tripod, unscrew one telescopic leg and adjust the height of Tripod in order to bring the air bubble of the Tribrach near to center as shown in fig

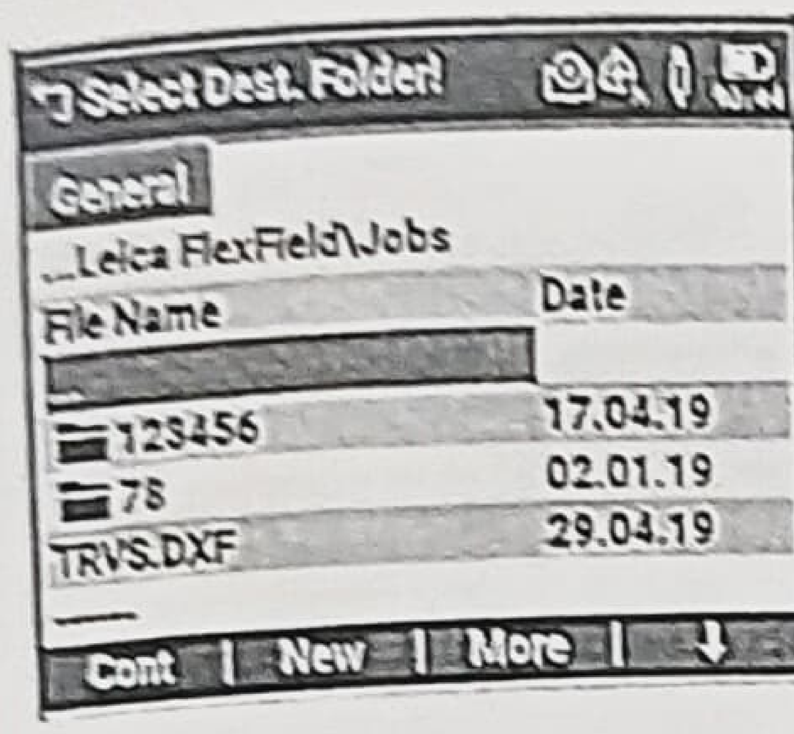
- Repeat the procedure for all the legs
- Carry out such trials few more times until the bubble is in center
- Check Optical plummet center again and there may be some small shifts
- Unscrew the Tribrach from the tripod head gentle and move it in the required direction in the hz plane to adjust the plummet center
- There may be again small bubble center problem

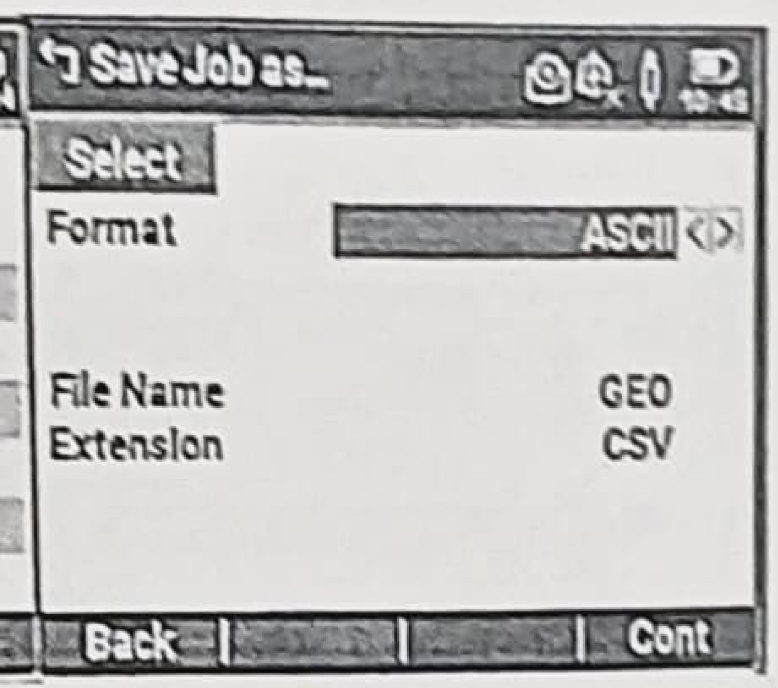


- Adjust this small bubble shift by Tribrach foot screws

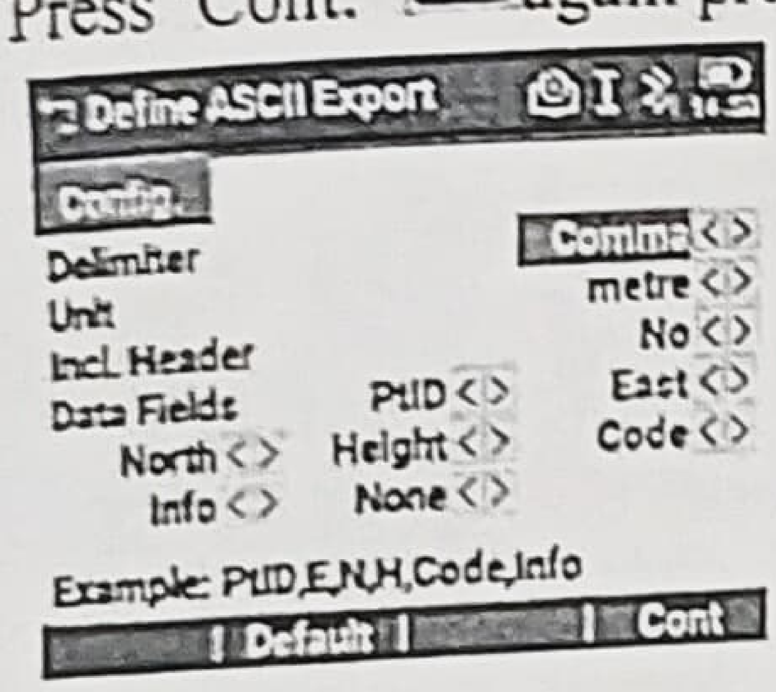


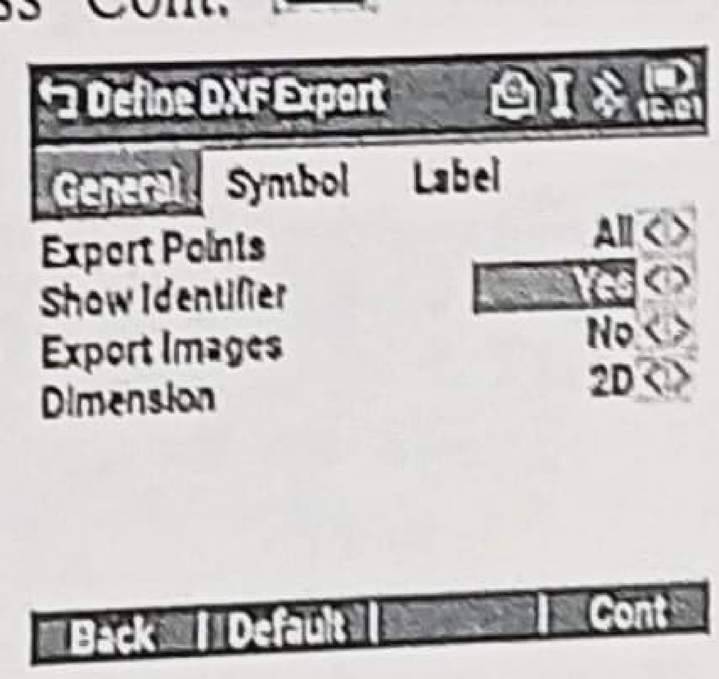
- Select 'USB Stick' then Select your job
- Press 'Cont.' F4 then press 'Cont.' F1





- After that Select your Data Format (GSI/XML/ASCII/DXF Customs/DXF/IDEX) Then Press 'Cont.' F4 again press 'Cont.' F4



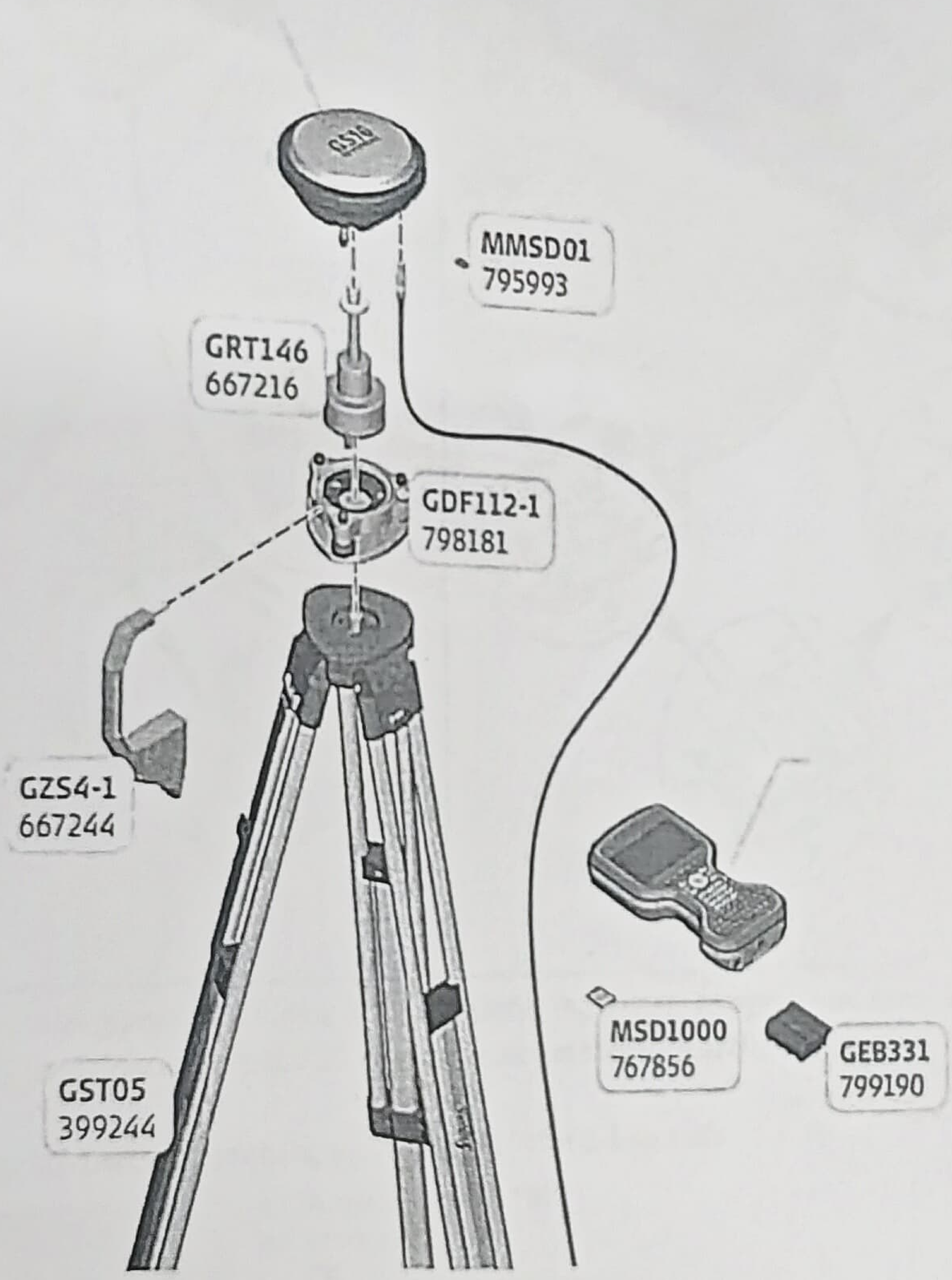


- **<u>STEPS ON COMPUTER</u>.**

- Copy the DXF file from your USB Stick's Job folder
- Open it
- Press Commend in AutoCAD
- Z (Enter)
- E(Enter)

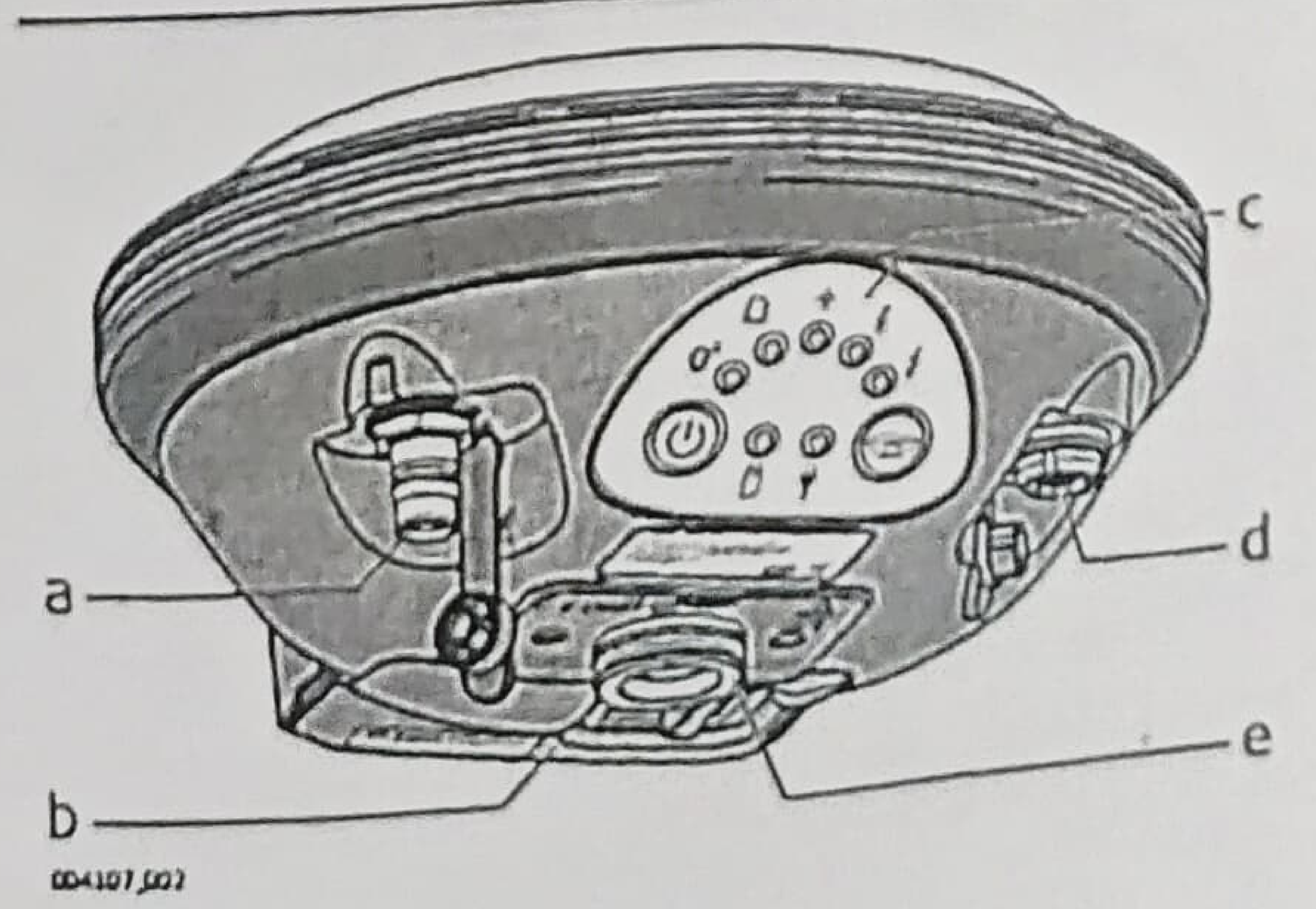
ne or two repeats will make both Plummet center and optical bubble center both adjusted
Now attach GS14 on the GRT146 antenna Carrier as in fig below
Take Height Hook GZS4-1 and insert the fixing pin
Then extend the inbuilt tape till the end touches to the ground point in a straight down fall without any shagging
- Read the height at the white marked point on the Height hook

all setup is given below



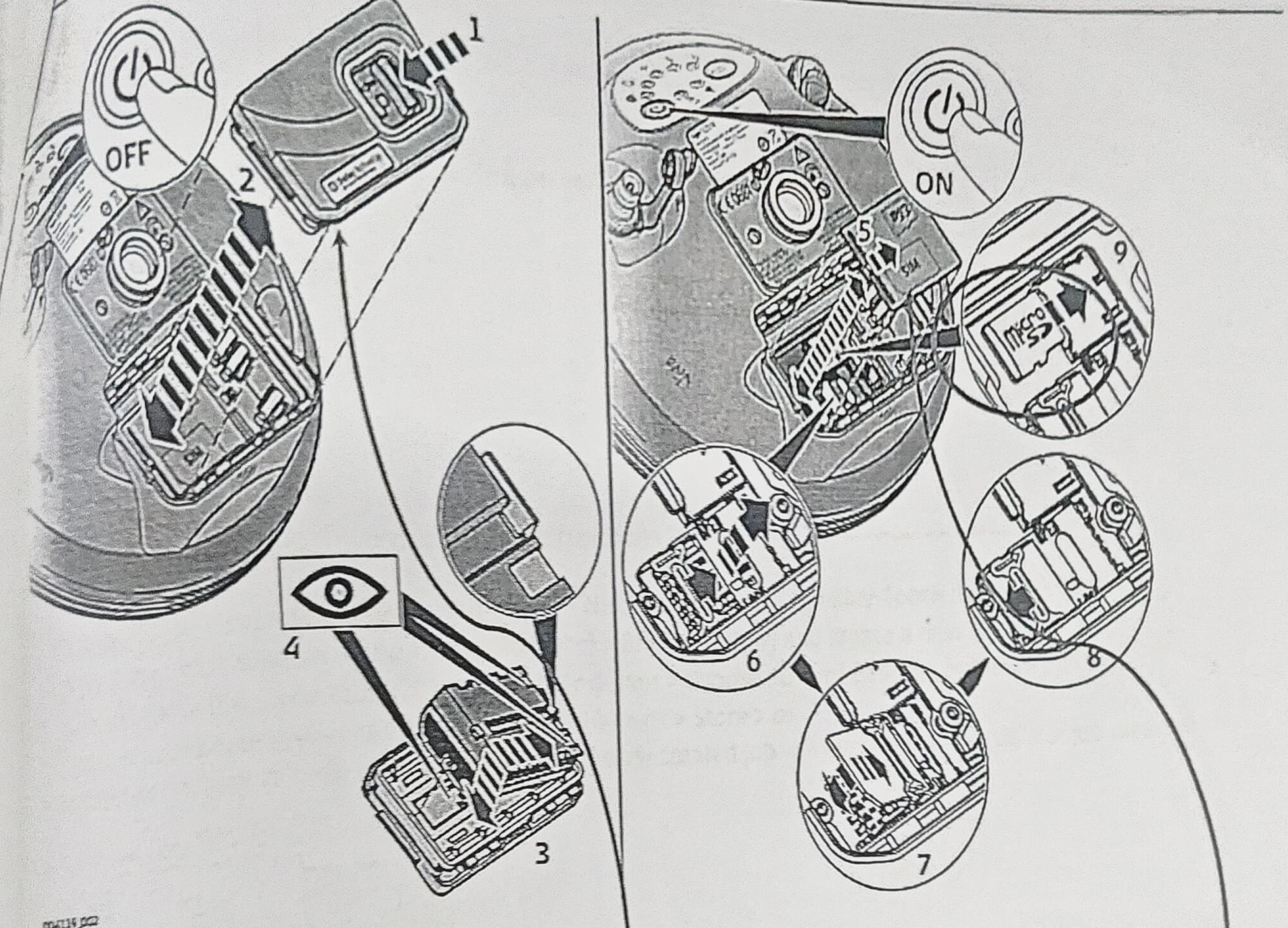
- Switch on GS16 by pressing power on/off button for 3 seconds

Instrument Components



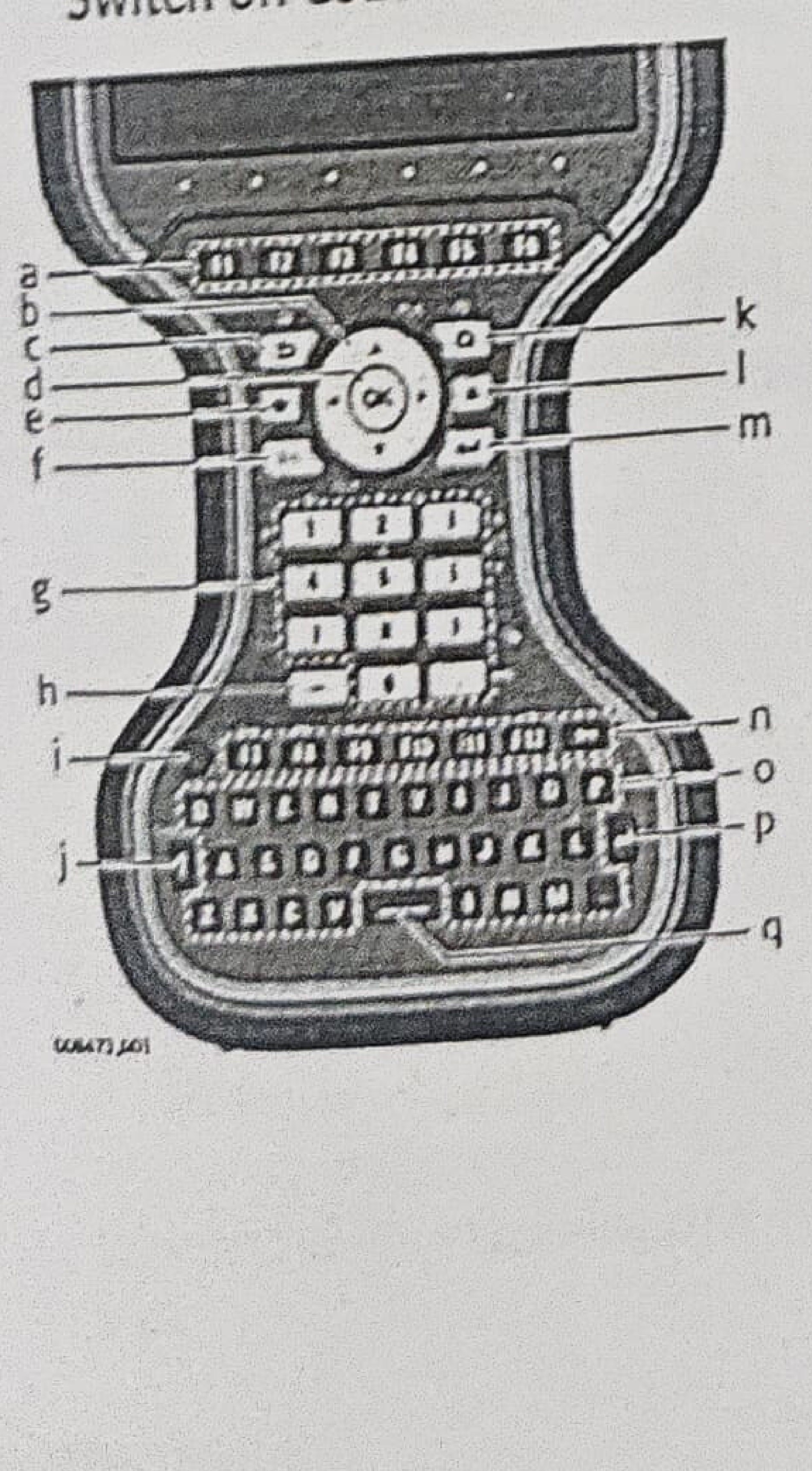
a) QN-connector for external UHF antenna, only for models with UHF radio
b) Battery compartment with microSD and SIM card slot
c) LEDs, ON/OFF button and Function button
d) LEMO port, serial and USB
e) Mechanical Reference Plane (MRP)

battery must be charged before using it for the first time.

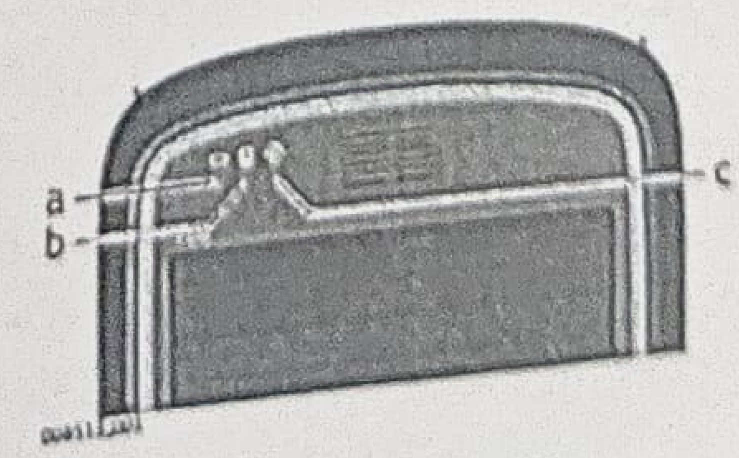


Battery Compartment to be opened by sliding the lock 1. Under the battery compartment there is another slot cover for Micro SD card and sim card. Place the micro SD card in the slot as shown in above pic.

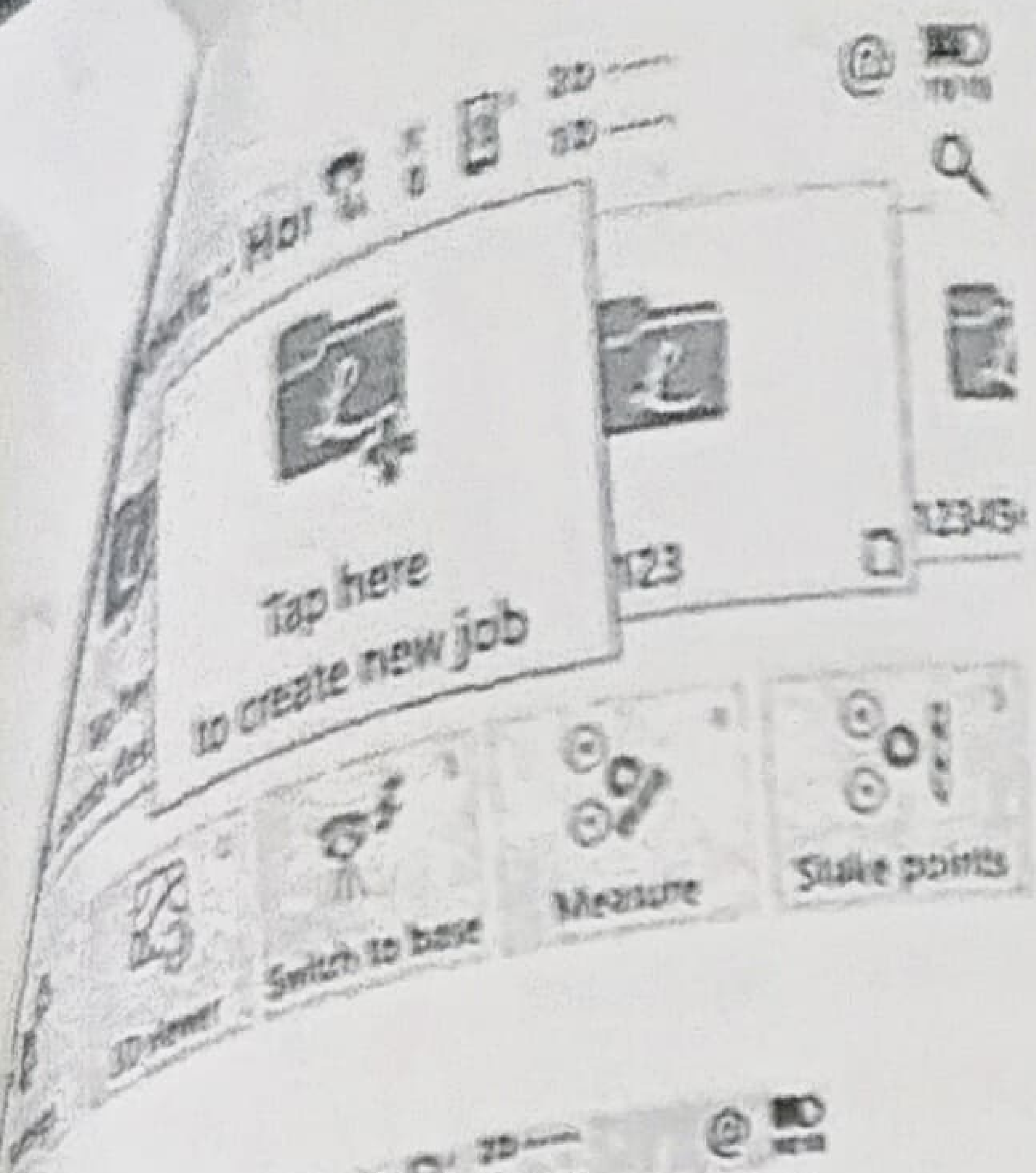
- Switch on CS20 Controller by pressing power button (i) for 2-3 seconds



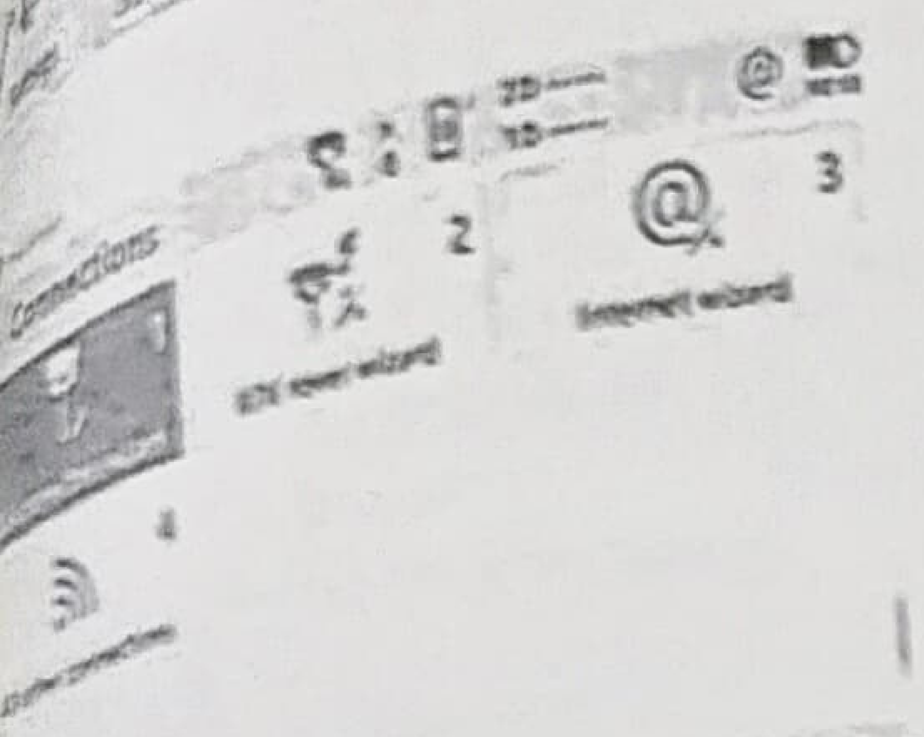
a Function keys **F1 - F6**
b Arrow keys
c ESC
d OK
e Home
f **Fn**
g Numeric keys
h ± key
i ON/OFF
j CAPS Lock
k Cameras
l Favourites
m ENTER
n Function keys **F7 - F12**; Backspace
o Alpha keys
p ENTER
q SPACE

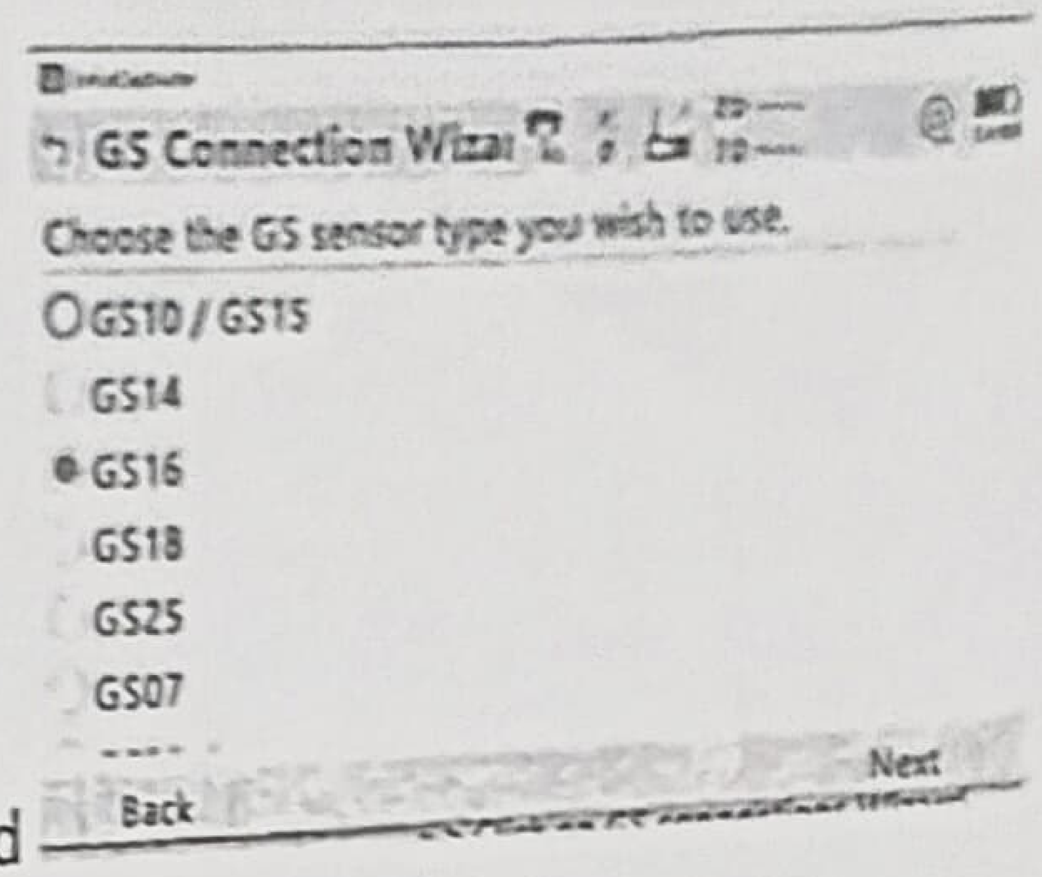


a Power LED
b Bluetooth LED



> click on settings > Click on Connections

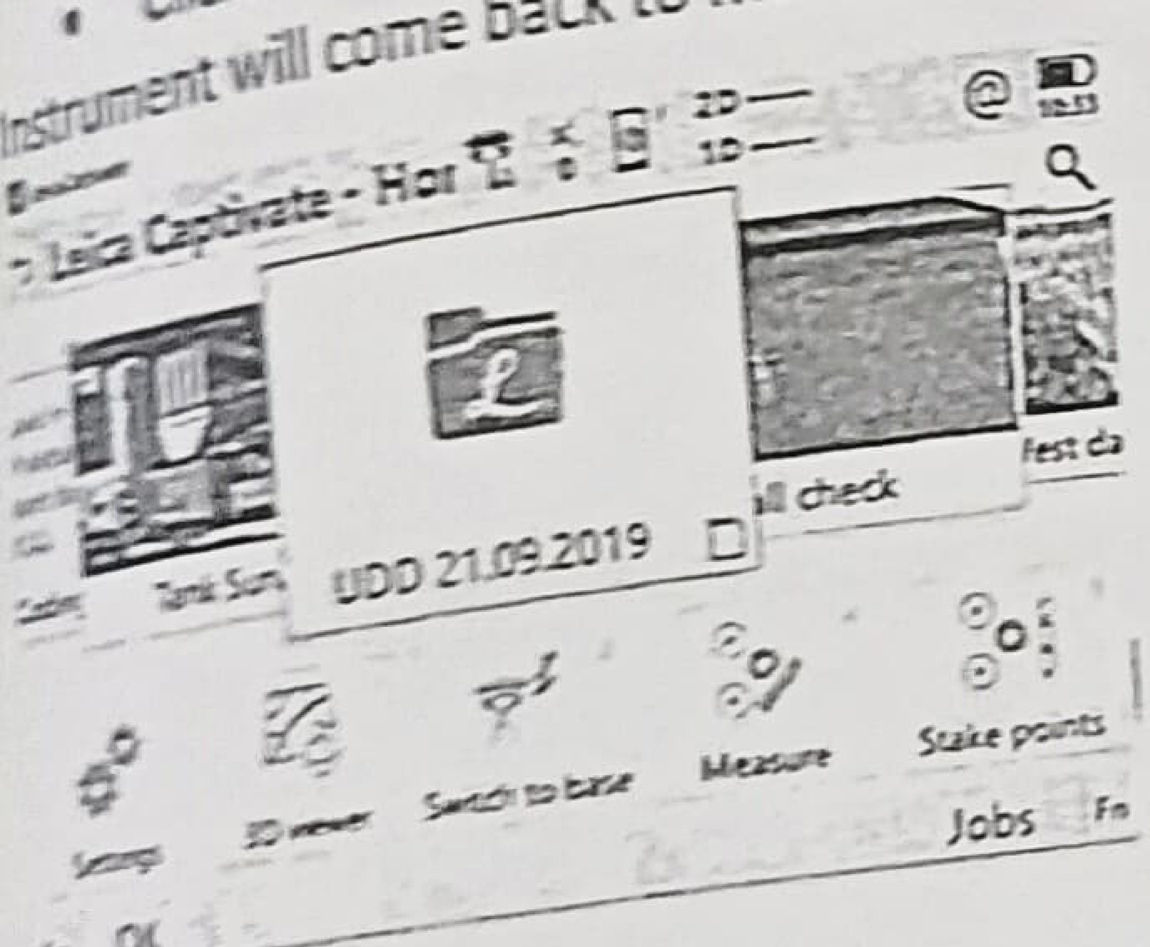




> Click on GS connections Wizard

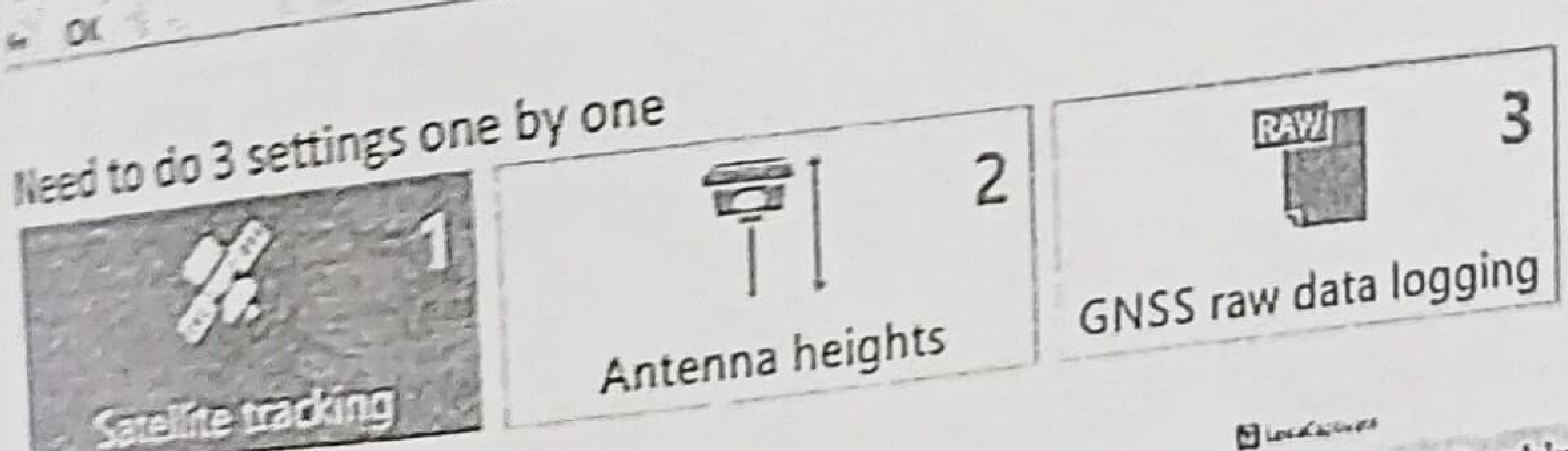
- Click on GS16> Next > Select Bluetooth> Next > Next > Select the GS16 Blue Tooth ID>Next>Finish
- CS20 comes back to main menu > Press F6 (Jobs) > Press F2 (New) and create a new Job>
- Give job name (Say xxxxx21.09.2019) and other details > Choose SD card (storage option) >
- Click on Coordinate system tab> Choose WGS1984 > ok > Store > ok

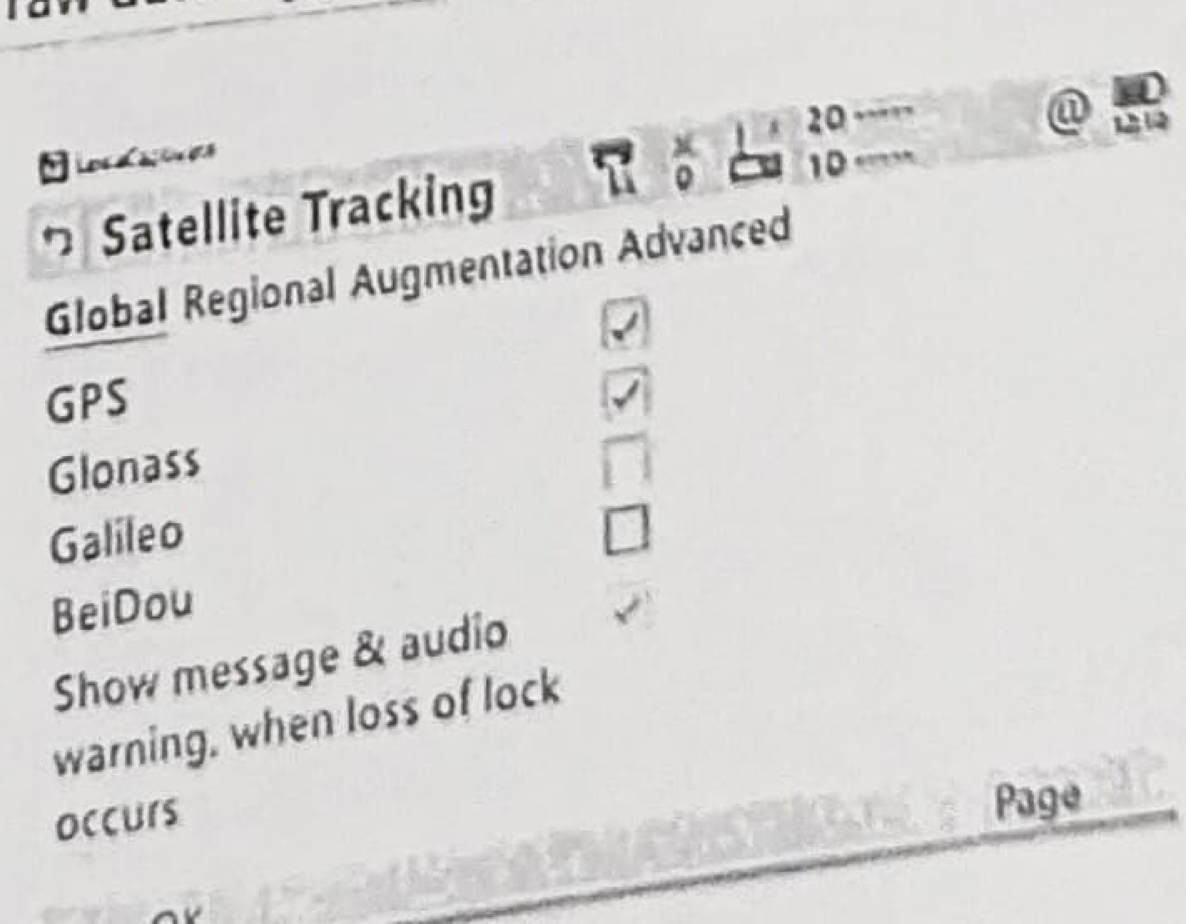
Instrument will come back to main menu again and the newly created job will appear in the middle of job carousel



> Again click on Settings > Click on GS sensor

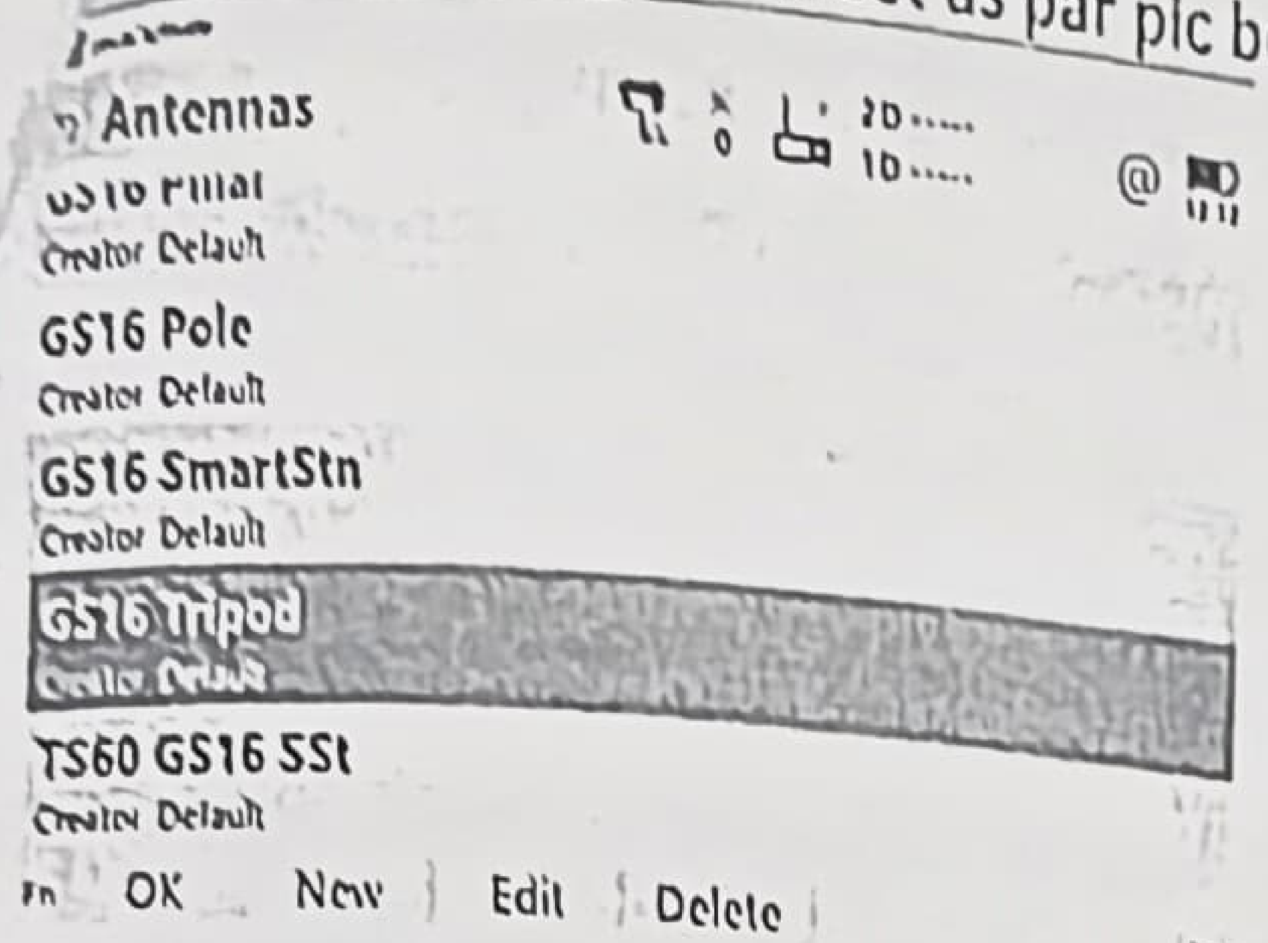
Need to do 3 settings one by one





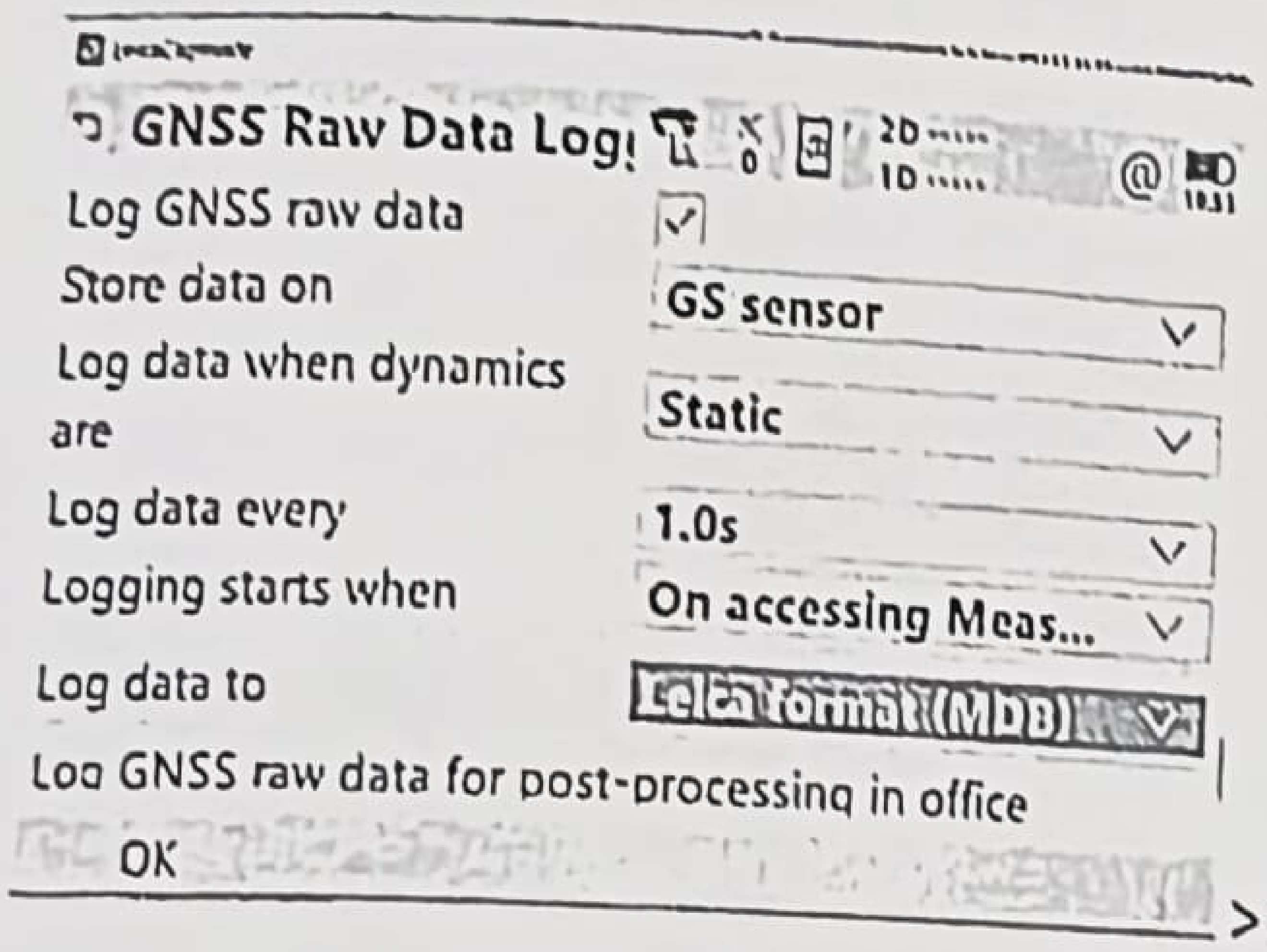
1. Click on Satellite tracking and set as par pic below > ok

ick on Antenna Heigh and set as par pic below



Fn > ok

3. Click on GNSS Raw data logging and set as par pic below



> ok

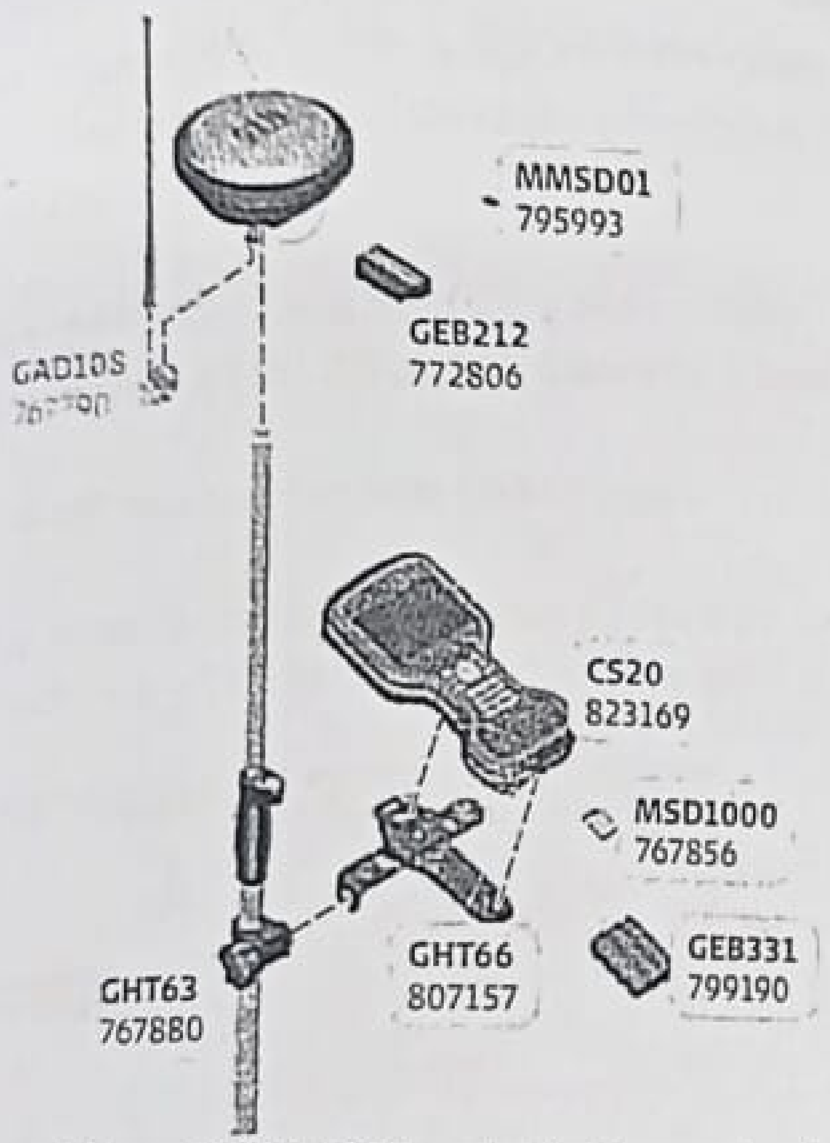
Survey data collection: -

- From Main menu > Click on Measure App>
- Input Point Id and Antenna Height > Press F1(Measure) > F1 function changes to Stop> Leave it as it is
- Do not press Stop > otherwise data logging will be stopped
- Wait till data collection is completed → Click on Stop →Click on Store

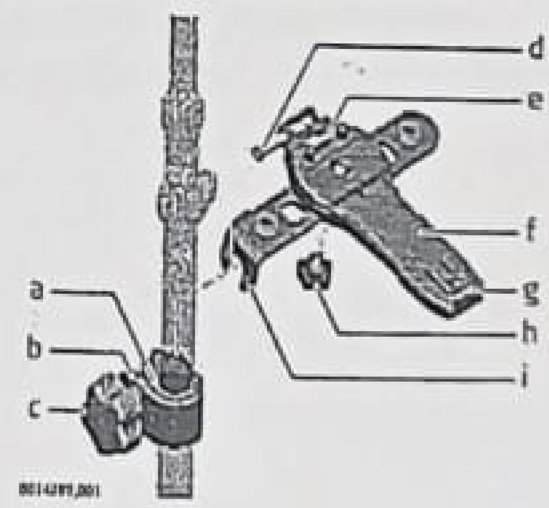
When operating with single controller take the controller to the Rover and leave GS to keep on logging rawdata

Steps for operating GS16 CS20 RTK Rover on pole setup

First Fit GS16 Rover on Pole and attach CS20 Controller with Pole, by Pole adapter as in Fig.



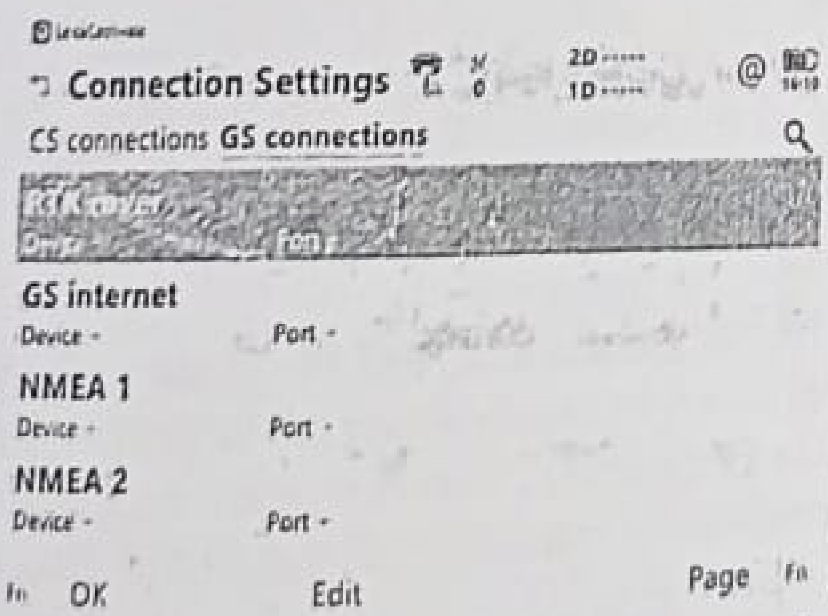
The GHT66 holder consists of the following components:

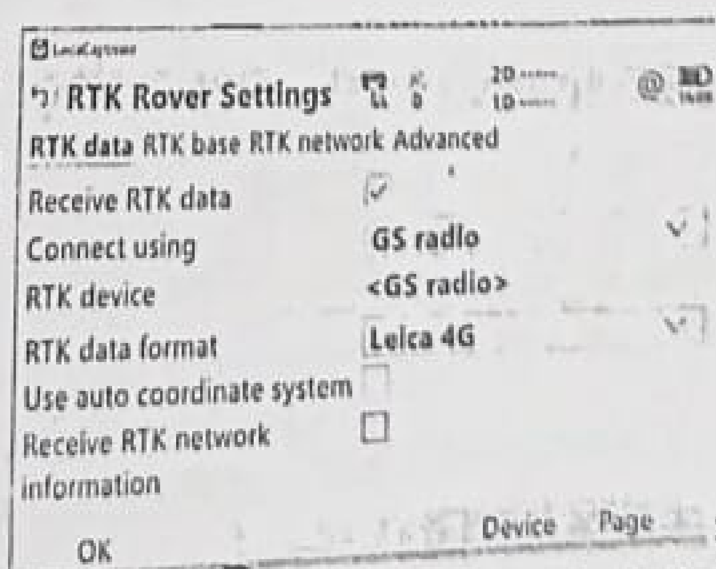


GHT63 clamp
- a Plastic sleeve
- b Pole clamp
- c Clamp bolt

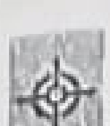
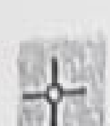
GHT66 holder
- d Locking pin
- e Top clip
- f Mounting plate
- g Bottom clip
- h Tightening screw
- i Mounting arm

- Switch on GS16 & CS20 controller by pressing the power key for 3 secs.
- In CS20, open new job with required Co-ordinate system (WGS84_UTM45_EGM08)
- From Main menu go to Settings > Connections > GS Connections > Connect GS16 as Rover
- Click on Settings > Connections> All other connections > GS connections > RTK Rover > Edit > set as fig. below
-

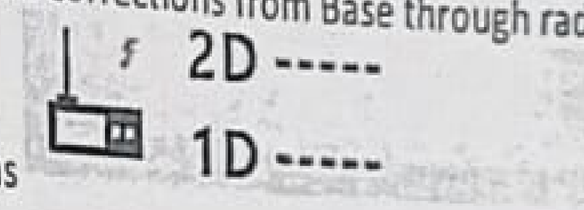




> ok >

- Click on control > Scan > Select the same channel and frequency as it was showing in Base setup > ok
- Ok >  will blinking inwards which Indiacate that corrections are being received from Base
- Check that GPS, GLONASS and other satellites are being tracked
- Check that 3D position is available
- After some time the position icon  will change to  & then to  > This indicates ambiguity is resolved as shown in fig.
- Every 8 seconds this icon will have ticks as shown in fig.
- This indicates rechecking of ambiguity status
- Go to work > Survey > Give Point Id of Rover point and wait till PDOP value is less than 8

- Press Meas >

(GS16 will start collecting GPS data from satellites and corrections from Base through radio, corresponding 3D co-ordinate quality will be displayed at the top panel as 

Wait for some time with Pole leveled to the extent possible and check 2D & 3D quality values

- Press Stop (when you feel the desired quality has been achieved)
- Press Store

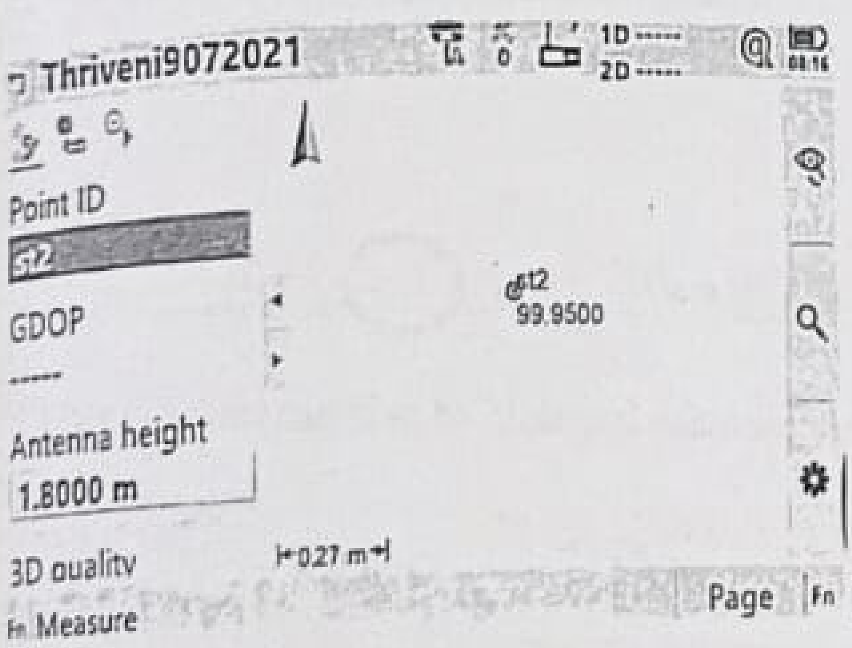
Move to next point .... next point .... and continue

In the map page you can see the plot of points only in Local Grid co-ordinates and not in WGS84 co-ordinates

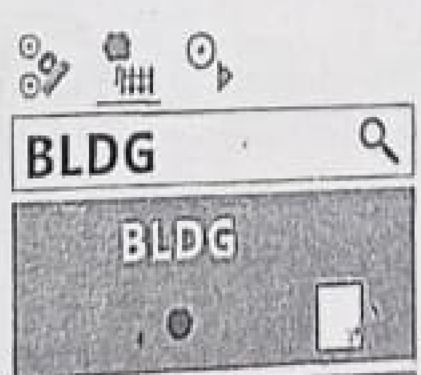
On screen detail map creation with feature codes

It is possible to create map from measured points, draw lines and areas as guided by codes

Go to Measure App > Give point (say st2) Id of the point to be measured and give Antenna height > Measure > stop> store



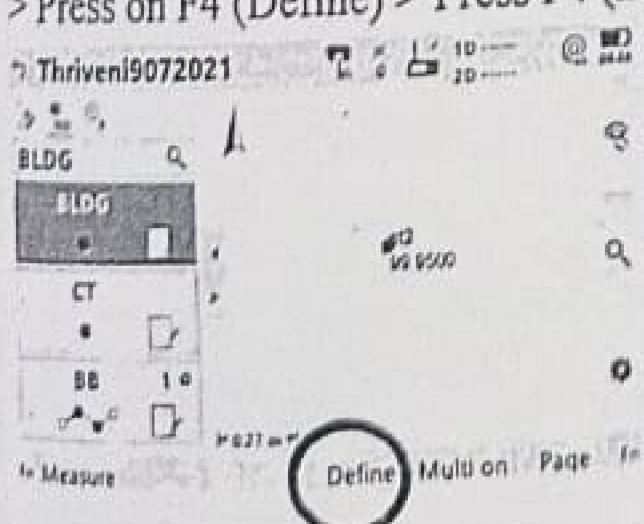
Now Click on code page > 

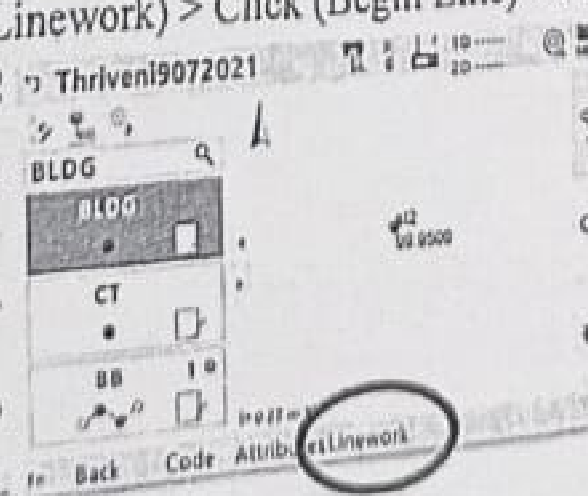


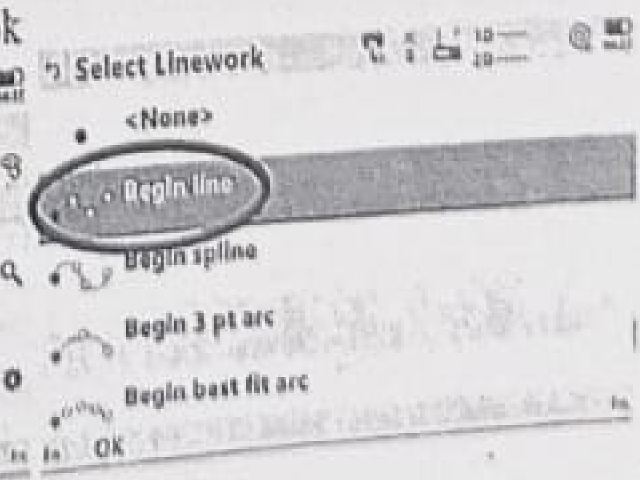
Type a new code say BLDG (Building corner) Dot below the code indicates it's a point

But for Building all the points should be joined by line and hence code need to be a line code

> Press on F4 (Define) > Press F4 (Linework) > Click (Begin Line) > ok







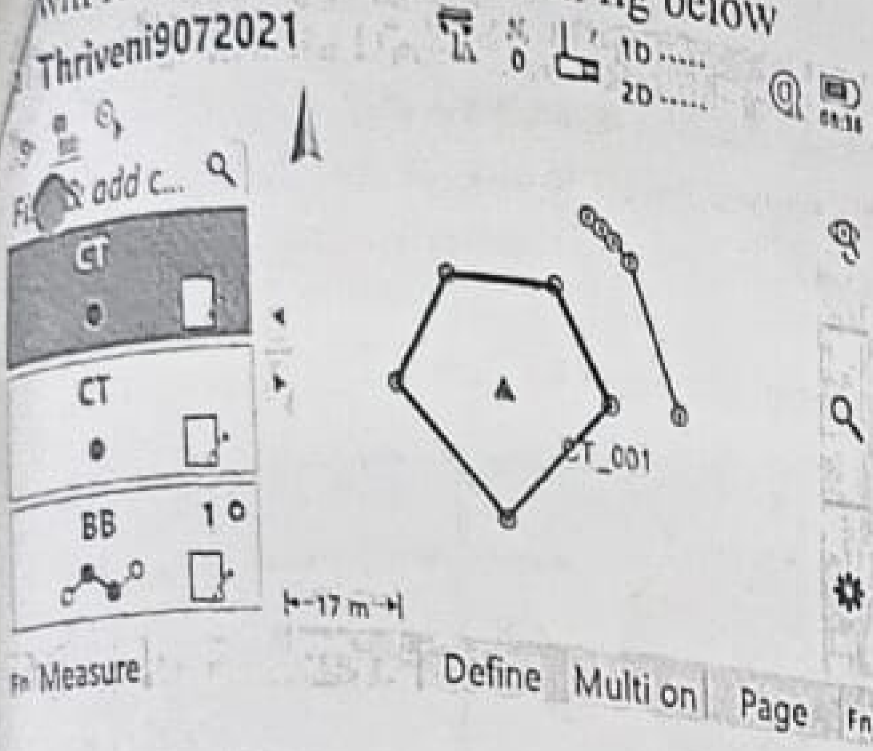
Then keep on measuring all the vertices of the building in a particular sequence .... As the points are measured they will be automatically joined by line

In order to make a clode polygon you need to select line close option before measuring the last point of the building

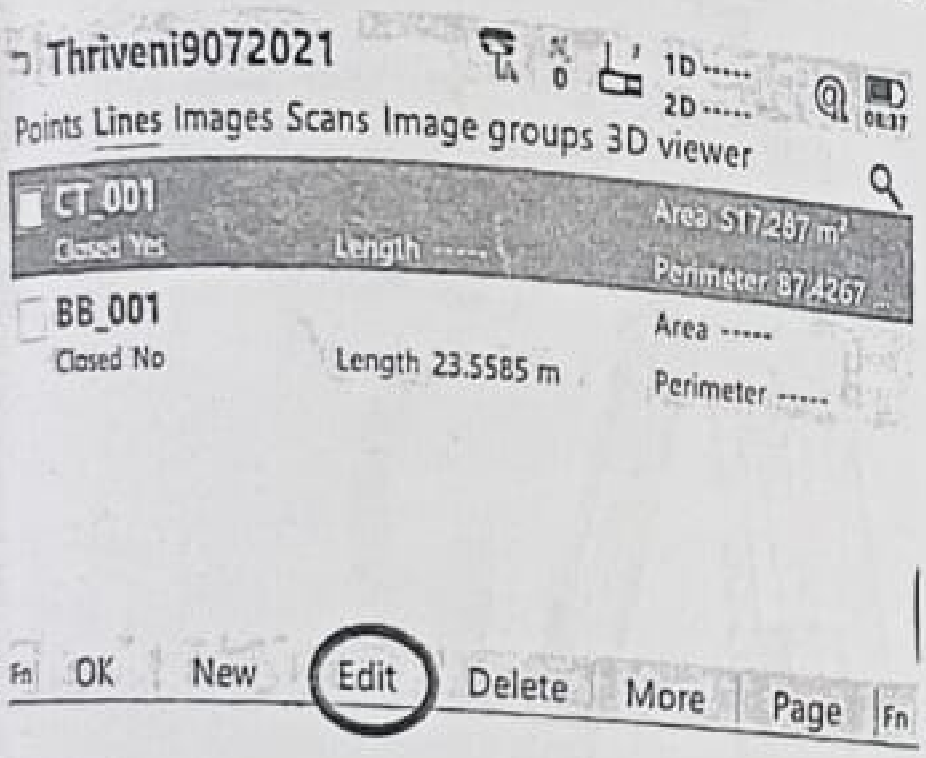
> Press on F4 (Define) > Press F4 (Linework) > Click (close Line) > ok

Then Measure > stop> store

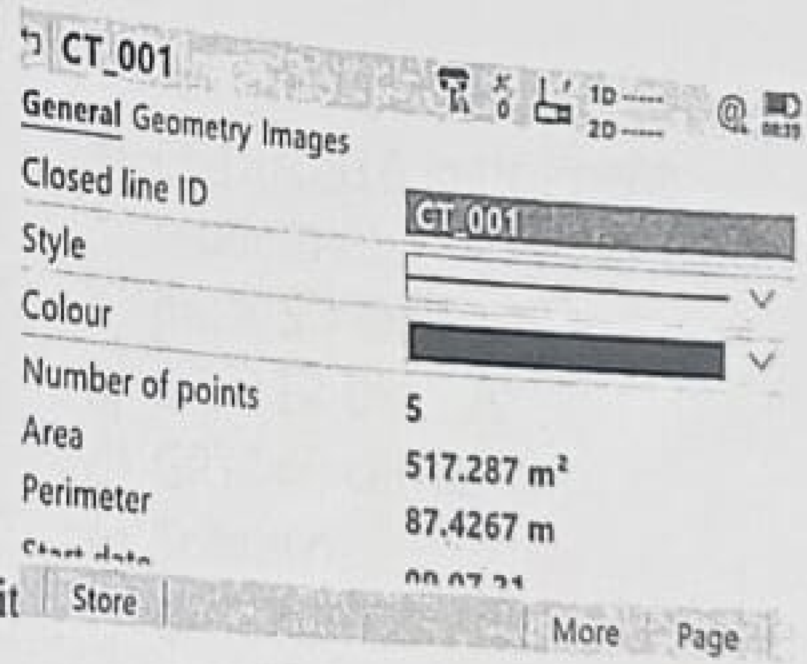
will form ... polygon as in fig below



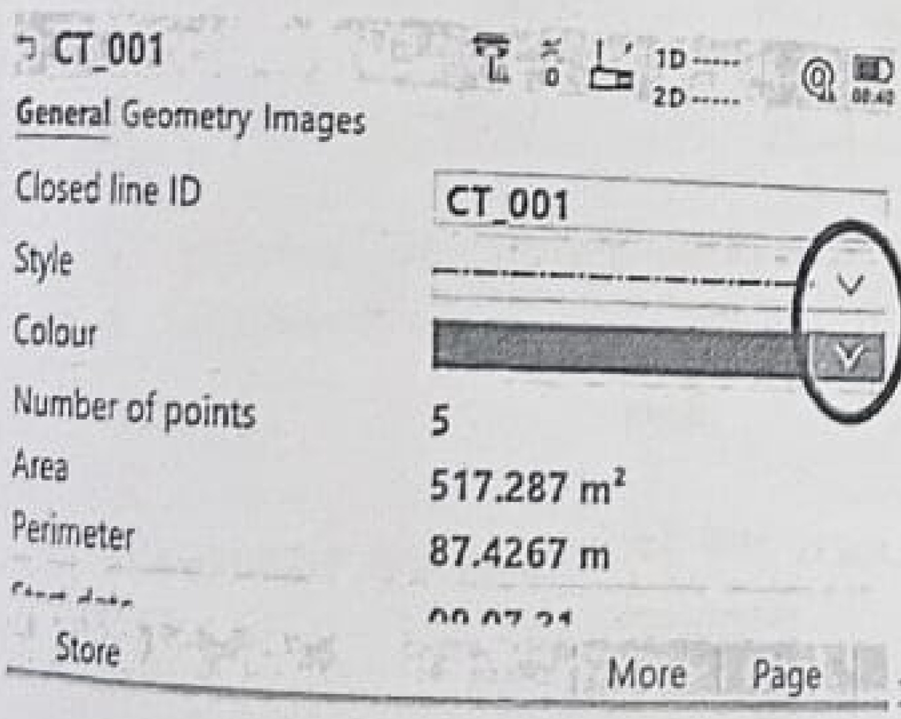
> Press F8 > Page (Lines) to see details of the polygon



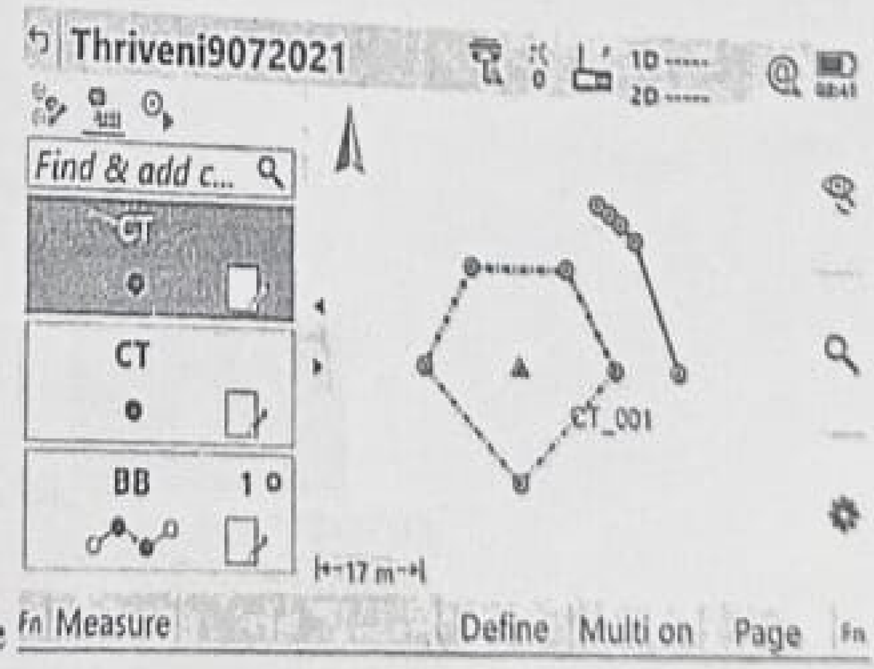
Edit

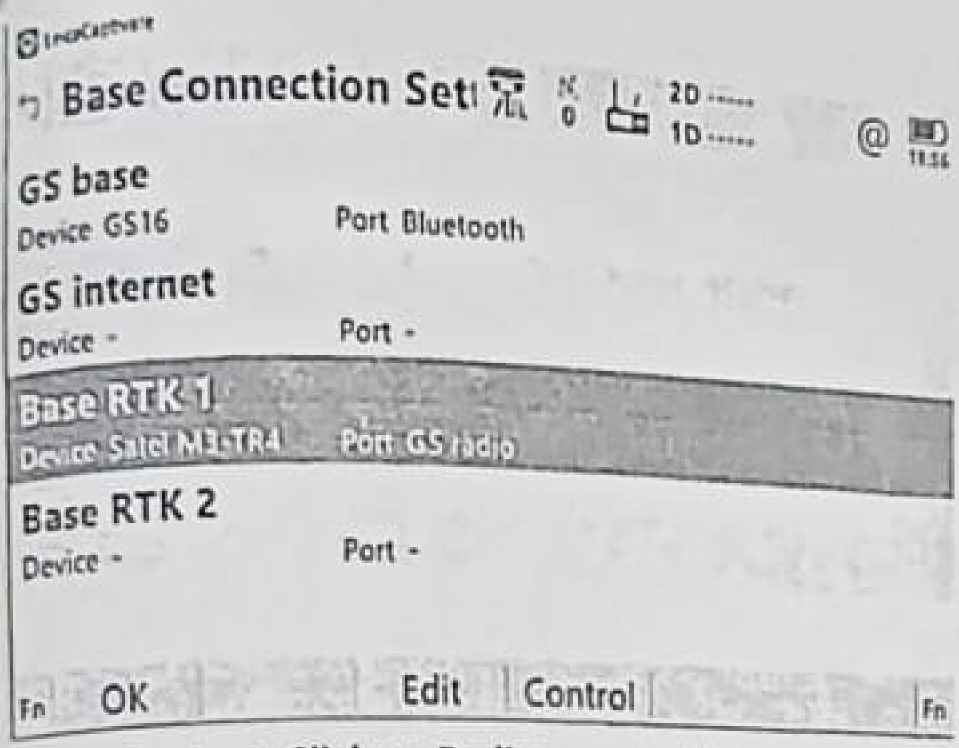


Line & colour can also be changed according to requirement



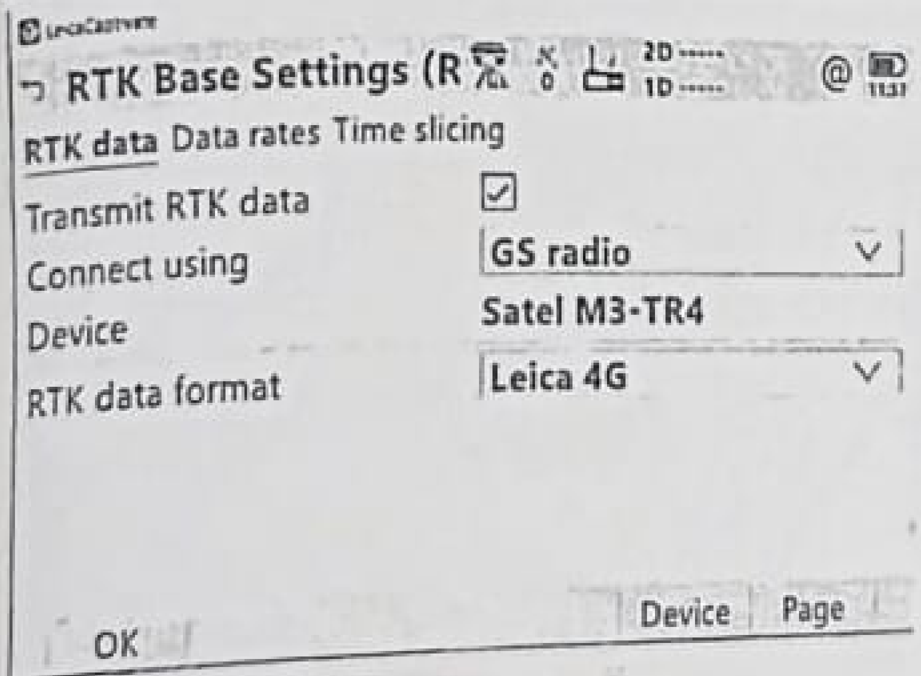
> store



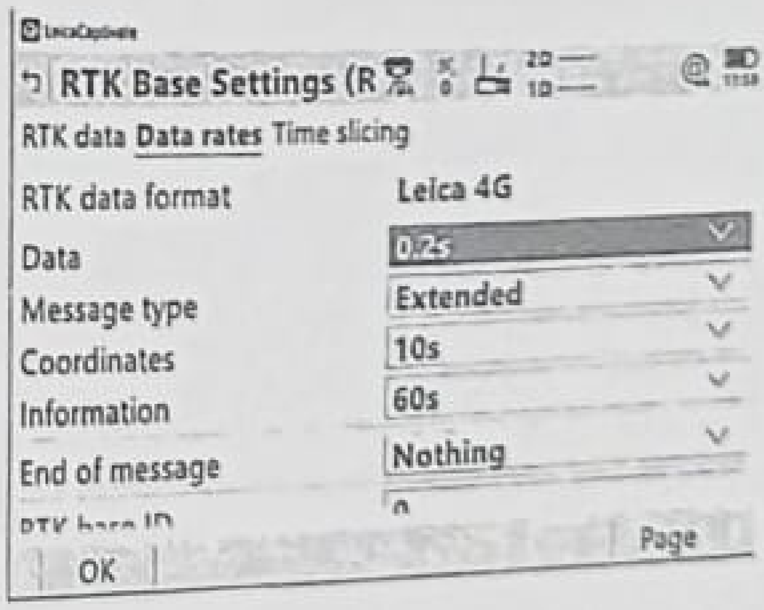


> Edit > Make changes as in Fig. below

Click on Device > Click on Radios page> Select Satel HPR2 > Edit > Make following comms parameters

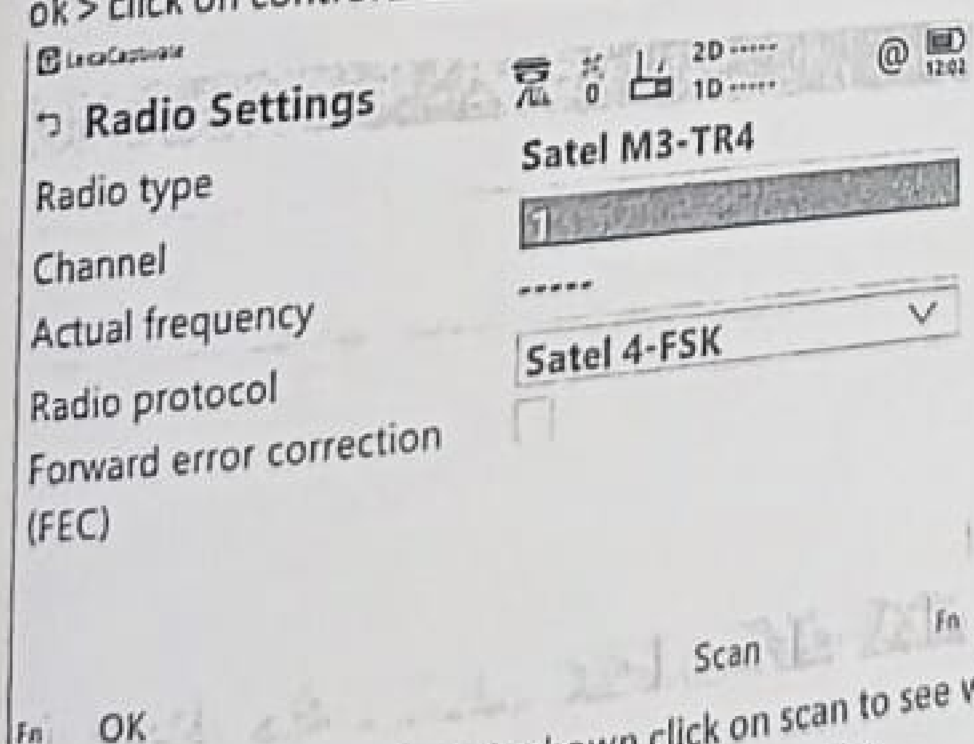


>



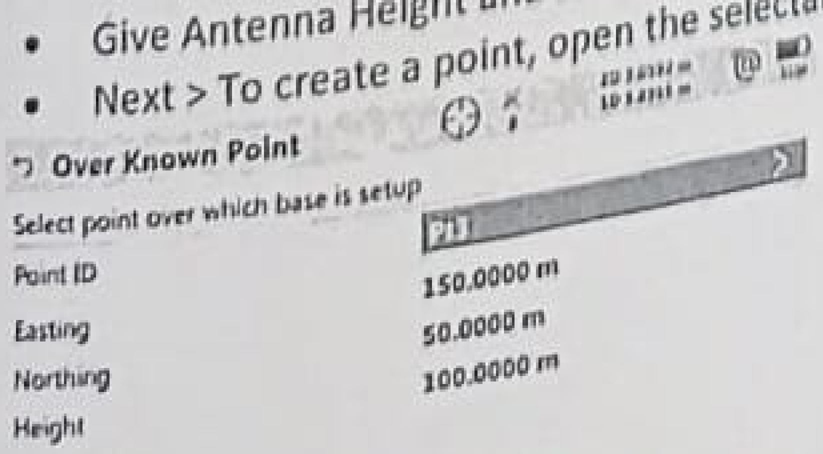
ok > click on control


>



> It will show the channel & actual freq. of RTK signal which channel and freq. it is transmitting>ok>ok

- If no channel or freq. is shown click on scan to see which channel and freq. it is transmitting>ok>ok
- Click Base setup > Click on Over known point
- Give Antenna Height and select Base antenna (Tripod) vertical offset will automatically be taken
- Next > To create a point, open the selectable list for Point ID and press New

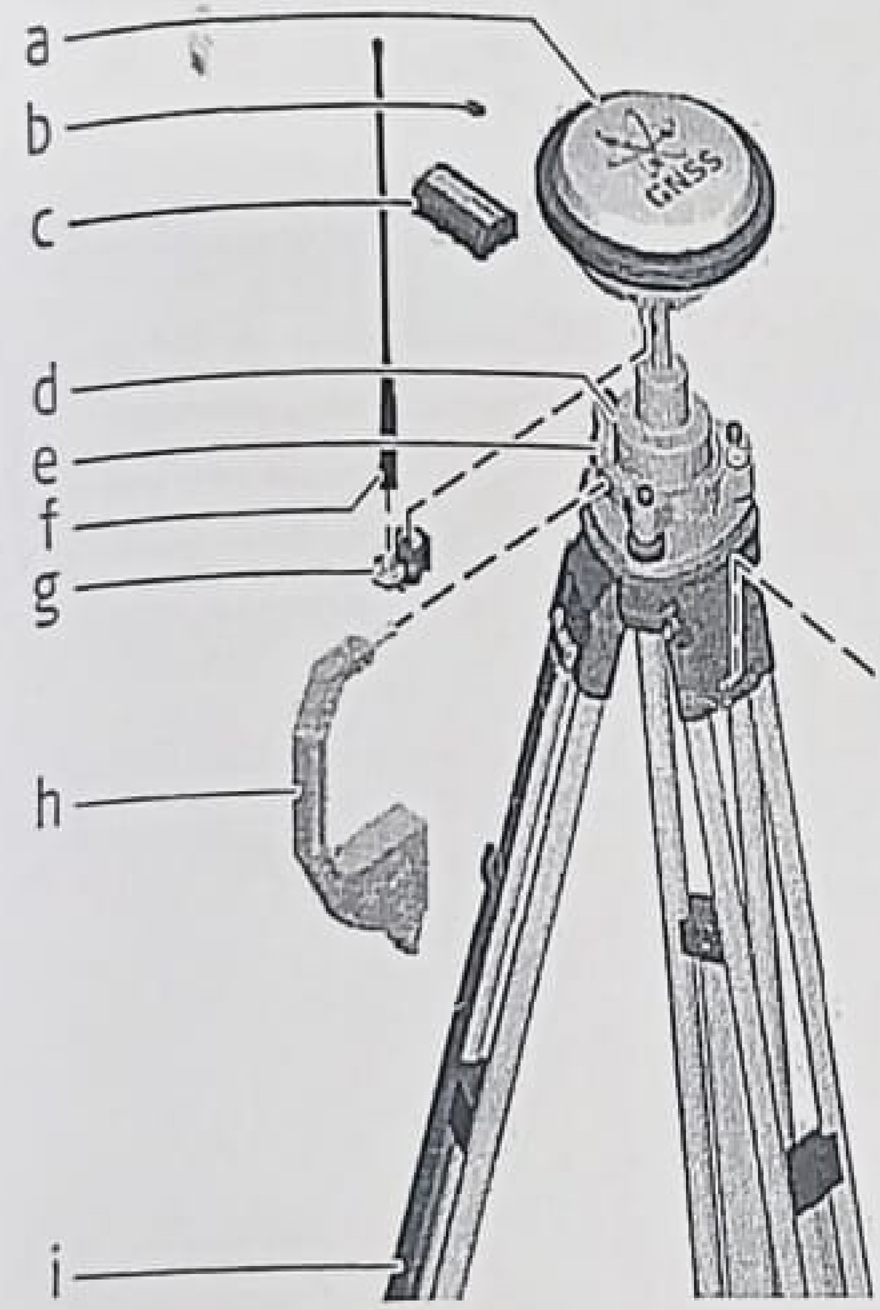


... setup complete > Follow Insructions on the panel

Steps for operating GS16 Base CS20 in RTK mode with External Radio

- First place GPS Antenna on Tribrach and antenna career on GST05 Tripod, level and plummet it on known point,
- Place GS16 on the side of Tripod, connect the GPS Antenna cable, base radio, CS20 controller, car battery etc. as shown in figure below.

We shall use GS16 Internal UHF Radio with external Radio Antenna connector as shown in Fig.



a) GS14/GS16 instrument modem
b) microSD card
c) GEB212 battery
d) GRT146 carrier
e) Tribrach
f) GAT1/GAT2 radio antenna
g) GAD108 arm, for UHF use only
h) Height hook
i) Tripod

- Switch on GS16 & CS20 controller by pressing the power key for 2 secs.
- Open New Job with Required Co-ordinate system
- Click on **Switch to Base** 

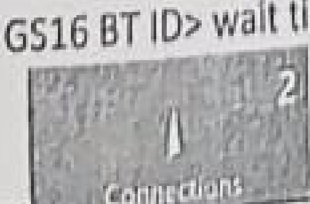
 > Click on Settings 

- Click on connections 

 > Connect to GS Base 

 >

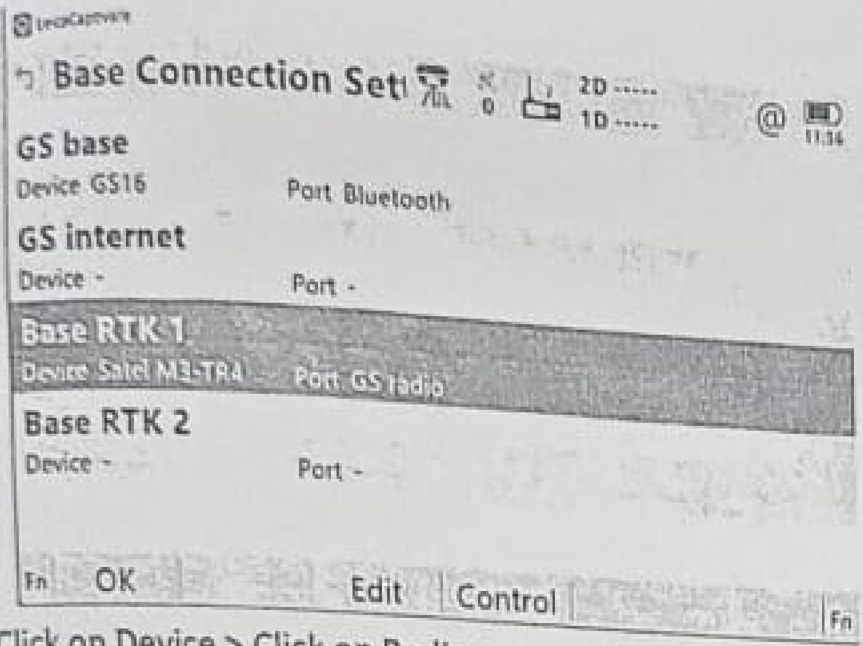
Sensor	GS16
Connect using	Bluetooth
Last used base	BT_Name_1
Bluetooth ID	BT_Address_1

- Select Sensor as GS16 using BlueTooth
- Search > Connect to GS16 BT ID> wait till connection is established> ok> Finish
- Again click on settings 

 > Click on connections 

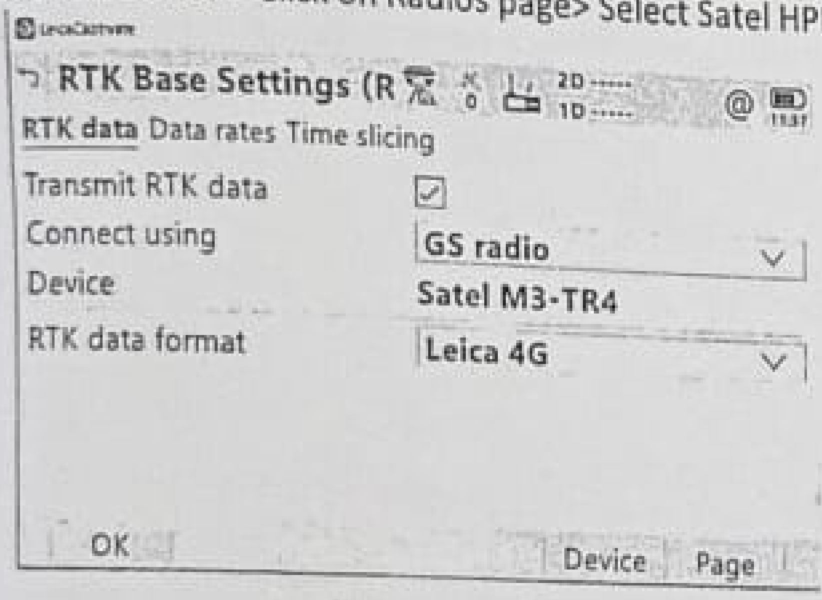
- Click on all other connections 

 >

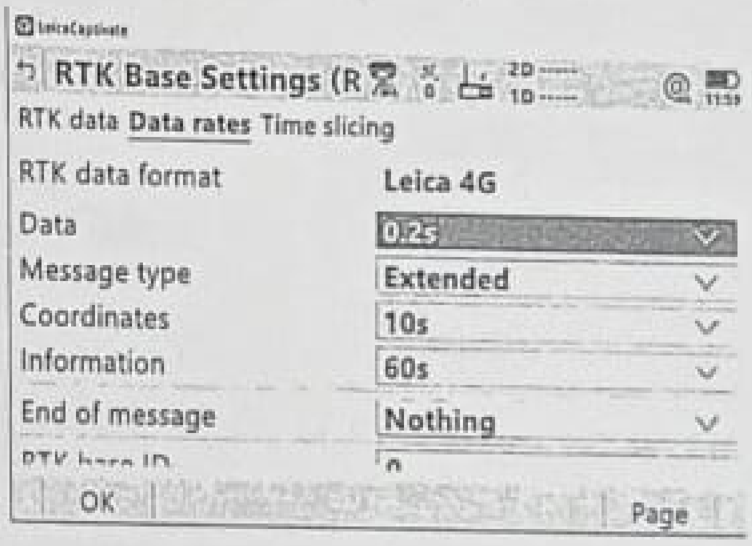


> Edit > Make changes as in Fig. below

Click on Device > Click on Radios page> Select Satel HPR2 > Edit > Make following comms parameters

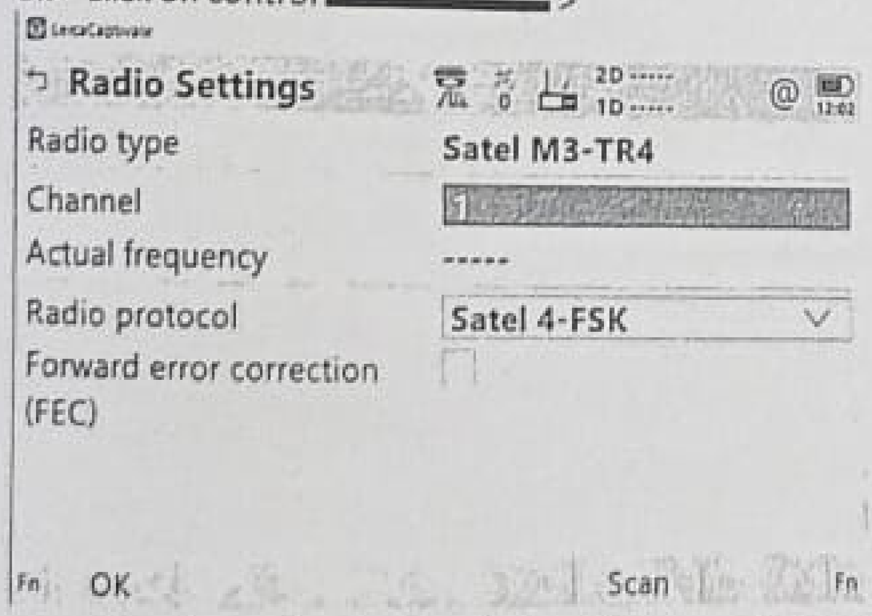


>



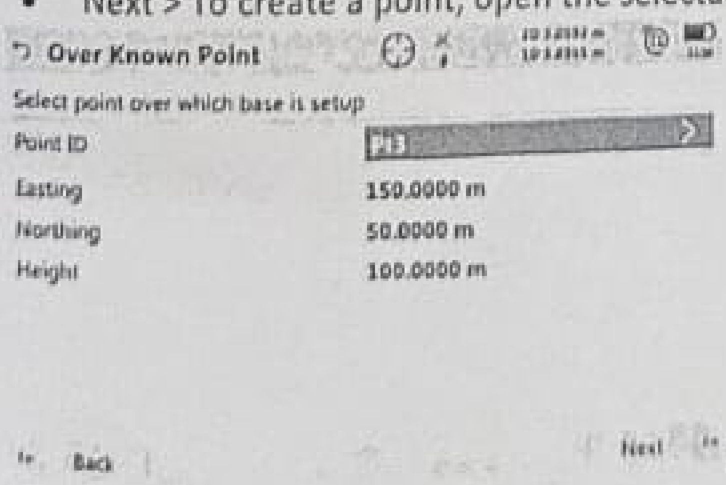
ok > click on control 

>



> It will show the channel & actual freq. of RTK signal

- If no channel or freq. is shown click on scan to see which channel and freq. it is transmitting>ok>ok
- Click Base setup > Click on Over known point
- Give Antenna Height and select Base antenna (Tripod) vertical offset will automatically be taken
- Next > To create a point, open the selectable list for Point ID and press New



> Next > Base setup complete > Follow Insructions on the panel

 Icon will start blinking out wards, which indicates it has started transmitting RTK corrections