PNS SCHOOL OF ENGINEERING & TECHNOLOGY

NISHMANI VIHAR , MARSHAGHAI, KENDRAPARA- 754213

SUBJECT-LAND SURVEY 2

6th Semester

Prepared by-Er. Madhusmita Nayak

DEPARTMENT OF CIVIL ENGINEERING

Chapter -1

TACHEOMETRY: (Only concepts; applications without derivation)

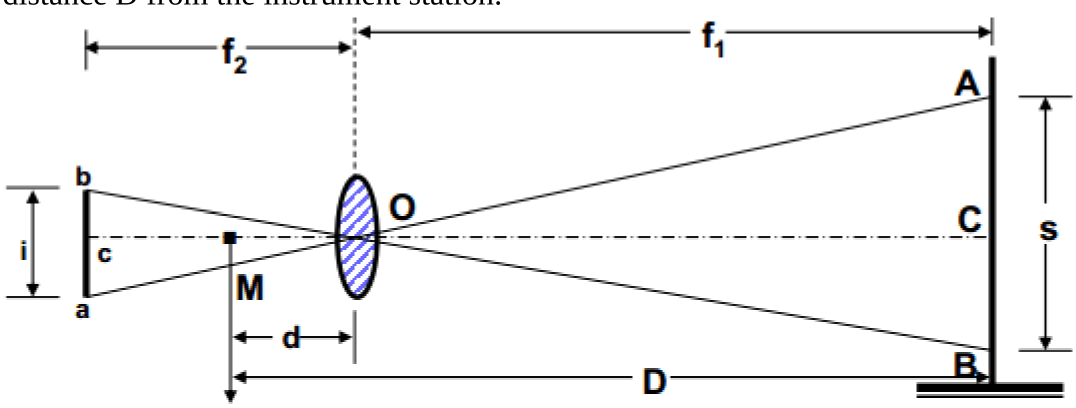
Tachometric is a branch of surveying in which horizontal and vertical distances are determined by taking angular observation with an instrument known as a tachometer. Tachometric surveying is adopted in rough in rough and difficult terrain where direct leveling and chaining are either not possible or very tedious. The accuracy attained is such that under favorable conditions the error will not exceed 1/100. and if the purpose of a survey does not require accuracy, the method is unexcelled. Tachometric survey also can be used for Railways, Roadways, and reservoirs etc. Though not very accurate. Tachometric surveying is very rapid, and a reasonable contour map can be prepared for investigation works within a short time on the basis of such survey.

Uses of Tachometry:-

Tachometry is used for preparation of topographic map where both horizontal and vertical distances are required to be measured; survey work in difficult terrain where direct methods of measurements are inconvenient; reconnaissance survey for highways and railways etc; Establishment of secondary control points.

Principles of Stadia Method:-

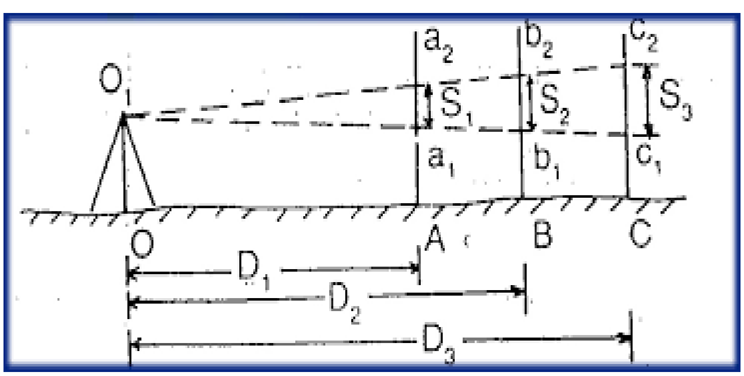
A tachometer is temporarily adjusted on the station P with horizontal line of sight. Let a and b be the lower and the upper stadia hairs of the instrument and their actual vertical separation be designated as i. Let f be the focal length of the objective lens of the tachometer and c be horizontal distance between the optical center 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 bed. Then, from the similar Ds ABF and a' b' F,
as a' b' = ab = i. The ratio (f / i) is a constant orf 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.

Theory of Stadia Tachometry
The following is the notation used in stadia tachometry
O = Optical center of object glass.
A 1, A 2, C = Readings on staff cut by three hairs a 1,
a 2, C = Bottom T op, and Central Hair of diaphragm a
1 a 2 , = i = length of image
A 1, A 2, = S = Staff Intercept
V = Vertical axis of instrument
f =Focal length of a object glass
d =distance between optical center and vertical axis of instrument
u=distance between optical center and staff
v=distance between optical center and image.
For s similar triangles a,



The quanta ties (f/i) and (f + d) are known as tachometric constants. (f/i) is called the multiplying constant, as already stated, and (f + d) the additive constant. by adopting an anal latic lens in the telescope of a tachometric, the multiplying constant is made 100, and the additive constant zero. However, in some tachometers the additive constants are not exactly zero, but vary from 30 cm to 60 cm.

Stadia tachometry with staff held vertical and with line of collimation horizontal or inclined:-

Uses of Stadia

The stadia method of surveying is particularly useful for following cases:

1. In differential leveling, the back sight and foresight distances are balanced conveniently if the level is equipped with stadia hairs.
2. In profile leveling and cross sectioning, stadia is a convenient means of finding distances from level to points on which rod readings are taken.
3. In rough trigonometric, or indirect, leveling with the transit, the stadia method is more rapid than any other method.
4. For traverse surveying of low relative accuracy, where only horizontal angles and distances are required, the stadia method is a useful rapid method.
5. on surveys of low relative accuracy - particularly topographic surveys-where both the relative location of points in a horizontal plane and the elevation of these points are desired, stadia is useful. The horizontal angles, vertical angles, and the stadia interval are observed, as each point is sighted; these three observations define the location of the point sighted.

Elevations and distances of staff stations

Distance and Elevation formulae for Staff Vertical : Inclined Sight

Let **P** = Instrument station; **Q** = Staff station

M = position of instruments axis; **O** = Optical centre of the objective

A, C, B = Points corresponding to the readings of the three hairs

s = AB = Staff intercept; **i** = Stadia interval

θ = Inclination of the line of sight from the horizontal

L = Length MC measured along the line of sight

D = MQ' = Horizontal distance between the instrument and the staff

V = Vertical intercept at Q, between the line of sight and the horizontal line

h = height of the instrument; **r** = central hair reading

β = angle between the two extreme rays corresponding to stadia hairs.

Errors in Stadia Measurement

Most of the errors associated with stadia measurement are those occur during observations for horizontal angle and differences in elevation .Specific sources of errors in horizontal and vertical distances computed from observed stadia intervals are as follows:

1. Error in Stadia Interval factor

This produces a systematic error in distances proportional to the amount of error in the stadia interval factor.

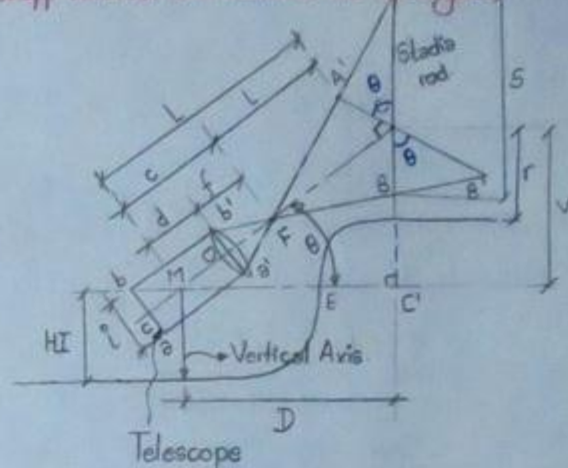
2. Error in staff graduations

If the spaces on the rod are uniformly too long or too short, a systematic error proportional to the stadia interval is produced in each distance.

3. Incorrect stadia Interval

The stadia interval varies randomly owing to the inability of the instrument operator to observe the stadia interval exactly. In a series of connected observations (as a traverse) the error may be expected to vary as the square root of the number of sights. This is the principal error affecting the precision.

Distance and Elevation Formula for staff vertical and inclined line of sight:



In $\Delta MCC'$,

$\angle CMC' = \theta$, $\angle MC'C = 90^\circ$

$\therefore \angle MCC' = 90^\circ - \theta$

and,

$\angle BCB' = 90^\circ - (90^\circ - \theta) = \theta$

$\angle ACA' = \angle BCB' = \theta$ [VOA].

In $\Delta FCB'$,

$\angle FCB' = 90^\circ$

$\angle B'FC = \frac{\beta}{2}$

$\therefore \angle FB'C = 90^\circ - \frac{\beta}{2}$ $(= \angle CB'B)$

In $\Delta FA'C$, $\angle A'FC = \frac{\beta}{2}$, $\angle A'CF = 90^\circ$

$\therefore \angle CA'F = 90^\circ - \frac{\beta}{2}$

and $\angle CA'A = 180^\circ - \left(90^\circ - \frac{\beta}{2}\right) = 90^\circ + \frac{\beta}{2}$

In Δ^s AA'C and BB'C, parallactic angle β is very small, can be neglected, then the angles AA'C and BB'C are right angles and the Δ^s AA'C and BB'C are right angled triangles.

From right angled Δ^s AA'C and BB'C,

$A'C = AC \cos\theta$ and $B'C = BC \cos\theta$.

$A'C + B'C = (AC + BC)\cos\theta = AB \cos\theta = S\cos\theta$ ——— (i)

From similar Δ^s A'B'F and a'b'F.

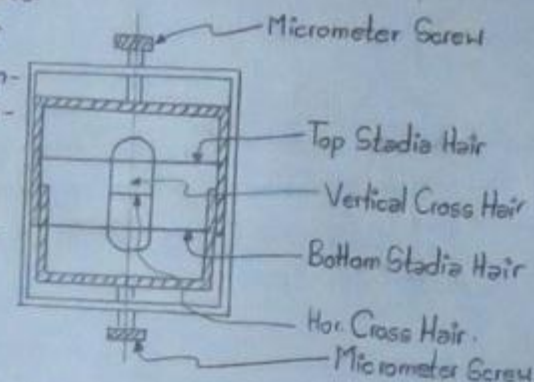
$\frac{CF}{FO} = \frac{A'B'}{a'b'}$ or, $\frac{L}{f} = \frac{S\cos\theta}{i}$

or, $L = \left(\frac{f}{i}\right) S\cos\theta = KS\cos\theta$ ——— (ii)

From figure,

Fixed Hair Method:

Stadia hairs are kept at fixed interval. The intercept on the levelling staff varies, depending upon the horizontal distance between the instrument station and the staff. The intercept used in computation is deduced by subtracting the lower stadia reading from the upper stadia reading.

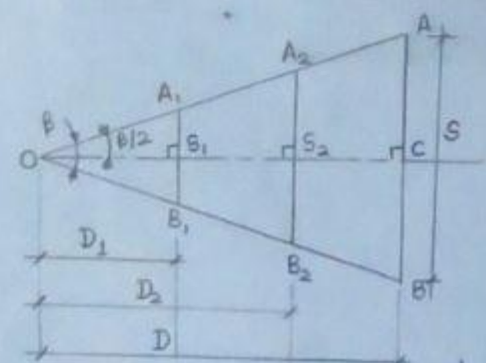


Diaphragm

Fixed Hair Method:

Principle of Stadia Tacheometric Method:

Ratio of base and altitude of similar isosceles Δ^s is always constant.



$$\frac{OC}{AB} = \frac{D}{S} = \frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{f}{i} = k \text{ (Constant)}$$

f = focal length, i = stadia interval

where, k is multiplying factor.

(f/i) is stadia interval factor — constant for a given instrument

From figure, $\tan \beta/2 = \dfrac{AB/2}{OC}$

or, $\dfrac{OC}{AB} = \dfrac{1}{2\tan \beta/2}$

or, $\dfrac{OC}{AB} = \dfrac{1}{2}\cot \beta/2$

or, $OC = AB \times \dfrac{1}{2}\cot\dfrac{\beta}{2}$

or, $\boxed{\dfrac{D}{S} = \dfrac{1}{2}\cot \beta/2 = k}$ (constant)

→ k depends on β.

$\therefore \boxed{D = kS}$

If the value of $\beta = 34'22''$,

$$k = \frac{1}{2}\cdot\cot\left(\frac{34'22''}{2}\right) = 100$$

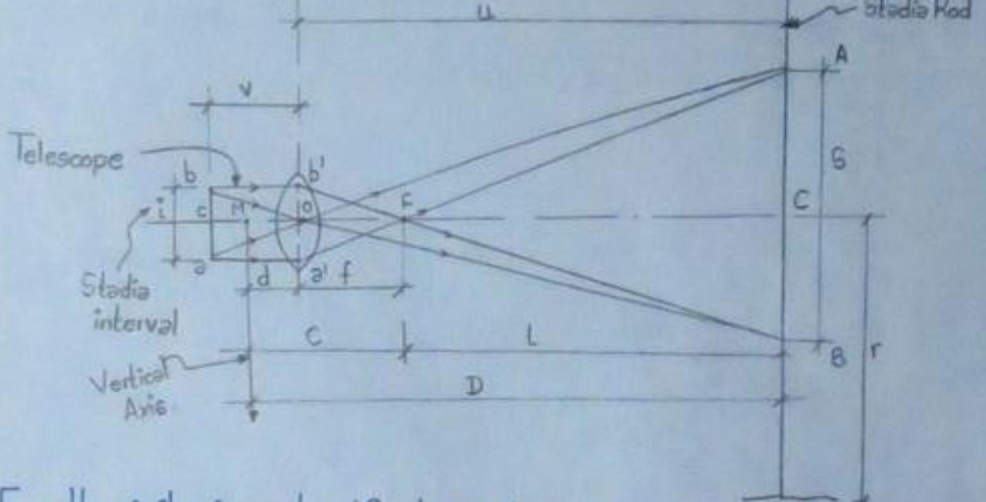
Distance and elevation formula for the staff vertical and horizontal line of sight:

M = instrument centre

O = optical centre

$C = MF = d + f$ = additive constant

S = staff intercept



From the similar isosceles Δ^s abO and ABO,

v, u ⇒ conjugate focal distances of lens.

$$\frac{Oc}{OC} = \frac{ab}{AB}$$

$$\text{or, } \frac{v}{u} = \frac{i}{S} \quad \text{or, } v = \frac{ui}{S} \text{ ——— (i).}$$

From Lens formula, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\text{or, } \frac{1}{f} = \frac{1}{u} + \frac{1}{\frac{ui}{S}} = \frac{1}{u} + \frac{S}{ui}$$

$$\text{or, } \frac{1}{f} = \frac{1}{u}\left(1 + \frac{S}{i}\right)$$

$$\text{or, } u = f\left(1 + \frac{S}{i}\right) \text{ ——— (ii)}$$

From the figure, Horizontal distance from the centre of instrument (M) to the stadia rod ⇒ $D = u + d$.

CHAPTER-2
CURVE

Definition of Curves

• Curves are regular bends provided in the lines of communication like roads, railways. etc. and also in canals to bring about the gradual change of direction. • They are also used in the vertical plane at all changes of grade to avoid the abrupt. Change of grade at the apex.

Types Of Curves In Surveying

Curves in surveying are classified into two main types. They are as follows:-

1. Horizontal curves
2. Vertical curves

1. Horizontal Curves

A horizontal curve is provided where two straight lines intersect with each other in a horizontal plane. When a curve is given in a horizontal plane, it is known as a horizontal curve. The horizontal curves are further divided as follows:

- Simple curve
- Compound curve
- Reverse curve
- Transition curve
- Combined curve

a) Simple Curve

A simple curve is a single arc of a circle, which is tangential to both the straight lines of the route. There are a few elements of a simple circular curve discussed below.

CURVES

2.1 Compound, Reverse and transition curves, Purpose and uses of different types of curves in field.

2.2. Elements of circular curves, Numerical problems

2.3. Preparation of curve table for setting out.

2.4. Setting out of circular curve by chain and tape and by instrument angular methods (i) Offsets from long chord (ii) successive bisection of arc (iii) offsets from tangents (iv) offsets from chord produced (v) Rankines method tangent angles (No derivation)

2.5 obstacles in curve ranging - point of intersection inaccessible.

2.1 CURVES

Curves are regular bends provided in the lines of communication like roads, Railways and canals etc. to bring about gradual change of direction or gradiant.

→ It may be of two types

① Horizontal curves

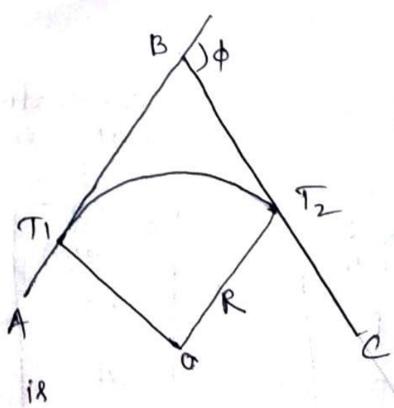
② Vertical curves

HORIZONTAL CURVES

The following are the different types of horizontal curves

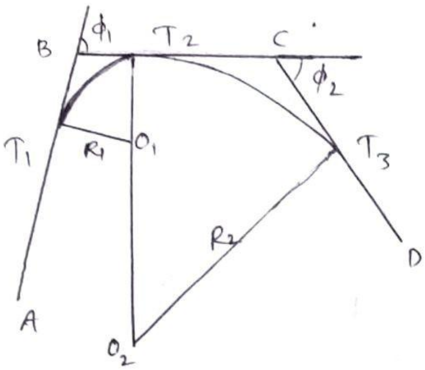
1. Simple circular curve:

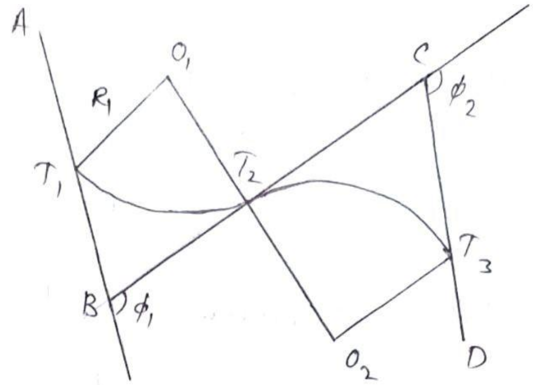
When a curve consists of a single arc with a constant radius connecting the two tangents, it is said to be a circular curve.



2. Compound curve

When a curve consists of two or more arcs with different radii, it is called a compound curve. Such a curve lies on the same side of a common tangent and the centres of the different arcs lies on the same side of their respective tangents.



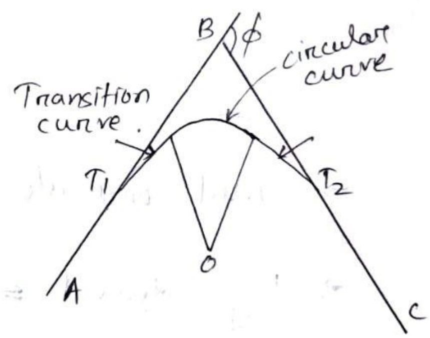


3. Reverse curve

A reverse curve consists of two arc bending in opposite directions. Their centres lie on opposite sides of the curve. Their radii may be either equal or different and they have one common tangent.

4. Transition curve:

A curve of variable radius is known as a transition curve. It is also called a spiral curve or easement curve. In railways, such a curve is provided on both sides of a circular curve to minimize superelevation. Excessive superelevation may cause wear and tear of the rail section and discomfort to passenger.



2.2. Elements of circular curve

→ Angle of intersection is given

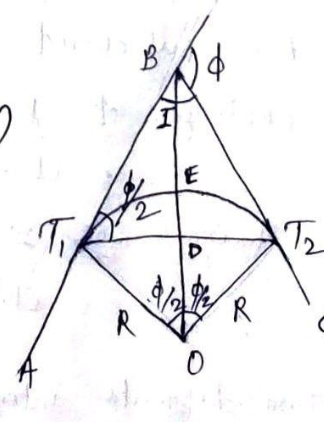
$$\phi = 180° - I$$ (I = Angle of intersection)

→ Radius is not given

$$R = \frac{1719}{D}$$ (D = Degree of curve)

→ Tangent length BT_1 or BT_2

$$BT_1 \text{ or } BT_2 = R \tan \phi/2$$



→ Length of curve = T_1ET_2

$= R \times \phi$ radians

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

→ Length of curve = $\frac{30\phi}{D}$ (if D is given)

→ Length of long chord = $2T_1D = 2OT_1 \sin\phi/2$

$= 2R\sin\phi/2$

→ Apex distance = BE = OB − OE

$= R\sec\phi/2 - R$

$= R(\sec\phi/2 - 1)$

→ mid ordinate = DE = OE − OD

$= R - R\cos\phi/2 = R(1-\cos\phi/2)$

→ Peg interval $\leq \frac{R}{20}$

Railway (20 − 30 m)

Road (< 10m)

→ Initial subchord

→ final subchord

→ chainage of 1st tangent point

= Chainage of B − tangent length.

→ chainage of 2nd tangent point

= Chainage of 1st tangent point + curve length

Q Two tangents intersect at a chainage of 1320.5m, the deflection being 24°. Calculate the following quantities for setting out a curve of radius 275m.

8

(a) Tangent length
(b) Length of long chord
(c) Length of the curve
(d) Apex distance
(e) versed sine of curve / Mid ordinate
(f) Chainage of point of commencement and tangency.

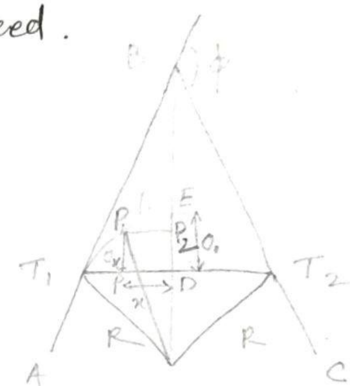
~~2.4. Setting out of circular curve~~

2.4. Setting out of circular curve by chain and tape.

→ It can be done by employing the following general Methods.

- Taking offsets from long chord
- Successive bisection of arc
- Taking offsets from the tangents
- Taking offsets from chord produced.

Offsets or ordinates from long chord



Let AB and BC be two tangents meeting at a point B, with a deflection angle ϕ.

→ For setting out the curve following data are calculated.

→ Tangent length $TL = R \tan \phi/2$

→ Tangent points T_1 and T_2 are marked.

→ Length of curve $CL = \frac{\pi}{180} R\phi$

→ The chainages of T_1 and T_2 are found out.

→ Length of long chord $L = 2R \sin \phi/2$

→ Long chord is divided into two halves.

→ Mid ordinate $\boxed{O_0 = DE = R(1-\cos \phi/2)}$

and $OD = R - O_0$

From $\triangle OT_1D$ $\quad OT_1^2 = OD^2 + T_1D^2$

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

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

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

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

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

$$\Rightarrow R^2 = \{(R - O_0) + O_x\}^2 + x^2$$

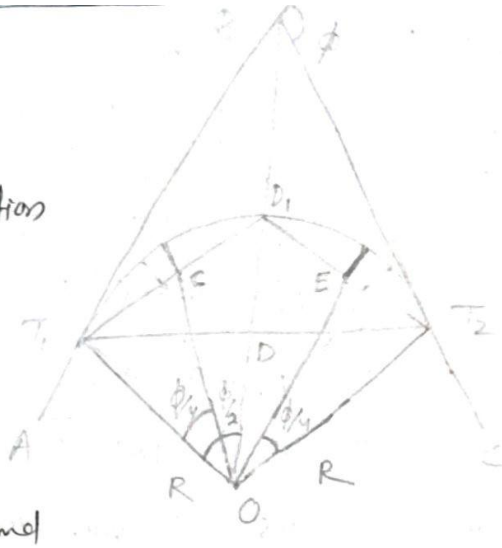
$$\Rightarrow R - O_0 + O_x = \sqrt{R^2 - x^2}$$

$$\Rightarrow O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

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

Q Two tangents AB and BC intersect at a point B at chainage 150.5 m. Calculate all the necessary data for setting out a circular curve of radius 100 m and deflection angle 30° by the method of offsets from the long chord.

Successive Bisection of Arcs.



- AB & BC are two tangents intersecting at B with deflection angle ϕ.
- Tangent length is calculated and T_1 & T_2 are marked.
- T_1T_2 is length of long chord is bisected at D.
- A perpendicular is set out and point D_1 is cut so that

$$DD_1 = R(1-\cos \phi/2) = \text{mid ordinate}$$

- Again distance T_1D_1 & T_2D_2 is measured and bisected at C and E

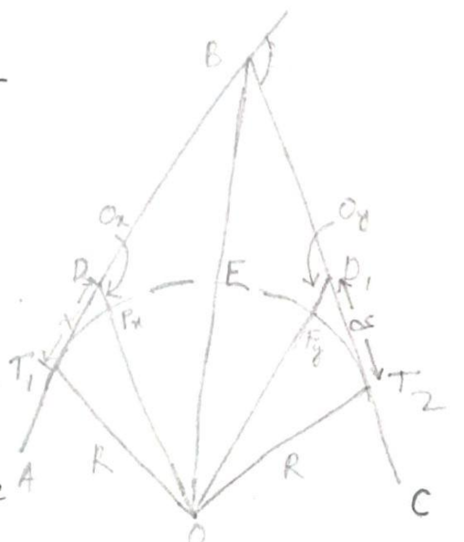
$$\text{Now} \quad CC_1 \ \& \ EE_1 = R(1-\cos \phi/4) = \text{New mid ordinate}$$

- The perpendiculars are drawn at C & E and point C_1 & E_1 are cut.
- this process is continued until the bisection is not practically possible

Offsets from tangent method

This may be
- Radial
- Perpendicular

Radial Offset



- AB and BC are two tangents intersecting at B and tangent points are T_1 and T_2.
- Let us take a point D on the rear tangent AB such that

$$T_1D = x$$

Let O_x be the radial offset at D.

from ΔT_1OD

$$OT_1^2 + T_1D^2 = OD^2$$

$$\Rightarrow \quad R^2 + x^2 = (R+O_x)^2$$

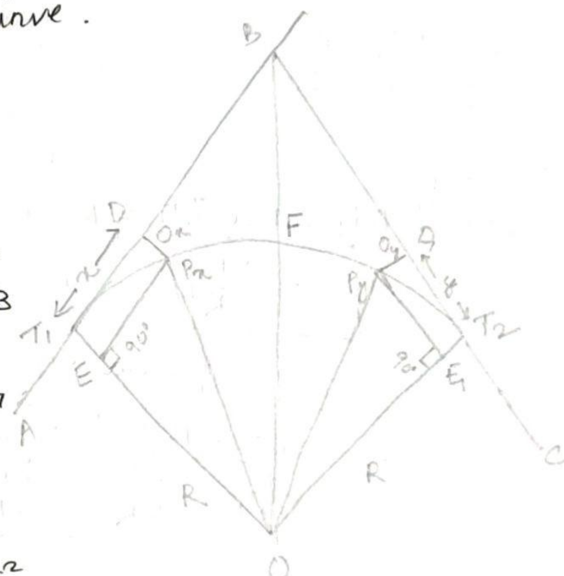
$$\Rightarrow \quad O_x = \sqrt{R^2+x^2} - R$$

→ Distance O_x is cut off from the radial line OD to get first point of curve P_x.

→ By increasing value of x we will get number of O_x and P_x

→ from T_1, one half of the curve can be set out.

→ following simillar procedure from T_2 we can obtain points of curve P_y for the other half of curve.



By Perpendicular offsets:

→ AB and BC are two tangents intersecting at B, and the tangent points are T_1 and T_2

→ A point D is taken along AB at a distance x from T_1. Let O_x be the perpendicular offset at D. The line EP_x is parallel to T_1D

From ΔOEP_x,

$$OP_x^2 = EP_x^2 + OE^2$$

$$\Rightarrow \quad R^2 = x^2 + (R-O_x)^2$$

$$\Rightarrow \quad R - O_x = \sqrt{R^2 - x^2}$$

$$\Rightarrow \quad O_x = R - \sqrt{R^2 - x^2}$$

→ the distance O_x is drawn perpendicular at D to get P_x

→ similarly by increasing x a series of offsets are obtain drawing which we will get point of curve for one half

→ for other halt a distance y is taken from T_2 to mark D_1.

$O_y = R - \sqrt{R^2 - y^2}$

→ Distance O_y is drawn perpendicular at D_1 to get point P_y.

→ This process is continued by increasing y ~~to~~ until we reach the apex F.

Offsets from chord Produced :

Let,

AB = Rear tangent point.

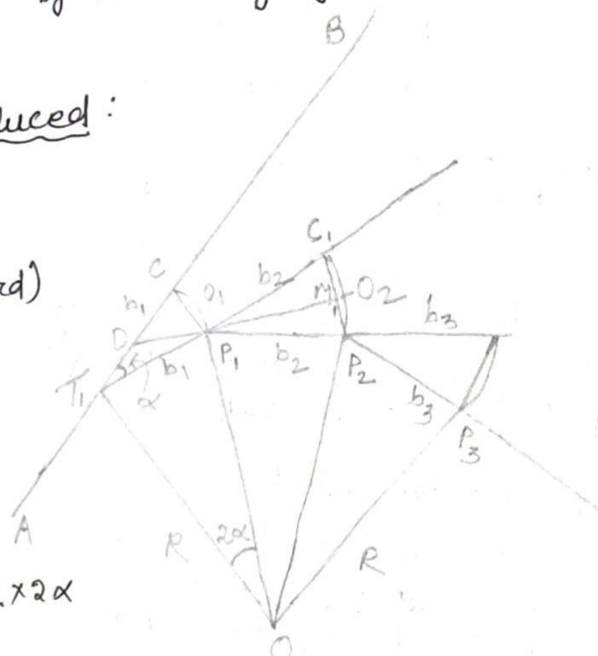
$T_1C = T_1P_1 = b_1$

(First cord / initial sub chord)

$CP_1 = O_1$ = first offset

$\angle CT_1P_1 = \alpha$ in radian

$\angle T_1OP_1 = 2\alpha$ in radian



Assuming

Chord T_1P_1 = arc $T_1P_1 = R \times 2\alpha$

$$\Rightarrow \boxed{\alpha = \frac{T_1P_1}{2R}}$$

Again chord $CP_1 \sim$ arc CP_1

$\therefore O_1 = CP_1 = T_1P_1 \times \alpha$

$$\Rightarrow \boxed{O_1 = \frac{T_1P_1^2}{2R} = \frac{b_1^2}{2R}} \quad \text{—— (1)}$$

→ Let P_2 be next point on curve, P_1C_1 is full chord $= d_2$

Now $P_1C_1 = P_1P_2 \sim b_2$

and chord C_1P_2 = arc $C_1P_2 = O_2$

→ At P_1 a tangent is drawn which meet AB at D and C_1P_2 at M_1.

Here $\angle C_1P_1M_1 = \angle DP_1T_1$

$\angle DP_1T_1 = \angle DT_1P_1$

$\angle C_1P_1M_1 = \angle DP_1T_1 = \angle DT_1P_1 = \angle CT_1P_1$

So ΔCT_1P_1 and $\Delta C_1P_1M_1$ are simillar

$$\frac{C_1M_1}{P_1C_1} = \frac{CP_1}{T_1P_1} \Rightarrow \frac{C_1M_1}{b_2} = \frac{O_1}{b_1}$$

$$\Rightarrow C_1M_1 = \frac{b_2 O_1}{b_1} = \frac{b_2}{b_1} \times \frac{b_1^2}{2R}$$

$$\Rightarrow \boxed{C_1M_1 = \frac{b_1 b_2}{2R}}$$

Also M_1P_2 is the offset from the tangent at P_1

so, according to eq. (1)

$$M_1P_2 = \frac{(P_1P_2)^2}{2R} = \frac{b_2^2}{2R}$$

$$\therefore O_2 = C_1P_2 = C_1M_1 + M_1P_2$$

$$\Rightarrow O_2 = \frac{b_1 b_2}{2R} + \frac{b_2^2}{2R}$$

$$\Rightarrow \boxed{O_2 = \frac{b_2(b_1 + b_2)}{2R}}$$

→ Similarly

$$O_3 = \frac{b_3(b_2+b_3)}{2R} = \frac{b_3^2}{R}$$

$$O_4 = \frac{b_4(b_3+b_4)}{2R} = \frac{b_4^2}{R}$$

$$\vdots$$

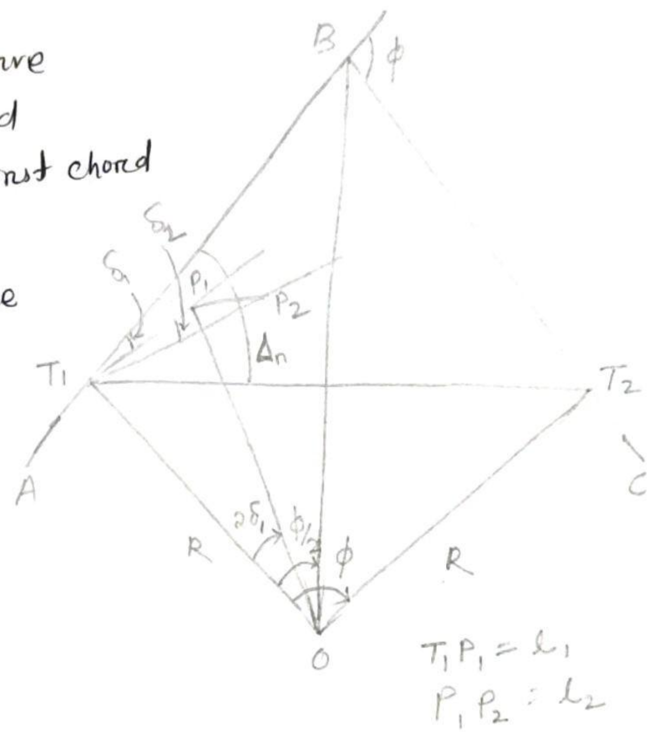
$$O_n = \frac{b_n(b_{n-1}+b_n)}{2R}$$

where b_n = final sub chord, b_{n-1} = last full chord.

Q Two tangents intersecting at a chainage of 1,000 m. The deflection angle being 30°. Calculate all the necessary data for setting out a circular curve of Radius 200 m by the method of offsets from the chord produced, taking a peg interval of 20m.

Rankines Method of Tangent Angles

→ AB and BC are tangents intersecting at B, ϕ is deflection angle and T_1 and T_2 are tangent points.



P_1 = first point on the curve

$T_1P_1 = l_1$ = length of first chord

δ_1 = deflection angle for first chord

R = Radius of curve

Δ_n = total deflection for the chords

Now, $\angle T_1OP_1 = 2\angle BT_1P_1 = 2\delta_1$

Chord $T_1P_1 \approx$ arc T_1P_1

Also $$\frac{\angle T_1OP_1}{l_1} = \frac{360^\circ}{2\pi R}$$

$$\Rightarrow 2\delta_1 = \frac{360^\circ l_1}{2\pi R}$$

$$\Rightarrow \delta_1 = \frac{360^\circ \times l_1}{2\, 2\pi R} \text{ degrees}$$

$$= \frac{360 \times 60\, l_1}{2 \times 2 \times \pi R} \text{ min}$$

$$= \frac{1718.9\, l_1}{R} \text{ min}$$

Similarly

$$\delta_2 = \frac{1718.9\, l_2}{R}$$

$$\delta_3 = \frac{1718.9\, l_3}{R}$$

$$\vdots$$

$$\delta_n = \frac{1718.9\, l_n}{R}$$

Again Degree of curve D is given

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

$$\delta_2 = \frac{D\, l_2}{60}$$

$$\vdots$$

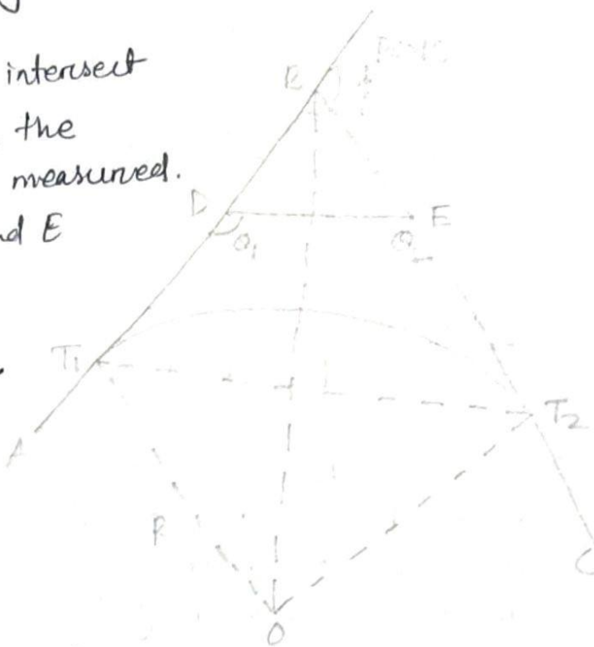
$$\delta_n = \frac{D\, l_n}{60}.$$

<u>check</u>

$$\delta_1 + \delta_2 + \delta_3 + \delta_4 + \dots + \delta_n = \Delta_n = \phi/2$$

Q Two tangents intersect at chainage 1250 m. The angle of intersection is 150°. Calculate all data necessary for setting out a curve of radius 250 m by the deflection angle Method. The peg intervals may be taken as 20 m. Prepare a setting out table when the least count of the venier is 20". Calculate the data for field checking.

2.5: Obstacles in curve ranging: Point of intersection inaccessible



Let two straight lines AB and BC intersect at B, which is inaccessible. So, the deflection angle ϕ can not be measured.

→ Let us select two points D and E along AB and BC respectively.

→ The distance DE is measured, and the angle θ_1 and θ_2 are measured by theodolite.

Now,

$$\angle BDE = 180 - \theta_1$$

$$\angle BED = 180 - \theta_2$$

Angle of intersection $I = 180 - (180 - \theta_1 + 180 - \theta_2)$

$$= \theta_1 + \theta_2 - 180^\circ$$

$$\therefore \phi = 180^\circ - I = 180^\circ - (\theta_1 + \theta_2 - 180^\circ)$$

$$\phi = 360 - (\theta_1 + \theta_2)$$

Apply sine rule in ΔBDE

$$\frac{BD}{\sin(180 - \theta_2)} = \frac{BE}{\sin(180^\circ - \theta_1)} = \frac{DE}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

$$\therefore BD = DE \frac{\sin(180^\circ - \theta_2)}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

$$BE = DE \frac{\sin(180^\circ - \theta_1)}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

$$BT_1 = R \tan\left(\frac{360^\circ - (\theta_1 + \theta_2)}{2}\right)$$

$$DT_1 = BT_1 - BD \quad \text{and} \quad ET_2 = BT_2 - BE$$

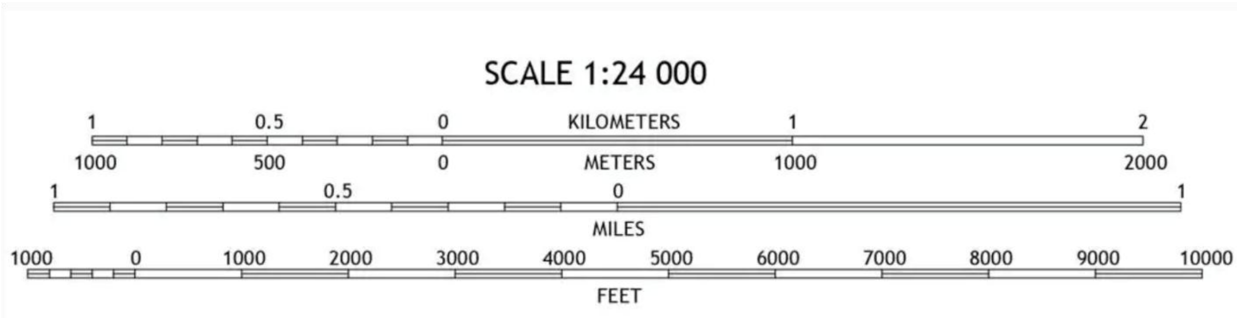
→ Now the tangent points are fixed by measuring distances DT_1 and ET_2. When T_1 & T_2 are fixed, the curve can be set out by any method.

CHAPTER-3

BASICS ON SCALE AND BASICS OF MAP

Fractional or Ratio Scale, Linear Scale, Graphical Scale:-

A fractional scale map displays a portion of an object or geographic feature on the map. This type employs a series of integers to represent an item or a landmark such as 1:24,000.



Linear Scale

A linear scale depicts the distance between two or more notable locations. On maps, the linear scale is a series of lines or dots that represent a landmark.

Verbal Scale

Simple terms are used to define a noticeable surface feature on this scale. A verbal map scale describes a location or object by expanding abbreviations, for example “One inch to the mile”.

Graphical or Bar Scale:

The second type of scale shows map distances and the corresponding ground distances using a line bar with primary and secondary divisions marked on it. This is referred to as the graphical scale or bar scale.

What is Map, Map Scale and Map Projections

A map is a topographic depiction of numerous components, such as location, locations, and regions. All of the information displayed on maps is visible on-site. The map represents a study of the entire area. It provides information on critical places. A MAP is a graphic depiction of a location. It may also be described as a symbolic representation that emphasizes interactions between aspects of that environment such as items, locations, and themes. There is a great deal of information on the map. It just depicts the most essential aspects of the area.

Map Scale

Map scale refers to the relationship (or ratio) between distance on a map and the corresponding distance on the ground. For example, on a 1:100000 scale map, 1cm on the map equals 1km on the ground.

Map scale is often confused or interpreted incorrectly, perhaps because the smaller the map scale, the larger the reference number and vice versa. For example, a 1:100000 scale map is considered a larger scale than a 1:250000 scale map.

Map Projections

Map projection is the method of transferring the graticule of latitude and longitude on a plane surface. It can also be defined as the transformation of spherical network of parallels and meridians on a plane surface. As you know that, the earth on which we live in is not flat. It is geoid in shape like a sphere. A globe is the best model of the earth. Due to this property of the globe, the shape and sizes of the continents and oceans are accurately shown on it. It also shows the directions and distances very accurately. The globe is divided into various segments by the lines of latitude and longitude. The horizontal lines represent the parallels of latitude and the vertical lines represent the meridians of the longitude. The network of parallels and meridians is called gratitude. This network facilitates drawing of maps. Drawing of the gratitude on a flat surface is called projection.

How Maps Convey Location and Extent

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.

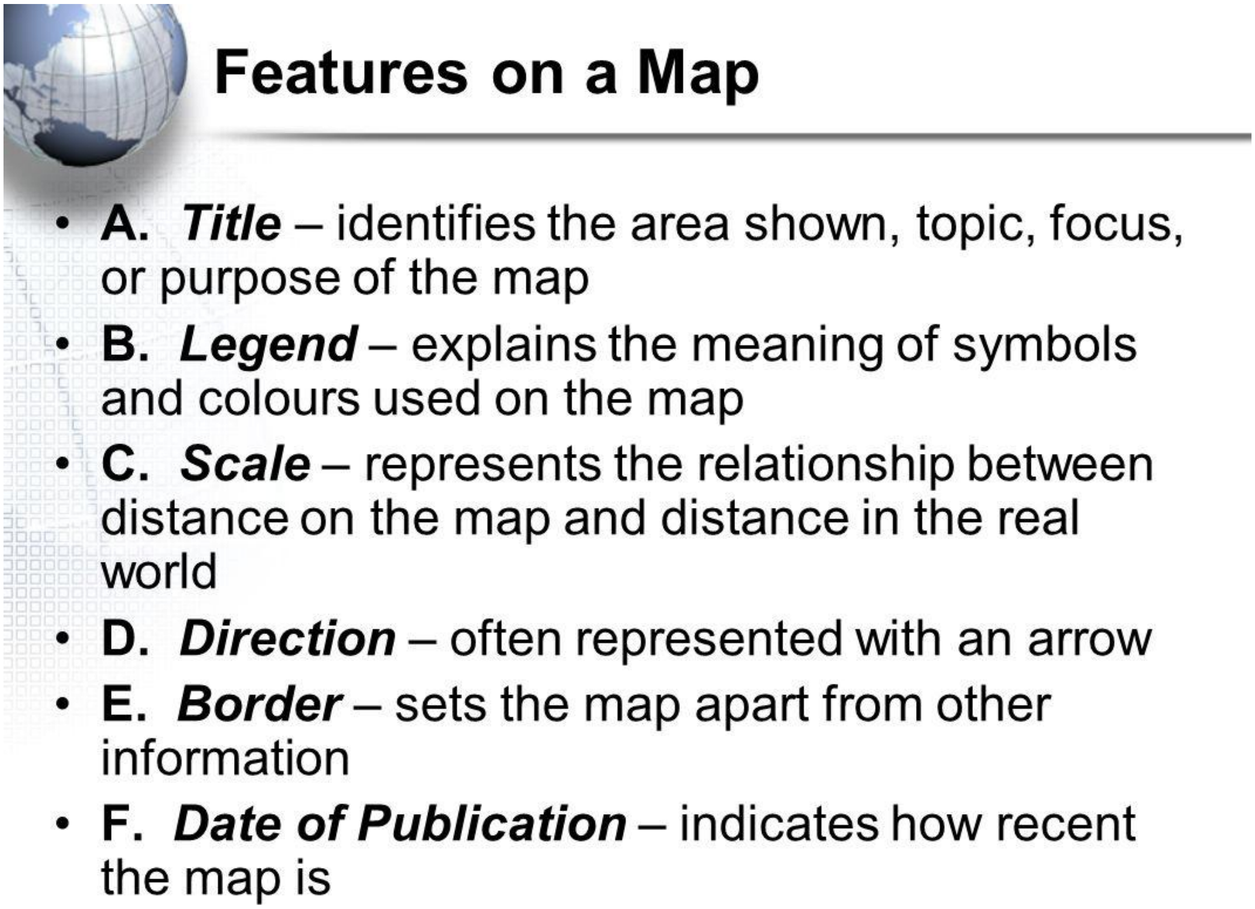
A map extent is the limit of a physical area that is represented on the Map tab or in map windows. When you use the map in spatially-enabled applications, the area of the map that is displayed is called a map extent.

Maps Convey characteristics of features

Some common features of maps include scale, symbols, and grids. All maps are scale models of reality. A map's scale indicates the relationship between the distances on the map and the actual distances on Earth. This relationship can be expressed by a graphic scale, a verbal scale, or a representative fraction.

Parts of a Map

1. **Title**
2. **Scale**
3. **Legend**
4. **Compass**
5. **Latitude and Longitude**



How Maps Convey Spatial Relationship

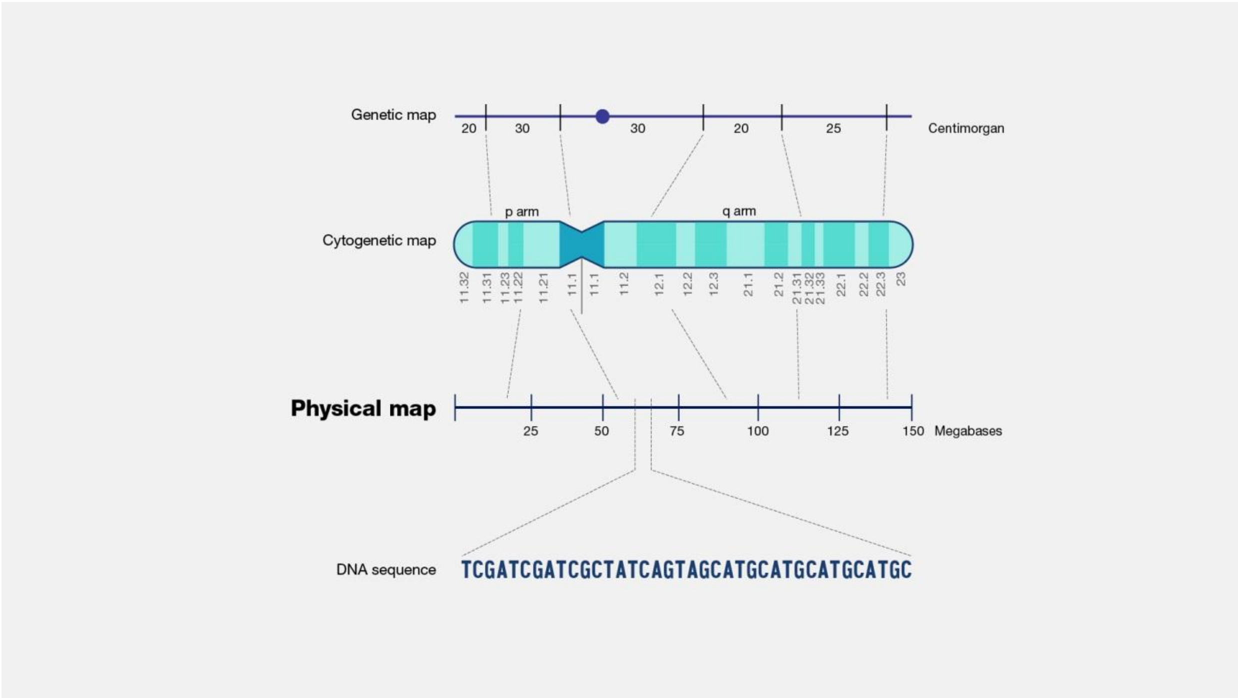
Maps can depict the distribution of objects on Earth, such as settlement patterns. They can pinpoint the precise position of houses and streets in a city area. Mapping identifies distinct map features, or spatial objects, linked to aggregated tables that are visually interpreted for spatial relationships.

A spatial relationship, also known as a spatial relation, is how one geometry is topologically associated with geometry. The association is made based on their interiors, boundaries, and exteriors. In this tutorial, you use the geometry Engine to determine spatial relationships between two geometries.

Classification of Maps

Physical Map:-

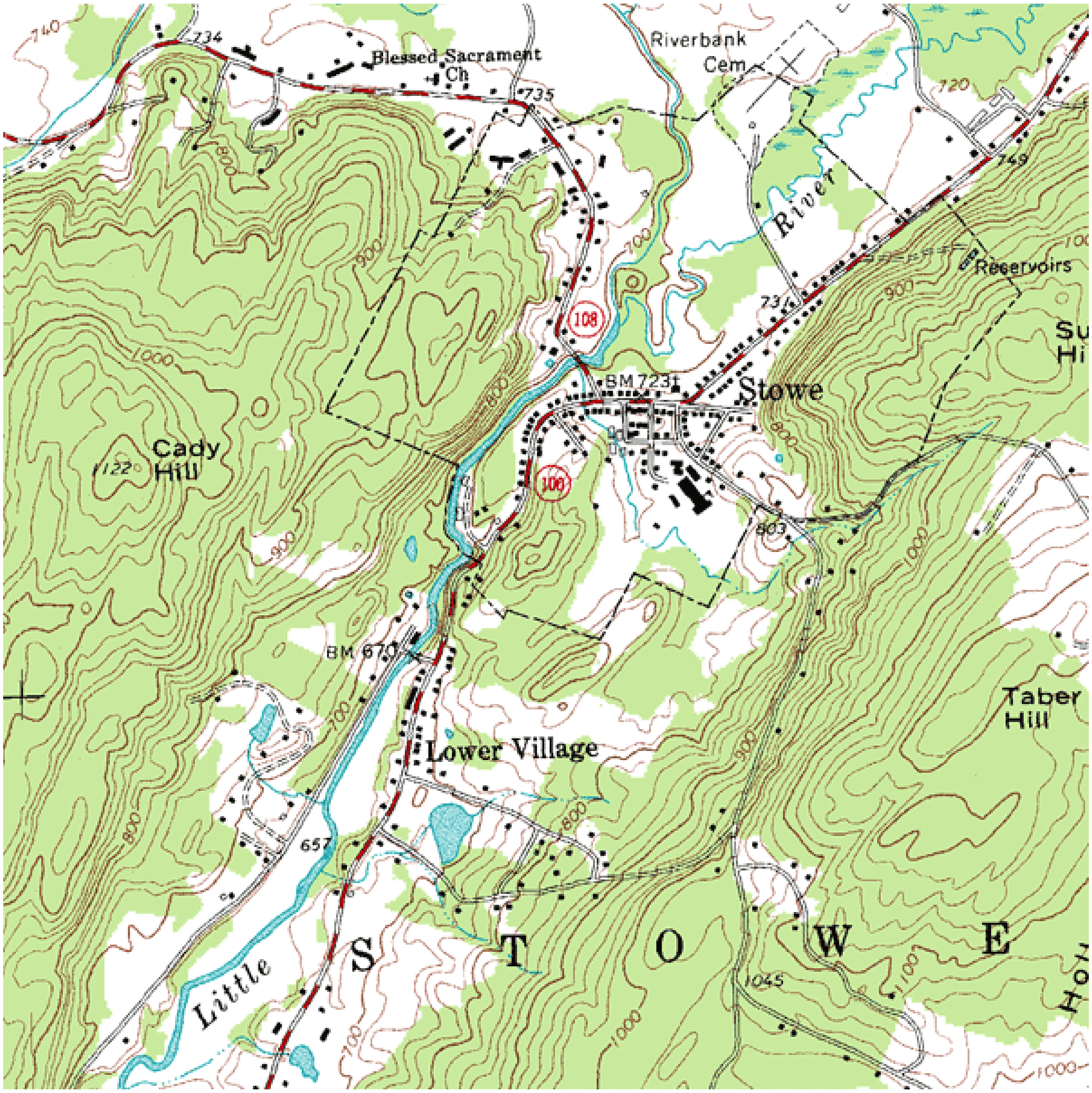
A physical map, as related to genomics, is a graphical representation of physical locations of landmarks or markers (such as genes, variants and other DNA sequences of interest) within a chromosome or genome. A complete genome sequence is one type of physical map.



Topographic Map

In modern mapping, a topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation), but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and artificial features.[1] A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Official topographic maps also adopt a national grid referencing system.

Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes. USGS topographic maps also show many other kinds of geographic features including roads, railroads, rivers, streams, lakes, boundaries, place or feature names, mountains, and much more.



740
734
Blessed Sacrament
Ch
735
Riverbank
Cem
720
749
River
Reservoirs
900
108
731
Su
Hi
BM 7231
Stowe
1000
Cady
Hill
1122
100
803
900
BM 670
Taber
Hill
Lower Village
657
S
T
O
W
E
Little
1045
1000

Road Map

A road map, route map, or street map is a map that primarily displays roads and transport links rather than natural geographical information. It is a type of navigational map that commonly includes political boundaries and labels, making it also a type of political map.

A roadmap is a strategic plan that defines a goal or desired outcome and includes the major steps or milestones needed to reach it. It also serves as a communication tool, a high-level document that helps articulate strategic thinking—the why—behind both the goal and the plan for getting there.

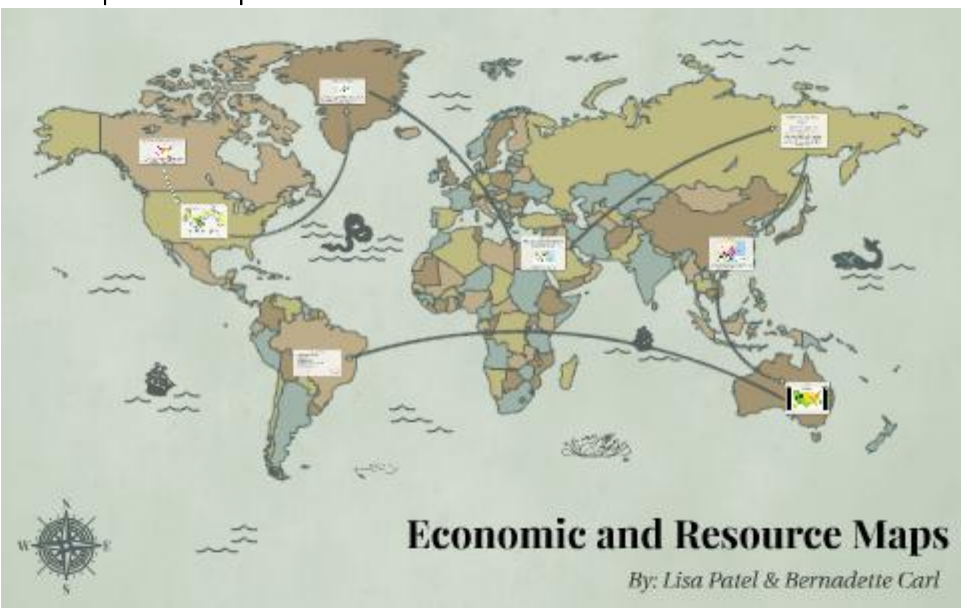
Political Map

A political map is a type of map that represents political divisions, or human-created boundaries, of the world, continents and major geographic regions. Political features are characteristics such as country borders, roads, population centers and landform boundaries.

Economic & Resources Map

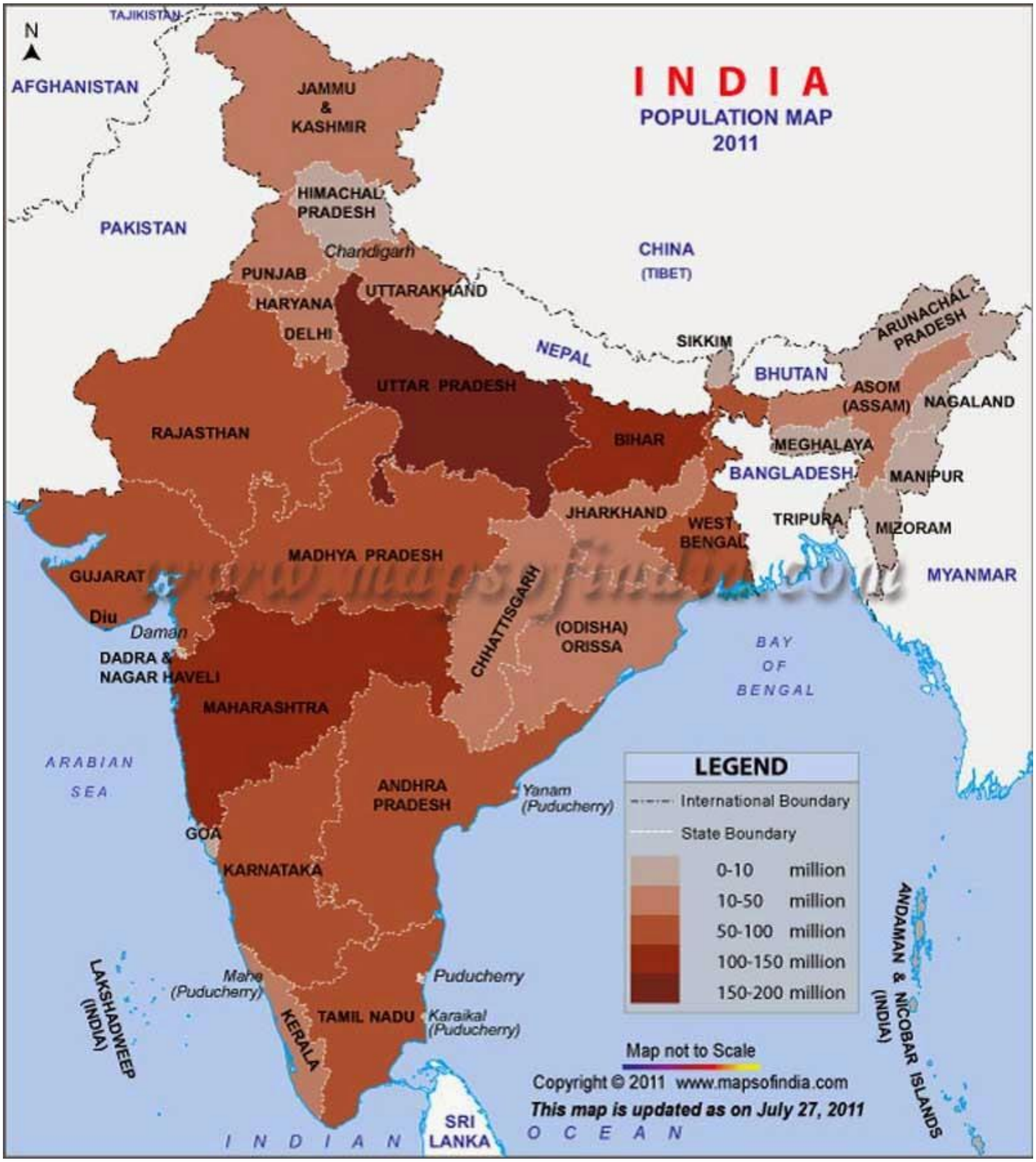
Economic and resource maps show what natural resources are in a place and how people in that place earn money. They can also include data about industries.

The most frequent application in economics is the use of **GIS** to visualize or map economic data with a spatial component.



Thematic Map

A thematic map is also called a special-purpose, single-topic, or statistical map. A thematic map focuses on the spatial variability of a specific distribution or theme (such as population density or average annual income), whereas a reference map focuses on the location and names of features.



Climatic map

chart that shows the geographic distribution of the monthly or annual average values of climatic variables—*i.e.,* temperature, precipitation, relative humidity, percentage of possible sunshine, insolation, cloud cover, wind speed and direction, and atmospheric pressure over regions ranging in area from a few tens of square kilometers to global. To minimize biasing the data because of one or two periods with abnormally high or low values, the data are averaged over at least 30 periods, whether they are months or years.

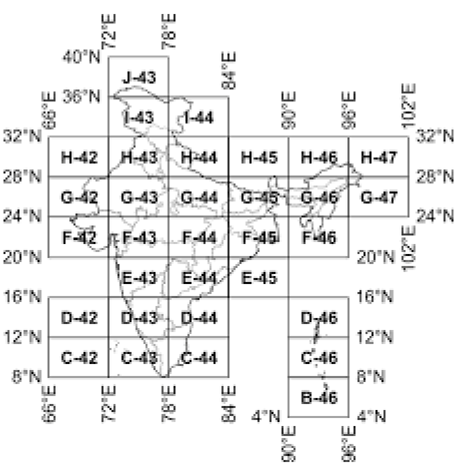
4 SURVEYS OF INDIA MAP SERIES

Open Series map:-

OSMs are brought out exclusively by SOI, primarily for supporting development activities in the country. OSMs bear different map sheet numbers and are in UTM Projection on WGS-84 datum. Each of these OSMs (in both hard copy and digital form) become 'Unrestricted'.

Survey of India (SOI) brings out two series of maps through the National Map Policy, 2005.

Defence Series Maps (DSMs) - These topographical maps (on Everest/WGS-84 Datum and Polyconic/UTM Projection) are on various scales (with heights, contours and full content without dilution of accuracy). These maps mainly cater for defence and national security requirements. This series of maps (in analogue or digital forms) for the entire country are classified by the Ministry of Defence.



Defense Series Map

Defence Series Maps: Maps of this series will be on Everest/WGS 84 Datum and Polyconic/Universal Transverse Mercator Projection at various scales. These maps will be brought out for defence and national security requirements. This series of maps for the entire country will be classified according to requirement and guidelines which will be formulated by the Ministry of Defence from time to time.

Quadrangle Name

A quadrangle is a four-sided, plane figure that closes in a space. Nine quadrangle shapes have names: trapezium, trapezoid, isosceles trapezoid, parallelogram, rhombus, rectangle, square, kite, and dart.

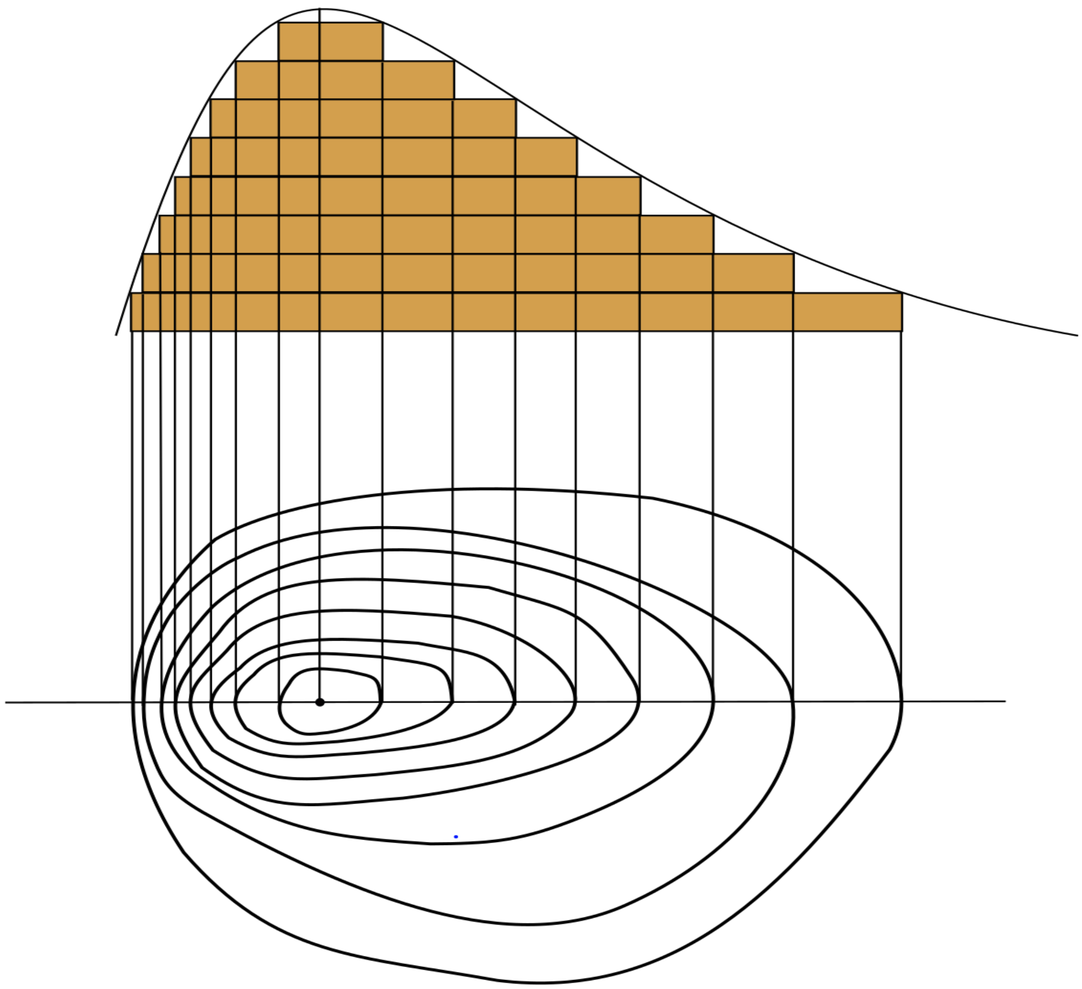
Latitude, Longitude, UTM's

The Universal Transverse Mercator (UTM) is a map projection system for assigning coordinates to locations on the surface of the Earth. Like the traditional method of latitude and longitude, it is a horizontal position representation, which means it ignores altitude and treats the earth as a perfect ellipsoid.

However, it differs from global latitude/longitude in that it divides earth into 60 zones and projects each to the plane as a basis for its coordinates. Specifying a location means specifying the zone and the *x*, *y* coordinate in that plane. The projection from spheroid to a UTM zone is some parameterization of the transverse Mercator projection. The parameters vary by nation or region or mapping system.

Contour Lines

Contour lines are curved, straight or a mixture of both lines on a map describing the intersection of a real or hypothetical surface with one or more horizontal planes. The configuration of these contours allows map readers to infer the relative gradient of a parameter and estimate that parameter at specific places. Contour lines may be either traced on a visible three-dimensional model of the surface, as when a photogrammetric viewing a stereo-model plots elevation contours, or interpolated from the estimated surface elevations, as when a computer program threads contours through a network of observation points of area centroids. In the latter case, the method of interpolation affects the reliability of individual isoclines and their portrayal of slope, pits and peaks.



Magnetic Declination

Magnetic declination, sometimes called magnetic variation, is the angle between magnetic north and true north. Declination is positive east of true north and negative when west. Magnetic declination changes over time and with location.

Public Land Survey System

The Public Land Survey System (PLSS) is the surveying method developed and used in the United States to plat, or divide, real property for sale and settling. Also known as the Rectangular Survey System, it was created by the Land Ordinance of 1785 to survey land ceded to the United States by the Treaty of Paris in 1783, following the end of the American Revolution. Beginning with the Seven Ranges in present-day Ohio, the PLSS has been used as the primary survey method in the United States. Following the passage of the Northwest Ordinance in 1787, the Surveyor General of the Northwest Territory platted lands in the Northwest Territory. The Surveyor General was later merged with the General Land Office, which later became a part of the U.S. Bureau of Land Management (BLM). Today, the BLM controls the survey, sale, and settling of lands acquired by the United States.

Field notes

Field notes are prepared to record all pertinent information, measurements, calculations, sketches, and observations made by the surveyor during the course of a survey. These notes become the permanent record of the survey. The continuous practice of keeping good field notes is imperative.

Ch-5 BASICS OF AERIAL PHOTOGRAPHY, PHOTOGRAMMETRY, DEM AND ORTHO IMAGE GENERATION

Aerial Photography:
Aerial surveying, also known as photogrammetry, is a method used to survey land that would be impossible or impractical to survey on the ground. In recent decades, advancements in GPS tracking and photoimaging technology have allowed this practice to flourish.

Film, Focal Length, Scale:-
Focal length is the distance (measured in millimeters) between the point of convergence of your lens and the sensor or film recording the image. The focal length of your film or digital camera lens dictates how much of the scene your camera will be able to capture.

Types of Aerial Photographs (Oblique, Straight):-
On the basis of the position of the camera axis, aerial photographs are classified into the following types:
(A) Vertical Aerial Photography
(B) Oblique Aerial Photography

(A) Vertical aerial photography is an aerial photography technique where the shots are taken from directly above the subject of the image. Allowable tolerance is usually + 3° from the perpendicular (plumb) line to the camera axis. This method of aerial photography is also referred as "overhead aerial photography." In vertical aerial photograph, the lens axis is perpendicular to the surface of the earth. In vertical photograph, we may see flat and map-like image of the rooftops and canopies of the building and structure being photographed. There are three common ways that vertical aerial photography can be conducted:
(i) Low Altitude – For this particular shot, the resulting images will show bigger and closer shots of the subject and its surroundings,
(ii) Medium Altitude – Here, the resulting images of the subject and the surroundings are smaller than those produced in low. altitude vertical aerial photography,
(iii) High Altitude – The images of the subject and its surroundings produced from high altitude vertical aerial photography are way smaller than those produced from low altitude and medium altitude vertical aerial photography. Nonetheless, they are able to cover a wider section of the land.

(B) Oblique Photography: The word oblique means having a sloping direction or angular position. Therefore, Photographs taken at an angle are called oblique photographs. Oblique Photography is of two types.
(i) Low Oblique Aerial Photography: Low oblique aerial photograph is a photograph taken with the

camera inclined about 30° from the vertical. In this type of photograph horizon is not visible. The ground area covered is a trapezoid, although the photo is square or rectangular. No scale is applicable to the entire photograph, and distance cannot be measured. Parallel lines on the ground are not parallel on this photograph; therefore, direction (azimuth) cannot be measured. Relief is detectable but distorted.
(ii) High Oblique Aerial Photography: The high oblique is a photograph taken with the camera inclined about 60° from the vertical. In this type of aerial photograph horizon is visible. It covers a very large area. The ground area covered is a trapezoid, but the photograph is square or rectangular. Distances and directions are not measured on this photograph for the same reasons that they are not measured on the low oblique. Relief may be quite detectable but distorted as in any oblique view.

Photogrammetry:

Classification of Photogrammetry:-

Two general types of photogrammetry exist: aerial (with the camera in the air) and terrestrial (with the camera handheld or on a tripod). Terrestrial photogrammetry dealing with object distances up to ca. 200 m is also termed close-range photogrammetry.

Aerial Photogrammetry:-

Aerial photogrammetry is a technique for creating two dimensional (2D) or three dimensional (3D) models from aerial photographs, which are pictures of the Earth from a high point, usually an airplane. These photographs are then turned into the models by cartographers.

Terrestrial Photogrammetry:-

Terrestrial photogrammetry is an important branch of the science of photogrammetry. It deals with photographs taken with cameras located on the surface of the earth. The cameras may be handheld, mounted on tripods, or suspended from towers or other specially designed mounts.

Photogrammetry Process:

Acquisition of Imagery using aerial and satellite platform:-

For most photogrammetric mapping purposes, the goal is to image as much of the actual ground surface as possible. For this reason, it is customary to fly projects when deciduous trees are without leaves, when the ground is clear of snow and ice, when lakes and streams are within their normal banks, and when the sun is high overhead, minimizing shadows. In many parts of the world, this limits the optimal season for mapping to early spring, when days are getting long, but trees are relatively bare. Add the need for cloud-free skies to all these other requirements, and you can see why the flight operations of most photogrammetric mapping companies are not a big profit center. For any given location, there are a relatively small number of days per year when all the conditions are right for image acquisition.

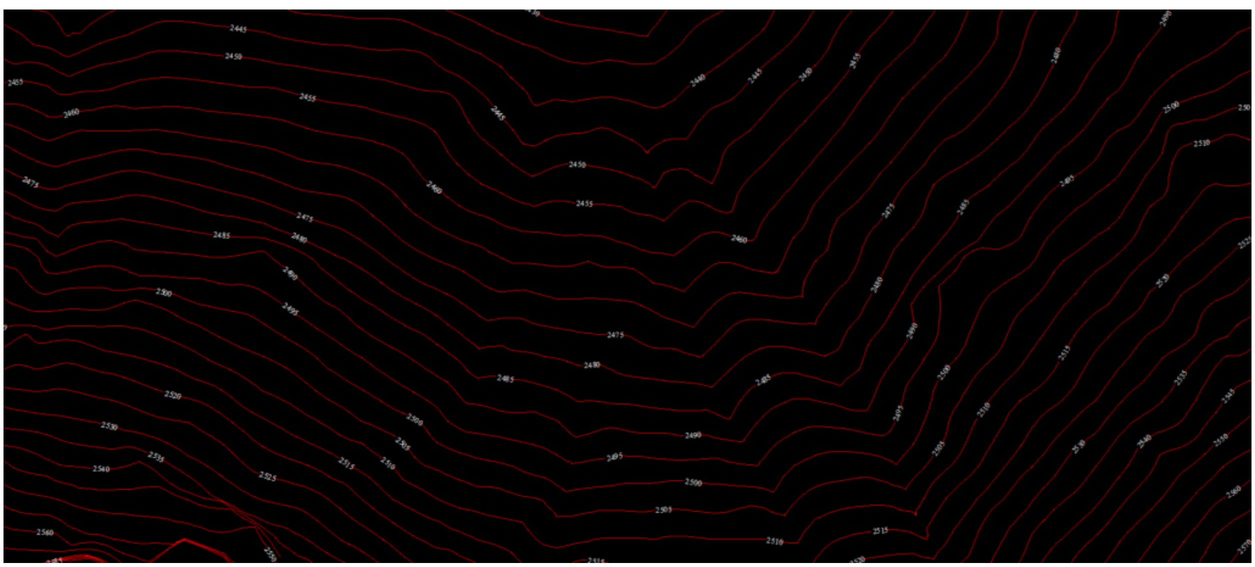
By the way, these requirements are no different for space-based image acquisition. You already know that the orbits of passive imaging satellites are designed to follow local noon. That takes care of the time of day requirement. Add in all the other requirements, plus the constraints of orbital parameters and revisit times, and you can easily see why large-scale state and county mapping projects are still accomplished with aircraft. I'm sure we'll eventually see seamless coverage of states and nations with large-scale (1 meter/pixel GSD or better) satellite imagery, but it won't all be taken in the same season or even in the same year. Not until there are many, many more high-resolution imaging satellites circling the globe.

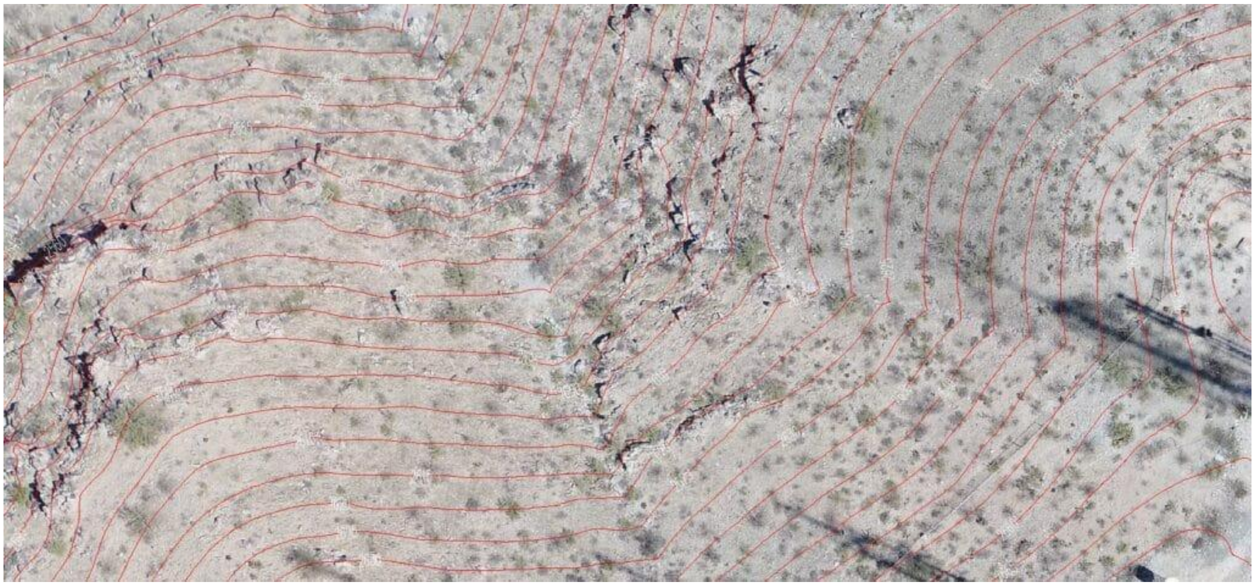
Control Survey:-

A control survey establishes reference locations on land or a construction site. These control points precisely locate and map other land or site characteristics, including buildings, roads, and utilities. Control surveys or survey controls provide reference points as a foundation for diverse building processes.

DTM/DEM Generation:-

A Digital Elevation Model (DEM) is a specialized database that represents the relief of a surface between points of known elevation. By interpolating known elevation data from sources such as ground surveys and photogrammetric data capture, a rectangular digital elevation model grid can be created.
A digital elevation model (DEM) can sometimes contain pixels with failed or incorrect values. You can edit a DEM to smooth out such irregularities to create a more accurate model and, in turn, generate more accurate orthorectified images. For example, areas, such as lakes, often contain misleading elevation values.





Ortho Image Generation:-

An orthophoto, orthophotograph or orthoimage is an aerial photograph /satellite images/drone images or image geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map.

Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt. Orthophotographs are commonly used in Geographic Information Systems (GIS) as a "map accurate" background image. An orthorectified image differs from "rubber sheeted" rectifications as the latter may accurately locate a number of points on each image but "stretch" the area between so scale may not be uniform across the image. A digital elevation model (DEM) is required to create an accurate orthophoto as distortions in the image due to the varying distance between the camera/sensor and different points on the ground need to be corrected. An orthoimage and a "rubber sheeted" image can both be said to have been "dereferenced" however the overall accuracy of the rectification varies. Software can display the orthophoto and allow an operator to digitize or place line work, text annotations or geographic symbols (such as hospitals, schools, and fire stations). Some software can process the orthophoto and produce the line work automatically.

An **orthophotomosaic** is a raster image made by merging orthophotos — aerial, satellite or drone photographs which have been transformed to correct for perspective so that they appear to have been taken from vertically above at an infinite distance.

Image rectification is a transformation process used to project images onto a common image plane. This process has several degrees of freedom and there are many strategies for transforming images to the common plane.

Ch-6 MODERN SURVEYING METHODS:

Principles of modern surveying method:-

Two basic principles of surveying are: • Always work from whole to the part, and • To locate a new station by at least two measurements (Linear or angular) from fixed reference points.

Features and use of modern surveying:-

Modern surveying instruments provide faster and more precise surveying than conventional instruments. Their types and uses are discussed in this article. In conventional surveying, chain and tape are used for making linear measurements while compass and ordinary theodolites are used for making angular measurements. Leveling work is carried out using a Dumpy level and a leveling staff. With such surveying instruments, survey work will be slow and tedious. Hence modern surveying instruments are becoming more popular and they are gradually replacing old surveying instruments such as compass and Dumpy level. With modern surveying instruments, survey work will be precise, faster and less tedious.

Modern Surveying Instruments and Their Uses

Following are the modern surveying instruments which are used for surveying:

- Electronic Distance Measurement (EDM) Instruments
- Total Station
- Global Positioning System (GPS)
- Automatic Level

1. Electronic Distance Measurement (EDM) Instruments

Direct measurement of distances and their directions can be obtained by using electronic instruments that rely on propagation, reflection and reception of either light waves or radio waves. They may be broadly classified into three types: a. Infrared wave instruments b. Light wave instruments c. Microwave instruments

a. Infrared Wave Instruments

These instruments measure distances by using amplitude modulated infrared waves. At the end of the line, prisms mounted on target are used to reflect the waves. These instruments are light and economical and can be mounted on theodolites for angular measurements. The range of such an instrument will be 3 km and the accuracy achieved is ± 10 mm. **E.g. DISTOMAT DI 1000 and DISTOMAT DI 5.**

DISTOMAT DI 1000 It is a very small, compact EDM, particularly useful in building construction and other Civil Engineering works, where distance measurements are less than 500 m. It is an EDM that makes the meaning tape redundant. To measure the distance, one has to simply point the instrument to the reflector, touch a key and read the result.

b. Light Wave Instruments

These are the instruments which measures distances based on propagation of modulated light waves. The accuracy of such an instrument varies from 0.5 to 5 mm / km distance and has a range of nearly 3 km. **Eg: Geodimeter Geodimeter Geodimeter** is an instrument which works based on the propagation of modulated light waves, was developed by E. Bergestand of the Swedish Geological Survey in collaboration with the manufacturer M/s AGA of Swedish. The instrument is more suitable for night time observations and requires a prism system at the end of the line for reflecting the waves.

c. Microwave Instruments

These instruments make use of high frequency radio waves. These instruments were invented as early as 1950 in South Africa by Dr. T.L. Wadley. The range of these instruments is up to 100 km and can be used both during day and might. **Eg. Tellurometer Tellurometer** It is an EDM which uses high frequency radio waves (micro-waves) for measuring distances. It is a highly portable instrument and can be worked with 12 to 24-volt battery. For measuring distance, two Tellurometers are required, one to be stationed at each end of the line, with two highly skilled persons, to take observations. One instrument is used as a master unit and the other as a remote unit. Just by pressing a button a master can be converted into remote unit and vice-versa. A speech facility (communication facility) is provided to each operator to interact during measurement.

Total Station

Total Station is a lightweight, compact and fully integrated electronic instrument combining the capability of an EDM and an angular measuring instrument such as wild theodolite. Total Station can perform the following functions:

- Distance measurement
- Angular measurement
- Data processing
- Digital display of point details
- Storing data is an electronic field book

The important features of total station are,

1. Keyboard-control - all the functions are controlled by operating key board.
2. Digital panel - the panel displays the values of distance, angle, height and the coordinates of the observed point, where the reflector (target) is kept.
3. Remote height object - the heights of some inaccessible objects such as towers can be read directly. The microprocessor provided in the instrument applies the correction for earth’s curvature and mean refraction, automatically.

4. Traversing program - the coordinates of the reflector and the angle or bearing on the reflector can be stored and can be recalled for next set up of instrument.
5. Setting out for distance direction and height -whenever a particular direction and horizontal distance is to be entered for the purpose of locating the point on the ground using a target, then the instrument displays the angle through which the theodolite has to be turned and the distance by which the reflector should move.

Global Positioning System (GPS)

Global Positioning System (GPS) is developed by U.S. Defense department and is called Navigational System with Time and Ranging Global Positioning System (NAVSTAR GPS) or simply GPS. For this purpose U.S. Air Force has stationed 24 satellites at an altitude of 20200 km above the earth's surface. The satellites have been positioned in such a way, at least four satellites will be visible from any point on earth The user needs a GPS receiver to locate the position of any point on ground. The receive processes the signals received from the satellite and compute the position (latitude and longitude) and elevation of a point with reference to datum.

Micro-optic theodolite:-

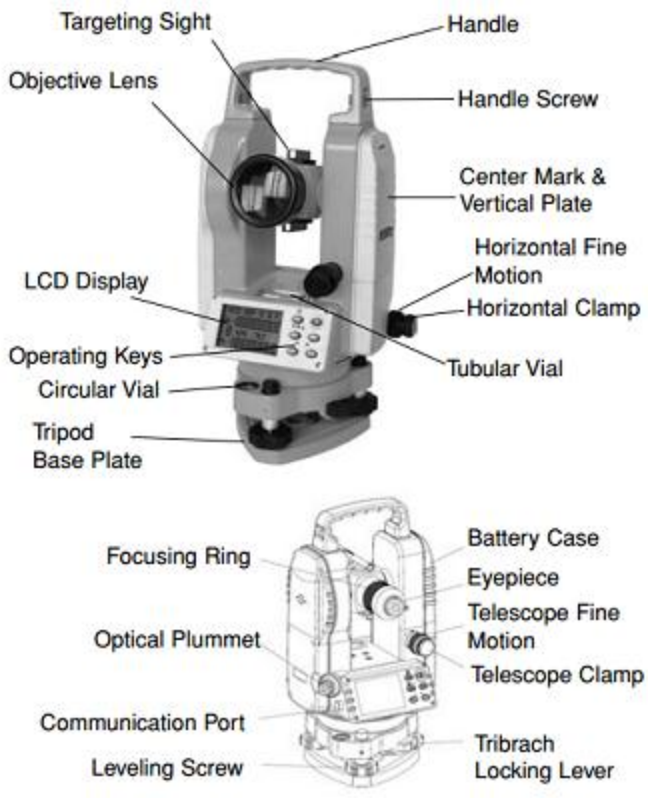
This single-reading Optical Micrometer Theodolite is classified as a lower-order instrument and is generally used in detail surveys and setting-out work where high accuracy is not required. The telescope has a length of 146 mm, a clear objective aperture of 38 mm and a shortest allowable focusing distance of 1.6 m.

Digital theodolite:-

Digital theodolites consist of a telescope that is mounted on a base, as well as an electronic readout screen that is used to display horizontal and vertical angles. Digital theodolites are convenient because the digital readouts take the place of traditional graduated circles and this creates more accurate readings. A digital theodolite consists of a telescope mounted on a base, as shown in Figure-1 below. A sight on the top of the telescope is used to align the target. The target is made clear by using the focusing knob on the instrument. The eyepiece of the telescope is used to find the target. An objective lens is present on the opposite side of the telescope used to sight and magnify the target as required. The parts of a digital theodolite are mostly similar to a non-digital theodolite, except for the presence of a liquid crystal display (LCD), which shows the reading of the target in focus. The display system also has operating keys for changing the device settings**.** Similar to the parts of non-digital theodolite, the leveling is performed using optical plummets or plumb bobs and the spirit or bubble level.

Working of Digital Theodolite

The theodolite is first made to stand vertically above the survey point with the help of a plumb bob or optical plummet. The device is later made in level to the horizon with the help of internal spirit levels. After completing the leveling process, the telescope is used to focus on the target and the respective horizontal and vertical angles are displayed on the screen.



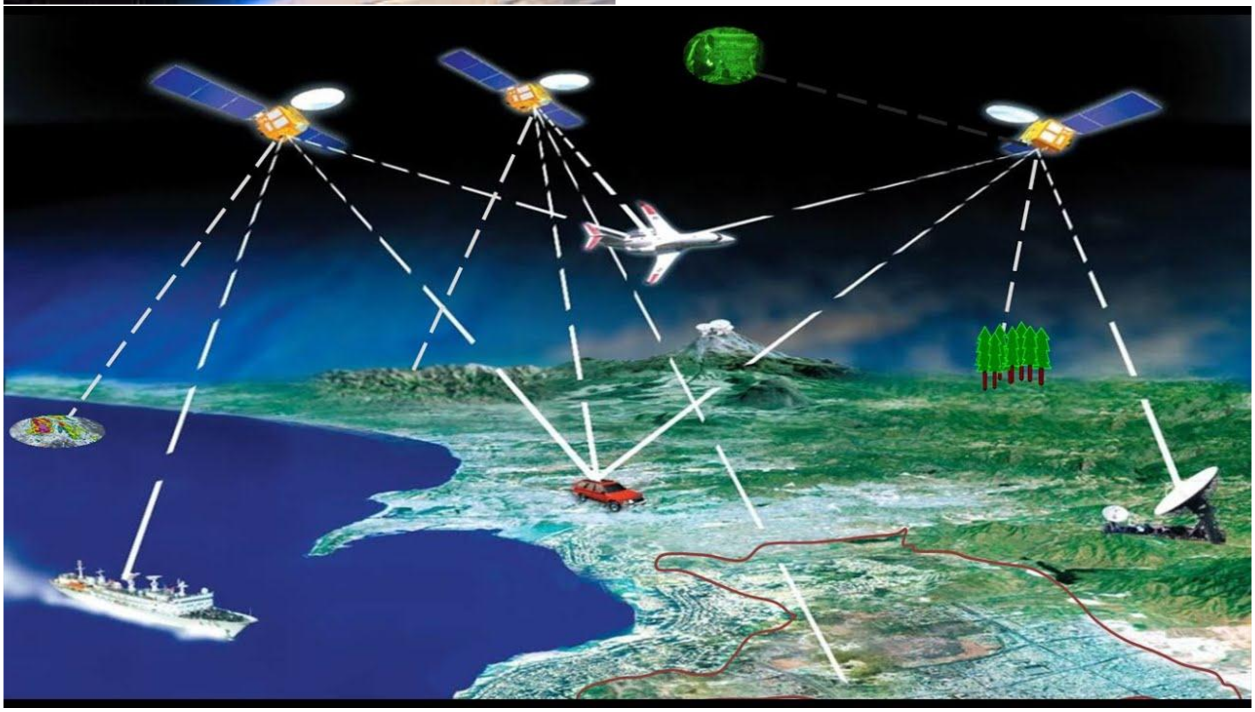
1. Mark the station on the ground using a stake or surveyor's needle, above which the theodolite is planned to be placed.
2. Place the tripod over the station. The height of the tripod is adjusted so that the instrument stays at eye level. The centered hole of the mounting plate must be over the station point.
3. Mount the theodolite over the tripod and screw it in place using the mounting knob.
4. The height difference between the ground and the instrument is measured. This height is used as a reference for other stations.
5. The theodolite is leveled by adjusting the tripod legs and the leveling knobs.
6. A plumb bob or vertical plummet can be tied at the bottom of the theodolite to adjust the level. The plummet must stay over the station nail.

7. After leveling, through the telescope, aim the crosshairs at the point to be measured. The knobs on the side of the theodolite are used to lock it to keep the target on point.
8. The horizontal and vertical angles are read from the LCD screen for the target.

CH-7 BASICS ON GPS & DGPS AND ETS

GPS: - Global Positioning:-

The Global Positioning System (GPS) is a space-based radio-navigation system consisting of a constellation of satellites broadcasting navigation signals and a network of ground stations and satellite control stations used for monitoring and control.



Working Principle of GPS:-

His manufacture of any product is indispensable for the support of the original technology, especially in the era with advanced technology, most of our products make full use of the innovative technology.
If our work and products are related to GPS, then it is necessary to understand the working principle of GPS.

For example, **GPS TRACKER** is a product based on GPS technology. Without the invention of GPS, GPS tracker cannot exist.

So It is essential to understand the working Principle of the GPS, which will help us use the GPS technology to manufacturer the related products.
In this article, we will introduce the Principle of the GPS to you. If you are interested in this topic, this may be a useful reference for you. And you will also know a little: what is the GPS;GPS receiver working principle; PS tracker working principle.

What is GPS ?

GPS is the abbreviation of Global Positioning System, which is a satellite navigation system, which is about 20,000km away from the Earth. It can provide us with location and time information. It can work 24 hours a day under any conditions.
A complete GPS requires at least 24 satellites. As technology develop, more than 33 satellites work together in the system of GPS

Now we can use GPS in the navigation of airplanes, cars and trucks,GPS tracker that is a terminal device based on GPS positioning technology.

The US Department of Defense (USDOD) initially only put these satellites into orbit for military use, such as controlling missile launches, until the 1980s, they were made available for civilian use. Since then,we can see that various applications of GPS appeared in our vision,for example GPS tracker, navigator.

Now anyone with a GPS device, be it a SatNav, mobile phone or handheld GPS unit, can receive the radio signals that the satellites broadcast, which greatly facilitates our lives.

What is the working Principle of the GPS ?

The system of GPS consists of three main parts, including the GPS satellites, the control system, and the control system.

The satellites have covered virtually every corner of the earth.No matter where you are,at least four GPS satellites can be visible at any time.

Everyone regularly transmits information about their location and real-time. These signals that are traveling at the speed of light are intercepted by the GPS receiver, and the GPS receiver calculates the distance of each satellite from us based on the length of time the information arrives.

What a GPS receiver does is locate the four or more satellites and calculate the distance between each one of them. Using this information the GPS tracking system in our car or other devices finds out its current location. The information is presented as maps, latitude And longitude specification, etc.

Once you have information about the distance between you and the three satellites, the GPS receiver can use a method called trilateration to determine your position. It is easy to understand this for the people who have learned math. From this, we can know that the more satellites above the horizon, the more accurately your device with GPS technology will determine your location. That is the reason why many countries need to deploy many satellites for their map.

What are the disadvantages of GPS ？

Even though GPS technology brings us greater convenience, it still has some limitations.
GPS satellite signals are too weak when compared to phone signals, so it doesn’t work as well indoors, underwater, under trees, etc.
The highest accuracy requires line-of-sight from the receiver to the satellite, this is why GPS doesn’t work very well in an urban environment.

How to solve the problem of weak GPS satellite signals

As we use GPS technology more and more in our daily lives, many derivative technologies have been born.
Now we can solve this problem of weak GPS satellite signals very well , we can install the GPS receiver where the GPS signal is weak.
GPS receiver can enhance the ability to receive GPS signals. So It can capture the very weak GPS signals.

GPS receiver working principle

The GPS receiver working principle you can reffer to this article:

How GPS Receivers Work

There are many different types of GPS receivers. GPS trackers can be also seen as GPS receivers.

The application of GPS technology

GPS technology can be applied to many fields, such as car navigation, military weapons and security.
To learn more about the application of GPS technology, you can read the article: https://grindgis.com/gps/50-uses-or-applications-of-gps

You will know 50 Uses or Applications of GPS technology

GPS tracker is also the one of application of GPS technology ,which is a combination of software technology and GPS technology.

Errors of GPS:-

1. Satellite Geometry
2. Satellite Orbits
3. Multipath Effect
4. Atmospheric Effects
5. Clock Inaccuracies and Rounding Errors

1. Satellite Errors:

- Slight inaccuracies in time keeping by the satellites can cause errors in calculating positions.
- Satellites drift slightly from their predicted orbits which contributes to errors.

Let the GPS receiver receive signals from 4 satellites, then there are two cases:

CASE 1

The satellites are at 90° to each other w.r.t the GPS receiver. For demonstration purpose we will take 2 satellites. The possible positions are marked by the light green circles. The point of intersection of the two circles is a rather small, more or less quadratic field (dark green), the determined position will be rather accurate.

CASE 2

The satellites are not at 90° to each other w.r.t the GPS receiver, the possible intersection area of the two circles is rather larger hence less accurate.

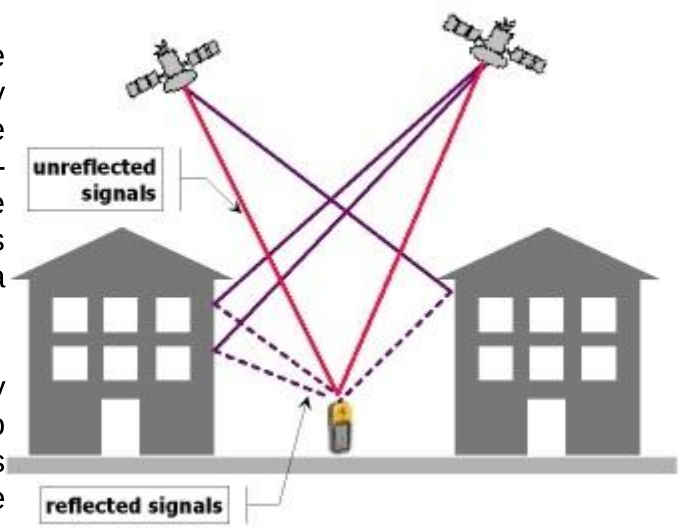
2. Satellite Orbits

Slight shifts of the orbits are possible due to gravitation forces

- Sun and moon have a weak influence on the orbits
- The resulting error being not more than 2 m

3. Multi-path error:

As the GPS signal finally arrives at the earth's surface, it may be reflected by local obstructions before it gets to the receiver's antenna. This is called multi-path error as the signal is reaching the antenna in single line path as well as delayed path. The effect is similar to a double image on a tv set.



The multipath effect is caused by reflection of satellite signals (radio waves) on objects. For GPS signals this effect mainly appears in the neighborhood of large buildings or other elevations. The reflected signal takes more time to reach the receiver than the direct signal. The resulting error typically lies in the range of a few meters.

4. Atmospheric Effects :

The GPS signals have to travel through charged particles and water vapors in the atmosphere which delays its transmission. Since the atmosphere varies at different places and at different times, it is not possible to accurately compensate for the delays that occur.

While radio signals travel with the velocity of light in the outer space, their propagation in the ionosphere and troposphere is slower. In the ionosphere (consisting of layers) in a height of 80 – 400 km a large number of electrons and positive charged ions are formed by the ionizing force of the sun. The layers refract the electromagnetic waves from the satellites, resulting in an elongated runtime of the signals. Since the Electromagnetic waves emit in form of a sphere, therefore, Inverse square law is employed and the waves are slowed down inversely proportional to the square of their frequency ($1/f^2$) while passing the ionosphere. The reasons for the refraction in troposphere are different concentrations of water vapors, caused by different weather conditions. The error caused that way is smaller than the ionosphere error, but cannot be eliminated by calculation. It can only be approximated by a general calculation model.

Receiver Error:

Since the receivers are also not perfect, they can introduce their own errors which usually occur from their clocks or internal noise. Despite the synchronization of the receiver clock with the satellite time during the position determination, the remaining inaccuracy of the time still leads to an error of about 2 m in the position determination. Rounding and calculation errors of the receiver sum up approximately to 1 m.

Error	**VALUE (Approx)**
Ionosphere	4.0 meters
Clock	2.1 meters
Orbit	2.1 meters
Troposphere	0.7 meters
Receiver	0.5 meters
Multipath	1.0 meter
TOTAL	10.4 meters

Selective Availability:

- Selective availability (SA) was the intentional error introduced by DoD to make sure that no hostile forces used the accuracy of GPS against the US or its allies.
- On May 1st, 2000, the White House announced a decision to discontinue the intentional degradation of the GPS signals to the public. Civilian users of GPS will be able to pinpoint locations up to ten times more accurately.

Methods of Correcting GPS Errors

1. Real Time Correction
2. Post-Processing Correction
3. Satellite Differential Services

Real Time Correction

- The base station calculates and broadcasts corrections for each satellite as it receives the data.
- The correction is received by the roving receiver via a radio signal and applied to the position it is calculating.
- As a result, the position displayed on the roving GPS receiver is a differentially corrected position.

Post Processing Correction

- Differentially correcting GPS data by post-processing uses a base GPS receiver that logs positions at a known location and a rover GPS receiver that collects positions in the field.
- The files from the base and rover are transferred to the office processing software, which computes corrected positions for the rover's file.
- This resulting corrected file can be viewed in or exported to a GIS.

DGPS: - Differential Global Positioning System

The Differential Global Positioning System (DGPS) service transmits correction signals to GPS navigation equipment on board vessels. The DGPS service improves the accuracy of your GPS position and the quality of the signal. The DGPS service consists of 12 DGPS stations on the Norwegian coast.

Differential Global Positioning Systems (**DGPSs**) supplement and enhance the positional data available from global navigation satellite systems (GNSSs). A DGPS for GPS can increase accuracy by about a thousand fold, from approximately 15 metres (49 ft) to 1–3 centimetres (½–1+¼ in).[1]

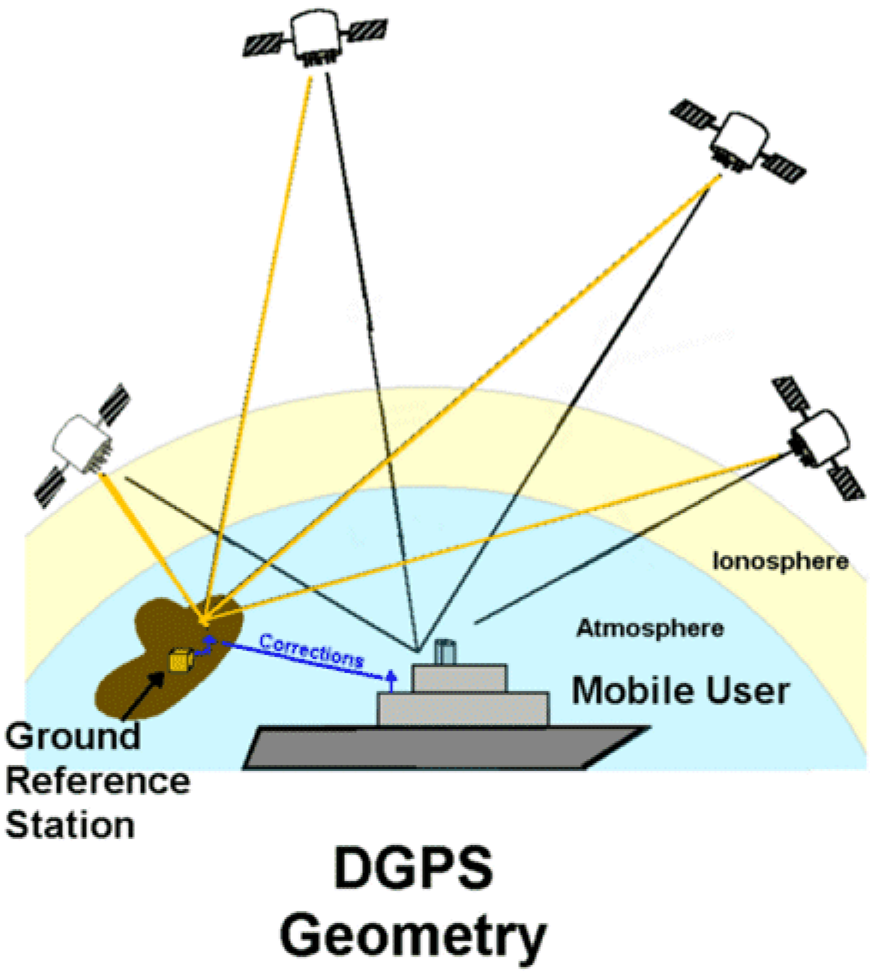
DGPSs consist of networks of fixed position, ground-based reference stations. Each reference station calculates the difference between its highly accurate known position and its less accurate satellite-derived position. The stations broadcast this data locally—typically using ground-based transmitters of shorter range. Non-fixed (mobile) receivers use it to correct their position by the same amount, thereby improving their accuracy.

The United States Coast Guard (USCG) and the Canadian Coast Guard (CCG) each run DGPSs in the United States and Canada on longwave radio frequencies between 285 kHz and 325 kHz near major waterways and harbors. The USCG's DGPS was named NDGPS (Nationwide DGPS) and was jointly administered by the Coast Guard and the U.S. Department of Defense's Army Corps of Engineers (USACE). It consisted of broadcast sites located throughout the inland and coastal portions of the United States including Alaska, Hawaii and Puerto Rico.[2] Other countries have their own DGPS.

A similar system which transmits corrections from orbiting satellites instead of ground-based transmitters is called a Wide-Area DGPS (WADGPS)[3] Satellite Based Augmentation System.

Base Station Setup

The underlying premise of differential GPS (DGPS) requires that a GPS receiver, known as the base station, be set up on a precisely known location. The base station receiver calculates its position based on satellite signals and compares this location to the known location.



ETS: - Electronic Total Station

It is an electronic transit theodolite integrated with electronic distance measurement (EDM) to measure both vertical and horizontal angles and the slope distance from the instrument to a particular point, and an on-board computer to collect data and perform triangulation calculations.

Electronic Total Station Distance Measurement:-

Measurement of distance is accomplished with a modulated infrared carrier signal, generated by a small solid-state emitter within the instrument's optical path, and reflected by a prism reflector or the object under survey. The modulation pattern in the returning signal is read and interpreted by the computer in the total station. The distance is determined by emitting and receiving multiple frequencies, and determining the integer number of wavelengths to the target for each frequency. Most total stations use purpose-built glass prism (surveying) reflectors for the EDM signal. A typical total station can measure distances up to 1,500 meters (4,900 ft) with an accuracy of about 1.5 millimeters (0.059 in) ± 2 parts per million.

Angle Measurement:-

Most total station instruments measure angles by means of electro-optical scanning of extremely precise digital bar-codes etched on rotating glass cylinders or discs within the instrument. The best quality total stations are capable of measuring angles to 0.5 arc-second.

CH-8 BASICS OF GIS AND MAP PREPARATION USING GIS

Components of GIS:-

A working GIS integrates five key components: hardware, software, data, people, and methods. Hardware Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. Software GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are: · Tools for the input and manipulation of geographic information · A database management system (DBMS) · Tools that support geographic query, analysis, and visualization · A graphical user interface (GUI) for easy access to tools Data Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data. People GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. Methods A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

Integration of Spatial and Attribute Information

GIS aids as decision support system with spatial maps and attribute databases. GIS integrates maps with reports, graphs and photographs to present results into powerful tools for decision-makers. This system allows users to select and extract a particular database or map output on the screen or printer etc.

Three Views of Information System:-

Many have characterized GIS as one of the most powerful of all information technologies because it focuses on integrating knowledge from multiple sources and creates a crosscutting environment for collaboration. In addition, GIS is attractive to most people who encounter it because it is both intuitive and cognitive. It combines a powerful visualization environment with a strong analytic and modeling framework that is rooted in the science of geography.

This combination has resulted in a technology that is science based; trusted; and easily communicated across cultures, social classes, languages, and disciplines.

To support this vision, GIS combines three fundamental aspects or views:

1. **The geodatabase view.** A GIS manages geographic information. One way to think of a GIS is as a spatial database containing datasets that represent geographic information in terms of a generic GIS data model— features, rasters, attributes, topologies, networks, and so forth.

   GIS datasets are like map layers; they are geographically referenced so that they overlay onto the earth's surface. In many cases, the features (points, lines, and polygons) share spatial relationships with one another. For example, adjacent features share a common boundary. Many linear features connect at their endpoints. Many point locations fall along linear features (e.g., address locations along roads).

2. **The map view.** A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Various map views of the underlying geographic information can be constructed and used as windows into the geographic database to support query, analysis, and editing of geographic information. Each GIS has a series of two-dimensional (2D) and three-dimensional (3D) map applications that provide rich tools for working with geographic information through these views.

3. **The geoprocessing view.** A GIS is a set of information transformation tools that derive new information from existing datasets. These geoprocessing functions take information from

existing datasets, apply analytic functions, and write results into new derived datasets. Geoprocessing involves the ability to string together a series of operations so that users can perform spatial analysis and automate data processing—all by assembling an ordered sequence of operations.

There are numerous spatial operators that can be applied to GIS data. The ability to derive new information within a GIS analysis process is one of the fundamental capabilities in GIS.

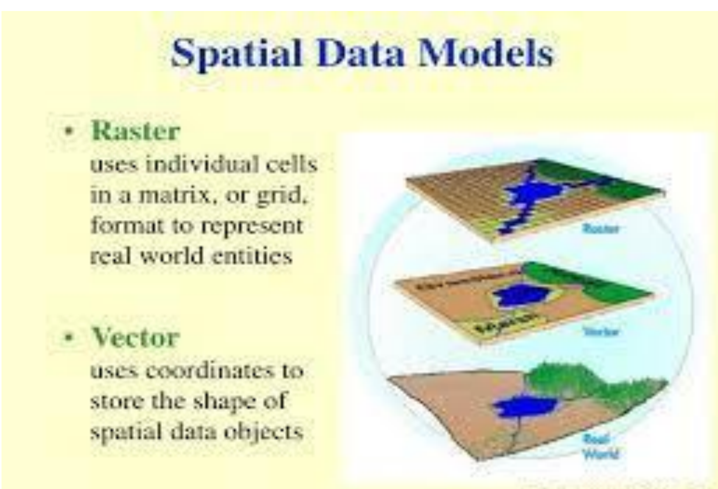
Database or Table View-

- A representation of tabular data for viewing and editing purposes. The table view created when a table is added to ArcMap is a copy of the actual table data stored in memory.

- It is the physical store of geographic information, primarily using a database management system or file system. You can access and work with this physical instance of your collection of datasets either through ArcGIS or through a database management system using SQL.

Spatial data model:-

There are two broad categories of spatial data models. These are vector data model and raster data models. The data base concept is central to a GIS and is the main difference between a GIS and drafting or computer mapping systems, which can produce only good graphic output.



What is vector data?

• A vector based system uses points, lines/arcs, or areas • cartesian coordinates define points in a vector system.

• Lines or arcs are a series of ordered points with a beginning and an end

• areas or polygons are also stored as ordered lists of points, but by making the beginning and end points the same node the shape is closed

• Vector systems are capable of very high resolution (less than or equal to .001 inch) and graphical output is similar to hand-drawn maps.

• Works well with directions, distances, and points, but it requires complex data structures and is less compatible with remote sensing data • vector data requires less computer storage space

• Digamma data and census data are an example of vector data • discrete data (Object) suit a vector structure.

What is a raster data?

• A raster based system stores data by using a grid of cells

• A unique reference coordinate represents each pixel either at a corner or in the middle of the cell

• Each cell or pixel has discrete attributes assigned to it

• Raster data resolution is dependent on the pixel or grid size and may vary from sub-meter to many kilometers.

• Raster data stores different information in layers; elevation, soil type, geology, forest type, rainfall rate, etc.

• generally, raster data requires less processing than vector data, but it consumes more computer storage space.

• Remote sensors on satellites store data in raster format

• Digital terrain models (DTM) and digital elevation models (DEM)

• Continuous data (FIELD) suit a raster structure

Attribute Data Management and Metadata Concept

Attribute data are the information linked to the geographic features (spatial data) that describe features. That is, attribute data are the on graphic information associated with a point, line, or area elements in

• Labels affixed to data points, lines, or polygons.

• Used to describe the feature that you want to map.

• Can include text or numeric descriptors: i.e. nominal, ordinal, or interval/ratio data types.

• Must be careful in how the different data types are integrated and used – dangerous to mix and match. Graphic representation of attributes Data Layers Are the result of combining spatial and attribute data. Essentially adding the attribute database to the spatial location.

Layer Types

A layer type refers to the way spatial and attribute information are connected. There are two major layer types, vector and raster.

Vector:

Points, lines and polygons (spatial data) associated with databases of attributes (attribute data) are considered vector layer types.

Raster:

A row and column matrix (pixels) of X & Y space with attribute information associated with each pixel is considered a raster layer type.

Topology

Topology is the “way in which geographical elements are linked together”. Topology is how geographic features are related to one another and where they are in relation to one another. Topology is the critical element that distinguishes a GIS from a graphics or automated cartography system. It is essential to the ability of a GIS to employ spatial relationships. Topology is what enables a GIS to emulate our human ability to discern and manipulate geographic relationships.

Latitude, Longitude, Height

• The most commonly used coordinate system

• The Prime Meridian and the Equator are used to define latitude and longitude

• latitude and longitude are defined as: – degrees, minutes, seconds – 360 o around the earth – each degree is divided into 60 minutes – each minute is divided into 60 seconds – decimal degrees – a degree expressed as a decimal (in degree units) Map Projections

• All map projections are attempts to portray the surface of the earth on a flat surface

• Distortions of shape, distance, direction, scale, and area result from this process

• Some projections minimize certain distortions while maximizing others

• other projections are attempts to moderately distort all of the above properties.

Universal Transverse Mercator (UTM)

• UTM projection is used to define horizontal, positions world-wide by dividing the surface of the Earth into 6 o zones, each mapped by the Transverse Mercator projection with a central meridian in the center of the zone.

• UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude.

• UTM zone characters designate 8 degree zones extending north and south from the equator.

Data acquisition

As data acquisition or data input of geospatial data in digital format is most expensive and procedures are time consuming. In GIS, the data sources for data acquisition should be carefully selected for specific application and scale. The following data sources are widely used: Analog maps Elevation, soil, landuse, climate, etc. Aerial photographs DEM, landuse (Urban) Satellite image Landuse (regional), vegetation, temperature, DEM Ground survey with GPS Ground truth information Reports and publications Attributes, statistics.

REFERENCE Materials1.

https://theconstructor.org/surveying/surveying-principles-methods-civil-engineering/13048/ 2.

https://www.novatel.com/an-introduction-to-gnss/chapter-2-basic-gnss-concepts/ 3.

http://gps.alaska.edu/jeff/Spatial_Reference/Freymueller_DOT_GPS.pdf 4.

https://drive.google.com/file/d/0B7srsI9Fr4QdUzAzSlRwZnNRZ3M/view :- 5. Surveying and Levelling by N.N. Basak, 2nd Edition 6.

https://2018.foss4gna.org/sites/default/files/slides/survey_resurvey_cadastral_layer_Odisha.pdf 7.

http://www.lawsofindia.org/pdf/orissa/2012/2012OR5.pdf 8.

http://revenueodisha.gov.in/sites/default/files/document/DILRMP/SOP_MRR_2016.pdf 9.

http://revenueodisha.gov.in/sites/default/files/document/Govt_Land/22958_4_8_14.pdf 10.

https://www.google.co.in/search?q=map+reading+and+interpretation+ppt&oq=Map+reading +and+&aqs=chrome.3.69i57j0l5.9755j0j7&sourceid=chrome&ie=UTF-8 11. Map Use: Reading, Analysis and Interpretation by Juliana O. Muehrcke and Philip Muehrcke 12.

http://indiageospatialforum.org/2012/proceedings/ppt/P%20K%20parida.pdf 13.

http://www.indiana.edu/~paleoind/Resources/Guide%20to%20Topographic%20Maps.pdf 14.

http://www.dst.gov.in/sites/default/files/nationalmappolicy.pdf 15. Remote sensing and GIS / BasudebBhatta, 2nd edition, New Delhi, India, Oxford University Press, - Oxford higher education. 16. http://www.gisresources.com/basic-of-photogrammetry_2/ 17. http://giswin.geo.tsukuba.ac.jp/sis/tutorial/Fundamentals_of_GIS_Estoque.pdf 18. Learning Material Approved by R&DM Deptt., Govt. of Odisha