BHADRAK ENGINEERING SCHOOL & TECHNOLOGY (BEST), ASURALI, BHADRAK

LAND SURVEY-II (Th-01)

(As per the 2020-21 syllabus of the SCTE&VT, Bhubaneswar, Odisha)

Sixth Semester

Civil Engg.

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TOPIC WISE DISTRIBUTION OF PERIODS & MARKS

Sl. No.	Chapter	Topics	Periods as per syllabus	Expected Marks
1.	**1.**	**Tacheometry**	09	**10**
2.	**2.**	**Curves**	08	**10**
3.	**3.**	**Basics on scale and basics of map**	08	**15**
4.	**4.**	**Survey of India map series**	10	**10**
5.	**5.**	**Basics of aerial photography, photogrammetry, DEM and ortho image generation**	10	**20**
6.	**6.**	**Modern surveying methods**	10	**15**
7.	**7.**	**Basics on GPS & DGPS and ETS.**	10	**10**
8.	**8.**	**Basics of GIS and map preparation using GIS**	10	**10**
	TOTAL		75	**100**

CHAPTER NO- 1

TACHEOMETRY

Learning objectives

1.1 *Principles*
stadia constants determination

1.2 *Stadia tacheometry with staff held vertical and with line of collimation horizontal or inclined numerical problems*
Numerical problems

1.3 *Elevations and distances of staff stations – numerical problems*
Numerical problems

General

Tachometry is the branch of angular surveying in which the horizontal and vertical distances of points are obtained by optical means as opposed to the ordinary slower process of measurements by tape or chain. The method is very rapid and convenient. Although the accuracy of Tachometry in general compares un-favorably with that of chaining, it is best adapted in obstacles such as steep and broken ground, deep ravines, stretches of water or swamp and so on, which make chaining difficult or impossible.

The primary object of tachometry is the preparation of contoured maps or plans requiring both horizontal as well as vertical control. Also, on surveys of higher accuracy, it provides a check on distances measured with the tape.

Tacheometer:

1. A tacheometer is nothing more than a theodolite fitted with stadia hair.
2. The stadia hairs are kept in the same vertical plane as the horizontal and vertical crosshair.
3. For short distance up to 100 m, ordinary leveling stadia may used.
4. According to measurement process system, it is classified under two categories

i. e 1. Stadia hair system

2. Tangential system

The stadia hair system again divided into two categories

i.e. 1. Fixed hair method

2. Movable hair method

Fixed hair method:

In this method, the distance between the upper hair and lower hair, i.e. stadia interval *i*, on the diaphragm of the lens system is fixed. The staff intercept *s*, therefore, changes according to the distance *D* and vertical angle θ.

Movable hair method

- In this method, the stadia interval '*i*' can be changed. The stadia hairs can be moved vertically upand down by using micrometer screws. The staff intercept *s*, in this case, is kept fixed. Two vanes (targets) are fixed on the staff at a fixed interval of 2 m or 3 m.

- The fixed hair method is the one which is commonly used and, unless otherwise mentioned, stadia method means fixed hair method. Movable hair method is not in common use due to difficulties in determining the value of *i* accurately

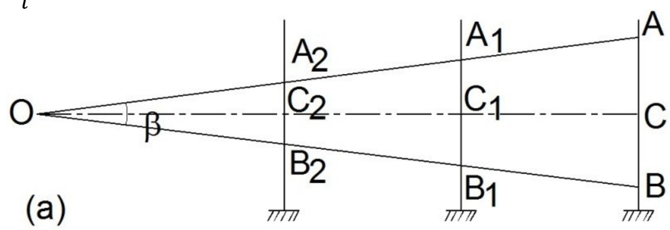
1.1PRINCIPLE OF STADIA METHOD

The stadia method is based on the principle that the ratio of the perpendicular to the base is constant in similar isosceles triangles. In figure (a), let two rays *OA* and *OB* be equally inclined to the central ray *OC*. Let A_2B_2, A_1B_1 and *AB* be the staff intercepts.

Evidently,

$$\frac{OC_1}{A_2B_2} = \frac{OC_1}{A_1B_1} = \frac{OC}{AB} = \frac{f}{i} \text{ (constant)}$$

Where $\frac{f}{i}$ is multiplying constant.



(a)

We will derive distance and elevation formulae for fixed hair method assuming line of sight as horizontal and considering an external focusing type telescope. In Figure below, *O* is the optical centre of the object glass. The three stadia hairs are *a*, *b* and *c* and the corresponding readings on staff are *A*, *B* and *C*. Length of image of *AB* is *ab*. The other terms used in this figure are

f = focal length of the object glass,

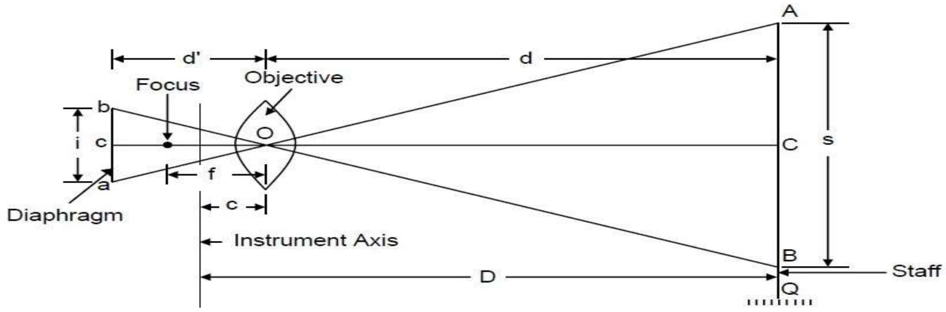
i = stadia hair interval = *ab*,

s = staff intercept = *AB*,
c = distance from *O* to the vertical axis of the instrument,

d = distance from *O* to the staff,

d' = distance from *O* to the plane of the diaphragm, and

D = horizontal distance from the vertical axis to the staff.



Principle of Stadia Method

From similar triangles oab and OAB $\frac{i}{s} = \frac{v}{u}$ --------------(1)

$v = \frac{iu}{s}$

From the properties of lenses $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ ------------------(2)

Putting the value of v in Eq----2

$$\frac{1}{iu/_{S}} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{u}\left(\frac{s}{i} + 1\right) = \frac{1}{f}$$

u= $\left(\frac{s}{i} + 1\right) f$

But D=u+d

D= $\left(\frac{s}{i} + 1\right) f + d$

=$\frac{s}{i}\ X\ f + f + d$

=$\frac{s}{i}\ X\ f + f + d = \left(\frac{f}{i}\right) X\ s + (f + d)$

Where the constant *K* is equal to (*f* /*i*). It is called **multiplying constant** of the tacheometer and is generally kept as 100. The constant *C* is equal to (*f* + *c*). It is called **additive constant** whose value ranges from 30 cm to 50 cm for external focusing telescopes and 10 cm to 20 cm for internal focusing telescopes. For telescopes fitted with anallactic lens, *C* equals zero.

Anallactic Lens

The basic formula for determination of horizontal distance in stadia tacheometry is

$$D = \frac{f\text{s}}{\text{i}} + (f + \text{c})$$

Or D = Ks + C

- Due to the presence of the additive constant *C*, *D* is not directly proportional to *s*. This is accomplished by the introduction of an additional convex lens in the telescope, called an *anallactic lens*, placed between the eyepiece and object glass, and at a fixed distance from thelatter.
- The anallactic lens is provided in external focusing telescope. Its use simplifies the reduction of

observations since the additive constant ($f + c$) is made zero and the multiplying constant k is made 100. However, there is objection to its use also as it increases the absorption of light in thetelescope thereby causing reduction in brilliancy of the image. Anallactic lens is not fitted in internal focusing telescopes.

STADIA CONSTANTS DETERMINATION

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. Markthe 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,$D_1 = K. s_1 + C$--------------- (i)
and $D_2 = K. s_2 + C$ ------------- (ii)

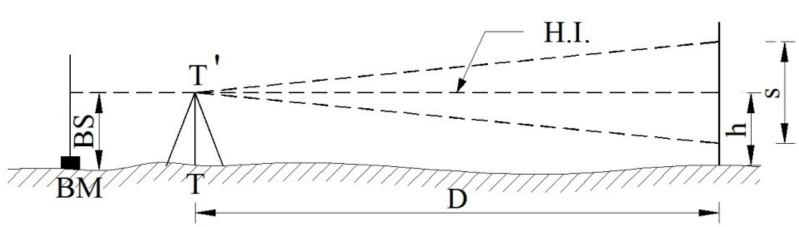
Solving Equations (i) and (ii), determine the values of K and C say K_1 and C_1 .

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 tacheometricconstants K and C of the instrument.

1.2 STADIA TACHEOMETRY WITH STAFF HELD VERTICAL AND WITH LINE OF COLLIMATION HORIZONTAL OR INCLINED NUMERICAL PROBLEMS

Case 1 When staff held vertical and with line of collimation horizontal



When the line of sight is horizontal , the general tacheometric equation for distance is given by

$$D = \frac{f s}{i} + (f + c)$$

The multiplying constant

RL of staff station P = HI – h

Where HI = RL of BM + BSh = central hair reading

BS = Back sight

HI = height of instrument

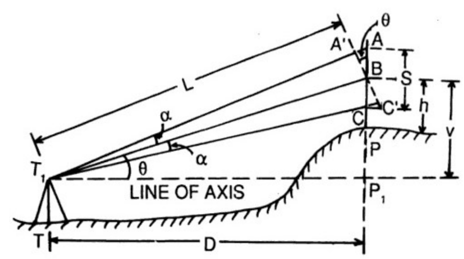
Case 2 When staff held vertical and with line of collimation inclined

(a) Considering Angle of elevation

Let

T = Instrument station T_1 = axis of instrument$P$ = staff station
A, B, C = position of staff cut by hairs
$S = AC$ = staff intercept
h = central hair reading
V = vertical distance instrument axis and

central hair



D = horizontal distance between instrument and staff L = inclined distance between instrument axis and B θ =angle of elevation

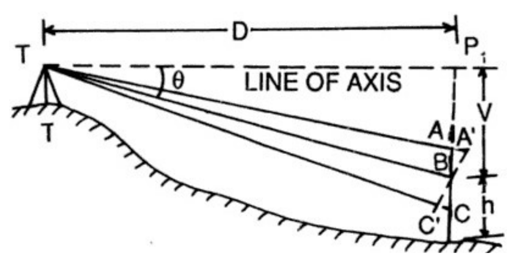
α =angle made by outer and inner rays with central ray

Also V = D tan θ

RL of staff station P = RL of axis of instrument + V − h

(b) Considering Angle of depression

In this case also the expressions for D and V are same. That is S $\cos^2\theta + (f\cos\theta)$

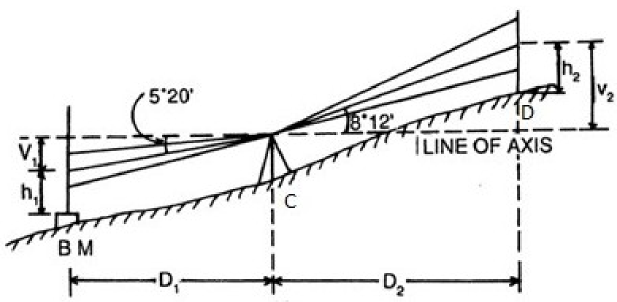


Problem-1

A tacheometer was set up at a station C and the following readings were obtained on staff vertically held.

Inst. Station	Staff station	Vertical angle	Hair readings	Remarks
C C	BM D	$-5^0\ 20'$ $+8^0\ 12'$	1.500 , 1.800, 2.450 0.750, 1.500, 2.250	RL of BM = 750.50 m

Calculate the horizontal distance CD and RL of D, when the constants of instrument are 100 and 0.15 .



Solution

When the staff is held vertically, the horizontal and vertical distances are given by the relations

$D_2 = 100 \times 1.50 \times \cos^2 8^0\ 12' + 0.15 \times \cos 8^0\ 12' = 147.097$ m

RL of axis of instrument = RL of BM + h_1 + V_1

= 750.500 + 1.800 + 12.045 = 764.345 m

RL of D = RL of axis of instrument + $V_2 - h_2$

= 764.345 + 21197 − 1.500 = 784.042 m

So, the distance CD = 147.097 m and RL of D = 784.042 m

1.3 ELEVATIONS AND DISTANCES OF STAFF STATIONS – NUMERICAL PROBLEMS

Problem-2

A staff held vertically at a distance of 50 m and 100m from the centre of the theodolite with a stadia hair, the staff intercept with the telescope is 0.500 and 1.000 respectively. The instrument was then setup over a station P of RL 1850.95 m and the total height of instrument was 1.475m. The hair reading on a staff held vertically at station Q were 1.050, 1.900 and 2.750 with the line of sigth horizontal. Calculate the horizontal distance of PQ and RL of Q point.

<u>Solution</u>

Calculation of tacheometric constant

D = KS + C
50 = K(0.005) + C------------ (1)
100 = K(1.000) + C----------- 2)

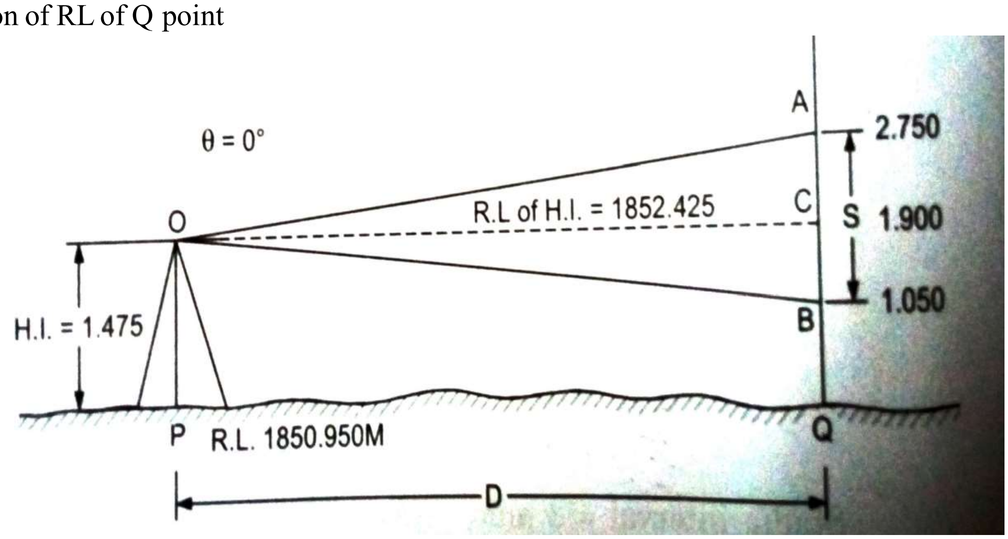
50 = K(0.005) + C----------- (1)
C = 50 – 0.005 K---------- (3)
Put the value of C in Eq 2

100 = K(1.000) + C (2)
100 = 1.000 K + 50 – 0.005 K
K = 100
Now put the value of K in eq 3C = 50 – 0.005 K --------------(3)
C = 50 – 0.005 (100)
C = 0
Note: if K = 100 and C = 0 means your instrument is perfect

Calculation of horizontal distance between PQ

D = KS + C (1)
Now
S = 2.750 – 1.050 = 1.700mK = 100
C = 0

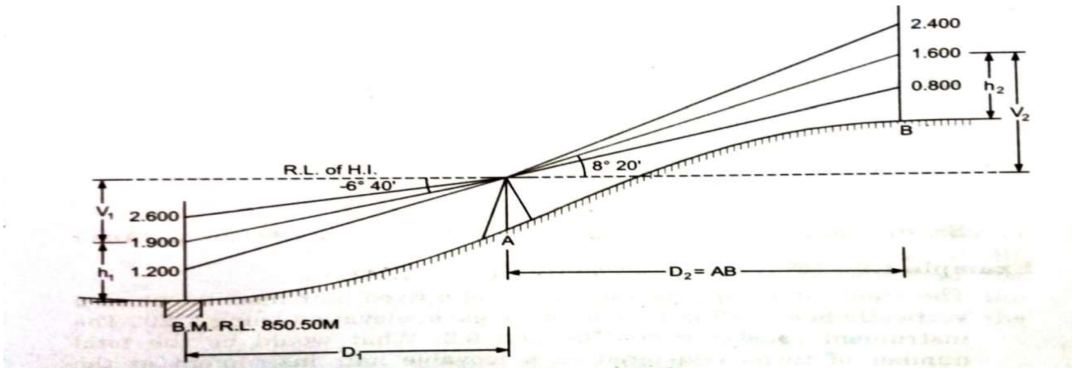
Put all the value in equation no 1D = 100 (1.700) + 0
D = 170m
Calculation of RL of Q point



RL of Q = 1850.95 + 1.475 – 1.900
= 1850.525

Problem-3

A tachometer was setup at a station A and the following readings were obtain on a staff held vertically, calculate the horizontal distance ABand RL of B, when the constant of instrument are 100 and 0.15



In the first observation

$S_1 = 2.600 - 1.200 = 1.400$m

$\Theta_1 = -6^0 40'$ (Depression)K = 100 and C = 0.15

Vertical Desistance $V_1 = KS \sin 2\theta/2 + C \sin\theta$

$= 100(1.400) \sin(2 \times 6^0 40')/2 +$ $0.15 \sin 6^{0} 40'$

= 16.143 + 0.0174

= 16.160m

In the second observationS2 = 2.400 – 0.800 = 1.600$\Theta_2 = +8^{02}0'$ (Elevation)

CO

Vertical Desistance $V_2 = KS \sin 2\theta/2 + C \sin\theta$

$= 100(1.600) \sin(2 \times 8^0 20')/2 +$ $0.15 \sin 8^0 20'$

= 22.944 + 0.022

= 22.966m

Horizontal distance $D_2 = KS \cos^2\theta + C \sin\theta$

$= 100\,(1.600) \cos^2 8^0 20'$ $+$ $0.15 \sin 8^0 20'$

= 156.639 + 0.148

= 156.787m

RL of Instrument Axis = RL of BM + h1 + V1

= 850.500 + 1.900 + 16.160

= 868.560m

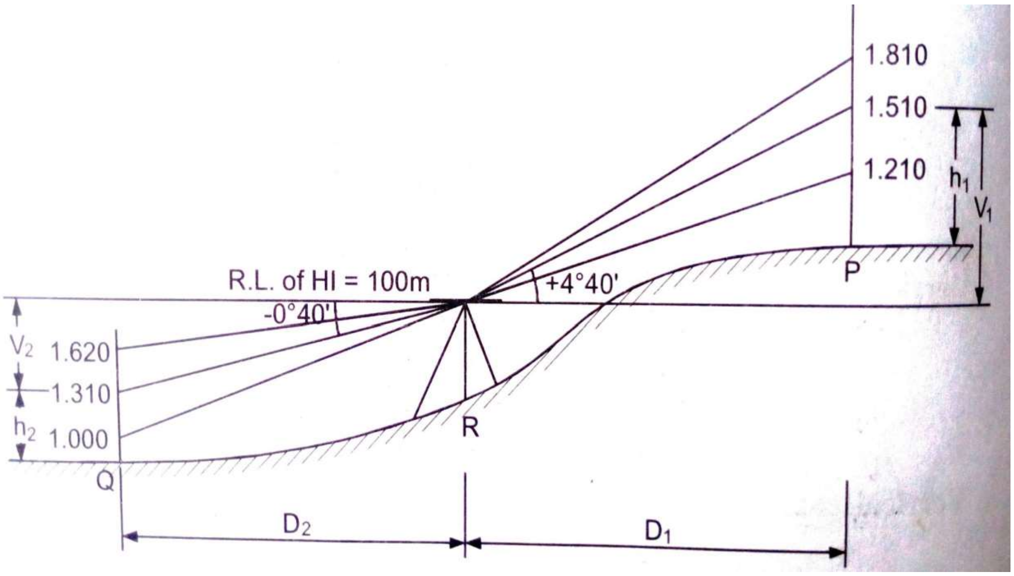
RL of B = RL of Inst. axis + V2 – h2

= 868.560 + 22.966 – 1.600

RL of B = 889.926m

Example 5

To determine the gradient between two point Pand Q a tacheometer was set up at a R station and the following observation where taken keeping the staff held vertical, if the horizontalangle PRQ is $36^0 20'$ determine the avg. Gradient between P and Q Point take K = 100 and C = 0 and RL of HI = 100m



In the first observation (From R to P)S_1 = 1.810 – 1.210 = 0.6m

$\Theta_1 = +4^0 40'$

Horizontal distance D = KS $\text{Cos}^2\theta$ + C Sinθ

$= 100 \times 0.6 \times \text{Cos}^2\ 4^o 40' + 0$

= 59.60m

Vertical Desistance V = KS Sin2θ/2 + C Sinθ

$= 100 \times 0.6 \times \text{Sin}(2 \times 4^o 40') / 2 \quad + 0$

= 4.865m

In the Second observation (From R to Q)S_2 = 1.620 – 1.000 = 0.62m

$\Theta_2 = -0^o 40'$

Horizontal distance D = KS $\text{Cos}^2\theta$ + C Sinθ

$= 100 \times 0.62 \times \text{Cos}^2\ 0^o 40' \quad + 0$

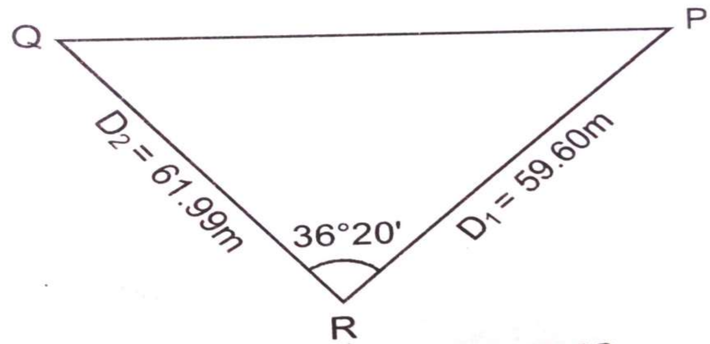
= 61.99m

Vertical Desistance V = KS Sin2θ/2 + C Sinθ

$= 100 \times 0.62 \times \text{Sin}(2 \times 0^o 40') / 2 \quad + 0$

= 0.721m

Avg. Gradient Between P and Q point



$PQ^2 = PR^2 + QR^2 - 2 \times PR \times QR \times \cos 36^0 20'$
$PQ^2 = (59.60)^2 + (61.99)^2 - 2 \times 59.60 \times 61.99 \times \cos 36^0 20'$
PQ = 37.978m
Difference of Elevation between P and Q
RL of P = RL of HI + $V_1 - h_1$
= 100 + 4.865 – 1.510
= 103.355m
RL of Q = RL of HI – $V_2 - h_2$
= 100 – 0.721 – 1.310
= 97.969m
Difference of RL of P & Q = 103.355 – 97.969
= 5.386
Average gradient between P and Q
= Difference in RL between P & Q / Distanceof P & Q

= 5.386 / 37.978

= 1 / 7.051

<u>Case : 3 (When the line of sight is inclined andstaff is held Normal to the line of sight)</u>

If angle is + ve

Horizontal distance

D = KS Cosθ + C Cosθ + h Sinθ

Vertical Desistance

V = KS Sinθ + C Sinθ

If angle is – ve

Horizontal distance

D = KS Cosθ + C Cosθ - h Sinθ

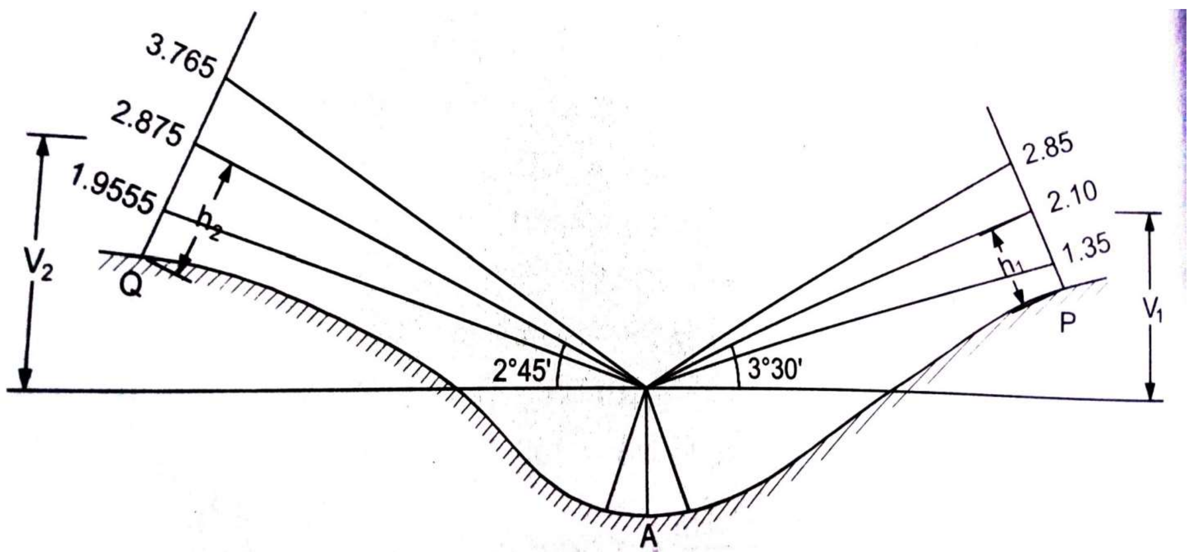
Vertical Desistance

V = KS Sinθ + C Sinθ

Example-6

Find out the distance between P and Q by using the bellow data given in table, the staff held normal to the line of sight in both the cases value of the tacheometer constant is 100and 0.3

Instrument	Staffat	Line	Bearing	Vertical angle	Hair Reading
A	P	AP	$84^0 36'$	$3^0 30'$	1.35, 2.10, 2.85
A	Q	AQ	$142^0 24'$	$2^0 45'$	1.955, 2.875, 3.765



$S_1 = 2.85 - 1.35 = 1.5m$

$S_2 = 3.765 - 1.955 = 1.809m$

Horizontal Distance

AP = D = $KS_1 \ Cos\theta_1 + C \ Cos\theta_1 + h_1 \ Sin\theta_1$

$= 100 \times 1.5 \times Cos\ 3^0 30' + 0.3 \times Cos\ 3^0 30'$

$+ 2.10 \times Sin\ 3^0 30'$

$= 149.72 + 0.299 + 0.128$

$= 150.147m$

AQ = D = $KS_2 \ Cos\theta_2 + C \ Cos\theta_2 + h_2 \ Sin\theta_2$

$= 100 \times 1.809 \times Cos\ 2^0 45' + 0.3 \times Cos\ 2^0 45' + 2.875 \times Sin\ 2^0 45'$

$= 180.742 + 0.299 + 0.138$

$= 181.179m$

Angle PAQ = Bearing ofAP – Bearing ofAQ

$= 142^0 24' - 84^0 36'$

$= 57^{0}48'$

Using Cosine rule

$PQ^2 = AP^2 + AQ^2 - 2 \times AP \times AQ \times \cos 57^{0}48'$

$PQ^2 = (150.147)^2 + (181.179)^2 - 2 \times 150.147 \times 181.179 \times \cos 57^{0}48'$ $PQ = 162.41m$

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 Define tacheometry.

Ans: Tachometry is the branch of angular surveying in which the horizontal and vertical distances of points are obtained by optical means as opposed to the ordinary slower process of measurements by tape or chain.

Q-2 Define stadia constants and write their values.

Ans: It is called multiplying constant of the tacheometer and is generally kept as 100. The constant C is equal to (f + c). It is called additive constant whose value ranges from 30 cm to 50 cm for external focusing telescopes and 10 cm to 20 cm for internal focusing telescopes. For telescopes fitted with anallactic lens, C equals zero.

Q-3 Define annalitic lens.

Ans: The anallactic lens is provided in external focusing telescope. Its use simplifies the reduction of observations since the additive constant $(f + c)$ is made zero and the multiplying constant k is made 100.

POSSIBLE LONG TYPE QUESTIONS

Q-1 A tacheometer was set up at a station C and the following readings were obtained on a staff vertically held.

Instrument station	Staff station	Vertical angles	Hair readings	Remarks
C	BM	$-5^{0}20'$	1.500 ,1.800, 2.450	RL of BM = 750.50 m
C	D	$+8^{0}12'$	0.750, 1.500, 2.250	

Calculate the horizontal distance CD and RL of D, when the constants of instrument are 100 and 0.15 .

Q-2 Write the procedure for calculation of horizontal and vertical distance for staff held vertical in plain surface.

CHAPTER NO-02

CURVES

Learning objective

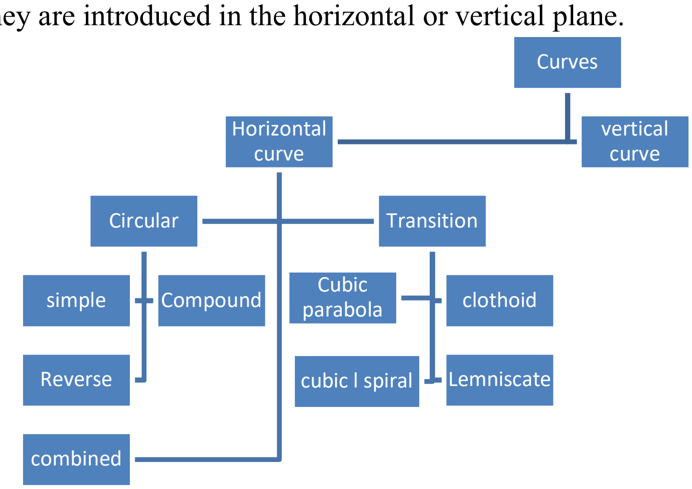
2.1 *Compound, reverse and transition curve, Purpose & use of different types of curves in field*
2.2 *Elements of circular curves, numerical problems*
2.3 *Preparation of curve table for Setting out*
2.4 *Setting out of circular curve by chain and tape and by instrument angular methods (i) offsets from long chord (ii) successive bisection of arc, (iii) offsets from tangents, (iv) offsets from chord produced, (v) Rankine's method of tangent angles (No derivation)*
2.5 *Obstacles in curve ranging – point of intersection inaccessible*

INTRODUCTION:

Curves are required to be introduced where it is necessary to change the direction of motion fromone straight section of a highway or a railway to another. These are provided due to the nature of terrain or other avoidable reasons to enable smooth passage of vehicles.

2.1 COMPOUND, REVERSE AND TRANSITION CURVE, PURPOSE & USE OF DIFFERENT TYPES OF CURVES IN FIELD

For survey purposes, curves are classified as horizontal or vertical, depending on whether they are introduced in the horizontal or vertical plane.



Horizontal Curves

Horizontal curves can be circular or non-circular (transitional) curves. Different types of horizontal curve are shown in figure below.

Simple Circular Curve

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

Compound Curve

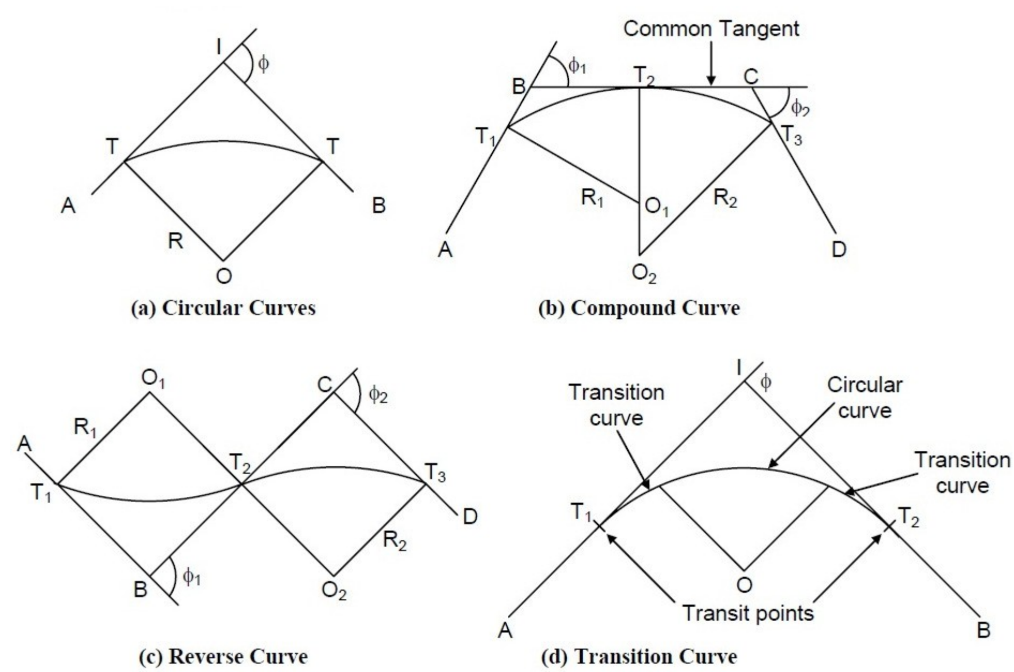
When a curve consists of two or more arcs with different radii, it is called a compound curve. Such a curve lies on the same side of a common tangent and thecentres of the different arcs lie on the same side of their respective tangents.

Reverse Curve

A reverse curve consists of two arc bending in opposite directions. Their centres lieon opposite sides of the curve. Their radii may be either equal or different, and theyhave one common tangent.

Transition Curve

A curve of variable radius is known as a transition curve. It is also called a easement curve. Such a curve is provided between a straight and a circular curve, or between branches of a compound or reverse curve to avoid an abrupt change in direction when the alignment changes. In railways, such curve is used on both sides of a circular curve to minimizesuperelevation.



(a) Circular Curves (b) Compound Curve (c) Reverse Curve (d) Transition Curve

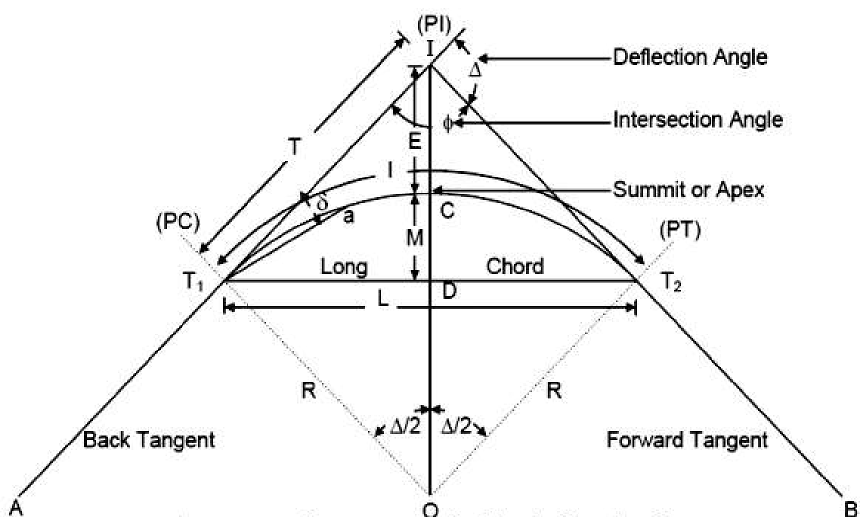
Type of Horizontal Curves

2.2 ELEMENTS OF CIRCULAR CURVES, NUMERICAL PROBLEMS

SIMPLE CIRCULAR CURVE

Figure shows a simple circular curve with two straight lines *AI* and *IB* intersect at the point *I*. The curve $T_1C\ T_2$ of radius *R* is inserted to make a smooth change of direction from *AI* to *IB*.

A simple circularcurve has various components whose definitions are given below.



Components of a Simple Circular Curve

Definition of Various Components Back Tangent

The tangent (AT_1) previous to the curve is called the back tangent or first tangent.

Forward Tangent

The tangent (T_2B) following the curve is called the forward tangent or second tangent.

Point of Intersection

If the two tangents AT_1 and BT_2 are produced, they will meet in a point *I* called the point ofintersection (PI) or vertex.

Point of Curve (PC)

It is the beginning of the curve (T_1) where the alignment changes from a tangent to a curve.

Point of Tangency (PT)

It is the end of the curve (T_2) where the alignment changes from a curve to tangent.

Intersection Angle

The angle between the tangent AT_1 and BT_2 is called the intersection angle (ϕ).

Deflection Angle

The angle Δ through which the forward tangent deflects is called the deflection angle of thecurve. It may be either to the left or the right.

Deflection Angle to any Point

The deflection angle δ to any point *a* on the curve is the angle at PC between the backtangent and the chord $T_1 a$ from PC to point on the curve.

Tangent Distance (*T*)

It is the distance between PC to PI (also the distance from PI to PT).

External Distance (*E*)

It is distance from the mid-point of the curve to PI. It is also known as the apex distance.

Length of the Curve (*l*)

L is the total length of the curve from PC to PT.

Long Chord (*L*)

It is the chord joining PC to PT.

Mid Ordinate (*M*)

It is the ordinate from the mid-point of the long chord to the mid-point of the curve. It isalso called the versine of the curve.

Normal Chord (*C*)

A chord between two successive regular stations on a curve is called a normal chord.

Sub-Chord (*c*)

Sub-chord is any chord shorter than the normal chord. These generally occur at the beginning orat the end of the curve.

Right-hand Curve

If the curve deflects to the right of the direction of the progress of survey, it is called theright-hand curve.

Left-hand Curve

If the curve deflects to the left of the direction of the progress of survey, it is called the left-hand curve.

Elements of Simple Circular Curve

Length of the Curve (*l*)

Length $l = T_1 CT_2 = R\,\Delta$, where Δ is in radians

$= (\pi R)\,\Delta/180^o$, where Δ is in degrees.

Tangent Length (*T*)

Tangent length, $T = T_1 I = IT_2$

$= OT_1 \tan \Delta/2 = R \tan \Delta/2$

Length of the Long Chord (*L*)

$L = T_1 T_2 = 2\ OT_1 \sin \Delta/2$

$= 2\ R \sin \Delta/2$

Apex Distance or External Distance (*E*)

$E = CI = IO - CO$

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

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

$= R \text{ exsec } \Delta/2$

Mid-ordinate (*M*)

$M = CD = CO - DO$

$= R - R \cos \Delta/2$

$= R (1 - \cos \Delta/2) = R \text{ versin } \Delta/2$

Problem :

Two tangents intersect at a chainage of 1250.50 m having deflection angle of 60 . If the radius of
the curve to be laid out is 375 m, calculate the Length of the curve, Tangent distance, Length ofthe long chord, Apex distance, Mid-ordinate, Degree of curve and Chainage of P.C. and P.T.

Solution :

Length of the curve, $l = (\pi R) \Delta/180$, where Δ is in degrees.
$= \pi \text{ X } 375 \times 60 / 180$

$= 392.69$ m

Tangent Length, $T = R \tan \Delta/2$
$= 375 \times \tan 60 / 2$

$= 216.50$ m

Length of the long chord, $L = 2\ R \sin \Delta/2$
$= 2 \times 375 \times \sin 60 / 2$

$= 375.00$ m

Apex distance, $E = R (\sec \Delta/2 - 1)$

$= 375 \times (\sec 60 / 2 - 1)$

$= 58.01$ m

Mid-ordinate, $M = R (1 - \cos \Delta/2)$

$= 375 \times (1 - \cos 60 / 2)$

$= 50.24$ m

Degree of Arc, D= 1718.9/R

= 1718.9/375

= 4 .58

Chainage of PC = Chainage of $I - T$

= 1250.50 – 216.50

= 1034.00 m

Chainage of PT = Chainage of $I + l$

= 1250.50 + 392.69

= 1634.19 m

2.3 PREPARATION OF CURVE TABLE FOR SETTING OUT

The following data have to be calculated for setting out the curve

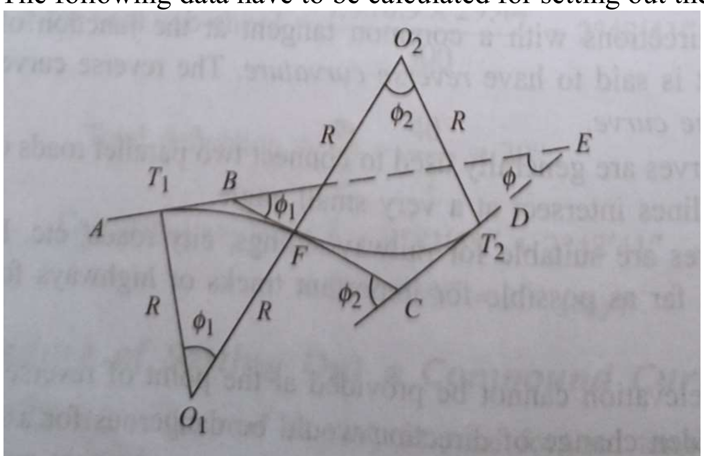


Fig. 10.24 Reverse Curve—Straights not Parallel

Let

Ø1=angle of deflection for first arc

Ø2=angle of deflection for second arc

Ø=angle of intersection between AB and DC

T1 and T2 = tangent points

F=point of reverse curve

R=common radius for the arc

1. Tangent length of first arc, T1B=BF=RtanØ1/2

2. Tangent length of second arc, T2C=CF=RtanØ2/2

3. Length of the common tangent, BE=BF+CF
=Rtan$\emptyset$1/2+Rtan$\emptyset$2/2

4. Length of first curve, T1F=πR$\emptyset$1/180°

5. Length of second curve, T2F=πR$\emptyset$2/180°

6. Chainage of T1=chainage of B-T1B.

7. Chainage of F=chainage of T1+1st curve length.

8. Chainage of T2=chainage of F+2nd curve length.

The length of the reverse curve is normally small. So, the may be set out by taking offset from .

(i) the long chord.

(ii) the chord produced.

Curve table for setting out

Point	Chainage	Chord length	Deflection angle for chord	Total deflection angle (Δ)	Angle to be set	Remark

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) RANKINE'S METHOD OF TANGENT ANGLES (NO DERIVATION)

The various methods used for setting curves may be broadly classified as:

(i) Linear methods
(ii) Angular methods.

Linear Methods Of Setting Out SimpleCircular Curves

The following are some of the linear methods used for setting out simple circularcurves:

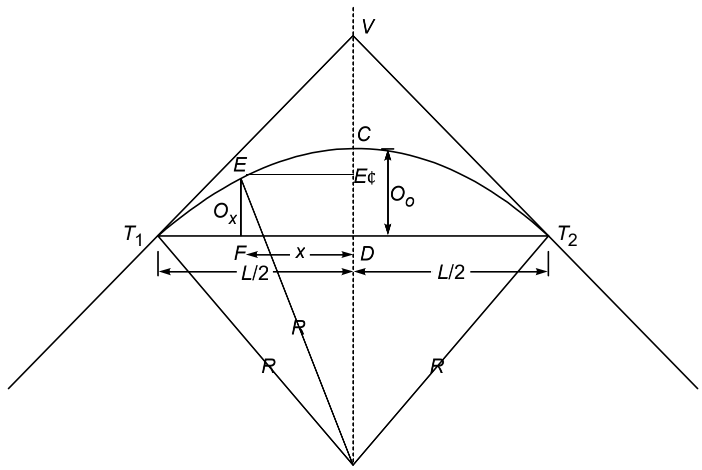
i. Offsets from long chord
ii. Successive bisection of chord
iii. Offsets from the tangents–perpendicular or radial
iv. Offsets from the chords produced.

Offsets from Long Chord

In this method, long chord is divided into an even number of equal parts. Taking centre of long chord as origin, for various values of *x*, the perpendicular offsets are calculated to the curve and the curve is set in the field by driving pegs at thoseoffsets.

R- radius of the curve
L- length of long chord
O_0 –mid-ordinate
Ox- ordinate at distance x from the mid-point of long chord

Ordinate at distance x = O_X = E'O – DO



$= \sqrt{R^2} - X^2 \text{-} \sqrt{R^2} - (\frac{L}{2})^2$

The above expression holds good for x-values on either side of d, since CD is symmetric axis.

Perpendicular offset at middle of long chord (D) is

$$CD = R - R\cos\frac{\Delta}{2} = R(1-\cos\frac{\Delta}{2})$$

Let D_1 be the middle of T_1C. Then perpendicular offset

$$C_1 D_1 = R(1-\cos\frac{\Delta}{4})$$

Similarly, $C_2D_2 = R(1-\cos\frac{\Delta}{8})$

Using symmetry points on either side may be set.

The offsets from tangents may be calculated and set to get the required curve.
The offsets can be either radial or perpendicular to tangents.

Offsets from the tangents–perpendicular or radial

(i) Radial offsets: Referring to Fig. 2.8, if the centre of curve *O* is accessible from the points on tangent, this method of curve setting is possible.

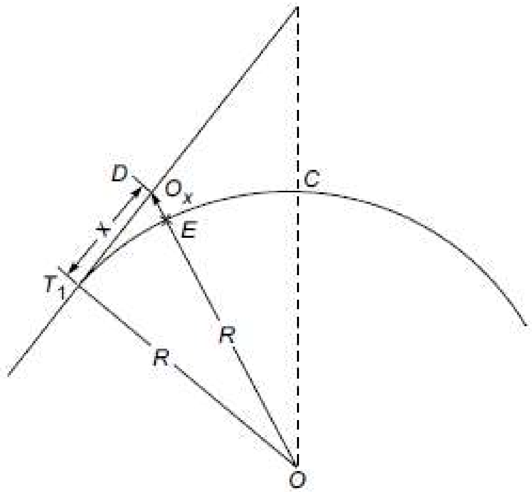


Fig. 2.8

Let D be a point at distance x from T_1 .Now it is required to find radial ordinate O_x = DE, sothat the point C on the curve is located .

From Δ OT_1 D, we get

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

$$(R + O_X)^2 = R^2 + x^2$$

i.e. $$O_X + R = \sqrt{R^2} + X^2$$

or $$O_X = \sqrt{R^2} + x^2 - R \qquad ....(2.12)$$

An approximate expression O_X may be obtained as explained below:

$$O = \sqrt{R^2} + x^2 \; - R$$

$$= R\sqrt{1 + (\frac{X}{R})^2} \; -R$$

$$= R(1+\frac{X^2}{2R^2} - \frac{X^2}{8R^4} + ...) - R$$

Neglecting small quantities of higher order ,

$$O_X = R(1+\frac{X^2}{2R^2}) - R$$

$$= \frac{X^2}{2R^2} \quad \text{(approx)} \qquad ....(2.13)$$

(ii) Perpendicular offsets: If the center of a circle is no visible, perpendicular offsets from tangent can be set to locate the points on the curve.

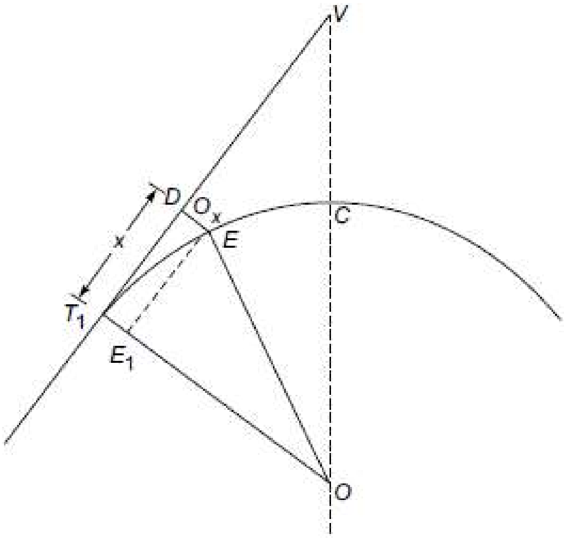


Fig. 2.9

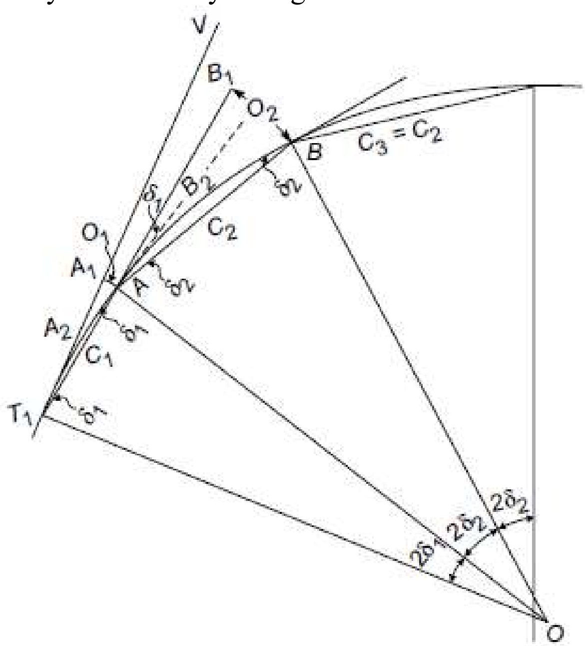
The perpendicular offset O_X can be calculated as given below:
Drop perpendicular EE_1 to OT_1. Then,

$$O_X = DE = T_1E_1$$
$$= OT_1 - OE_1$$
$$= R - \sqrt{R^2 - X^2} \text{ (Exact)} \qquad ...(2.14)$$
$$= R - R\left(1 - \frac{X^2}{2R^2} - \frac{X^4}{8R^4} ...\right)$$
$$= \frac{X^2}{2R} \quad \text{(approx)}$$

Offsets from the chords produced.

This method is very much useful for setting long curves. In this method, a point on the curve is fixed by taking offset from the tangent taken at the rear point of a chord.

Thus, point A of chord T1A is fixed by taking offset O1 = AA1 where T1A1 is tangent at T1.
Similarly B is fixed by taking offset O2 = BB1 where AB1 is tangent at A.



Let $T_1A = C_1$ be length of first sub-chord

$AB = C_2$ be length of full chord

σ_1 = defection angle A_1T_1A

σ_2 = deflection angle $B_1 AB$

Then from the property of circular curve

$T_1 OA = 2\partial_1$

C_1 = chord T_1A = Arc $T_1A = R2\sigma_1$

i.e. $\partial_1 = \frac{C1}{2R}$

Now, offset O_1= arc AA_1

$= C_1\sigma_1$

Substituting the value of σ_1 from equation (i) into equation (ii), we get

$$O_1 = C_1 \text{ X } \frac{C1}{2R} = \frac{C1^2}{2R}$$

$$O_2 = C_2 \ (\partial_1 + \partial_2)$$

$$= C_2\left(\frac{C1}{2R} + \frac{C2}{2R}\right)$$

$$= \frac{C2}{2R} \ (C_1 + C_2)$$

Similarly, $O_3 = \frac{C3}{2R} (C_2 + C_3)$

But, $C_3 = C_2$ $\therefore O_3 = \frac{C2^2}{R}$

Thus , upto last chord i.e. n-1 the chord

$$O_{n-1} = \frac{c2^2}{2R}$$

If last sub-chord has length C_n , then,

$$O_n = \frac{Cn}{2R} (C_{n-1} + C_n)$$

Note that C_{n-1} is full chord

Angular Method

Following are some of the angular method used to set out a simple circular curve :

Tape and theodolite method

Two theodolite method

Tachometric method

Total station Method

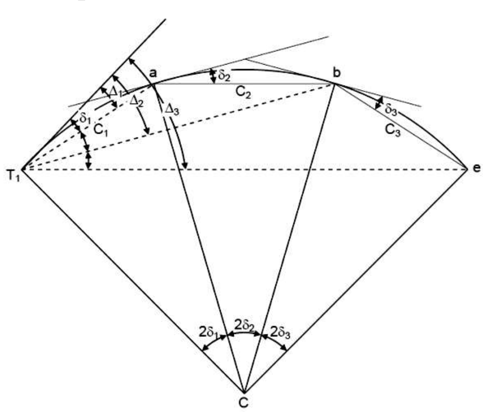
Tape and Theodolite Method

In this method, a tape is used for making linear measurements and a theodolite is used for making angular measurements. The curve can be set out by the following procedures :

Rankine's Method

The method is known as Rankine's method of tangential angle or the deflection angle method. The method is accurate and is used in railways and highways.

Let *T ab* be a part of a circular curve with *T* , the initial tangent point.



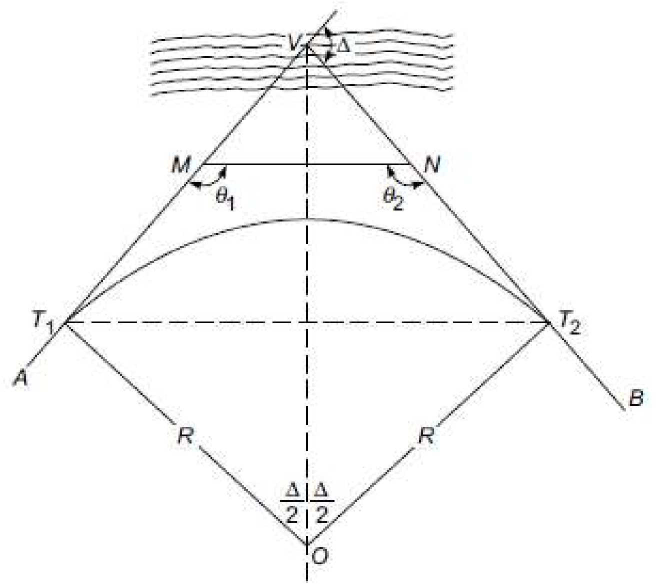
Rankine's Method

2.5 OBSTACLES IN CURVE RANGING – POINT OF INTERSECTION INACCESSIBLE

Obstacles in setting out of curves may be classified as due to inaccessibility, due to non-visibility and/or obstacles to chaining of some of the points.
This type of obstacles can be further classified as inaccessibility of:
(a) Point of Intersection (PI)
(b) Point of Curve (PC)
(c) Point of Tangency (PT)
(d) Point of Curve and Point of Intersection (PC and PI).
(e) Point of Curve and Point of Tangency (PC and PT)

The method of overcoming these problems are presented below:

(a) Point of Intersection is Inaccessible: When the intersection point *V* falls in a lake, river, wood or behind a building, there is no access to the point *V*. Referring to Fig. 2.16, *T*1 and *T*2 be the tangent points and *V* the point
of intersection. It is required to determine the value of the deflection angle D between the tangents and locate the tangent points *T*1 and *T*2.



POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1Define reverse curve ?

Ans-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.

Q-2 What is the point of commencement of curve ?

Ans- It is the beginning of the curve (*T*) where the alignment changes from a tangent to a curve.

Q-3 Define deflection angle?
Ans-The angle Δ through which the forward tangent deflects is called the deflection angle of the

curve. Itmay be either to the left or the right.

Q-4-Wite the formula for calculating the tangent length ?

Ans- = $R \tan \Delta/2$
Where R= radius of the curve.

Q-5 what is a transition curve?

Ans-A curve of variable radius is known as a transition curve. It is also called a easement curve. Such a curve is provided between a straight and a circular curve, or between branches of a compound or reverse curve to avoid an abrupt change in direction when the alignment changes. In railways, such curve is used on both sides of a circular curve to minimize superelevation.

Q-6 Wrire down the formula for length of long chord?

Ans-= $2 R \sin \Delta/2$

95

POSSIBLE LONG TYPE QUESTIONS

Q-1 Two tangents intersect at a chainage of 1250.50 m having deflection angle of 60 . If the radius of the curve to be laid out is 375 m, calculate the Length of the curve, Tangent distance, Length of the long chord, Apex distance, Mid-ordinate, Degree of curve and Chainage of P.C. and P.T.

Q-2 Describe the components of a sumple circular curve with neat sketch?

Q-3 Write down the steps for setting out a simple circular curve with offset from tangent method?

CHAPTER NO-3
BASICS ON SCALE AND BASICS ON MAP

Learning objectives

3.1 Fractional or Ratio Scale, Linear Scale, Graphical Scale
3.2 What is Map, Map Scale and Map Projections
3.3 How Maps Convey Location and Extent
3.4 How Maps Convey characteristics of features
3.5 How Maps Convey Spatial Relationship
3.5.1 Classification of Maps
3.5.1 Physical Map
3.5.2 Topographic Map
3.5.3 Road Map
3.5.4 Political Map
3.5.5 Economic & Resources Map
3.5.6 Thematic Map
3.5.7 Climate Map

3.1 FRACTIONAL OR RATIO SCALE, LINEAR SCALE, GRAPHICAL SCALE:

Mapping is a map creation process to show a part of Earth's specific surface detail. A map creator positions the exact location of a mountain, building, road, and bridge. Mapping uses computer graphic, hand drawing, and painting to show the detail of the map's landmarks.
Mapping provides important information about the landmark features. Maps analyze changes to a structure or landmark. A map requires regular update if there are significant changes observed in land features. One example is showing the presence of newly constructed buildings, roads, and bridges.

Scale:

A map scale is the map distance ratio that corresponds to the actual ground distance. The scale on the map presents a distance measurement between each landmark. As an example on a 1: 1000000 cm scale map shows that 1 centimeter is equal to 1 kilometer on the ground.

Scale Importance:

· Scale updates recent changes in the map distance. These are the presence of new buildings or road networks.
· When a new map is recently created, the scale compares the differences between the new and old maps. The comparison detects changes or improvements between the two maps.
· The presence of scales in a map educates the readers about the prominent landmarks and structures. The map users learn the distance value and the name of prominent features in a specific land area.
· A map scale guides anyone when visiting an unfamiliar landmark. The scale provides details about the landmark including their distance on the map.

Three Types of Scale:

1. **Fractional or Ratio Scale:** A fractional scale map shows the fraction of an object or land feature on the map. This type uses a set of numbers that represents the object or a landmark. As an example on the left photo, the orange-shaded scale represents a 2/3 fractional scale.

2. Linear Scale: A linear scale shows the distance between two or more prominent landmarks. The linear scale on maps is a set of lines or dots that represents a landmark. An example on the left photo is a map using a linear scale on each road.

3**. Graphical scale**

The **graphic scale** is a divided line on the map with the line lengths designated as to the equivalent distance on the real earth. Several different graphic scales are usually given on a map so that different units of measurement may be applied. Note that the 0 is often NOT on the left edge but rather a small portion of the scale with finer subdivisions than to the right.

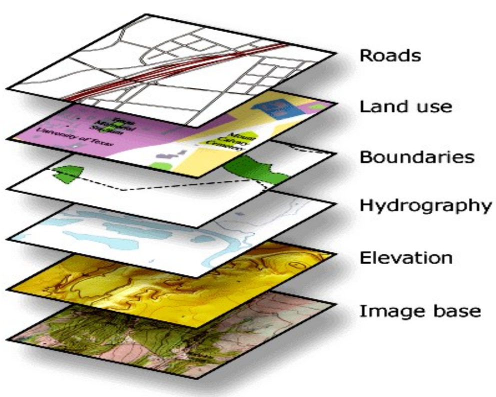
3.2 WHAT IS MAP, MAP SCALE, AND MAP PROJECTION

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

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 projection:

In cartography, a **map projection** is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into locations on a plane.

All projections of a sphere on a plane necessarily distort the surface in some way and to some extent. Depending on the purpose of the map, some distortions are acceptable and others are not; therefore, different map projections exist in order to preserve some properties of the sphere-like body at the expense of other properties. The study of map projections is the characterization of the distortions. There is no limit to the number of possible map projections.

3.3 HOW MAP CONVEY LOCATION AND EXTENT

The field of geography relies on many different types of maps in order to study the features of the earth. Some maps are so common that a child would recognize them, while others are used only by professionals in specialized fields. Some of the most common types are political, physical, topographic, climate, economic, and thematic maps.

Simply defined, maps are pictures of the Earth's surface. General reference maps document landforms, national boundaries, bodies of water, the locations of cities and so on.
Thematic maps display specific data, such as the average rainfall distribution for an area or the distribution of a certain disease throughout a county.

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.

- 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.).

3.4 HOW MAP CONVEY CHARACTERISTICS OF FEATURES

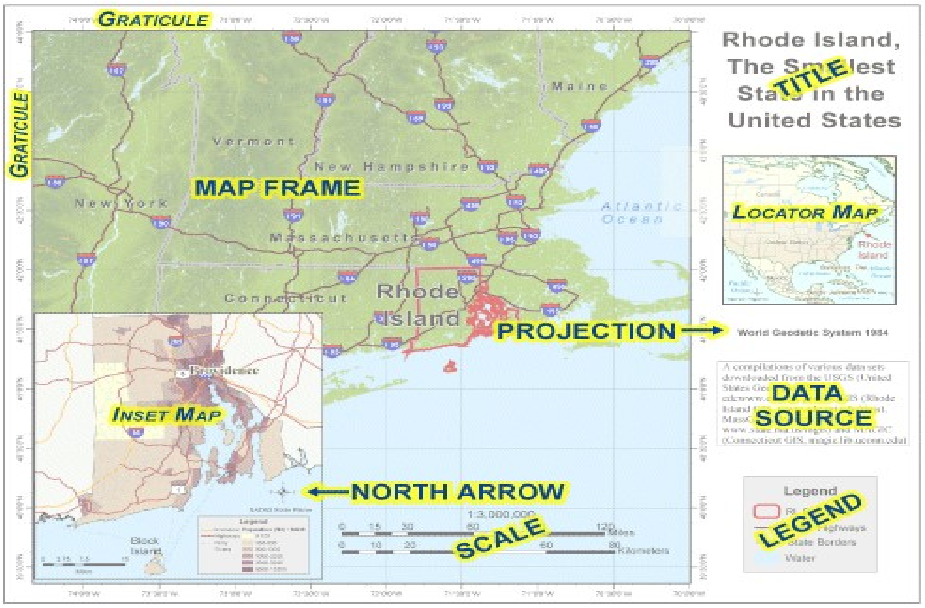
Characteristics of Maps:
The word 'Map' is derived from the Latin word 'Mappe' which means Napkin of cloth cover. The whole or part of the earth can be represented on a map.

1. A map is much smaller than the earth that it represents. Altitudes, Longitudes and Scales are very essential to draw maps.

2. Every map should have a bold title on the top. There is an arrow mark in one corner of the map showing north. With the help of this mark other directions are known.

3. Index or legend is necessary for every map. Universally accepted conventional symbols are used on every map like RF (Reserved Forest), etc.

4. Maps are shaded with different colours also. White indicates ice caps, Blue for water, Green for forest, Yellow for agricultural belt, etc



the 9 elements of a map

- Color. Use color to highlight the theme (main point of map).
- Author. Write name, period, and due date in upper right hand corner.
- Title. Have a creative title.
- Scale. The scale of the map you create needs be relative and correlate to one another.
- Date.
- Orientation.
- Legend.
- Lables.

3.5 HOW MAP CONVEY SPATIAL RELATIONSHIPS

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.

- 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 Capital.)
- 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).

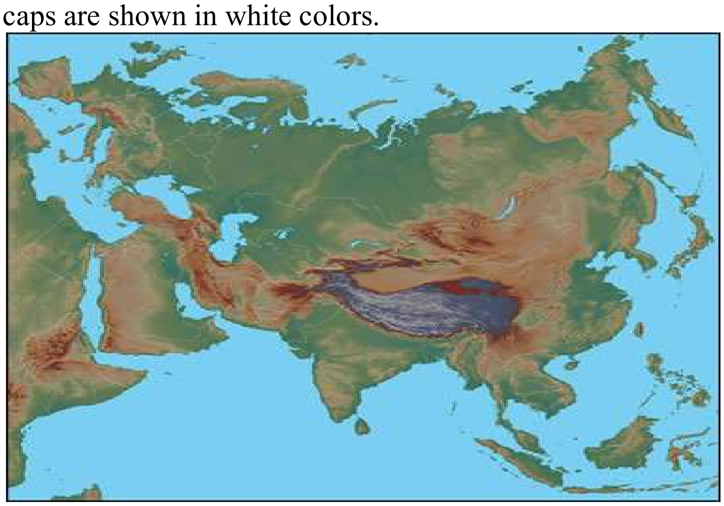
3.5.1 CLASSIFICATION OF MAP

Different elements of a map play an important role in describing map details. Numbered here are descriptions of cartographic elements commonly found on map layouts. These essential features of a map are found on almost every map around us. They are- title, direction, legend(symbols), north areas, distance(scale), labels, grids and index, citation – which make it easier for people like us to understand the basic components of maps. There are following types of maps are available

- Physical map
- Topographical map
- Road map
- Political map
- Economic and resources map
- Thematic map
- Climate map

3.5.2 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.



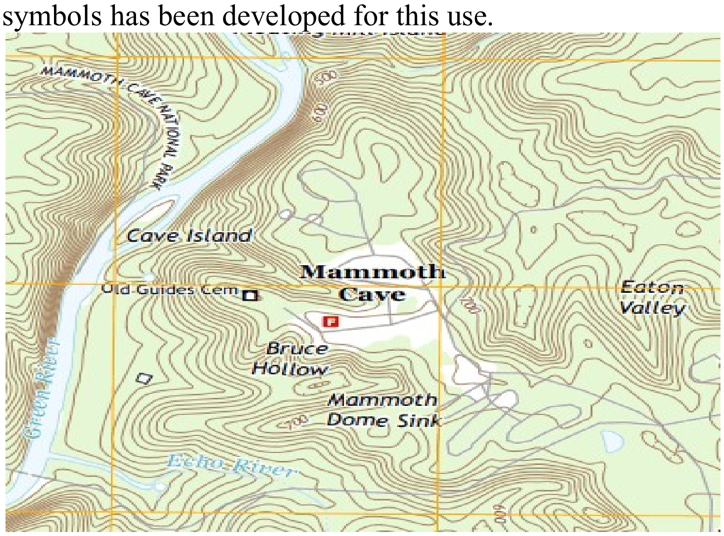
Physical maps usually show the most important political boundaries, such as state and country boundaries. Major cities and major roads are often shown. This cultural information is not the focus of a physical map, but it is often included for geographic reference and to increase the utility of the map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

3.5.3 TOPOGRAPHIC MAP

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.



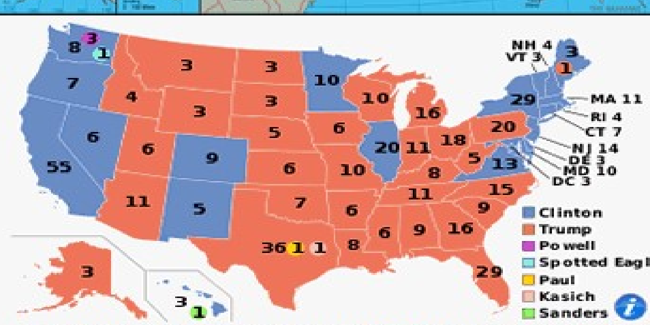
3.5.3 ROAD MAP

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

3.5.4 POLITICAL MAP

"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.



Presidential election results map. Red denotes states won by Trump/Pence, blue denotes those won by Clinton/Kaine. Numbers indicate electoral votes allotted to the winner of each state. Faithless electors: Colin Powell 3 (WA), John Kasich 1 (TX), Ron Paul 1 (TX), Bernie Sanders 1 (HI), Faith Spotted Eagle 1 (WA)

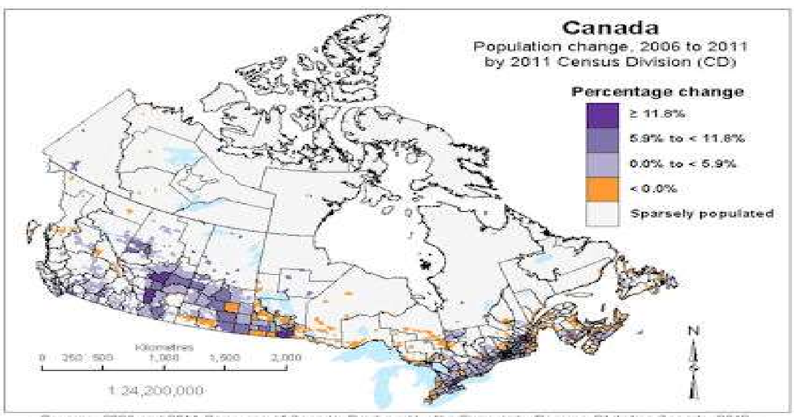
3.5.5 ECONOMIC & RESOURCES MAP

A distinction is made between general economic maps, which describe the economy as a whole (including maps of economic regions, territorial-production complexes, economic centers, economic ties, levels of economic development, and specialization of production), and maps of various branches of production and spheres of circulation (including industry maps, agricultural maps, transportation and communications maps, and maps of the construction industry and trade and finances).

Maps depicting labor resources and natural resources as components of economic activity are also classified as economic maps. Resource evaluation maps (depicting agro climatological resources, conditions of economic development of regions, conservation, and the like) are classified midway between economic maps and maps of the natural world

3.5.6 THEMATIC MAP

A thematic map shows the spatial distribution of one or more specific data themes for selected geographic areas. The map may be qualitative in nature (e.g., predominant farm types) or quantitative (e.g., percentage population change).



Sources: 2006 and 2011 Censuses of Canada. Produced by the Geography Division, Statistics Canada, 2012.

3.5.7 CLIMATE MAP

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.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 Define scale of map.

Ans: A map scale is the map distance ratio that corresponds to the actual ground distance. The scale on the map presents a distance measurement between each landmark. As an example on a 1: 1000000 cm scale map shows that 1 centimeter is equal to 1 kilometer on the ground.

Q-2 what are the map layers?

Ans: 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.

Q-3 what is a physical map?

Ans:

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.

Q-4 what is a political map?

Ans: "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.

POSSIBLE LONG TYPE QUESTIONS

Q-1 Describe about the types of map.

Q-2 What are the map elements briefly describe about it?

Q-3 What is map scale and write about different types of scale?

CHAPTER NO-04
SURVEY OF INDIA MAP SERIES

Learning objectives

4.1 Open Series map
4.2 Defense Series Map
4.3 Map Nomenclature
4.3.1 Quadrangle Name
4.3.2 Latitude, Longitude, UTM's
4.3.4 Contour Lines
4.3.5 Magnetic Declination
4.3.6 Public Land Survey System
4.3.7 Field Notes

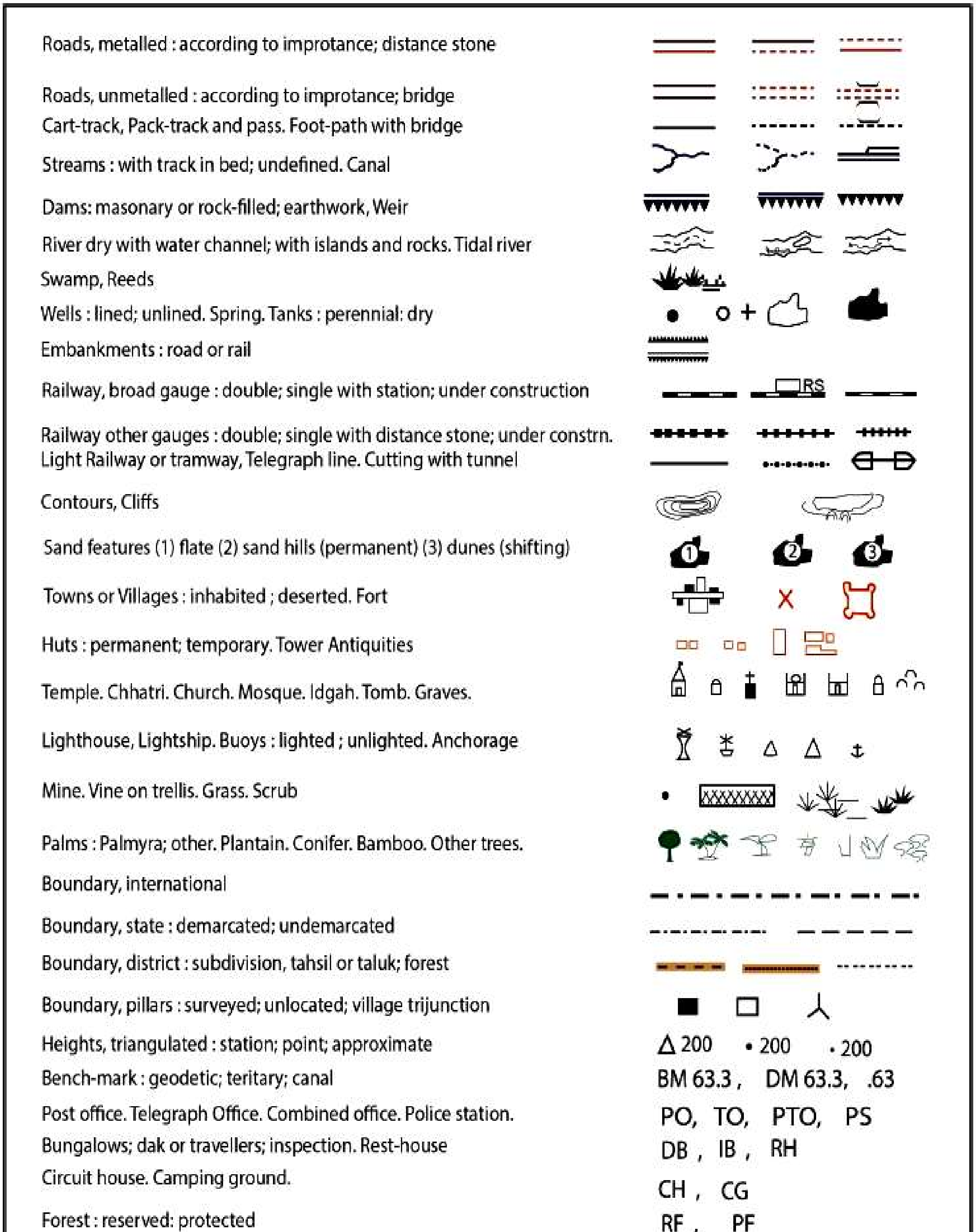
4.1 OPEN SERIES MAPS

Open Series Maps

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

Open Series Maps (OSMs) - 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'.

Figure 11.2 Open Series Map



A number of methods have been used to show the relief features of the Earth's surface on maps, over the years. These methods include hachure, hill shading, layer tints, benchmarks and spot heights and contours. However, contours and spot heights are predominantly used to depict the relief of an area on all topographical maps.

Figure 11.1 Conventional Signs and Symbols

4.2 DEFENSE SERIES MAP

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.

Apparently, the Ministry of Defence (MoD) has raised some issues with regard to data pertaining to border areas and the coastal line being made available openly.

Restrictions on free access to topographic data (Frontline, October 27, 2000) were in place essentially because of the security concerns of the MoD, the prime user of the data as well as the regulating authority for the map dissemination policy until now.

This is indeed surprising because the new map policy, which was evolved in consultation with the MoD (Frontline, February 3, 2001) and which the Cabinet cleared on May 19, has been designed to take care of these.

According to the new policy there will be two series of maps: Defence Series Maps (DSMs) and Open Series Maps (OSMs), a sanitised version where sensitive data, such as military/civil Vulnerable Areas and Vulnerable Points (V.As/V.Ps) and other related data, are removed.

4.3 MAP NOMENCLATURE

Different elements of a map play an important role in describing map details. Numbered here are descriptions of cartographic elements commonly found on map layouts. These essential features of a map are found on almost every map around us. They are- title, direction, legend(symbols), north areas, distance(scale), labels, grids and index, citation – which make it easier for people like us to understand the basic components of maps.

1.Title:
The title of a map is one of its vital features. It is the keyword that grabs the reader’s attention. A short ‘title’ might be apt if readers are familiar with the theme being presented. The need for a suitable title, whether small or long, depends on the reader but the title should provide an answer to their “What? Where? When?”

2. Direction: Direction is shown on a map by using a compass rose. The compass rose shows the directions of the map so that map readers can relate those directions to the real world. Sometimes a compass rose will just show North. If you know which way North is, you can figure out East, West, and South.

3. Legend: The principal reference to the map symbols; subordinated to the title and direction. However, this is still a key element for map reading; describing all unknown or unique map symbols used.

4. North Arrows: North arrows indicate the orientation of the map and maintain a connection to the data frame. When that data frame is rotated, the north arrow element rotates with it. North arrow properties include its style, size, color, and angle. The size of the north arrow is in points. Decimal fractions can be entered here.

5. Distance(Scale): Distance or scale must always be indicated or implied unless the audience is so familiar with the map area or distance of such little relative importance that it can be assumed by the audience.

Distance and scale can be indicated in a variety of ways on a map in verbal, numeric, or graphic form. In using computer systems, the graphic form of representing scale is often preferred. With computers, maps are often drafted at different scales than they are printed.

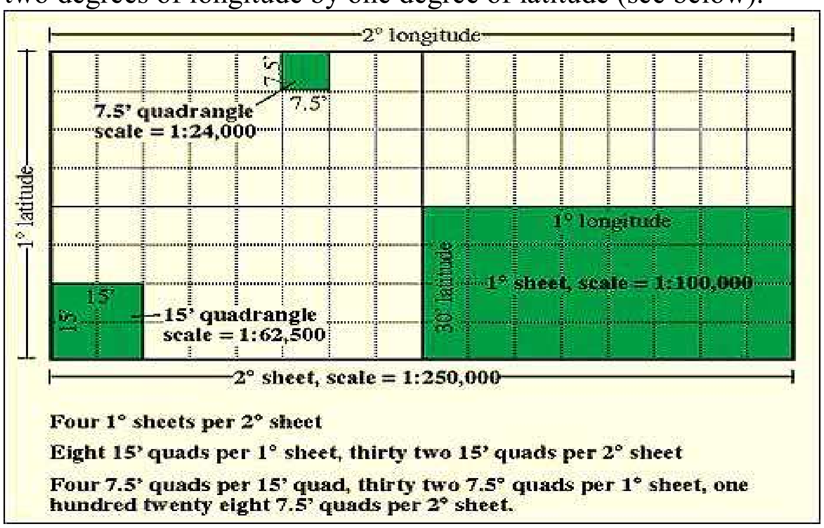
6. Labels: Labels are the words that identify a location. They show places (streets, rivers, and establishments) with specific names and can also be used to represent something if there is only one of it, instead of making up a symbol to just represent one thing.

7. Grid and Index: Not all maps use a grid and index, but it really helps in finding locations. A grid and index are common in an atlas and on roadmaps. A grid represents a series of horizontal and vertical lines running across the map whereas index helps the map reader find a particular location by following the numbers and letters in the grid.

8. Citation: The citation portion of a map constitutes the metadata (description) of the map. This is the area where explanatory data about the data sources and currency, projection information and any caveats are placed. Citations help the viewer determine the use of the map for their own purpose.

4.3.1 QUADRANTAL NAME

Individual topographic maps are commonly referred to as quadrangles (or quads), with the name of the quadrangle giving an idea of the amount of area covered by the map. The largest area covered by most topographic maps used for scientific mapping purposes (i.e. geologic mapping, habitat studies, etc.) are two degrees of longitude by one degree of latitude (see below).



The concept of a quadrant

The Cartesian system consists generally of these elements:

X-Axis: The horizontal line

Y-Axis: The vertical line

Coordinates: A pair of numbers representing a point on the plane

Coordinates on a graph appear as (x,y), with x representing the number of units to the right or left of the y-axis and y representing the number of units above or below the x-axis.

Specifically:

(0,0) is the coordinate for the origin

"x" is to the right of the y-axis

"-x" is to the left of the y-axis

"y" is above the x-axis

"-y" is below the x-axis

Quadrants and the coordinate system
The intersection of the x-axis and y-axis create four quadrants, which are identified by Roman numerals.
These quadrants go counterclockwise:
Quadrant I: Right of y-axis, above x-axis (x,y)
Quadrant II: Left of y-axis, above x-axis (-x,y)
Quadrant III: Left of y-axis below x-axis (-x-y)
Quadrant IV: Right of y-axis, below x-axis (x,-y)

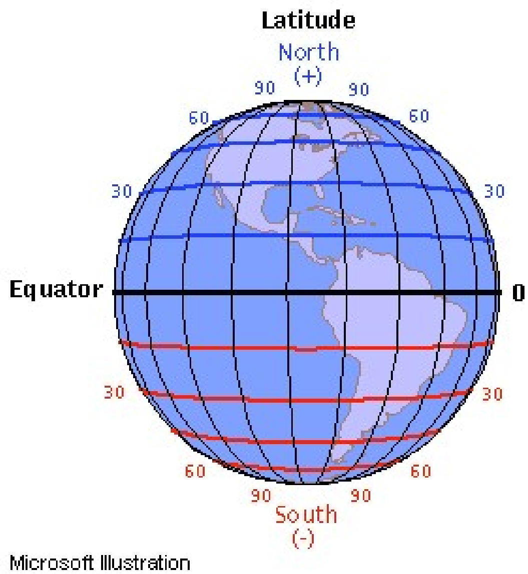
Quadrants and directions

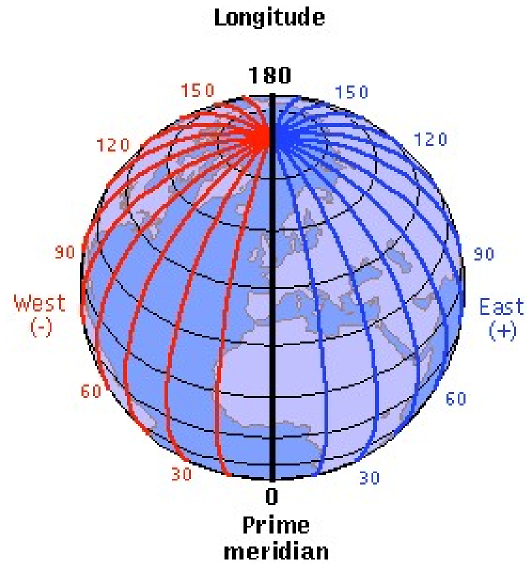
You can relate what are the four quadrants on a map to the direction in which you might travel, at least from a point of origin.
Points above the x-axis are north, while those below it are south. "X" points located to the right of the y-axis are east of the y-axis, and those to the left lie to the west.
As such, quadrants have the following directions or bearings from the origin:
Quadrant I: Northeast
Quadrant II: Northwest
Quadrant III: Southwest
Quadrant IV: Southeast
To help illustrate quadrants, consider the references you sometimes hear to the northeastern quadrant of a hurricane as typically having the strongest winds and heavy rains.
When you use a compass, you will see a series of numbers ranging from 0 to 360 degrees.
This is the azimuth method of indicating direction:
0/360 degrees is due north
90 degrees is due east
180 degrees is due south
270 degrees is due west
The quadrant bearing method more readily helps you identify quadrants. The reading begins with either "(N)" (north) or "S" (south) and then a number of degrees either east or west.
For instance, if your bearing calls for you to move "north 35 degrees east," then you are in Quadrant I.
A bearing of "south 12 degrees west" puts your control point in Quadrant III.
If your compass provides only azimuth numbers, you can convert the azimuth to a quadrant bearing as follows:
1 to 89 (Northeast/Quadrant I): No adjustment is necessary. You simply use the azimuth bearing as the quadrant bearing
91 to 179 (Southeast/Quadrant II): 180 degrees minus the measure of the azimuth angle
181 to 269 (Southwest/Quadrant III): The measure of the azimuth angle minus 180 degrees
271 to 359 degrees (Northwest/Quadrant IV): 360 degrees minus the measure of the azimuth angle

4.3.2 LATITUDE , LONGITUDE , UTM'S

Latitude and Longitude:
Your GlobalAddress

Every location on earth has a global address. Because the address is in numbers, people can communicate about location no matter what language they might speak. A global address is given as two numbers called coordinates. The two numbers are a location's latitude number and its longitude number ("Lat/Long").





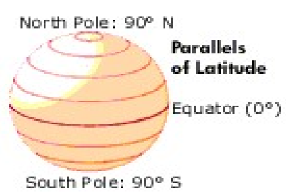
Credit: Illinois State University

Grid Mapping

Using Lat/Long is different from using a street address. Instead of having a specific street address, Lat/Long works with a numbered grid system, like what you see when you look at graph paper. It has horizontal lines and vertical lines that intersect. A location can be mapped or found on a grid system simply by giving two numbers which are the location's horizontal and vertical coordinates; or, to say it another way, the "intersection" where the place is located).

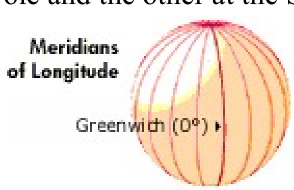
Latitude

Horizontal mapping lines on Earth are lines of latitude. They are known as "parallels" of latitude, because they run parallel to the equator. One simple way to visualize this might be to think about having imaginary horizontal "hula hoops" around the earth, with the biggest hoop around the equator, and then progressively smaller ones stacked above and below it to reach the North and South Poles. (Can you think of other ways to visualize the parallels of Latitude?)



Longitude

Vertical mapping lines on Earth are lines of longitude, known as "meridians". One simple way to visualize this might be to think about having hula hoops cut in half, vertically positioned with one end at the North Pole and the other at the South Pole.



Visualize hula hoops cut in half, vertically positioned with one end at the North Pole and the other at the South Pole.

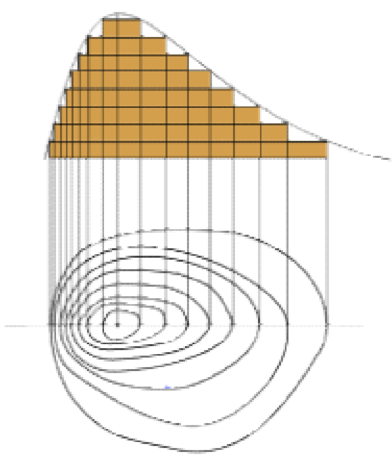
UTM'S

UTM is the acronym for Universal Transverse Mercator, a plane coordinate grid system named for the map projection on which it is based (Transverse Mercator). The UTM system consists of 60 zones, each 6-degrees of longitude in width. The zones are numbered 1-60, beginning at 180-degrees longitude and increasing to the east. The military uses their own implementation of the UTM system, called the Military

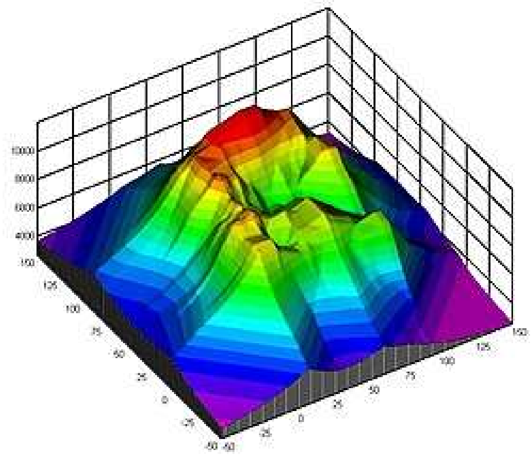
Grid Reference System (MGRS).
Convert Lat Long to UTM
This is an effective and fast online *Lat Long to UTM converter*. It can be used to make the stated conversions at any time and any place. Type the latitude and longitude values to convert from lat long coordinate system into **UTM** (Universal Transverse Mercator) coordinate system

4.3.4 CONTOUR LINES

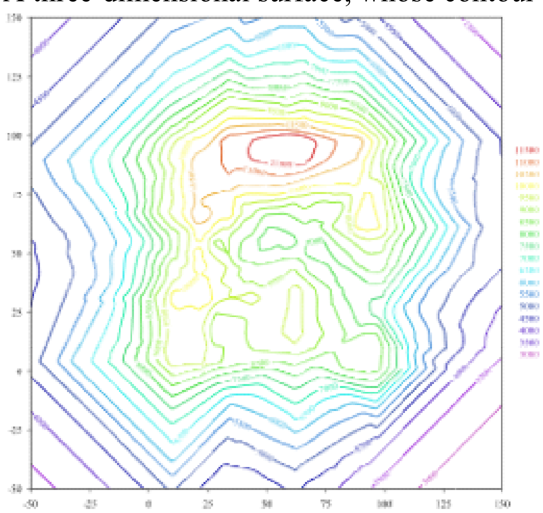
A contour line (also isoline, isopleth, or isarithm) of a function of two variables is a curve along which the function has a constant value, so that the curve joins points of equal value. It is a plane section of the three-dimensional graph of the function $f(x, y)$ parallel to the (x, y)-plane. In cartography, a contour line (often just called a "contour") joins points of equal elevation (height) above a given level, such as mean sea level. A contour map is a map illustrated with contour lines, for example a topographic map, which thus shows valleys and hills, and the steepness or gentleness of slopes. The contour interval of a contour map is the difference in elevation between successive contour lines.



The bottom part of the diagram shows some contour lines with a straight line running through the location of the maximum value. The curve at the top represents the values along that straight line.



A three-dimensional surface, whose contour graph is below.



A two-dimensional contour graph of the three-dimensional surface in the above picture.

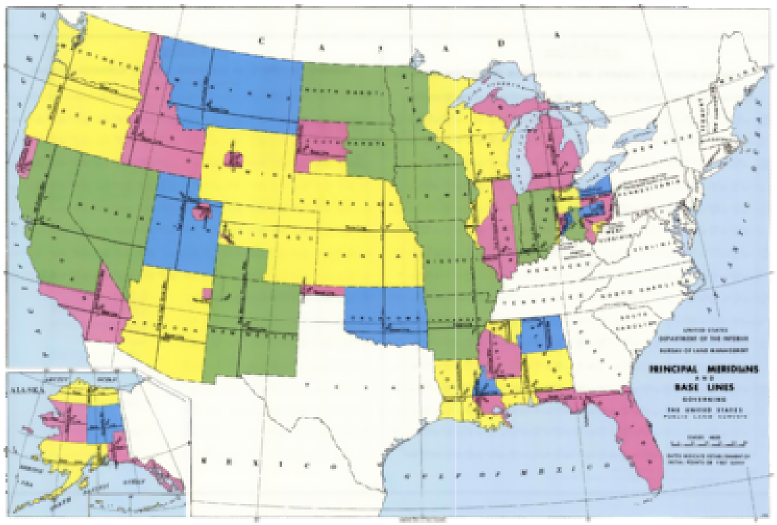
4.3.5 MAGNETIC DECLINATION

Declination is simply a manifestation of the complexity of the geomagnetic field. The field is not perfectly symmetrical; it has non-dipolar "ingredients," and the dipole itself is not perfectly aligned with the rotational axis of the Earth. If you were to stand at the north geomagnetic pole, your compass, held horizontally as usual, would not have a preference to point in any particular direction, and the same would be true if you were standing at the south geomagnetic pole. If you were to hold your compass on its side, the north-pointing end of the compass would point down at the north geomagnetic pole, and it would point up at the south geomagnetic pole.

A diagram at the bottom of most USGS topographic maps shows three north arrows--true north, grid north, and magnetic north--and the angles between them. Some maps, especially very old maps, do not have this diagram.

4.3.6 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,



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.
There are two separate and distinct systems of land surveys in the United States:

4.3.7 FIELD NOTES

Field notes record the detailed observations of geologists working in the outdoors. Typical notebook entries include sketches of geomorphological landforms and outcrop features, preliminary maps and cross-sections (q.v.), detailed maps of critical or complex areas (e.g., contacts and faults), stratigraphic sections, tabulated quantitative data (e.g., structural measurements), pit and trench logs (see Vol. XIII: *Pipeline Corridor Evaluation*) lists and descriptions of samples and fossils, and a variety of written notes.

The notebook contains the first record of the field geologist's observations and the interpretation of what he or she sees in the field and is a testament to the old Chinese proverb that "the faintest ink is better than the best memory."
The field notebook represents the first link in a long chain of geological data gathering, mapping (see Geological Survey and Mapping), interpretation, and presentation. It represents not only the first record but also the most complete
.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 Define open series map?
Ans: Open Series Maps (OSMs) - 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'

Q-2 what are the defense series maps?
Ans: Defense Series Maps (DSMs) - These topographical maps (on Everest/WGS-84 Datum and Polyclone /UTM Projection) are on various scales (with heights, contours and full content without dilution of accuracy). These maps mainly cater for defense and national security requirements. This

series of maps (in analogue or digital forms) for the entire country are classified by the Ministry of Defense.

Q-3 Define latitude and departure of a map system?

Ans: Every location on earth has a global address. Because the address is in numbers, people can communicate about location no matter what language they might speak. A global address is given as two numbers called coordinates. The two numbers are a location's latitude number and its longitude number ("Lat/Long").

Q-4 Define magnetic declination?
Ans: Declination is simply a manifestation of the complexity of the geomagnetic field. The field is not perfectly symmetrical; it has non-dipolar "ingredients," and the dipole itself is not perfectly aligned with the rotational axis of the Earth. If you were to stand at the north geomagnetic pole, your compass, held horizontally as usual, would not have a preference to point in any particular direction, and the same would be true if you were standing at the south geomagnetic pole. If you were to hold your compass on its side, the north-pointing end of the compass would point down at the north geomagnetic pole, and it would point up at the south geomagnetic pole.

POSSIBLE LONG TYPE QUESTIONS

Q-1What are the map nomenclatures. Describe about it?
Q-2 Describe briefly about public land use system.
Q-3 Define survey of India map series and write about its map classification system.

CHAPTER NO- 5

BASICS OF AERIAL PHOTOGRAPHY, PHOTOGRAMMETRY, DEM AND ORTHO IMAGE GENERATION

Learning objectives

5.1 Aerial Photography:
5.1.1 Film, Focal Length,
Scale
5.1.2 Types of Aerial Photographs (Oblique, Straight)
5.2 Photogrammetry:
5.2.1 Classification of Photogrammetry
5.2.2 Aerial Photogrammetry
5.2.3 Terrestrial Photogrammetry
5.3 Photogrammetry Process:
5.3.1 Acquisition of Imagery using aerial and satellite platform
5.3.2 Control Survey
5.3.3 Geometric Distortion in Imagery Application of Imagery and its support data Orientation and Triangulation Stereoscopic Measurement 19.9.1 X-parallax 19.2.2 Y-parallax
5.4 DTM/DEM Generation 5.5 Ortho Image Generation

5.1 AERIAL PHOTOGRAPHY

Aerial photography (or **airborne imagery**) is the taking of photographs from an aircraft or other flying object. Platforms for aerial photography include fixed-wing aircraft, helicopters, unmanned aerial vehicles (UAVs or "drones"), balloons, blimps and dirigibles, rockets, pigeons, kites, parachutes, stand-alone telescoping and vehicle-mounted poles. Mounted cameras may be triggered remotely or automatically; hand-held photographs may be taken by a photographer.

An aerial photograph using a drone of Westerheversand Lighthouse, Germany.

An aerial vief of the city of Pori, Finland.

Air photo of a military target used to evaluate the effect of bombing.

[Air photography from flight

Aerial photography should not be confused with air-to-air photography, where one or more aircraft are used as chase planes that "chase" and photograph other aircraft in flight.

5.1.1 FILM, FOCAL LENGTH , SCALE

Basic Concepts of Aerial Photography

Film: most air photo missions are flown using black and white film, however colour, infrared, and false-colour infrared film are sometimes used for special projects.

Black and White Film

Black-and-white panchromatic (B/W) film primarily consists of a black-and-white negative material with a sensitivity range comparable to that of the human eye. It has good contrast and resolution with low graininess and a wide exposure range.

COLOUR FILM

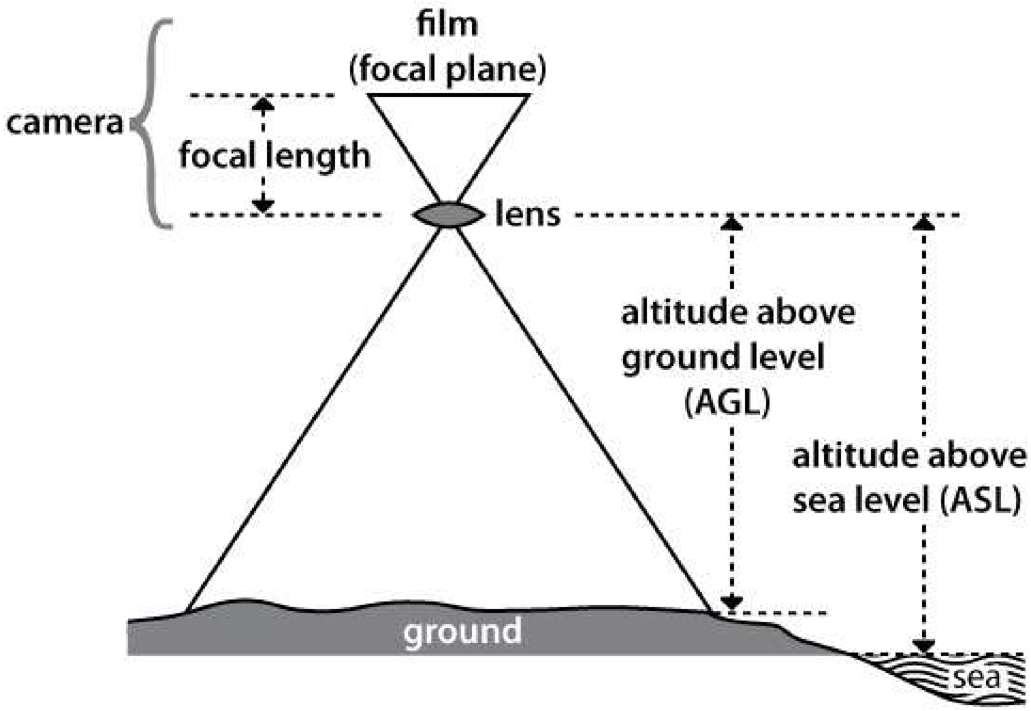
Natural color (also referred to as conventional or normal color) film contains three emulsion layers which are sensitive to blue, green, and red (the three primary colors of the visible spectrum). This film replicates colors as seen by the human eye.

Focal length: the distance from the middle of the camera lens to the focal plane (i.e. the film). As focal length increases, image distortion decreases. The focal length is precisely measured when the camera is calibrated.

Scale: the ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e. 1 unit on the photo equals "x" units on the ground). If a 1 km stretch of highway covers 4 cm on an air photo, the scale is calculated as follows:

$$\frac{\text{PHOTO DISTANCE}}{\text{GROUND DISTANCE}} = \frac{4\text{ cm}}{1\text{ km}} = \frac{4\text{ cm}}{100\,000\text{ cm}} = \frac{1}{25\,000} \quad \text{SCALE: } 1/25\,000$$

Another method used to determine the scale of a photo is to find the ratio between the camera's focal length and the plane's altitude above the ground being photographed.



If a camera's focal length is 152 mm, and the plane's altitude Above Ground Level (AGL) is 7 600 m, using the same equation as above, the scale would be:

$$\frac{\text{FOCAL LENGTH}}{\text{ALTITUDE (AGL)}} = \frac{152\text{ mm}}{7\,600\text{ m}} = \frac{152\text{ mm}}{7\,600\,000\text{ mm}} = \frac{1}{50\,000} \quad \text{SCALE: } 1/50\,000$$

Scale may be expressed three ways:

- Unit Equivalent
- Representative Fraction
- Ratio

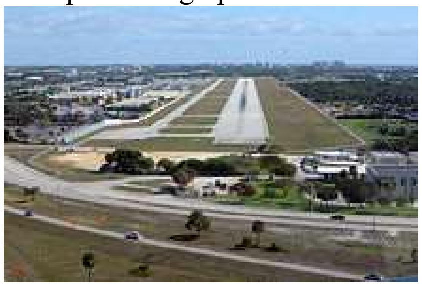
A photographic scale of 1 millimetre on the photograph represents 25 metres on the ground would be expressed as follows:
Unit Equivalent - 1 mm = 25 m
Representative Fraction - 1/25 000
Ratio - 1:25 000
Two terms that are normally mentioned when discussing scale are:

Large Scale - Larger-scale photos (e.g. 1:25 000) cover small areas in greater detail. A large scale photo simply means that ground features are at a larger, more detailed size. The area of ground coverage that is seen on the photo is less than at smaller scales.

Small Scale - Smaller-scale photos (e.g. 1:50 000) cover large areas in less detail. A small scale photo simply means that ground features are at a smaller, less detailed size. The area of ground coverage that is seen on the photo is greater than at larger scales.

5.1.2 TYPES OF AERIAL PHOTOGRAPHS (OBLIQUE , STRAIGHT)

Oblique Photographs



Oblique Aerial Photo

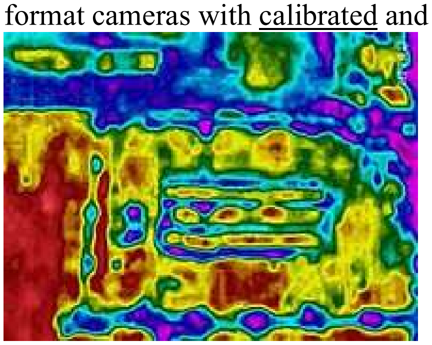
Photographs taken at an angle are called oblique photographs. If they are taken from a low angle relative to the earth's surface, they are called low oblique and photographs taken from a high angle are called high or steep oblique.

An aerial photographer prepares continuous oblique shooting in a Cessna 206

Straight photographs

Vertical Orientation Aerial Photo

Straight photographs are taken straight down. They are mainly used in photogrammetry and image interpretation. Pictures that will be used in photogrammetry are traditionally taken with special large format cameras with calibrated and documented geometric properties.



A vertical still from a kite aerial thermal video of part of a former brickworks site captured at night.

Vertical aerial photography is used in cartography (particularly in photogrammetric surveys, which are often the basis for topographic maps land-use planning, aerial archaeology. Oblique aerial photography is used for movie production, environmental studies, power line inspection, surveillance, construction progress, commercial advertising, conveyancing, and artistic projects.

5.2 PHOTOGRAMMETRY

Photogrammetry

The classical definition of Photogrammetry is the process of deriving metric information about an object through measurement made on the photograph of the object. **Photogrammetry is the science of making measurements from photographs. Photogrammetry means the measuring of features on a photograph.**

.

Photogrammetry describes from three words:
'photo' – light
'gram' – drawing
'metry' – measurement
The output of photogrammetry is typically a map, drawing, measurement, or a 3D model of some real-world object or scene. Many of the maps we use today are created with photogrammetry and photographs taken from aircraft.

Fundamental principle of Photogrammetry

The fundamental principle used by photogrammetry is triangulation. By taking photographs from at least two different locations, so-called "lines of sight" can be developed from each camera to points on the object. These lines of sight (sometimes called rays owing to their optical nature) are mathematically intersected to produce the 3-dimensional coordinates of the points of interest. Triangulation is also the principle used by theodolites for coordinate measurement. If you are familiar with these instruments, you will find many similarities (and some differences) between photogrammetry and theodolites. Even closer to home, triangulation is also the way your two eyes work together to gauge distance (called depth perception).

5.2.1 CLASSIFICATION OF PHOTOGRAMMETRY

Photogrammetry can be classified based on camera location during photography. On this basis we have Aerial Photogrammetry, Terrestial Photogrammetry and Space Photogrammetry.

1` Aerial Photogrammetry: The camera is mounted in an aircraft and is usually pointed vertically towards the ground. Aerial photographs are taken from the air by special camera mounted in an aircraft flying over the area with the camera axis vertical or nearly so. Multiple overlapping photos of the ground are taken as the aircraft flies along a flight path. These photos are processed in a stereo-plotter (an instrument that lets an operator see two photos at once in a stereo view). These photos are also used in automated processing for Digital Elevation Model (DEM) creation.

2. Terrestial Photogrammetry: is that branch of photogrammetry where photographs are taken from a fixed, and usually known, position on or near the ground and with the camera axis horizontal or nearly so. The position and orientation of the camera are often measured directly at the time of exposure. The instrument used for exposing such photograph is called photo theodolite.

3. Space Photogrammetry: The space photogrammetry embraces all aspects of extraterrestrial photography and subsequent measurement wherein the camera may be fixed on earth, contained in an artificial satellite, or positioned on the moon or a planet.

The term photo interpretation is applied to that branch of photogrammetry wherein aerial or terrestrial photographs are used to evaluate, analyze, classify, and interpret images of objects which can be seen on the photographs. Consequently, photogrammetry must be considered as a combination of measurement and interpretation.

5.3 PHOTOGRAMMETRY PROCESS

There are two types of photogrammetry process as follows:

- Interpretative Photogrammetry.
- Metric Photogrammetry.
- Planimetric mapping.
- Topographical mapping.

Interpretative Photogrammetry

Interpretative photogrammetry involves recognizing and identifying objects and judging their significance through careful and systematic analysis from photographic images.

These images created from satellite imagery which senses energy in wavelengths.

Forms basis for remote sensing (art or science of gathering information about an object or image without actually coming into physical contact).

Photo interpretation involves in the study of photographic images, while remote sensing involves not only the analysis of photography but also the use of data collected from remote sensing instruments.

Metric Photogrammetry

It consists of making precise measurements on photographs and other information to determine relative locations of points.

Common application of Metric Photogrammetry consists of planimetric mapping and topographical mapping.

Applications used to determine distances, elevations, areas, volumes, and cross-sections to compile topographical maps from photographic measurements

The photographs used for this purpose are mostly aerial photographs, but terrestrial photographs also used sometimes.

Classification of Aerial Photographs

Aerial photographs which are normally used for mapping and photo interpretation can be classified in to two main categories viz. vertical and tilted.

Vertical Photograph:

An aerial photograph taken with the optical axis of the camera held in a vertical or nearly vertical position is classified as vertical photograph. When the geometry of a vertical photograph is considered, the photograph is assumed to be taken with the optical axis truly vertical.

Tilted Photograph:

In practice, the camera axis is nearly held vertical. But due to unavoidable aircraft tilts the camera axis is unintentionally tilted from the vertical. Then the resulting photograph is called tilted photograph.

If tilt of the camera axis from the plumb line is less than 3 degree the photograph is called vertical. For tilt more than 3 degree, it is called tilted photograph. Tilted photograph may again be classified in two categorizes viz. low oblique and high oblique.

Oblique photograph: An oblique photograph in which the apparent horizon appears is termed as high oblique photograph. Apparent horizon: it is the line in which the earth appears to meet the sky as visible from a point.

Low oblique photograph: is one on which the apparent horizon does not appear. A pair of low oblique taken in sequence along a flight direction in such a manner that both photographs cover basically the same area is called convergent photographs

5.3.1 ACQUISITION OF IMAGERY USING AERIAL AND SATELLITE PLATFORM

Satellite Imagery

The term "satellite imagery" may refer to a number of types of digitally transmitted images taken by artificial satellites orbiting the Earth. The United States launched the first satellite imaging system in 1960 to spy on the Soviet Union. Since then, in addition to military applications, satellite imagery has been used for mapping, environmental monitoring, archaeological surveys and weather prediction. Governments, large corporations and educational institutions make the most use of these images.

While a digital surface model (DSM) may be useful for landscape modeling, city modeling and visualization applications, a digital terrain model (DTM) is often required for flood or drainage modeling, land-use studies, geological applications, and other applications, and in planetary science

The term aerial imagery refers to all imagery taken from an airborne craft which can include drones, balloons or airplanes.

This bird’s eye view of the world is known as an aerial perspective. By placing ourselves in the air and looking down, we are able to create aerial photographs.

Aerial and satellite imagery

Aerial and satellite data complement each other in terms of what they offer.

Satellites provide high temporal resolutions, often with regular revisits over the same area of the globe. On the other hand, aerial imagery offers incredible spatial resolution —up to 1-5 cm per pixel.

The field of view covered in an aerial photograph is much smaller compared to satellite images. This is since satellites orbit the Earth and have global coverage, whereas aerial data providers conduct survey campaigns over niche areas that they serve.

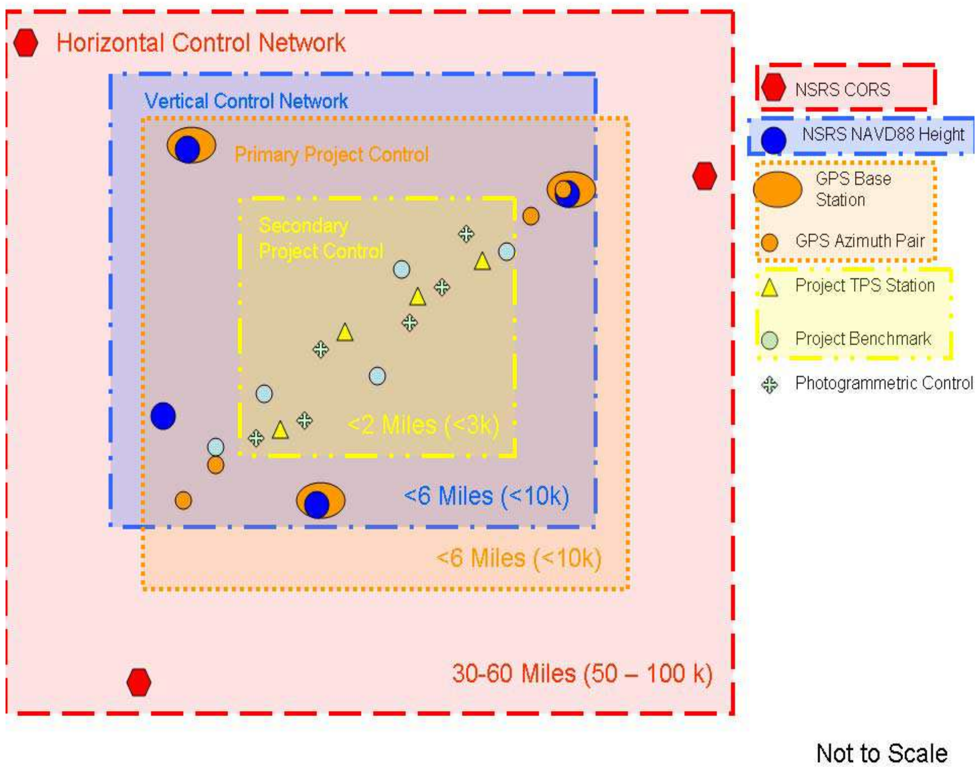
Due to these differences, the kinds of projects that you can use aerial and satellite imagery for vary depending on what you’re looking to do.

For example, satellite images have greater large-scale applications thanks to its high temporal resolution, while aerial photography is great for more localized applications that make the most of its high spatial resolution.

This complementary relationship between the two makes aerial and satellite data both powerful sources of useful geospatial information. Find them on the UP42 platform to explore each of them more.

5.3.2 CONTROL SURVEY

When the term photogrammetric control is used in this manual it refers to the ground control targets or photo identifiable points occurring within the area of a project. The photo control can be selected before (pre-marking, e.g. targets), or after (post-marking, e.g. photo-identifiable points) the aerial photography flight. Whenever possible, targets should be used. Photo control is used to control the photogrammetric mapping and DTMs required for a project. Points established under these standards and procedures are generally within the work limits of the project and are assumed to be expendable.
Photogrammetric control traverses, level runs, and GPS networks should begin and end on at least secondary project control stations.



5.3.3 GEOMETRIC DISTORTION IN IMAGERY , APPLICATION OF IMAGERY AND ITS SUPPORT DATA ORIENTATION AND TRIANGULATION STEREOSCOPIC MEASUREMENT 19.9.1 X-PARALLAX . 19.2.2 Y- PARALLAX

DISTORTIONS.

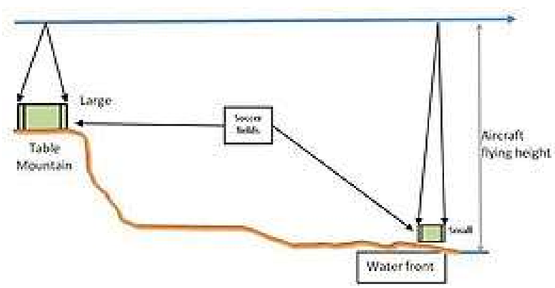
A shift in the location of an object that changes the perspective characteristics of the photo.

There are four types of distortion that cause changes in the apparent location of objects in photos.
Film and Print Shrinkage- due to atmospheric conditions such as humidity, heat etc.

Atmospheric refraction of light ray- effectively displacing the image of an object on a photograph (i.e refraction).The effects from these sources are usually very small

Image motion - due to aircraft movement

Lens distortion - inherent in the manufacture of the lenses resulting in flaws in the optical components. These effects are radial from the center of the photograph making objects appear either closer to or farther from the principal point than they actually are. This can be photogrammetrically corrected.



Displacement

This is a shift in the location of an object in a photo that does not change the perspective characteristics of the photo

Aerial Triangulation

Aerial Triangulation(AT) represents the mathematical process of establishing precise and accurate relationships between the individual image coordinate systems and a defined datum and projection (ground).
The main objective of aerial triangulation is to produce from ground control, sufficient points in the photogrammetric models to ensure that each model can be oriented accurately as required for stereo compilation in either orthophoto or line mapping.
There are mainly three stages of aerial triangulation:

Preparation

- Point identification of ground control
- Numbering settings for points, images and strips
- Input data: flight details (photo coordinates plus omega, phi and kappa rotation), camera calibration and scanned or digital images

Image Measurement

- Interior orientation (fiducial marks measurement for analogue cameras)
- Automatic tie points determination using images pyramid levels

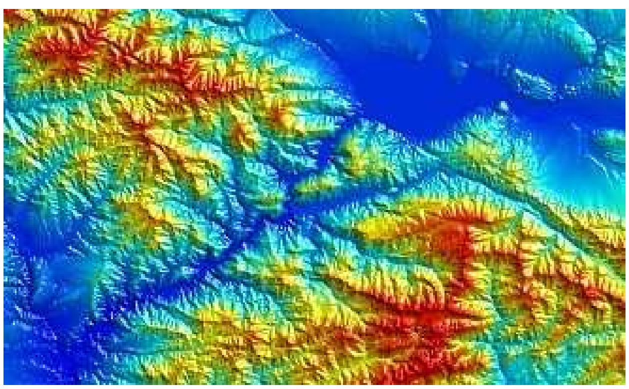
- Ground control points measurement
- Manual tie points measurement if necessary (in cases where automatic measurement could not determine an acceptable number of tie points per image or in failure situations.

Block Adjustment

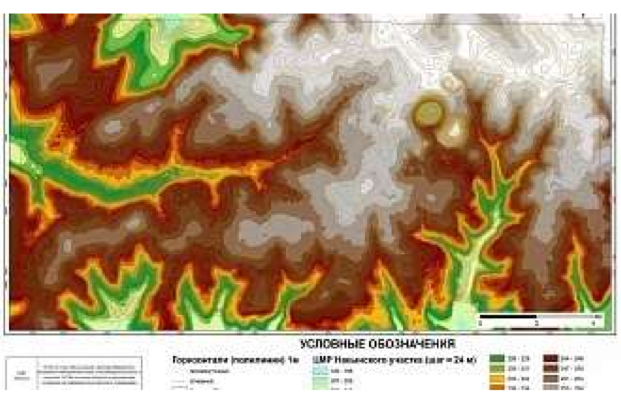
- The input of observations (x, y, z coordinates or GPS/IMU, ground control) and initial parameter values.
- Preliminary data processing, including generation of initial values for bundle adjustment parameters.
- Interactive solution (including specials algorithms for determination of blunders and error propagation)
- Acceptance of results (after accuracy and reliability assessment)
- The final output of results (EO data)

5.4 DTM/ DEM GENERATION

A digital terrain model (DTM or DEM) is a three-dimensional representation of the earth's surface, represented as an array of points with a defined height. The terrain model contains information about the height without considering vegetation, buildings, and other objects. In some countries, digital elevation model is synonymous with digital terrain model. However, in the US and other countries, digital terrain model has a slightly different meaning. A digital terrain model is a set of vector data consisting of regularly spaced points and natural features, such as ridges, inflection lines, etc.



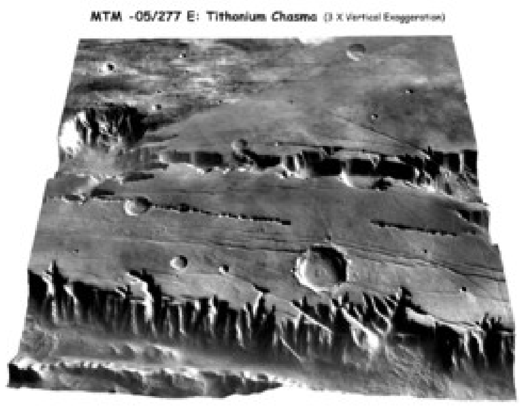
Example of a digital terrain model



Digital terrain model based on processing and interpretation of remote (space) sensing materials

Organizing the process of creating a digital terrain model or digital elevation model
Receiving and approving data from the Customer. It is necessary to understand the purpose of creating a digital model of the terrain and elevation model, to know the size and nature of the terrain and the required accuracy of creating products in order to calculate the cost and timing of work, as well as to plan the work.
Planning and ordering the shooting. Depending on the size of the territory and other information about the object, you can choose and order the type of survey, as well as other source data.
Processing of materials. The specialized software products available at GEO Innoter allow you to obtain a digital surface model (digital terrain model or digital elevation model) in an automated mode, with the accuracy, form and format required by the Customer
Transfer of materials to the Customer. We transmit the results of the work to the Customer in the required form and format.

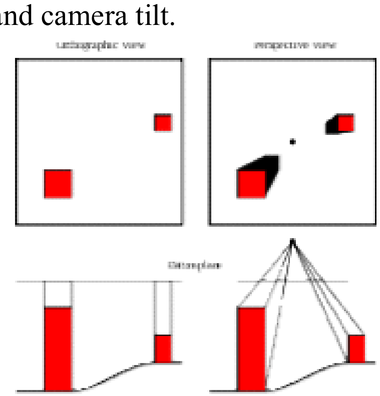
A **digital elevation model** (**DEM**) is a 3D computer graphics representation of elevation data to represent terrain, commonly of a planet (e.g. Earth), moon, or asteroid. A "global DEM" refers to a discrete global grid. DEMs are used often in geographic information systems, and are the most common basis for digitally produced relief maps.



3D rendering of a DEM of Tithonium Chasma on Mars

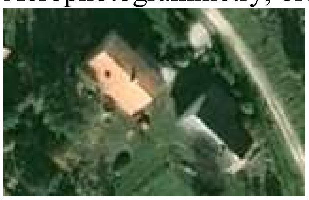
5.5 ORTHO IMAGE GENERATION

An **orthophoto**, **orthophotograph** or **orthoimage**
is an aerial photograph or satellite imagery geometrically corrected ("orthorectified") such that the scale is uniform: the photo or image follows a given map projection. Unlike an uncorrected aerial photograph, an orthophoto 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.



Orthographic views project at a right angle to the data plane. Perspective views project from the surface onto the datum plane from a fixed location.

Aerophotogrammetry, orthophoto from drone, Città Alta, Bergamo, Italy.



This photo is properly projected on elevation model, yet on a single building scale, a small tilt is noticeable. This is an orthophoto, but not a true orthophoto (not all vertical features are reprojected).

This photo is assembled from several overlapping photos from UAV, completely removing any residual tilt of the buildings. This is a true orthophoto.

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

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 What do you mean by aerial photography ?

Ans; Aerial photography (or airborne imagery) is the taking of photographs from an aircraft or other flying object. Platforms for aerial photography include fixed-wing aircraft, helicopters, unmanned aerial vehicles (UAVs or "drones"), balloons, blimps and dirigibles, rockets, pigeons, kites, parachutes, stand-alone telescoping and vehicle-mounted poles. Mounted cameras may be triggered remotely or automatically; hand-held photographs may be taken by a photographer.

Q-2 what are the components of the aerial photography?

Ans-there are three components of aerial photography

Film

Focal length

Scale

Q-3 Define scale of aerial photography.

Ans; **Scale:** the ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e. 1 unit on the photo equals "x" units on the ground).

Q-4 Define oblique photography.
Ans : Photographs taken at an angle are called oblique photographs. If they are taken from a low angle relative to the earth's surface, they are called low oblique and photographs taken from a high angle are called high or steep oblique.

Q-5 Define photogrammetry.
Ans: The classical definition of Photogrammetry is the process of deriving metric information about an object through measurement made on the photograph of the object. **Photogrammetry is the science of making measurements from photographs. Photogrammetry means the measuring of features on a photograph.**

POSSIBLE LONG TYPE QUESTIONS

Q-1 Describe briefly the classification of photogrammetry.
Q-2 What do you mean by ortho image generation describe briefly ?
Q-3 Describe about the components of aerial photography.

CHAPTER NO-6
MODERN SURVEYING METHODS

Learning objectives

6.1 Principles, features and use of (i) Micro-optic theodolite, digital theodolite

6.2 Working principles of a Total Station (Set up and use of total station to measure angles, distances of points under survey from total station and the co-ordinates (X,Y & Z or northing, easting, and elevation) of surveyed points relative to Total Station position using trigonometry and triangulation.

6.1 PRINCIPLES, FEATURES AND USE OF (I) MICRO-OPTIC THEODOLITE, DIGITAL THEODOLITE

Micro-optic Theodolites :-

A theodolite works by combining optical plummets (or plumb bobs), a spirit (bubble level), and graduated circles to find vertical and horizontal angles in surveying. An optical plummet ensures the theodolite is placed as close to exactly vertical above the survey point.

Features

- Micro-optic theodolites can read angles to an accuracy of 10” or even less. The essential principle is illustrated in Fig. The special features of such theodolites are as follows.

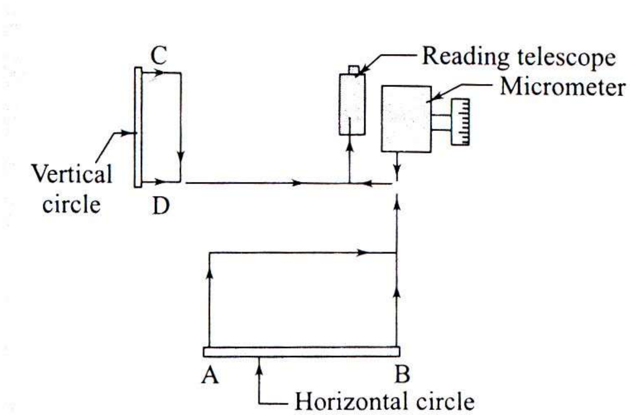
- Conventional metal circles are replaced by glass circles on which the graduations are etched by photographic methods. The graduations can be made finer and sharper by this technique. Both the horizontal and vertical circles are made of glass and generally graduated to 10.

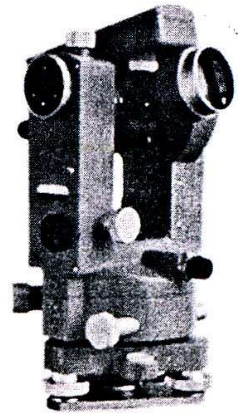
- Light passing through the circle at the point of the reading is taken through a set of prisms to the field of view of the observer. For passing light through glass circles, sunlight is reflected through a reflecting prism and passed through the circle. In case night operation is required, the battery-operated light provided in the instrument can be used.

- Both the horizontal and vertical circles are seen at the same in the field of view. This is an advantage, as the readings of both the circles can be taken at the same time. Some manufacturers make a switching arrangement so that the horizontal or vertical circle reading can be seen along with the micrometer reading.

- The optical micrometer is used to read fractions of the main scale division. Depending upon the reading system, angles can be read up to 10’ or less.

- The circles are generally graduated to 10’ or 20’ of the arc. The micrometer can be read after coinciding the index with the nearest main scale division. The fractions are then read from the micrometer scale, which is also seen in the field of view.





Digital theodolites:-

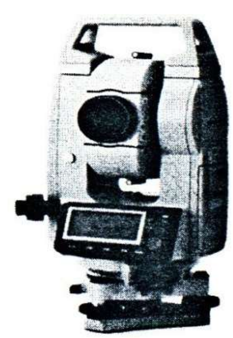
Digital theodolites are very fine instruments for angle and distance measurements. The instruments are light weight and are simplar to electronic theodolites in construction.

The instrument is set up over a station as in the case of normal theodolites. They will have extendable tripod legs which can be adjusted for comfortable viewing. The centering and leveling operations are done with a circular vial for coarse setting one has to press only a measure button to get the readings of angles and distances.

Some models also have a laser pointer for easy alignment in critical cases and for staking out operations. With the arrival of total stations, these theodolites have less demand though they are cheaper compared to a total station.

Features

The following are typical features in a digital theodolite:
Angle measurement – by absolute encoding glass circle;
Diameter – 71 mm
Horizontal angle- 2 sides; vertical angle – one side;
Minimum reading – 1"/5"
Telescope – Magnification – 30x;
Length – 152 mm;
objective lens – 45 mm



Fig

Field of view - $1^0 30'$ Minimum focus distance – 1m
Stadia values: Multiplying constant – 100; additive constant-0
Laser pointer – coaxial with telescope; 633 nm class II laser; Method – focusing for alignment and stake out operations.
Display on both sides; 7-segment LCD unit
Display and reticle illuminated
Compensator- tilt sensor; vertical tilt sensitivity + 3'
Optical plummet – magnification – 3x; field of view - 3^0; focusing from 0.5 m ti infinity
Level sensitivity – Plate vial – 40"/2mm; circular vial – 10'/2mm
Power supply – 4 AA size batteries; Operating times – Theodolite only – 140 hours

Laser only – 80 hours; Theodolite + laser – 45 hours
Weight – 4.2 kg.

(ii) Electronic Distance Meter (EDM):

- EDM equipment can be classified based upon the type of wave used, into M (microwave) DM and EO (electro-optical) DM equipment. The first type uses low-frequency short radio waves while the second type uses high-frequency light waves. They cal also be classified based upon the range as follows.

- Short-range equipment such as teleprompters and mekenometers with a range of up to 3 km.

- Medium-range equipment such as geodimeters with a range of up to 25 km. The range is about 5 km during the day and can go upto 25 km at night.

- High – range equipment with a range of up to 150 km. Tellurometers and distomats come under this category.

- The accuracy varies with the range. Short-range equipment has an accuracy of ± (0.2 mm) + 1 mm/km. Medium-range equipment has an accuracy of ± (5 mm + 1 mm/km) while high-range equipment ha san accuracy of ± (10 m + 3 mm/km).

- Distomats have replaced other forms of equipment due to their compact design, ease of operation, and precision.

6.2 WORKING PRINCIPLES OF A TOTAL STATION (SET UP AND USE OF TOTAL STATION TO MEASURE ANGLES, DISTANCES OF POINTS UNDER SURVEY FROM TOTAL STATION AND THE CO-ORDINATES (X,Y & Z OR NORTHING, EASTING, AND ELEVATION) OF SURVEYED POINTS RELATIVE TO TOTAL STATION POSITION USING TRIGONOMETRY AND TRIANGULATION.

Total Stations

One of the recent developments in surveying equipment is the integration of distance- and angle-measuring components in one piece of equipment. A total station is the integration of an electronic theodolite with the EDM equipment. Many companies market total stations. Though the technology details used by different manufacturers may be different, they all have common features, which will be discussed below.

A digital theodolite is combined with one of the many forms of EDM equipment to obtain a very versatile instrument that can perform the required functions very easily.

Digital Theodolite:

The electronic or digital theodolite was discussed in Chapter 4. We will just recapitulate some salient points. These instruments have glass circles, which are encoded in the incremental or absolute mode. These are read by an optical scanning system and the reading is converted into angles and displayed or stored by the instrument. All the instruments are provided with an optical plummet for centeringand a compensator system (single-axis or dual-axis) to take care of the tilt of the and the displayed angles and distances are previously corrected for such minor errors. The user can choose the required accuracy of angular measurement. These theodolites are normally operated by a rechargeable battery pack. The charged batteries can work for 40-80 hours. Some instruments need a prisms. Even reflecting tapes are used. A digital theodolite comes with the following facilities.

- Zero-setting
- Bidirectional measurement
- Precision setting
- Horizontal and vertical angles
- Slant distance and horizontal distance
- Difference in elevations
- Entry and display of data
- Display and storage of result
- Data management system and data transfer facility

A total station has all the above facilities and in addition measures horizontal distance using a built-in EDM module. Total stations come with a lot more facilities of data storage and manipulation. The following are the salient features of a total station.

Angle measurement:-

Horizontal and vertical angles are measured to an accuracy of 1”-5”. The angles are displayed on the display unit of the console. Many instruments have console units on both sides of the instrument.

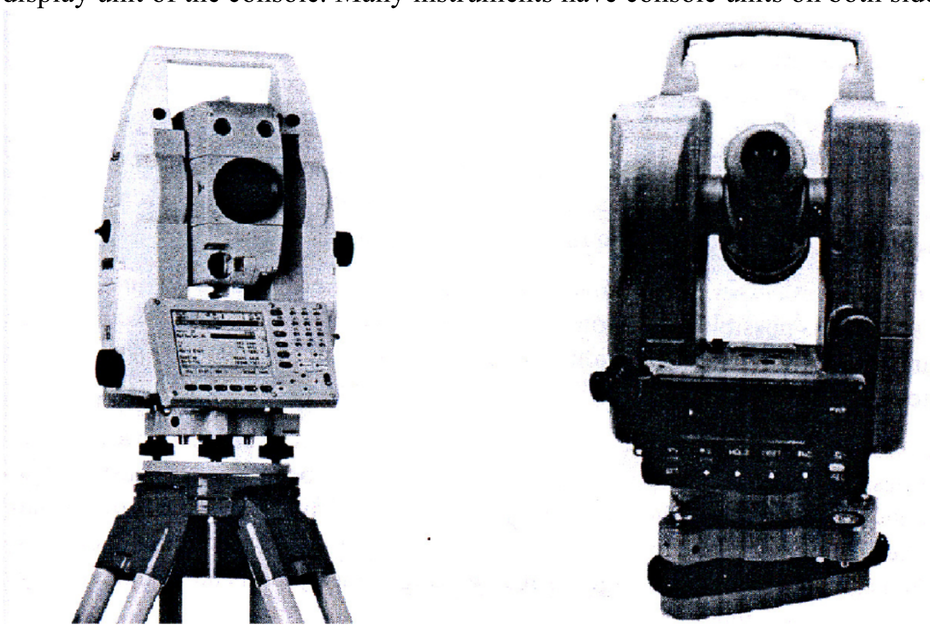


Fig.9.3

Remember that when the instrument is powered on it has a random X,Y coordinate system: you must align the instrument with your working coordinate system.
Level the instrument on the desired starting survey marker. Make sure that on the last leveling step the optical plummet is centered on the survey point

- Select “Backsight” and then “Angle” from the menu
- Sight the landmark/target of known azimuth relative to instrument with telescope
- Select “Angle” from menu. Note that the menu displays the zenith angle (ZA) and current horizontal angle (HAR) and is waiting for you to enter the known angle with [EDIT]
- Note: if you enter an azimuth angle as “85.4514” this will be interpreted as 85 degrees, 45 minutes, 14 seconds
- IMPORTANT! You must select [OK] to accept the angle.

Distance measurement:- This is done with an EDM module functioning coaxially with the telescope tube. The distance measured is the slant distance if the stations are at different elevations. Reflecting multiple prisms are commonly used as targets, even though reflectorless distance measurement has also been made possible. The instrument uses the vertical angle measured by the theodolite and calculates the horizontal distance measurement can be done in different modes such as standard or coarse mode, precision mode, and fast mode, and fast mode. The precision and time taken vary depending upon the mode.

Microprocessor and software:- The onboard software in total stations can per form many functions. The processor is per-programmed, and in some cases can be programmed by the user to perform many useful functions with the measured data. The details may very with the manufacturers but some of the common features are as follows.

Automatic target recognition:- Most of the modern total stations have the facility of automatic target recognition (ART). In ATR, the telescope has to be roughly pointed towards the target while the measurement key is pressed. The instrument automatically points to the target before measurement. The instruments have motorized endless drives to facilitate ATR.

Reflectorless distance measurement:-Until recently, total stations had to be used with special multiple prisms as targets for EDM. The new versions of total stations can measure distances without a prism target. This means that distances to points where a target cannot be erected can now be measured easily without any extra survey effort. This has been made possible by a red laser, which can direct to a point on any surface.

Computation of reduced levels:- The reduced levels are measured from slope distance and vertical angle. Data input enables the user to input the height of instrument, height of target prism, and the RL of the station occupied. The instrument calculates the RL of the target station and displays the same.

Orientation:- The instrument automatically orients to any direction specified by the user. If the coordinates of two points are input, the horizontal circle will be oriented to measure the bearing of the line automatically.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q –1 What is a total station ?
Ans; **The total station** is an electronic/optical instrument used in modern surveying. The total station is an electronic theodolite integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

Q -2 Define EDM.
Ans; EDM equipment can be classified based upon the type of wave used, into M (microwave) DM and EO (electro-optical) DM equipment. The first type uses low-frequency short radio waves while the second type uses high-frequency light waves.

Q-3 What is the data management in total station ?
Ans: Total stations have a very efficient data management system. Data transfer to data recorders, computers, or flash cards is possible. The in-built memory can store up to 10,000 blocks of data

POSSIBLE LONG TYPE QUESTIONS

Q-1 Describe about the features of a digital theodolite.

CHAPTER NO-07
BASICS ON GPS & DGPS AND ETS

Learning objectives

7.1 GPS: - Global Positioning
7.1.1 Working Principle of GPS,GPS Signals,
7.1.2 Errors of GPS,Positioning Methods
7.2 DGPS: - Differential Global Positioning System
7.2.1 Base Station Setup
7.2.2 Rover GPS Set up
7.2.3 Download, Post-Process and Export GPS data
7.2.4 Sequence to download GPS data from flashcards
7.2.5 Sequence to Post-Process GPS data
7.2.6 Sequence to export post process GPS data
7.2.7 Sequence to export GPS Time tags to file
7.3 ETS: - Electronic Total Station
7.3.1 Distance Measurement
7.3.2 Angle Measurement
7.3.3 Leveling
7.3.4 Determining position
7.3.5 Reference network

7.1 GPS: GLOBAL POSITIONING

The Global Positioning Satellite (GPS) system was established by the United States Department of Defense (DoD) to provide a real-time navigation system for the US military. Since its inception it has grown to provide not only world-wide, all-weather navigation, put precise position determination capabilities to all manner of users. The resulting precision available exceeds any previously attainable without large expenditures of time and resources. This introduction will provide a brief description of how the system works and how it may be used.

GPS, which stands for Global Positioning System, is the only system today able to show you your exact position on the Earth anytime, in any weather, anywhere.

Applications of GPS

• Providing Geodetic Control
• Photogrammetry
• Finding out location of offshore drilling
• Pipe line and power line survey
• Navigation of civilian ships and planes
• Crustal movement studies

7.1.1 WORKING PRINCIPLE OF GPS AND GPS SIGNALS

Three Components to GPS
Space Segment –the satellites orbiting the earth and transmitting timing and ranging messages.
User Segment - the handheld or other receivers used to interpret the messages broadcast from the satellites.
Control Segment - monitors the health and position of them satellites in the space segment and transmits correction information back up to the satellites

The GPS Signal
All GPS satellites broadcast on the same two frequencies. The primary signal isbroadcast on what is referred to as L1 frequency, which is 1,575.42 MHz. The signals are broadcast using spread-spectrum techniques, which allow many signals to coexist on the same frequency, and for receivers to detect and separate the different signals from each other. The L1 signal is modulated with two information signals called C/A (for Coarse and Acquisition code) and P (for Precise code). In addition, the satellites also broadcast a copy of the P code on the second frequency called L2, which is 1,227.60 MHz. (Note that later satellites may add additional codes to L1 and/or L2, and may also add extra frequencies.)

7.1.2 ERRORS OF GPS

That decrease the accuracy of your GPS readings

• Number and geometry of satellites visible
• Signal multi-path
• Orbital and Satellite Clock errors
• Ionosphere and troposphere delays
• Receiver clock errors

Positioning Methods

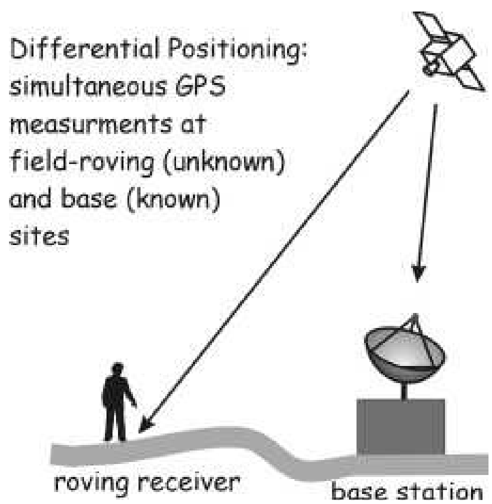
Calculating a Position
• Measure distance to satellites.
• Obtain satellite positions.
• Perform triangulation calculations. (Trilateration)
• Adjust local clock bias. Obtain Satellite positions.
• Orbital data (Ephemeris) is embedded in the satellite data message.
• Ephemeris data contains parameters that describe the elliptical path of the satellite.
• Receiver uses this data to calculate the position of the satellite. (X,Y,Z)

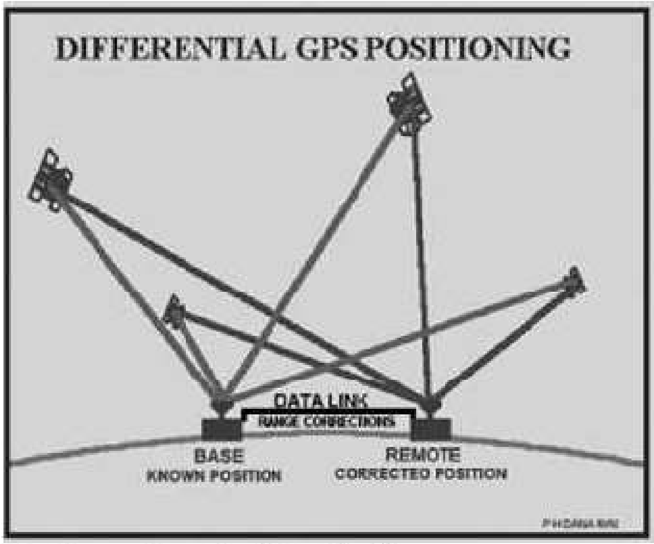
Perform triangulation calculations. Triangulation in 2D position lies somewhere on a circle.
• Could be anywhere along circle A
• If location of point A is known, and the distance to point A is known, desired
Triangulation in 2D
Distance to two points are known.
Desired position is in one of two locations

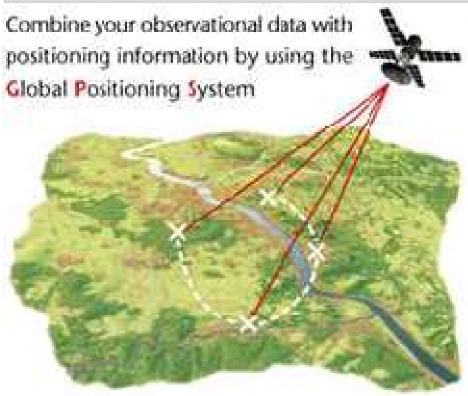
Distance to threepoints are known. Position is known!
DATA DISPLAY IN GPS
Once the GPS receiver has located its position it is usually displayed in one of two common formats:
– Latitude and longitude
– Universal transverse mercator (UTM).

7.2 DGPS : DIFFERENTIAL GLOBAL POSITIONING SYSTEM

Differential positioning user finds the point position derived from the satellite signals and applies correction to that position. These corrections, difference of the determined position and the known position are generated by a Reference Receiver ,whose position is known and is fed to the instrument and are used by the second Receiver to correct its internally generated position. This is known as Differential GPS positioning.







7.2.1 BASE STATION SETUP

1. Set up base station GPS antenna on a level tripod and measure the height of the antenna above ground (see figure 1).
2. Install charged battery into base Z-Surveyor unit . Connect Port A of ZSurveyor to laptop with serial cable .
3. Login to laptop: x administrator; password or think pad: u w bradar; password
4. Ensure base Z-Surveyor is connected to antenna.
5. Turn on Z-Surveyor by pushing the power button on left of unit. “Sysinfo” message will display on the front panel for a few seconds.
6. Run **eval32** on laptop
7. Select “connect to Z-Surveyor receiver (last setting)”. Com1 is the port operating at 9600 baud.
8. Check sky chart by clicking its icon at top of window.
9. Check indicator panel by clicking its icon at top of window.
10. Select terminal by clicking its icon at top of window.

7.2.2 ROVER GPS SETUP

1. Install charged battery into rover Z-Surveyor unit (figure 2). Battery will provide uninterrupted power to Z-Surveyor if inverter shuts down.

2. Bring up SIRE program on PC. Turn GPS settings ON. A series of commands is automatically sent to Z-Surveyor from PC.

3. Perform the following commands in SIRE GPS window: Select: **Flash Rec ON** Type: **PASHS,CLM** (Format flash card. Takes about 4 min.)

Select: **Flash Rec OFF** (queues command during format and stops flashing LED when format is complete.)

7.2.3 DOWNLOAD, POST-PROCESS, AND EXPORT GPS DATA

- After the test is completed, the GPS data stored in Ashtech's data format are downloaded from the flash memory card onto a laptop computer .

- We then convert the base and rover data, which contain carrier phase, position, ephemeris, site information and time stamp of each epoch, into Waypoint's Graf Nav format The Graf Nav software is a high precision post-processing engine that supports static and kinematic modes

- We use the kinematic method to post-process the data. The top figure shows the "zoom-in" raw un-processed aperture position of the rover at a site, and the bottom figure shows the same data apertures after post-processing.
- In general, the post processed data show a dramatic improvement of the aperture position, where centimeter resolution is possible

7.2.4 SEQUENCE TO DOWNLOAD GPS DATA FROM FLASH CARDS

1. Create dated, descriptive top-level folder on laptop for download files. Create subfolder "Base" for base station files and "Rover" for mobile GPS files.

2. Run **dload32** command . Select the flash card drive for source data. Select corresponding folder on C: drive for destination, either "Base" or "Rover". Drag the file name from the source area to the destination area.
3. The user can provide the base antenna height in the program after completion of base download. Information will be stored for later use in the GrafNav post-processing program.

7.2.5 SEQUENCE TO POST-PROCESS GPS DATA

1. Run GrafNav program on PC. Requires software protection dongle.
2. Select "Convert raw GPS to GPB4" (for base station data)
3. Find folder for base files and select "add all".
4. Select "global options" and **uncheck "make all epochs kinematic"**. Select convert.
5. Select "Convert raw GPS to GPB"(for rover data).
6. Find folder for rover files and select "add all".
7. Select "global options" and **check "make all epochs kinematic"**. Select convert.
8. Select "file, new project". Provide new configuration file name.
9. Select "file, add master GPB file" (converted base station data). Open base file in base directory. Add base antenna height, if missing.
10. Select "file, add remote GPB file" (converted rover data). Open a rover file in rover directory.
11. Select "Process, Process Differential" . Under process tab, "auto" should be checked and under general tab, data interval is 0.1 (s). Click "process" button.

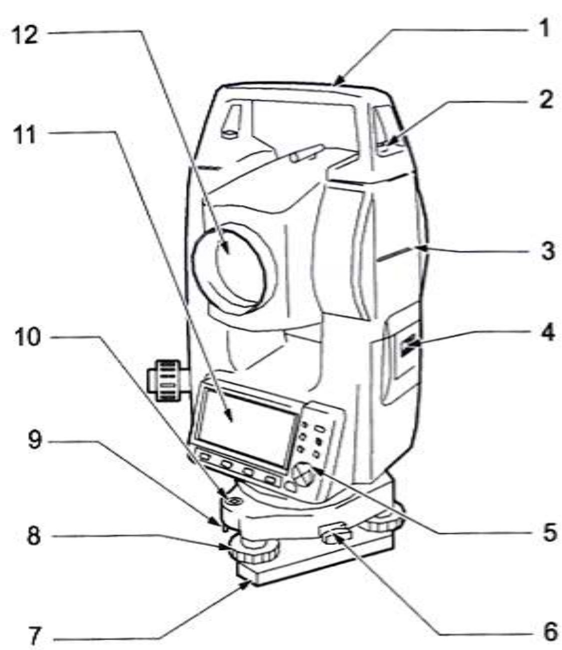
7.2.7 SEQUENCE TO EXPORT GPS TIME TAGS TO FILE

1. Perform differential post-processing according to previous section.
2. Select Output menu, Export Wizard.
3. Pick an output file name and the SIRE GPS data profile.
4. Accept the defaults and hit next. When asked for local time parameters, enter 4 if daylight saving time or 5 if eastern standard time. Hit finish to process.

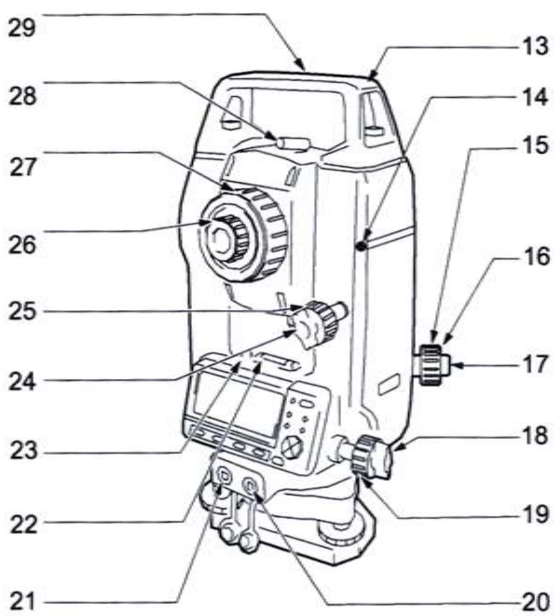
7.3 ETS :- ELECTRONIC TOTAL STATION

The total station is an electronic/optical instrument used in modern surveying. The total station is an electronic theodolite integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

The Total station is designed for measuring of slant distances, horizontal and vertical angles and elevations in topographic and geodetic works, tachometric surveys, as well as for solution of application geodetic tasks. The measurement results can be recorded into the internal memory and transferred to a personal computer interface



1 Handle
2 Handle securing screw
3 Instrument height mark
4 Battery cover
5 Operation panel
6 Tribrach clamp (SET310S/510S/610S: Shifting clamp)
7 Base plate
8 Levelling foot screw
9 Circular level adjusting screws
10 Circular level
11 Display
12 Objective lens



13 Tubular compass slot
14 Beam detector for wireless keyboard (Not included on SET610/610S)
15 Optical plummet focussing ring
16 Optical plummet reticle cover
17 Optical plummet eyepiece
18 Horizontal clamp
19 Horizontal fine motion screw
20 Data input/output connector (Beside the operation panel on SET610/610S)
21 External power source connector (Not included on SET610/610S)
22 Plate level
23 Plate level adjusting screw
24 Vertical clamp
25 Vertical fine motion screw
26 Telescope eyepiece
27 Telescope focussing ring
28 Peep sight
29 Instrument center mark

7.3.1 DISTANCE MEASUREMENT

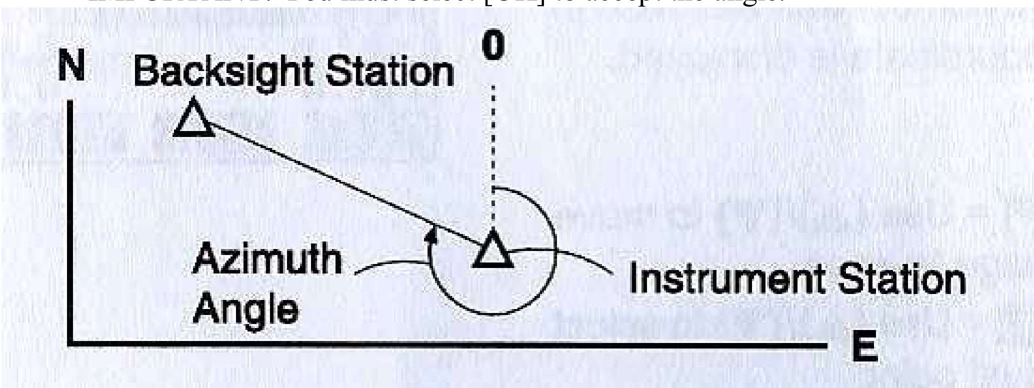
Remote distance measurement (RDM) or Missing line measurement (MLM):
The process of finding the distance between two points A & B (which are not inter-visible from each other) from another point 'I' (instrument position) is known as RDM.
This method is very useful for finding distances between two points which has an obstruction between them. It is of two types:
Continuous
Radial
Distances can be obtained either in the **continuous mode** i.e., AB, BC,CD, DE,EF etc., or in the **radial mode** i.e., AB,AC,AD,AE,AF etc., however, the field procedure is same for both only the selection of operation varies. This is required when there are obstructions in between survey line.

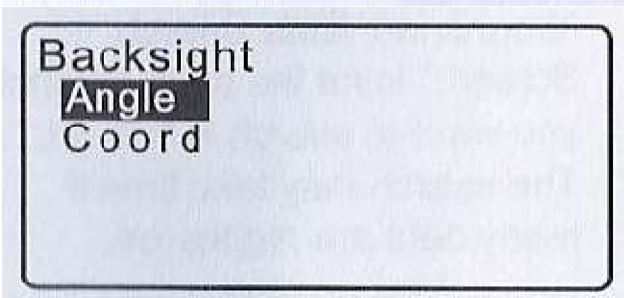
7.3.2 ANGLE MEASUREMENT

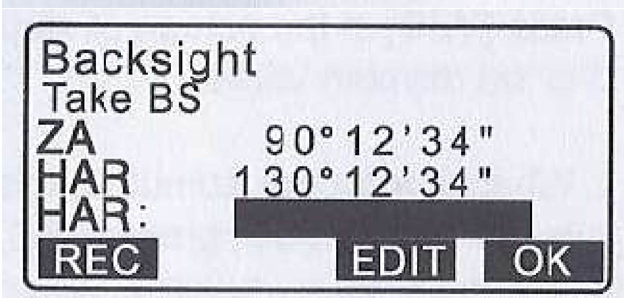
Remember that when the instrument is powered on it has a random X,Y coordinate system: you must align the instrument with your working coordinate system.
Level the instrument on the desired starting survey marker. Make sure that on the last leveling step the optical plummet is centered on the survey point

- Select "Backsight" and then "Angle" from the menu

- Sight the landmark/target of known azimuth relative to instrument with telescope
- Select “Angle” from menu. Note that the menu displays the zenith angle (ZA) and current horizontal angle (HAR) and is waiting for you to enter the known angle with [EDIT]
- Note: if you enter an azimuth angle as “85.4514” this will be interpreted as 85 degrees, 45 minutes, 14 seconds
- IMPORTANT! You must select [OK] to accept the angle.



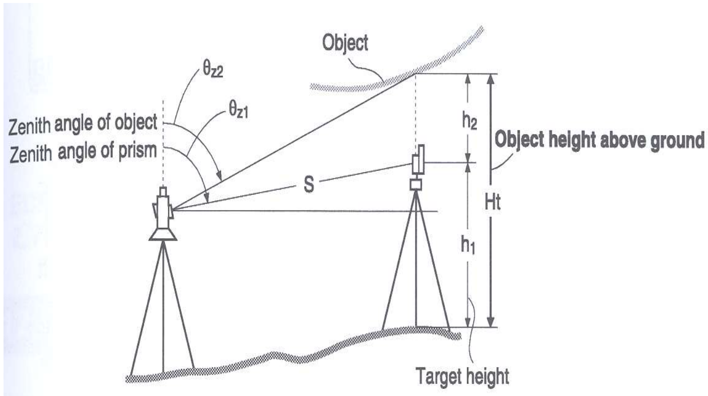


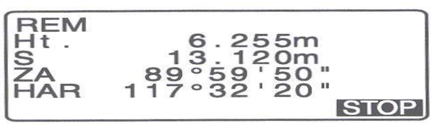


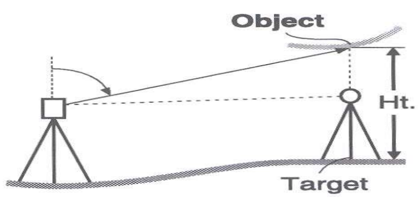
7.3.3 LEVELING

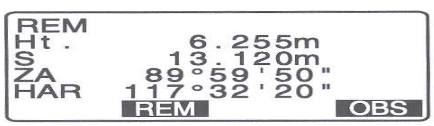
Remote Elevation Measurement (REM)
The process of finding the height of objects without actually going to the top of the object is known as Remote Elevation Measuring (REM) i.e., a total station placed remotely (faraway) from the object is used to measure the heights.

Method: The prism is kept at the base of the object sight the telescope to the prism, and measure the slope distance ‘d’, now tilt the telescope up-to the tip of the object. The height of the object is displayed, from the bottom of the prism depending upon the instrument.
This feature measures the elevation of a point where a prism can not be placed directly. The measurement is extended along the plumb line while the elevation is continuously displayed.
Remote Elevation Measurement:



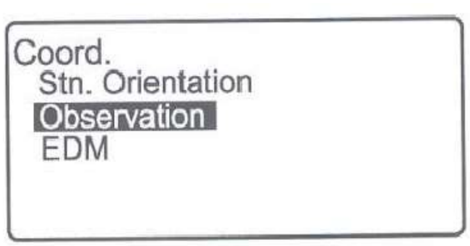


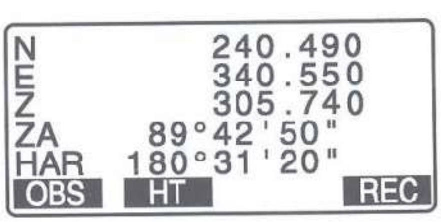




7.3.4 DETERMINING THE POSITIONS

Used to determine XYZ coordinates of target point.
Make sure the instrument height and target height are already set.
Make sure backsight/resection have already "locked" the instrument into a mapping coordinate system
From MEAS select Menu > Coord > Observation





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REFERENCE NETWORKS

In order to evaluate the accuracy and precision of the surveyed data, primary it has been established a network of control points which can serve as a reference for comparison with RTK and TLS measurement. The reference network was established fourteen control points using a Leica 1201 total station. To determine the network with high precision, measurements have been taken in two faces with two rounds.

Therefore, to accomplish the objectives of this project, data were collected from field measurement. The field measurements were taken using three different surveying instruments: - Global Positioning System (GPS), laser scaner (LS) and total station (TS). To eliminate instrumental errors such as line of sight errors, tilting axis errors and vertical index errors (see Table 3.3), two face measurements were taken. Reconnaissance of the project area was the first step in the establishment of control network and followed by marking fourteen control points which are visible each other. Those control points were also suitable for satellite visibility, because rtk method was needed to compare with the ts control points.

ERRORS AND ACCURACY

Following are different types of total station errors:

1. Horizontal Collimation or Line of Sight Error
Horizontal collimation or line of sight error is when the line of sight is not perpendicular to the tilting axis of the instrument. This is an axial error.
Line of sight error effects the horizontal angle readings and increases with steep sightings. The error can be overcome or eliminated by observing on two faces.
2. Tilting Axis Error or Tilt Error
Tilting axis or tilt error is the error when the axis to the total station is not perpendicular to the vertical axis or plumb line. The error effect on horizontal readings when the instrument is tilted (steep sightings) but have no effect on sightings taken when the instrument is horizontal..

3. Vertical Collimation Error or Vertical Index Error
If the horizontal base line of angle from 0° to 180° in the vertical circle does not coincide with the vertical axis of instrument. This zero point error is present in all vertical circle readings and like the horizontal collimation error, it is eliminated by taking FL and FR readings or by determining i.

4. Compensator Index Error
This error is caused by not leveling the total station correctly and carefully. This error can't be eliminated by taking two face (face left and face right) readings unlike the horizontal collimation error.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 what is a GPS ?
Ans : The Global Positioning Satellite (GPS) system was established by the United States Department of Defense (DoD) to provide a real-time navigation system for the US military. Since its inception it has grown to provide not only world-wide, all-weather navigation, put precise position determination capabilities to all manner of users.

Q-2 Define DGPS.
Ans : Differential positioning user finds the point position derived from the satellite signals and applies correction to that position. These corrections, difference of the determined position and the known position are generated by a Reference Receiver ,whose position is known and is fed to the instrument and are used by the second Receiver to correct its internally generated position. This is known as Differential GPS positioning.

Q-3 Define the horizontal collimation error in a total station.

Horizontal collimation or line of sight error is when the line of sight is not perpendicular to the tilting axis of the instrument. This is an axial error.
Line of sight error effects the horizontal angle readings and increases with steep sightings. The error can be overcome or eliminated by observing on two faces.

POSSIBLE LONG TYPE QUESTIONS

Q-1 Write about the process of rover station setup and base station setup in DGPS.
Q-2 Write the process of the measuring the elevation of a point through ETS.

CHAPTER NO-08
BASICS OF GIS AND MAP PREPARATION USING GIS

Learning objectives

8.1 Components of GIS, Integration of Spatial and Attribute Information
8.2 Three Views of Information System
8.2.1 Database or Table View, Map View and Model View
8.3 Spatial Data Model 8.4 Attribute Data Management and Metadata Concept
8.5 Prepare data and adding to Arc Map.
8.6 Organizing data as layers.
8.7 Editing the layers.
8.8 Switching to Layout View.
8.9 Change page orientation.
8.10 Removing Borders.
8.11 Adding and editing map information.
8.12 Finalize the map

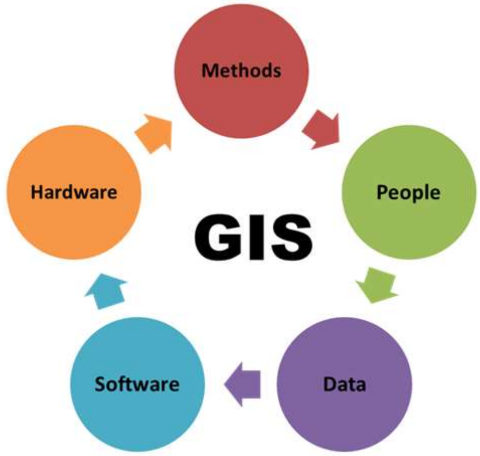
Geographic Information Systems (Gis)

A Geographic Information System (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows users to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps users answer questions and solve problems by looking at data in a way that is quickly understood and easily shared, and GIS technology can be integrated into any enterprise information system framework.
A GIS is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. GIS technology integrates common database operations, such as query and statistical analysis, with the unique visualization and geographic analysis benefits offered by maps.

8.1 COMPONENTS OF GIS , INTEGRATION OF SPATIAL AND ATTRIBUTE INFORMATION

Hardware

Hardware is the computer on which a GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in standalone or networked configurations.



Software
GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are:

- A database management system (DBMS).
- Tools for the input and manipulation of geographic information .
- Tools that support geographic query, analysis, and visualization.
- A graphical user interface (GUI) for easy access to tools .

People
GIS technology is of limited value without the people who manage the system and to develop plans for applying it. GIS users range from technical specialists who design and maintain the system, to those who use it to help them do 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.

Data
Maybe the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or bought from a commercial data provider. Most GIS employ a DBMS to create and maintain a database to help organize and manage data.

INTEGRATION OF SPATIAL AND ATTRIBUTE INFORMATION

GIS play fundamental role in the application of spatial data to any environmental modeling with or without remote sensing data. The integration of spatial data and corresponding attribute data which refer to qualities or characteristics of places with spatial and location information (data base management systems) with the help of computers have revolutionized environmental modeling. These developments have played a prominent role in rapid and reliable analysis of spatial data.

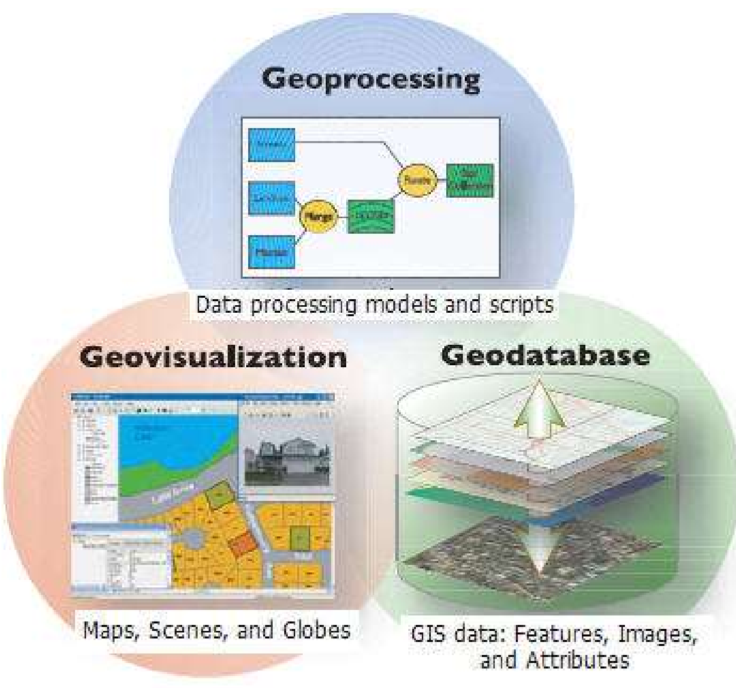
8.2 THREE VIEWS OF INFORMATION SYSTEM

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

- Database or table view
- Map view
- Model view

Database or table view ,Map view and Model view

The database 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).
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.
The model 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.



8.3 SPATIAL DATA MODELS

A data model is a way of defining and representing real world surfaces and characteristics in GIS. There are two primary types of spatial data models: Vector and Raster.
Vector data represents features as discrete points, lines, and polygons
Raster data represents features as a rectangular matrix of square cells (pixels)

Vector Data Model
Vector data is very common, and is often used to represent features like roads and boundaries. Vector data comes in the form of points and lines that are geometrically and mathematically associated.

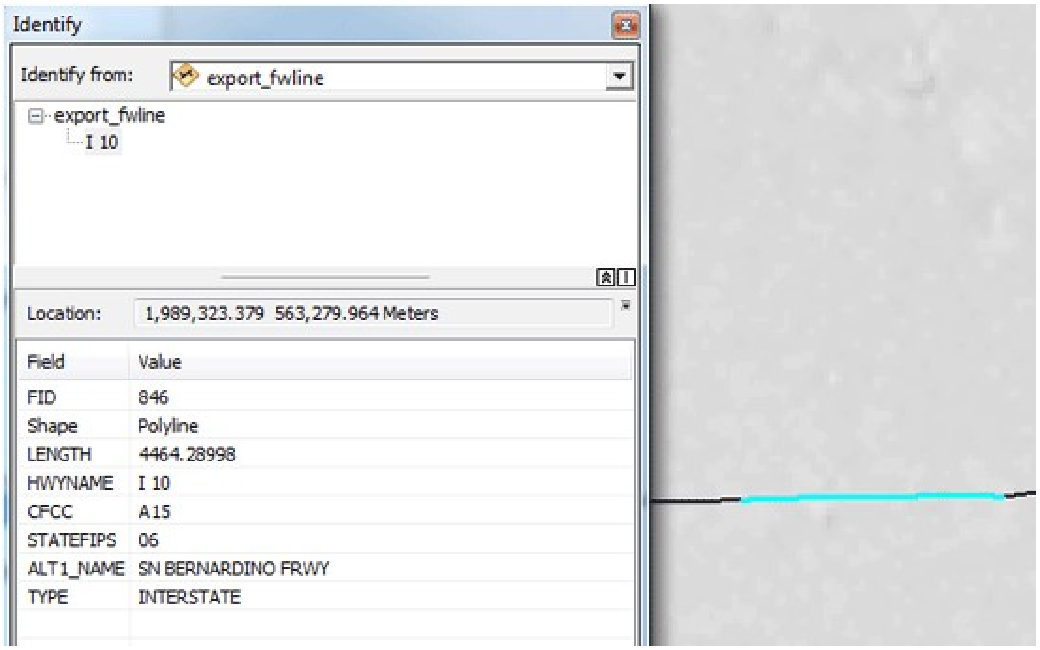
Raster Data Model
Raster data models represents surfaces as a matrix of cells, more commonly known as pixels, that are organized into rows and columns. Each cell contains a value that represents data. When you use a digital camera to capture a photo, your image is being stored as raster data. In remote sensing, a majority of the data encountered is raster data. The below image is a Digital Elevation Model (DEM) which is a common type of raster data. Each pixel represents the elevation of the area on the ground. Raster data models can be used to store reflectance data, elevation data and categorical data like soil or land cover type

8.4 ATTRIBUTE DATA MANAGEMENT AND METADATA CONCEPT FOR GIS

There are two components to GIS data: spatial information (coordinate and projection information for spatial features) and attribute data. Attribute data is information appended in tabular format to spatial features. The spatial data is the where and attribute data can contain information about the what, where, and why. Attribute data provides characteristics about spatial data.

Types of Attribute Data

Attribute data can be store as one of five different field types in a table or database: character, integer, floating, date, and BLOB.
Character Data
The character property (or string) is for text based values such as the name of a street or descriptive values such as the condition of a street. Character attribute data is stored as a series of alphanumeric symbols.
Numeric Data
Integer and floating are numerical values (see: the difference between floating and integer values). Within the integer type, the is a further division between short and long integer values. As would be expected, short integers store numeric values without fractional values for a shorter range than long integers. Floating point attribute values store numeric values with fractional values. Therefore, floating point values are for numeric values with decimal points (i.e numbers to the right of the decimal point as opposed to whole values).
Numeric values will be sorted in sequentially either in ascending (1 to 10) or d



Metadata concept

Information that describes items in ArcGIS is called metadata. When care is taken to provide good descriptions, you can find appropriate items with a search and evaluate which of the items in your search results is the correct one to use.

In an item's metadata you can record whatever information is important for your organization to know about that item. This might include information about how accurate and recent the item is, restrictions associated with using and sharing the item, important processes in its life cycle such as generalizing features, and so on.

A metadata style configures ArcGIS to create the metadata you want. Choosing a metadata style is like applying a filter to an item's metadata. The style controls how you view the metadata and also the pages that appear for editing metadata in the **Description** tab. A metadata style may be designed to support a metadata standard or profile. If so, the style will determine how metadata is exported and validated for that standard or profile.

8.5 PREPARE DATA AND ADDING TO ARC MAP

There is a big difference between the concepts of data and information. A GIS is a Geographical Information System, but it uses geographical data.

Data is a set of values or elements used to represent something. For instance, the string 502132N is data.

We can interpret that data as being a geographical reference, in which case it could be a latitude value, in particular 50_210 3200 North. If we interpret it as being a reference to an identity card (such as a driver's license) associated with a person, the information that we get is completely di_erent. It is the same data, containing six digits and a letter, but the information that we extract from it is di_erent, since we understand and interpret it differently.

The metadata editor and buttons in the **Description** tab, the buttons on the **Metadata** toolbar in **ArcCatalog**, and most of the metadata geoprocessing tools are designed to work with information stored in the new ArcGIS metadata format. If you have metadata created with ArcGIS Desktop 9.3.1 or the FGDC metadata editor add-in, or a stand-alone XML file containing metadata stored in a standard-compliant format, you can view that content in the current version of ArcGIS for Desktop, but it is read-only. Existing content must be upgraded to the new format, or standard-compliant XML files must be imported to ArcGIS before you can edit content and use the buttons in the **Description** tab

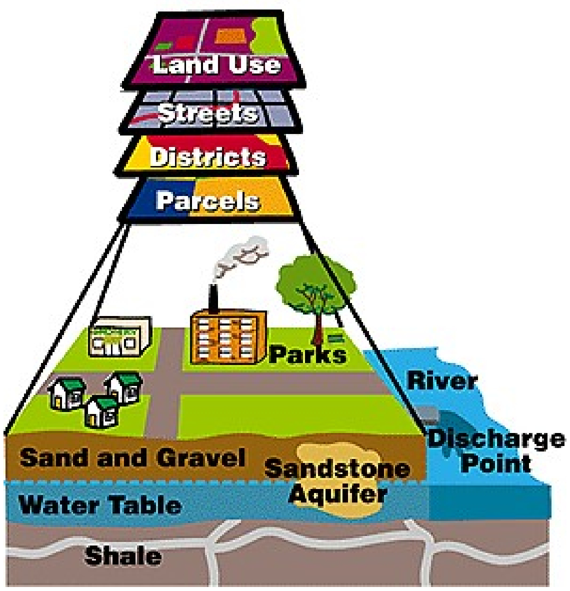
8.6 ORGANIZING DATA AS LAYERS

Layer

Layers are used in GIS based on ease of use and data collection. If you think about the way most data is collected, layers make sense. Data is generally collected as a layer (i.e. a road survey collects data about roads, a vegetation survey collects data about vegetation).

A map layer is a GIS database containing groups of point, line, or area (polygon) features representing a particular class or type of real-world entities such as customers, streets, or postal codes. A layer contains both the visual representation of each feature and a link from the feature to its database attributes. Maps in a Geographic Information System are made by combining multiple layers.

In any GIS project a variety of data layers will be required. These must be identified before the project is started and a priority given to the input or digitizing of the spatial data layers. This is mandatory, as often one data layer contains features that are coincident with another, e.g. lakes can be used to define polygons within the forest inventory data layer. Data layers are commonly defined based on the needs of the user and the availability of data. They are completely user definable.



The definition of data layers is fully dependent on the area of interest and the priority needs of the GIS. Layer definitions can vary greatly depending on the intended needs of the GIS.

When considering the physical requirements of the GIS software it is important to understand that two types of data are required for each layer, attribute and spatial data. Commonly, data layers are input into the GIS one layer at a time. As well, often a data layer is completely loaded, e.g. graphic conversion, editing, topological building, attribute conversion, linking, and verification, before the next data layer is started. Because there are several steps involved in completely loading a data layer it can become very confusing if many layers are loaded at once.

The proper identification of layers prior to starting data input is critical. The identification of data layers is often achieved through a *user needs analysis*. The user needs analysis performs several functions including:

- identifying the users;
- educating users with respect to GIS needs;
- identifying information products;
- identifying data requirements for information products;
- priorizing data requirements and products; and
- determining GIS functional requirements.

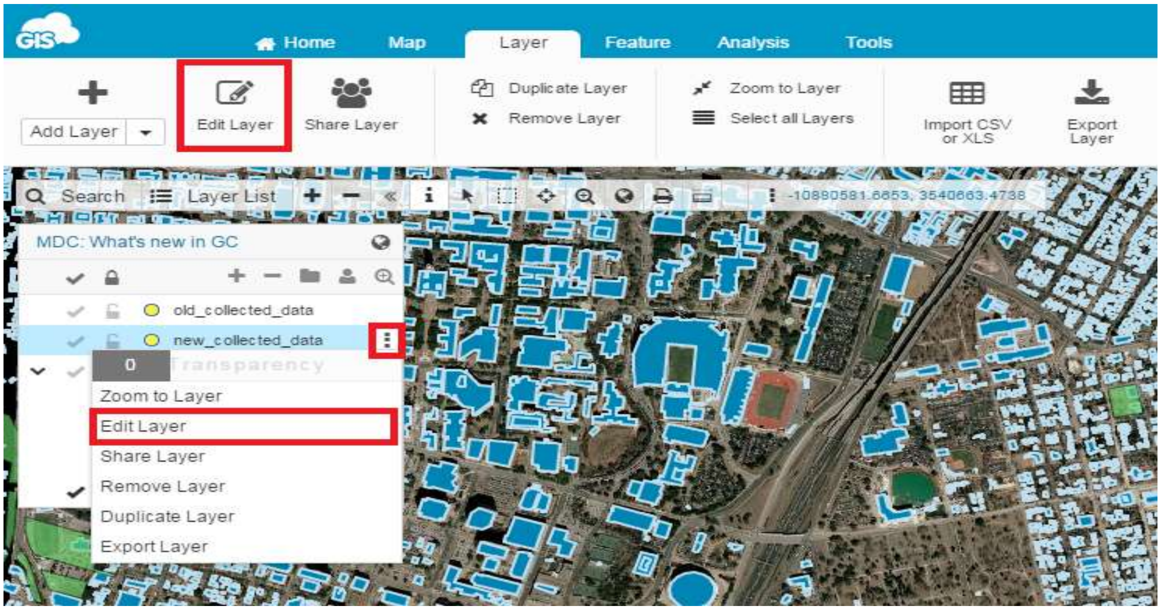
8.7 EDITING THE LAYERS

Creating a new layer

In addition to uploading data layers, you can also create new layers by following the steps listed below:
Select the Layer Tab.
Select Create Layer from the Add layer dropdown menu.
Choose or enter the data (attributes) that the layer will have:
Table name – Enter the name of your new data layer.
Geometry type – Select point, line, multiline, polygon or multipolygon as your feature type.
Projection – Select a new projection or select an existing one being used in the active map.
Overwrite if exists – You have the option to overwrite an existing data layer if it bears the same name as your new data layer.
Copy Structure Form – You may define the structure of your data layers table by copying the attribute table from another existing layer. This operation does not define point, line or polygon geometry.
Attributes – Enter the desired field names for your new data layer and define the field type:
String – Input any text
Real – Input numbers containing a decimal point
Integer – Input whole numbers

Layer Editing

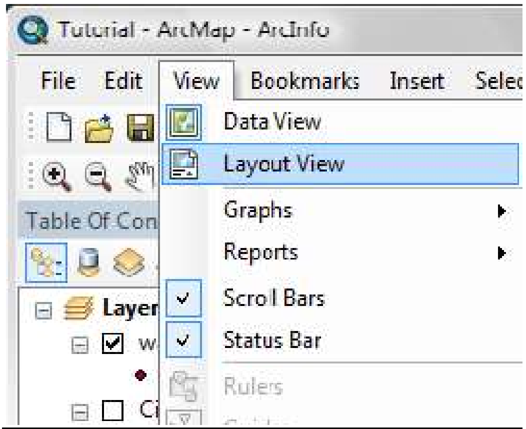
A layer can be edited through Layer Properties. There are several ways to access Layer Properties:
Double click on the layer in the Layer List.
Select a layer and Edit Layer tool from the Layer tab.
Select Edit Layer function from the dropdown menu.



Visual editing
It is possible to visually edit a layer through Layer Properties and Appearance.
Double click on a layer to open Layer Properties.
Click on the colored square.
Style – set visual settings: colors, symbology, line width, hatch patterns.
Labels – set persistent labels.
Levels – set from which to which zoom level layer will be visible.
Here you can find more information about visual layer editing.
Geometry editing
Features in the layer can be edited by following these steps:
Select a layer on the Layer List.
Select the Edit feature from the ribbon (on the Feature tab).
Select the feature which geometry you wish to edit and move the point to the desired location.
Choose Save to save a new point location or Cancel to undo editing.

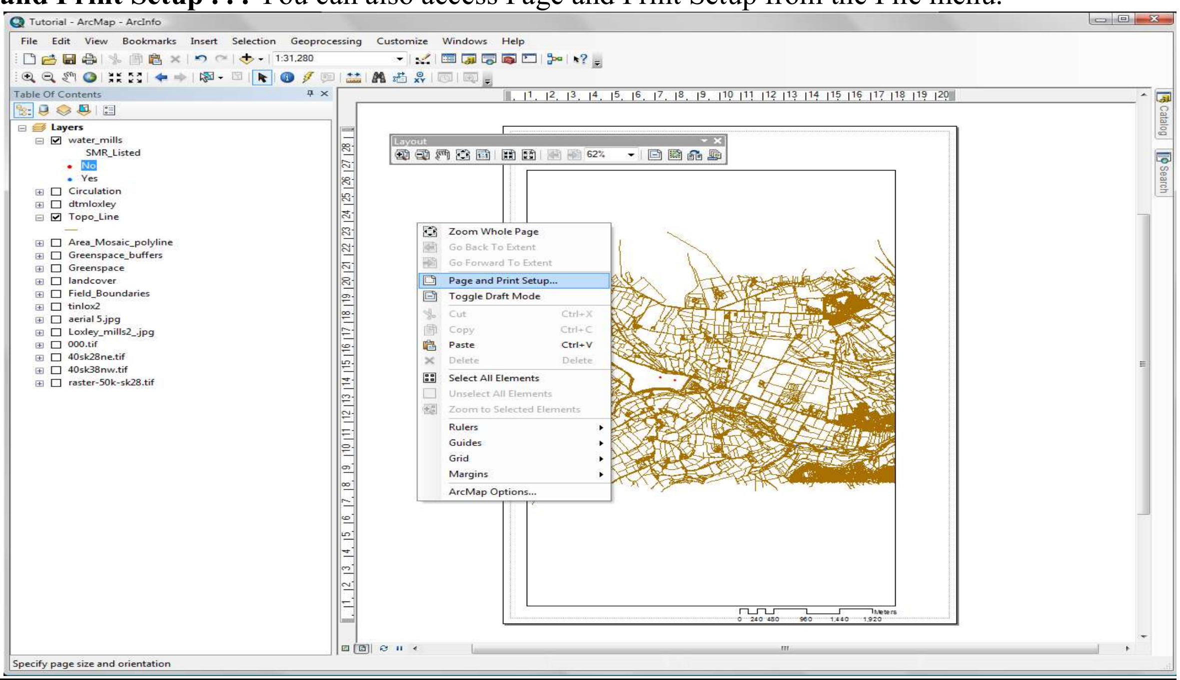
8.8 SWITCHING TO LAYOUT VIEW

Up until now you have been working in ArcMap's data view. The **'Data View'** is used for exploring and editing the
data layers. ArcMap also has a **'Layout View'**, which is used to view and set out maps for exporting and printing.
To access the layout view, click on '**View**' in the menu bar along the top of the ArcMap window. Select **'Layout**
View'. The **'Layout'** toolbar will appear and the map display area will change to show the page layout with rulers
along the top and side. You can also access the **Layout** toolbar from Customize,
Toolbars, Layout.
***Note:** It is best to finish symbolising your data in the 'Data
View' before you begin setting out your layout plan.
Any changes to the layers in the 'Data View' will update in the layout view.



8.9 CHANGE PAGE ORIENTATION

To access the page and print set up, right click anywhere in the white background of the layout view. Select **Page and Print Setup . . .** You can also access Page and Print Setup from the File menu.



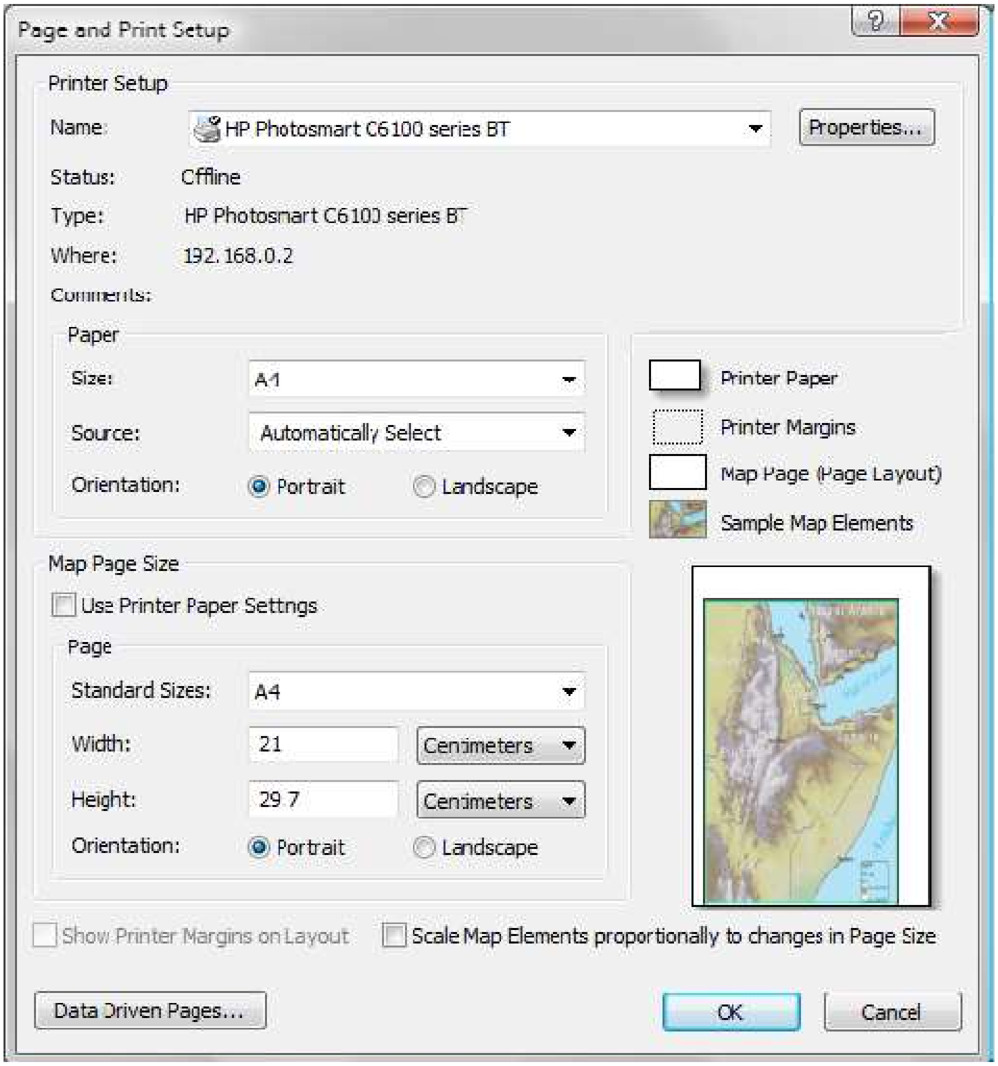
Make sure that under **'Map Page Size'** the option to '**Use printer Paper Settings**' is **not** ticked. You will then be able to select a page size and paper orientation. You do not have to select aprinter at this stage.

Set the layout's page size and orientation using the options under 'Map Page Size'.

The option at the bottom of the window **'Scale Map Elements proportionally to changes in Paper Size'** will rescale your data to fit your new page size.

When you are happy with your settings, click **OK**.

The layout page and rulers will change according to the new page size and orientation. In this case the paper size has been increased and the orientation has been changed from portrait to landscape



8.10 REMOVING BORDERS

There are other options to customise a data frame, which can also be accessed in the 'Data Frame Properties' window. To access these options, right click on data frame's name in the table of contents and select **Properties**. Then click on the **Frame** tab.

It can also be done through a mosaic dataset:
After constructing the mosaic dataset, ArcGIS provides two ways to remove the black edges of the image. The first way is to set the Nodata value, and directly set the zero value to an invalid value, that is, set the zero value to a transparent color. The second method is to construct a Footprint, which obtains the image contour line by extracting the coordinates of the corner points and boundary points of the image.

8.11 ADDING AND EDITING MAP INFORMATION

Map authors build their maps to include the layers and configurations needed to achieve the purpose of the map. When one of the purposes of a map is to gather community or organizational input, the map author includes editable feature layers in the map. For example, an author might include an editable feature layer that allows the birding community to post their bird sightings directly on the map and

attach media files—such as photographs, audio files, and video files—to the specific observation points. Feature layer edits include adding, altering, or deleting the features on the map, as well as adding, altering, or deleting the information (attribute values) associated with the features. The edits you make to the feature layer in Map Viewer Classic are automatically saved to the layer; there is no Save button to click. When you add, delete, or edit a feature or attribute and realize you made a mistake, you can click **Undo** to delete your edit.
The following steps describe how to edit a feature layer in Map Viewer Classic. For instructions on editing tables in Map Viewer Classic, see Edit tables.
Open the map that contains the feature layer you want to edit in Map Viewer Classic, or open the feature layer in a new map.
If necessary, check the box beside the layer you want to edit, and click **Edit**.
Follow these steps to add a feature:
Choose a feature template for the layer from **Add Features**.
When adding a polygon or line feature that needs to align with or join to existing features, press the Ctrl key to enable snapping.
Click the location on the map where you want to add or draw a feature. If you are using snapping, continue to press the Ctrl key while drawing the new feature to keep snapping to the nearest existing feature.
When you finish adding the feature, a pop-up appears that allows you to populate the attributes for the new feature. The fields available are unique to the layer.
For each attribute, type a value that is relevant to the new feature or, if a drop-down list of values exists for the attribute, choose the relevant value from the list.
For the bird sightings map example, you might type the bird species, whether it was male or female, its approximate age (fledgling, juvenile, or adult), and the date and time you saw the bird.
If the layer is enabled to allow attachments, you can attach an image or other files relevant to the feature. To do this, click **Browse** in the **Attachments** section of the pop-up and choose the file from your computer. The file can be up to 10 MB in size. See Edit tables for a list of file types that are supported as attachments.

8.12 FINALIZING THE MAP

Map elements

- North arrows
- Scale bars
- Scale text
- Legends
- Frames
- Converting map elements to graphics

Converting map elements to graphics.

It is important to note that once you convert a map element into a graphic, it is no longer connected to its original data and will not respond to changes made to the map. For instance, with a legend element, if you decide to add another layer to the map after the legend has been converted to a graphic, the legend will not automatically update. It will have to be deleted and rebuilt again using the **Legend Wizard**. Therefore, it is a good idea to convert elements to graphics only after your map's layers and symbology are finalized.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1 Define GIS.

Ans : A Geographic Information System (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows users to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Q-2 what are the components of GIS?

Ans

- Hardware
- Software
- Data
- People
- Methods

Q-3 What do you mean by numeric data?

Ans: Integer and floating are numerical values (see: the difference between floating and integer values). Within the integer type, the is a further division between short and long integer values. As would be expected, short integers store numeric values without fractional values for a shorter range than long integers.

Q-4 Define layer in GIS.

Ans: Layers are used in GIS based on ease of use and data collection. If you think about the way most data is collected, layers make sense. Data is generally collected as a layer (i.e. a road survey collects data about roads, a vegetation survey collects data about vegetation

POSSIBLE LONG TYPE QUESTIONS

Q-1 Write about the views of GIS.

Q-2 Define layer and write the procedure for adding a layer.

Q-3 How to change the page orientation in GIS?