MODULE 1: CURVES

Curve is an arc of a circle or a parabola. Curves are provided on highways and railways to have a smooth change in the direction.

Depending on the place in which the curves are provided they are classified as horizontal curves (Curves provided in horizontal plane) and vertical curves (curves provided in vertical planes)

Classification of Curves:

A) **Simple curves**: A type of circular curve which has only one arc of a circle between the tangents.

B) Compound curves: It is a curve of two or more radii bending in the same direction.

C) **Reverse curve**: It is a curve of two or more radii bending in the opposite direction.

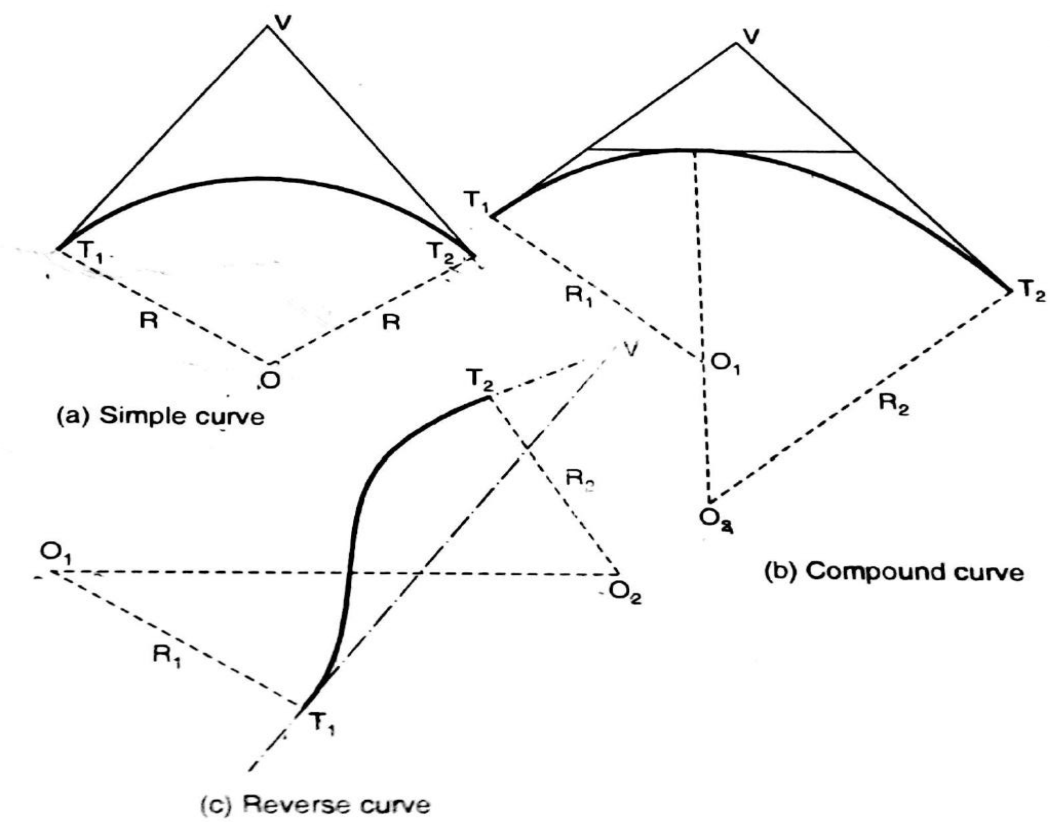


FIG. 1.1. CURVES.

Elements of a Simple Circular curve

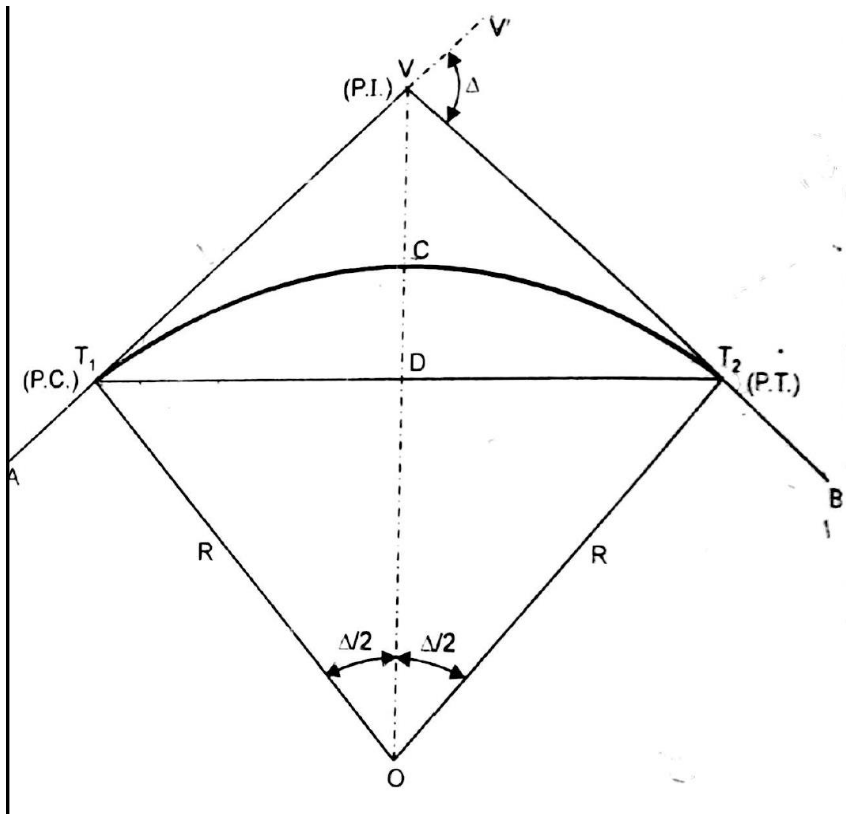


FIG. 1.2. PARTS OF A CIRCULAR CURVE.

R = Radius of simple circular curve, O = Centre of the simple circular curve

T_1 V = Back tangent / rear tangent, T_2V = Forward tangent

T_1 = Point of curve T_2 = Point of tangency, V = Point of intersection

Definitions & Notations

1. Tangent length = $T_1V= T_2V=T = R \tan \Delta/2$

2. Long chord length= $T_1 T_2 = L= 2R \sin \Delta/2$

3. Length of curve= $l = \pi R\Delta / 180$

4. Mid ordinate =CD= $O_0 = R (1 - \cos \Delta/2)$

5. Vertex distance/external distance : VC= $R (\sec \Delta/2 - 1)$

Designation of a curve

Degree of curve is expressed in terms of either:

a. Radius : (Adopted in Britain)

b. Degree of curve : (Adopted in India, USA, Germany)

Degree of curve is the central angle subtended at the centre by an arc of 30m /20 m length.

Setting Out Curves:

Simple circular curves can be set out by two methods.

a. **Linear method**: Here, only chain and tape is used as a major device for setting out curves. The method is adopted for small curves and in roadway construction.

b. **Angular / Instrumental method**: Here theodolite is used as a major device along with tape and chain. The method is adopted in setting out large curves, in railway line construction and where accuracy is preferred.

Linear method of setting out curves:

Following are the different methods through which simple circular curve is set on the field.

D) **Reverse curve**: It is a curve of two or more radii bending in the opposite direction.

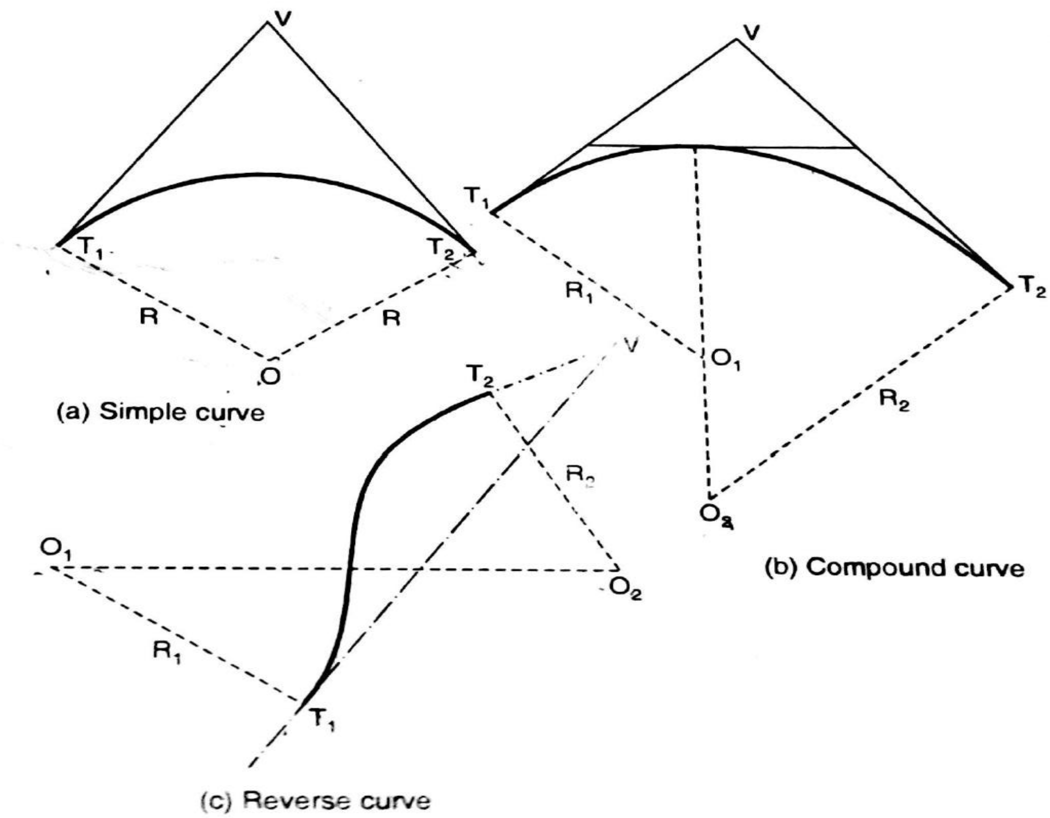
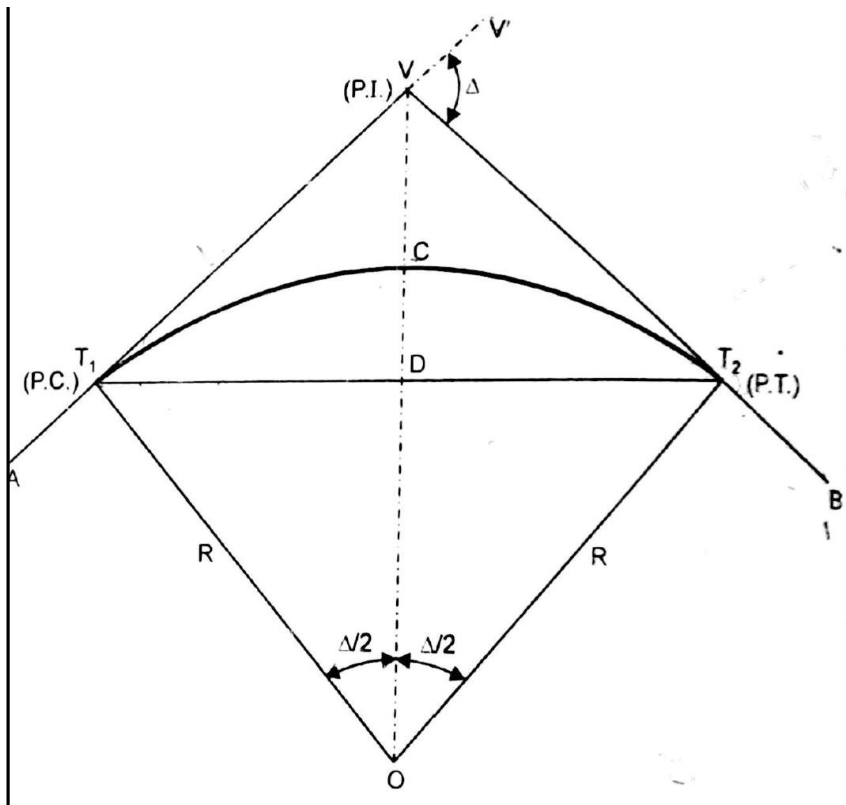


FIG. 1.1. CURVES.

Elements of a Simple Circular curve



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8. Length of curve=l= $\pi R\Delta / 180$

9. Mid ordinate =CD=O_0 = $R (1 - \cos \Delta/2)$

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Designation of a curve

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Setting Out Curves:

Simple circular curves can be set out by two methods.

c. **Linear method**: Here, only chain and tape is used as a major device for setting out curves. The method is adopted for small curves and in roadway construction.

d. **Angular / Instrumental method**: Here theodolite is used as a major device along with tape and chain. The method is adopted in setting out large curves, in railway line construction and where accuracy is preferred.

Linear method of setting out curves:

Following are the different methods through which simple circular curve is set on the field.

1. **Offsets from long Chord:**

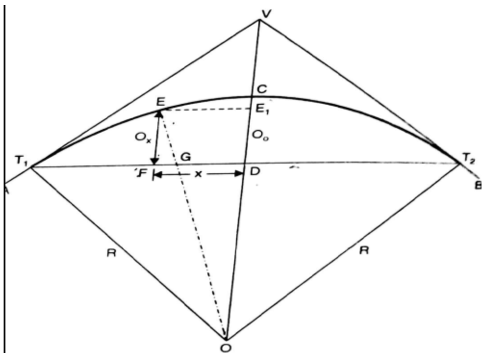


FIG. 1.5. BY ORDINATES FROM THE LONG CHORD

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

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

2. **By successive bisection of chords:**

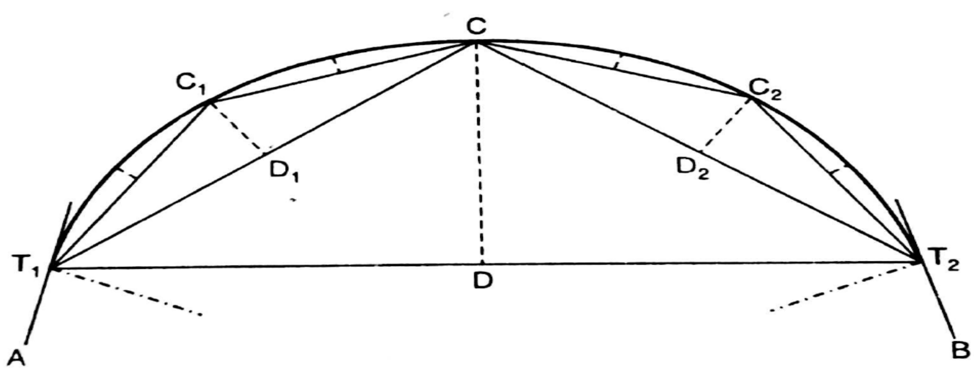


FIG. 1.6. SUCCESSIVE BISECTION OF ARCS.

Calculations: $CD = R(1-\cos\Delta/2)$,

$C_1D_1 = C_2D_2 = R(1-\cos\Delta/4)$

3. Offset from tangents:

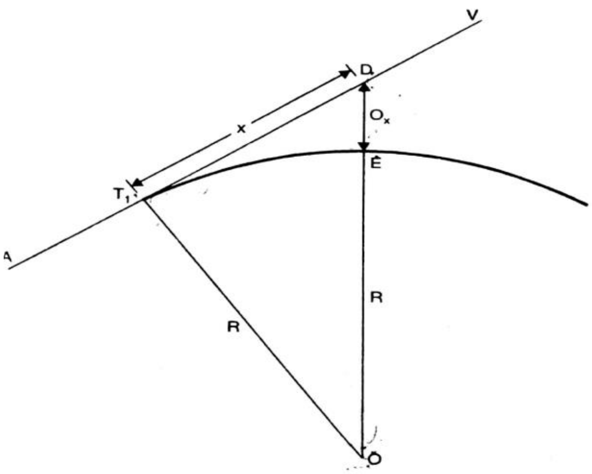
<table>
<tr><th>Radial offset method</th><th>Perpendicular offset method</th></tr>
<tr><td>


FIG. 1.7. SETTING OUT BY RADIAL OFFSETS.

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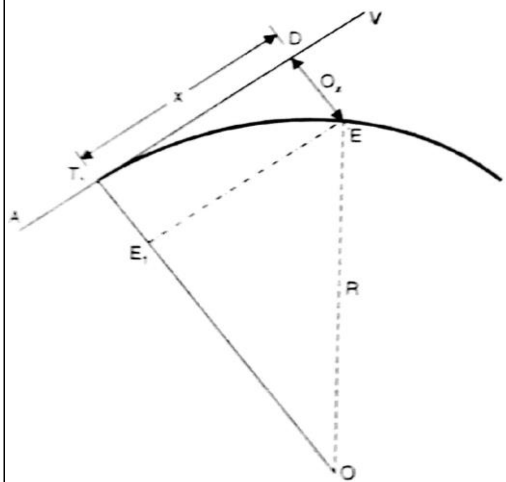

FIG. 1.8. SETTING OUT BY PERPENDICULAR OFFSETS

$$O_x = \sqrt{R^2 + x^2} - R$$
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4. Offsets from chord produced (Deflection distance method)

This method is an important one which is used to set out large curves on high ways or railway constructions.

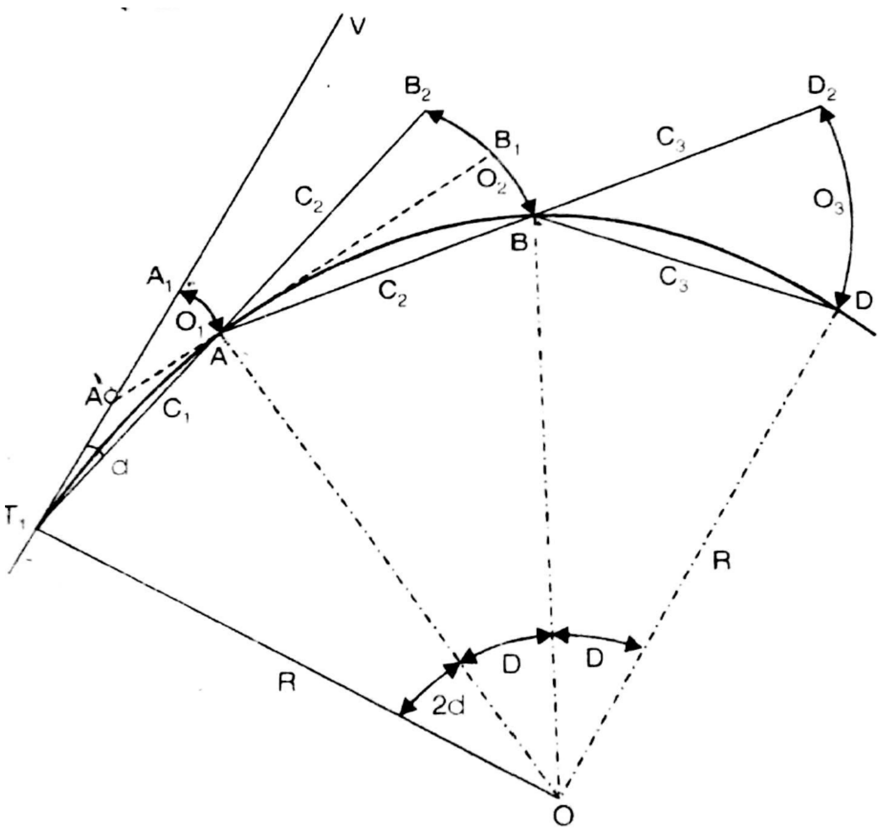


FIG. 1.9. SETTING OUT THE CURVE BY DEFLECTION DISTANCES.

On=Cn/2R(Cn-1+Cn)

Problems:

1) Calculate the necessary data required to set out a simple circular curve when two tangents intersect at an angle of 132^0 for a radius of curve – 48m by the method of (a) Perpendicular offset from tangent (b) Deflection distance method (c) Offset from the long chord.

2) Two straight lines intersecting at an angle of 145^0 are to be connected by a circular curve of radius 250m. If the chain age of intersection is 1000m calculate the necessary data to set out a curve by the method of radial offsets from tangents. Take peg internal as 10m.

3) A circular curve of a radius of 90 + 20 chain is to be set between 2 tangents with the deflection angle of 48^0 the peg internal is taken as 1 chain length of 20m calculate the required data to set out the curve by the method of offsets from chords produced chain age of pt of intersection 1600m.

4) Two straight lines are intersecting at a chinage of 40+20 links. Calculate the data required to set out simple circular curve , having degree of curve as D = 20 by the method of perpendicular offsets from tangents and deflection angle 62^0.

Instrumental Method: Rankine's Method

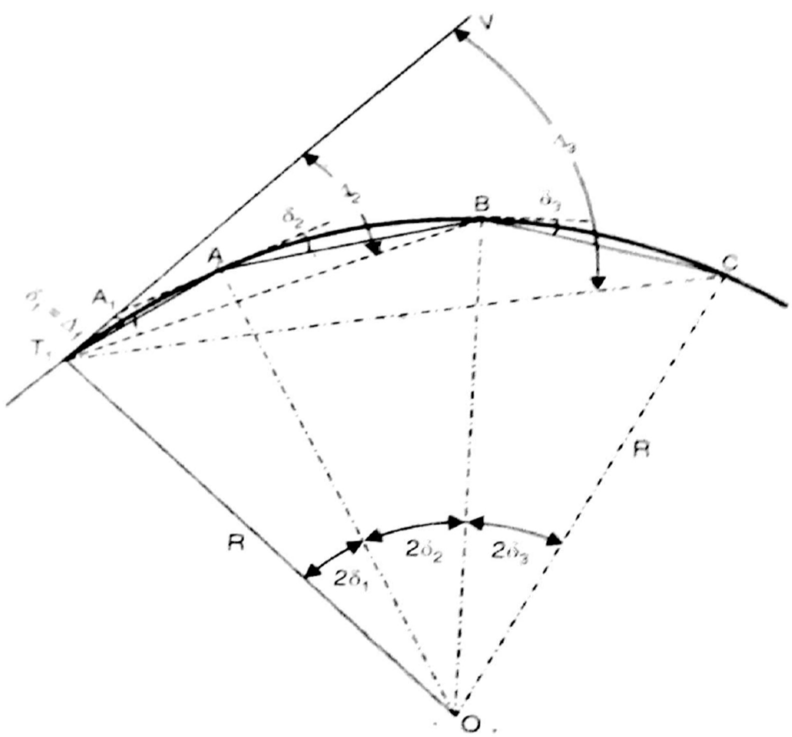


FIG. 1.10. RANKINE'S METHOD OF TANGENTIAL ANGLES

$$\delta = 1718.9 \frac{C}{R} \text{ minutes}$$

ELEMENTS OF A COMPOUND CURVE

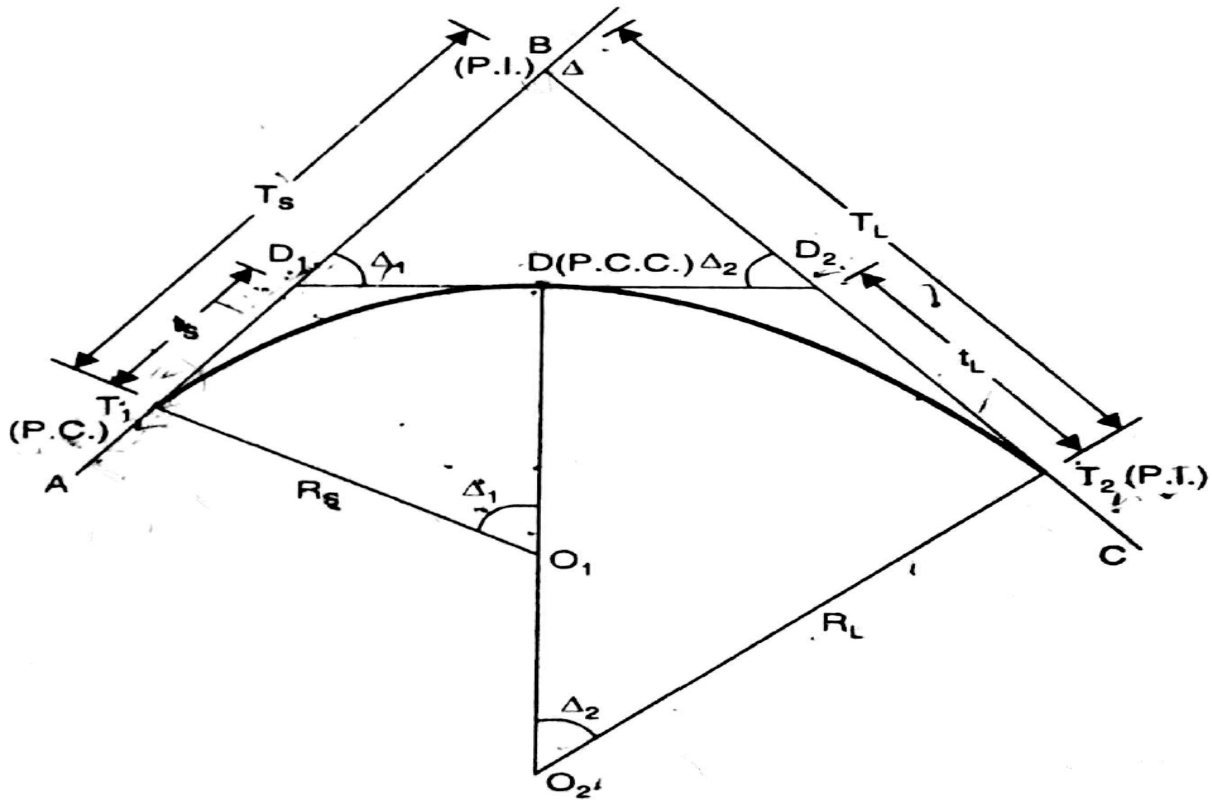


FIG. 2.1. TWO CENTRED COMPOUND CURVE.

Transition curves

Introduction

Transition curves: A non - circular curve of varying radius introduced between a straight and a circular curve for the purpose of giving easy changes of direction of route is called a Transition Curve.

Characteristics of Transition Curve

1. In order to fit in the transition curve at the ends a circular imaginary curve of slightly greater radius has to be shifted towards the center. The distance through which the curve is shifted is known as shift (S) of the curve equal to $L^2/24R$, where L is the length of each transition curve and R is the desired circular curve
2. Length of the combined curve is equal to

   $$= (R + S) \tan \Delta/2 + L/2$$
3. Spiral angle $\varphi_1 = L/2R$ radians
4. The central angle for the curve = $\Delta - 2\varphi_1$
5. Length of circular curve is equal to $\pi R(\Delta - 2\varphi_1) / 180^0$
6. Length of combined curve = $\pi R(\Delta - 2\varphi_1) / 180^0 + 2L$
7. Chainage of beginning of combined curve = chainage of intersection point – total length for combined curve
8. Chainage of junction point of transition curve and circular curve = chainage of tangent point + length of transition curve
9. Chainage of other junction point of the circular curve and the other transition curve is equal to chainage of E + length of circular curve.
10. Chainage of the end point of the combined curve = chainage of T + length of combined curve
11. The deflection angle for any point on the transition curve distant l from the beginning of combined curve = L/6R radians

Length of Transition Curve

1. Length may be assumed on the basis of experience and judgment.
2. Length may be such that super elevation is applied at a uniform rate 1 in 300 to 1 in 1200.
3. The length of the transition curve may be such that super elevation is applied at an arbitrary time rate of "a" cm/sec. The super elevation attained = (L/v) x a = h.
4. The radial acceleration on the circular curve is $L = v^3/CR$, where v is the speed in m/sec , C is the rate of change of radial acceleration in m/sec^2 , R is the radius of curve in meters.

Setting out Cubic Parabola and Bernoulli's Lemniscates

Bernoulli's Lemniscates is commonly used in road work where it is required to have the curve transitional throughout. The super elevation continuously increases till the apex is reached. It is used in preference to following reasons:

1. Radius of curvature decreases more gradually
2. Rate of increase of curvature diminishes towards the transition curve.
3. It corresponds to an autogenous curve of an auto mobile.

Vertical curves

Vertical curves are introduced at changes of gradient to avoid impact and to maintain good visibility. They are set out in a vertical plane to round off the angle and to obtain gradual change of gradient. They are also called as summit curves if they have convexity upwards and valley curves if they have concavity upwards.

Problems

1. Find the length of the vertical curve connecting two uniform

gradients of +0.8% and –0.6%. the rate of change of grad. being 0.1% per 30m.

Solution: Length of vertical curve = Algebraic difference of two grades / rate of change of grade

$$= [0.8 - (-0.6) / 0.1] \times 30$$

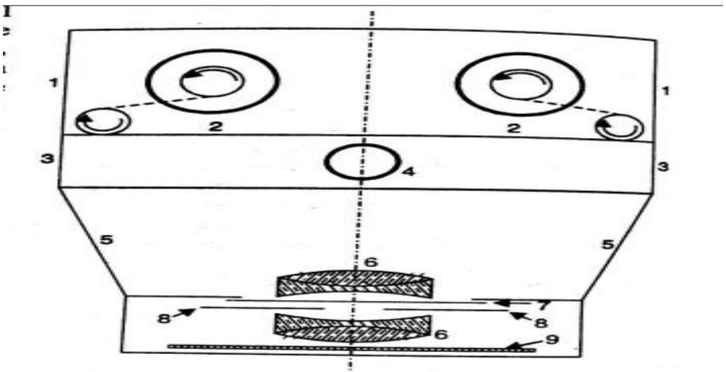
$$= 420m$$

MODULE 4: PHOTOGRAMMETRIC SURVEYING

Photogrammetry is the science and art of obtaining accurate measurements by using photographs for various purposes such as the construction of planimetric and topographic maps, classification of soils, interpretation of geology, acquisition of military intelligence etc.

1.1.1 Terrestrial Photogrammetry: It is the branch of Photogrammetry where in photographs are taken from a fixed position on or near the ground.

1.1.2 Aerial Photogrammetry: It is the branch of Photogrammetry where in photographs are taken by a camera mounted in an aircraft flying over the area.



1. MAGAZINE 2. FOCAL PLANE 3. BODY
4. TRUNNION 5. CONE 6. LENS
7. SHUTTER 8. DIAPHRAGM 9. FILTER

FIG. 14.16 SCHEMATIC DIAGRAM OF AERIAL CAMERA.

1.2 DEFINITION OF TERMS:

1.2.1 Vertical Photograph: It is an aerial photograph made with the camera axis coinciding the direction of gravity.

1.2.2 Titled Photograph: It is an aerial photograph made with the camera axis unintentionally tilted from the vertical by a small amount, usually less than 3°.

1.2.3 Oblique Photograph: It is an aerial photograph taken with the camera axis directed intentionally between the horizontal and the vertical.

1.2.4 Perspective Projection: It is the one produced by straight lines radiating from a common point and passing through points as the sphere or the plane of projection. A photograph is a perspective projection.

1.2.5 Exposure Station: It is a point in a space occupied by the camera lens at the instant of exposure.

1.2.6 Flying Height: It is the elevation of the exposure station above sea level or any other datum.

1.2.7 Flight line: It is a line drawn on a map to represent the track of the aircraft.

1.2.8 Focal Length: It is the distance from the front nodal point of the lens to the plane of the photograph.

1.2.9 Principal Point: It is a point where a perpendicular dropped from the front nodal point strikes the photograph.

1.3 Comparison between Aerial photograph and Topographic maps:

Sl. No.	Points of comparison	Aerial photo	Topo map
1.	Projection	Perspective	Orthographic
2.	Scale	Varying	Constant
3.	Convectional signs	Variation of light and shade	Standard symbols
4.	Portrayal of details	All details. Too much of unwanted details	Selective details according to importance
5.	Ground visits	Needed again for interpretation	Have it in one operation
6.	Facility of reading	Difficult	Easier
7.	Cost of reproduction	Costly	Cheaper
8.	Distortion	Various distortion due to lens, relief, tilt	No distortion
9.	Dimension of vision	3D possible with stereos	2D only
10.	Nomenclature	No names of town roads, rivers	Names available
11.	Geographic details	No latitude, longitude	Graticules are furnished
12.	Uptodateness and reliability	Very much and used in military	Often outdated
13.	Time for making	Less	More
14.	Usefulness	Stereo photos better than a map	Map better than a single photo

1.4 Advantages and disadvantages of Photogrammetry:

1.4.1 Advantages:

- Useful in climate restricted areas such as arctic, tropical and desert areas.
- Useful for remote, swampy, marshy or heavily wooded areas.
- Personnel requirement (Technical) is less.
- Gives panoramic perspective view.
- Objection by the land owners for convectional survey can be overcome.
- Photograph is more up to date and reliable.

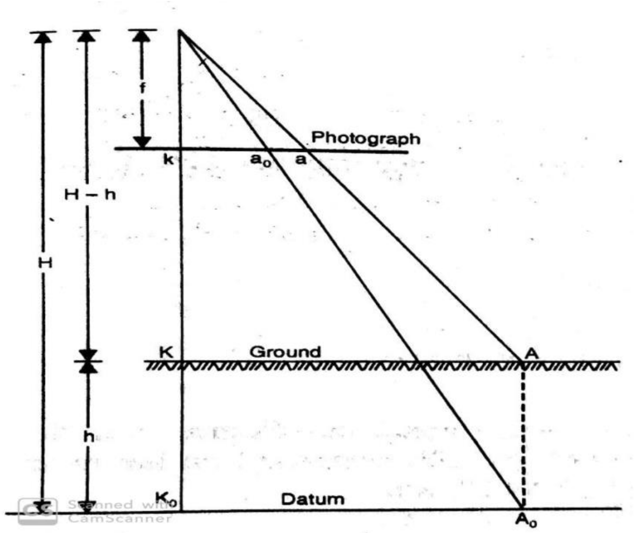
1.4.2 Disadvantages:

- Cloudy, rainy and snowy weather is unsuitable.
- Distortion of images.
- Professional skill and experience to study and interpret photographs is required.

Comparison between Aerial and Terrstrial photogrammetry

Sl. No.	Comparison	Aerial	Terrestrial
1	Configuration of terrain	Suitable for all type of terrain	Flat terrain is unsuitable
2	Scale	Low limits of variation	Tremendous variation
3	Accuracy in altimetry	Less	More
4	Accuracy in planimetry	Good	Less
5	Time requirement	Less	More
6	Equipment	Costly	Cheaper
7	Cost	Costly	Cheaper
8	Usefulness	More versatile	Less useful

To find the scale of a photograph:



Since the photograph is a perspective projection, the images of ground points are displaced where there are variations in the ground elevation. Thus in the figure the images of the two points A and Ao, vertically above each are displaced on a vertical photograph and are represented by a and a_o respectively. Due to this displacement, there is no uniform scale between the points.

Thus, Scale = $\frac{\text{map Distancee}}{\text{Ground distance}} = \frac{\text{ka}}{\text{H}-\text{KA}} = \frac{\text{f}}{\text{H}-\text{h}}$ Datum Scale = $\frac{\text{f}}{\text{H}}$

Where H= Height of exposure
f = focal length
h= Height of ground above msl

If the images of two ground points of equal elevation and know horizontal distance appear on the photograph, the scale of the photograph can be determined by comparing the ground length and the corresponding length.

$Scale = \frac{\text{l}}{\text{L}} = \frac{\text{Photo Distance}}{\text{Ground Distance}}$

If the focal length, flying height above msl is known then

$$Scale = \frac{\text{f}}{\text{H} - \text{h}}$$

Photographic scale can also be determined by comparing the photo distance and the map distance.

Thus, $\frac{\text{Photo Scale}}{\text{Map Scale}} = \frac{\text{Photo Distance}}{\text{Map Distance}}$

1. Derive an expression for the scale of a vertical photograph when the terrain is flat.

2. The elevation of a point A is 123.2 m and the scale at that point on the aerial photograph is 1:32000. The elevation of point B is 275.6 m. compute the scale at the image for point B and the average scale of photograph, if the focal length is 152.4 mm.

3. A vertical photograph is taken from a flying height of 2670m above an airport where the elevation is 380m above sea level. Determine the representative fraction, expressing the scale of the photograph al a point at which the elevation is 221m above sea level. The focal length of the lens is 152.4 mm. (6 Marks)

4. A section line AB appears to be 10.16 cm on a photograph for which the focal length is 16 cm. The corresponding line measures 2.54 cm on a map, which is to a scale of 1/50000. The train has an average elevation of 200 m above mean sea level. Calculate the flying altitude of the aircraft above mean sea level when the photograph was taken. (10 Marks)

5. On a vertical photograph a runway measured 150 mm. The same runway measured 100 mm on a map plotted to a scale of 1 in 20000. Determine the scale of the photograph. If the focal length of the camera is 15 cm and the mean elevation of the runway above MSL is 1250 m. calculate the flying height of aircraft above MSL.

PROBLEM ON DETERMINING THE LENGTH BETWEEN TWO STATIONS

14.12. COMPUTATION OF LENGTH OF LINE BETWEEN POINTS OF DIFFERENT ELEVATIONS FROM MEASUREMENTS ON A VERTICAL PHOTOGRAPH

In Fig. 14.21, let A and B be two ground points having elevations h_a and h_b above datum, and the co-ordinates (X_a, Y_a), (X_b, Y_b) respectively with respect to the ground co-ordinate axes which coincide in direction with the photographic co-ordinates x and y-axis. The origin of the ground co-ordinates lie vertically beneath the exposure station.

Let a and b be the corresponding points of the photograph, and (x_a, y_a), (x_b, y_b) be the corresponding co-ordinates. From similar triangles,

$$\frac{Ok}{OK_a} = \frac{x_a}{X_a} = \frac{y_a}{Y_a} = \frac{f}{H - h_a} \quad ..(1)$$

Also,

$$\frac{Ok}{OK_b} = \frac{x_b}{X_b} = \frac{y_b}{Y_b} = \frac{f}{H - h_b} \quad ..(2)$$

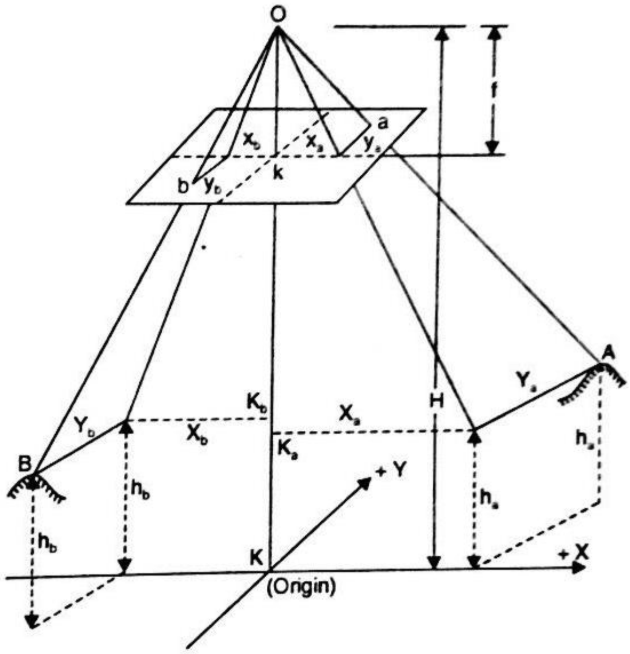


FIG. 14.21. COMPUTATION OF LENGTH OF A LINE.

Hence, we have

$$X_a = \frac{H - h_a}{f} \cdot x_a \quad ...[14.14\ (a)]$$

$$Y_a = \frac{H - h_a}{f} \cdot y_a \quad ...[14.14\ (b)]$$

$$X_b = \frac{H - h_b}{f} \cdot x_b \quad ...[14.14\ (c)] \quad ; \quad Y_b = \frac{H - h_b}{f} \cdot y_b \quad ...[14.14\ (d)]$$

And, in general, the co-ordinates X and Y of any point at an elevation are :

$$X = \frac{H - h}{f} x \quad ; \quad Y = \frac{H - h}{f} y.$$

The length L between the two points A and B is then given by

$$L = \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2} \quad ...(14.15)$$

The value of X_a, X_b and Y_a and Y_b must be substituted with their proper algebraic signs.

- Two points A and B which appear in a vertical photograph taken from a camera having a focal length of 150mm and from an altitude of 2300m, have their elevation as 350m and 400m respectively. Their corrected photo co-ordinates are as under.

Point	Photo co-ordinates	
	X (mm)	Y (mm)
A	+ 21.5	+ 15.2

B	-14.2	-25.3

Determine the length of ground line AB. (10 Marks)

(Ans: AB=692.4 m)

Flight Planning

Flight Planning for Aerial Photography

When vertical photographs are to be used for the preparation of maps, photographs are to be taken at proper interval along each strip to give the desired overlap of photograps. Each strip is spaced at predetermined distances to ensure desired side lap between adjacent strips.

The overlap of photographs in the direction of flight line is called longitudinal overlap and it should be 55 to 65%. The overlap between adjacent flight lines is known as lateral or side lap and it will be about 15 to 35%.

Reasons for Overlap:

1) To tie the different points together accurately.
2) To view the pairs of photographs stereoscopically
3) If the flight line is not maintained straight and parallel, the gap between adjacent strips will be left. These gaps can be avoided by having side lap.
4) Due to overlap, each portion of the territory is photographed 3 to 4 times. Hence any picture distorted can be rejected.

Flight Planning data:

The following information is required by a photographer for effective and successful planning.

1. Camera Focal Length
2. Photographic scale
3. 3. Flight attitude
4. Ground coverage
5. Air base
6. Base-height ratio
7. Flight line spacing
8. No. of Flight lines
9. No. of Photographs per flight line
10. Total No. of Photographs
11. No. of Film rolls
12. Exposure
13. Max exposure time
14. Drift Angle

No. of photographs necessary to cover a given area:

Number of Photographs=N= $\frac{A}{a}$

Where A= Area of the field to be photographed

a= net ground area covered by each photograph

a= $(1-P_l)Sl\ (1-P_w)\ Sw$

S= Scale of the field to be photograph

P_l= longitudinal overlap

P_w= side over lap

l = length of the photograph

w = width of the photograph

No. of photographs necessary to cover a given area:-

Instead of total area, If rectangular strip is given, the number of photographs required are computed by calculating the number of strips and the number of photographs required in each strip and multiplying the too.

No. of photographs in each strip= $N_1 = \frac{L_1}{(1-Pl)Sl} + 1$

No. of strips $= N_2 = \frac{L_2}{(1-Pw)Sw} + 1$

$$N = N_1 \times N_2$$

Interval between exposure:

$$t = \frac{(l-Pl)sl}{v}$$

V=Velocity of Aircraft in m/s

Problems on flight planning

1.The scale of an aerial photograph is 1cm=100m.the photograph size is 20cmx20cm.determine the number of photographs required to cover an area 100 sq.km,if the longitudinal lap is 60% and the side lap is 30%.

(Ans. a=1.12 Sq.km N=90)

2. An area 45km in North South direction and 38km in East West direction is to be photographed with a lens having focal length 200mm.the photograph size is 20cmx20cm.The average scale is to be 1:10,000 effective at an elevation of 420m above datum. Overlap is to be 60% and the side lap is to be 30%.the ground speed of the aircraft will be maintained at 210kmph.Calculate

i)Flying height of the aircraft

ii)No. of photographs in each flight

iii)No. of flights

iv)Total no. of photographs

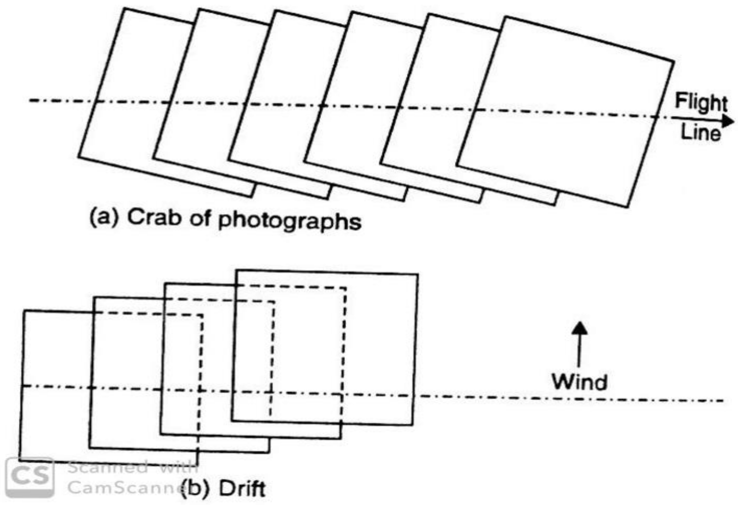
v)Exposure interval

(Ans.H=2420m,N1=58,n2=29,N=1682,t=14s)

Crab: It is the term used to designate the angle formed between the flight line and the edges of the photograph in the direction of flight.

If the camera is not squared with the direction of flight crab is caused. Crabbing should be eliminated since it reduces effective coverage of the photograph.

Drift: It is caused by the failure of the Aircraft to stay on the predetermined flight line due to wind velocity.



Mosaics

Mosaics-Vertical photographs look like the ground that a set can be fitted together to form a map like photograph. Such as assembly of a series of overlapping photographs is called as mosaics. A mosaics has an overall average scale comparable to the scale of a planimetric map.

Types-(1) Controlled mosaics (2) Uncontrolled mosaics

A Controlled mosaic is obtained when the photographs are carefully assembled so that the horizontal control points agree with the plotted positions,making controlled mosaic is an art. A mosaic which is assembled without regard to any plotted control is called as uncontrolled mosaic.

The photographs are laid in a sequence to allow the photo number and flight number of each photograph. This assembly is called an index mosaic and it is a form of uncontrolled mosaic.

A mosaic differs from a map in the following respects.

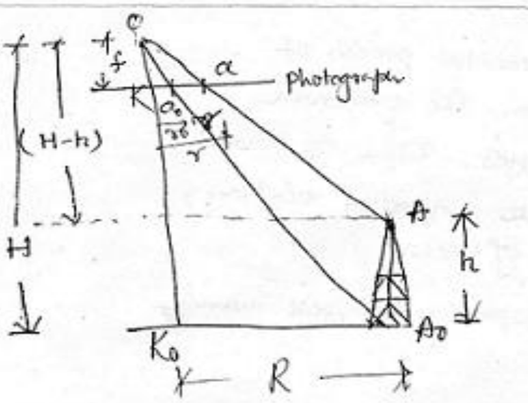
1) A mosaic is a series of perspective of the area where as map is a single orthographic projection.
2) A mosaic contains relief displacement. Tilt distortion and non uniform scale, which map is a uniform scale.
3) Realistic photographic images on a mosaic, where as they are portrayed by standard symbols on a map.

Uses of Mosaics

1) Useful in land use planning
2) Useful in planning engineering projects
3) Soil type, drainage pattern, geological features can be identified.
4) Used to study natural resources
5) To study the growth of cities
6) Useful for reservoir planning.

Relief displacement on a vertical photograph:

When the ground is not horizontal, since the photograph is perspective view, the ground relief is seen on the photograph. The displacement of a point from its true orthographic position is known as relief displacement.



From Similar Δle,

$$\frac{f}{(H-h)} = \frac{r}{R} \quad \therefore r = \frac{R \cdot f}{H-h}$$

Also

$$\frac{f}{H} = \frac{r_0}{R}, \quad \therefore r_0 = \frac{Rf}{H}$$

Relief displacement (d) is given by

$$d = r - r_0 = \frac{Rf}{H-h} - \frac{Rf}{H}$$

$$d = \frac{Rfh}{H(H-h)}$$

But $R = \frac{r(H-h)}{f} = \frac{r_0 H}{f}$

$$d = \frac{r(H-h)}{f} \cdot \frac{Rfh}{H(H-h)} = \frac{rh}{H} \quad \text{—① ie} \quad d = \frac{rh}{H} \quad \text{—①}$$

$$d = \frac{r_0 H}{f} \cdot \frac{fh}{H(H-h)} = \frac{r_0 h}{H-h}, \quad d = \frac{r_0 h}{H-h} \quad \text{—②}$$

Characteristics of Relief Displacement

1. The relief displacement increases as the distance from the principal point increases.

2. The relief displacement decreases with the increase in the flying height.

3. For points above datum, the relief displacement is positive being radially out ward.

4. For points below datum , the relief displacement is negative, being radially inward.

5. The relief displacement of the point vertically below the exposure station is zero.

Problem on Relief displacement

- The flying height for a vertical photograph is -1500m. f=20.6cm.The distance measured from the centre of the photograph to the image of the bottom and top of a radio tower were found to be 6.92 cm and 7.85 cm. Compute the height of the tower.

Ground control for Photogrammetry :

The ground position of a point may be defined as its horizontal position w.r.t. horizontal datum. (called horizontal control or planimetry or x-y co-ordinates and its elevation w.r.t. to a level datum). The ground control survey consists in locating the ground positions of points which can be identified on Aerial photographs. The ground control is essential for establishing the position and orientation of each photograph in space relative to the ground. The ground survey for establishing the control can be divided into two parts.

1) Basic control (2) Photo control

The basic control consists of establishing horizontal and vertical control of stations. The points include triangulation and traverse stations, bench marks.

Photo control points are the actual image points appearing in the photos that are used to control photogram-metric operations. The horizontal photo control points are located w.r.t. the basic control by third or fourth order triangulation or traversing etce. vertical photo control is established by Fly leveling.

The photo control can be established by two methods.

I) Post marking method 2) Pre marking method

In the post marking method, the photo control points are selected after the aerial photography. The advantage of this method is in positive identification and favorable location of points.

In the premarking method, the photo control points are selected on the ground first and then included in the photograph. These marked points on the ground can be identified on the subsequent photograph. The control stations that are to be incorporated in the photo control network are marked with paint, flagsetc in such a way that identification on the photographs becomes easier. The selected control points should be sharp and clear in plan.

Photo interpretation:

Photo interpretation means identifying and recognizing the objects in the Aerial photographs. The success of a project depends upon thr ability of an engineer to interpret photographs accurately. A photo interpreter should have a lot of training, experience and patience. Interpretation is greatly assisted when a stereo pair is viewed stereoscopically. Local knowledge of the area, skill and experience will contribute towards correct interpretation. Colour photographs are easier to interpret compared to black and white photographs.

Characters of photo images:

1. **Shape:**Impo rtant factor for recognizing objects. A railway line can be distinguished from highway beacause it consists of long straight tangents and gentle curves.
2. **Size:**Objects can be misinterpreted of the sizes are not properly evaluated. A canal may be interpreted as road side drain and a dog house may be confused with a barn (farm building).
3. **Pattern:** Means spatial arrangement of the objects photographed. Eg: Buildings, roads etc have a particular pattern which can easily be recognized.
4. **Shadow:** The outline of a shadow gives the profile of an object, which aid in ineterpretation.
5. **Texture:** it is the frequency of the change in tone in photographic image. As the photo scale is reduced, the texture of a given object becomes finer. On large scale photographs the large leaf tree species are likely to be distinguished from small leaf species.
6. **Site:** The location of an object in realation to its surrounding is helpful in identification. A building , in a forest might not be identified, where as it can be easily identified in residential areas. A ferries wheel is easy to identify in an amusement park rather than in a field near a barn.

For a detailed interpretation it is necessary to have a large scale photographs (1:5000 to 1:100000)

Air Photo interpretation keys: Helps the interpreter to evaluate the information. A key consists of two parts.

1) Collection of annotated or captioned stereographs,
2) Graphic or description for image recognition.

Plotting from aerial photographs

Radial line method of plotting (Arundel's method)

The radial line method of plotting called also as "photo triangulation" is the accurate means of plotting a planimetric map from A/P, without the use of expansive instruments.

The displacement of image due to relief is radial from the principal point of vertical photograph. Hence the angles measured on the photograph at the principal point are true horizontal angles, independent of the height of the object and the flying height.

The radial line method is based on the following properties of a vertical photograph.

1) The displacement due to ground relief is of radial from the principal point.
2) The images near the principal point are free from tilt.
3) The position of a point may be located on the map.

Where three rays from three known points intersect. Principles of radial line is resection and intersection.

To locate the Principal point of photographs on a map

A map represents the true horizontal positions of all points at map scale which is uniform. The map position of principal point of a vertical photograph can be located by (1) Three point resection (2) Two point resection

a) **Map position of principal point Three point resection**

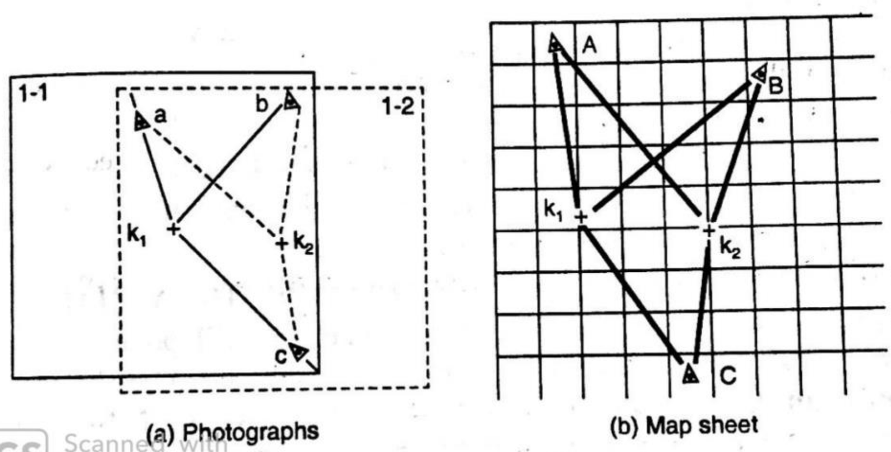
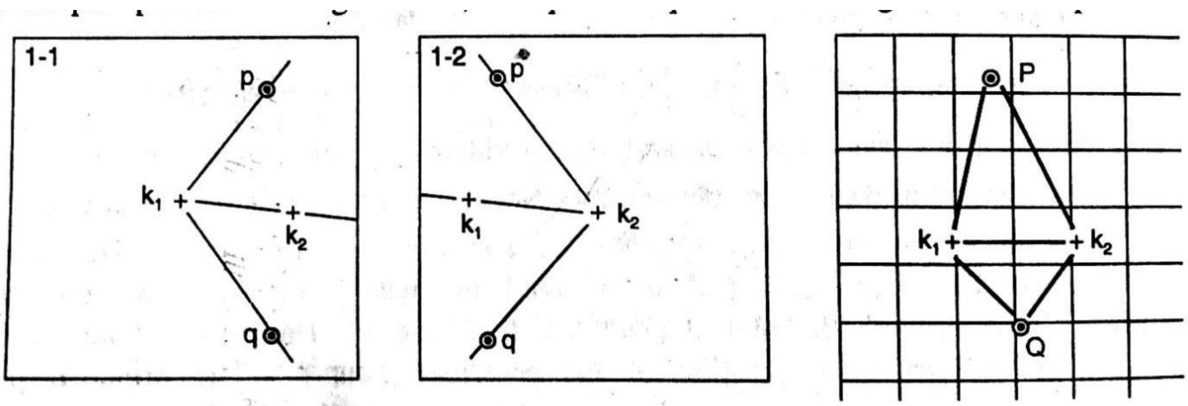


FIG. 14.36. LOCATION OF PRINCIPAL POINTS BY 3-POINT RESECTION.

a) To transfer images from a photograph to a map

Since the angles measured on the photograph at the principal point are true horizontal angles, the position of appoint can be located by the rays to that from two principal points.

Let P and Q be the images of two points. On each photo draw rays k1p, k1q, k2p and k2q. Trace the rays. Traced sheets are placed on the map sheet and properly oriented. The intersection of rays gives the position of P and Q

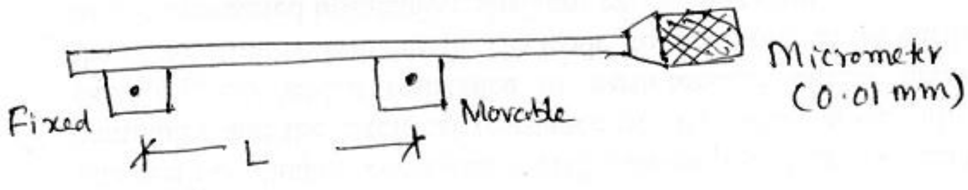


(a) Photograph 1 (b) Photograph 2 (c) Map sheet

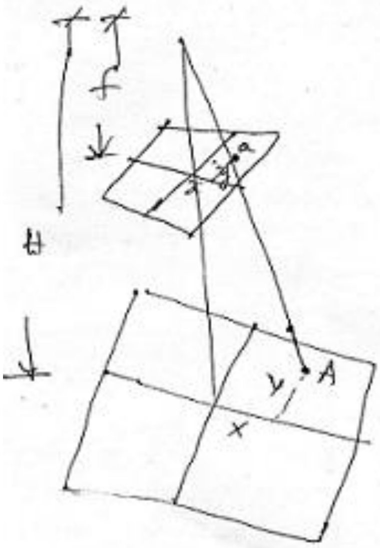
FIG. 14.38. LOCATION OF POINTS BY INTERSECTION.

Parallax: It is the apparent displacement in the position of an object ,with respect to a frame of reference caused by a shift in the position of observation.

Parallax Bar: Parallax bar is used to measure the parallax difference of two points.



Parallax Equation:-



Assume vertical photograph without tilt.

photo co-ordinates of a point $= (x, y)$

Ground coordinates (X, Y, Z) @ msl.

$$\text{Scale} = \frac{f}{H} = \frac{x}{X} = \frac{y}{Y}$$

On a second photograph $\frac{f}{H} = \frac{x'}{X'} = \frac{y'}{Y'}$

If the point is 'h' above msl

$$\text{Scale} = \frac{f}{H-h}$$

$$\therefore \frac{x}{X} = \frac{f}{H-h} \quad \text{and} \quad \frac{x'}{X'} = \frac{f}{H-h}$$

ie $x = \frac{f}{H-h} \cdot X \qquad x' = \frac{f}{H-h} \cdot X'$

$x - x' = \text{parallax} = P = \frac{f}{H-h}(X - X')$

$(X - X') =$ Difference in x coordinates of ground point $=$ Air base $= B$

$$\therefore P = \frac{f B}{H-h}$$

Plax Eqn.

We have, $p_1 = \frac{fB}{H - h_1}$ and $p_2 = \frac{fB}{H - h_2}$

$\therefore$ $\Delta p = p_2 - p_1 = fB\left(\frac{1}{H - h_2} - \frac{1}{H - h_1}\right) = fB\frac{h_2 - h_1}{(H - h_1)(H - h_2)}$

But $\Delta h = h_2 - h_1$ and $h_2 = \Delta h + h_1$

$\therefore$ $\Delta p = fB\frac{\Delta h}{(H - h_1)(H - \Delta h - h_1)}$

or $\Delta p\,(H - h_1)^2 - \Delta p\,(H - h_1)\,\Delta h = fB\,\Delta h$

or $\Delta h\,[(H - h_1)\,\Delta p + fB] = (H - h_1)^2\,\Delta p$

or $\Delta h = \frac{(H - h_1)^2\,\Delta p}{(H - h_1)\,\Delta p + fB}$

Dropping the suffix of h, we get

$$\Delta h = \frac{(H - h)^2\,\Delta p}{(H - h)\,\Delta p + fB}$$

where h is the elevation of lower point above datum.

Putting $fB = Hb$, we get $\Delta h = \frac{(H - h)^2\,\Delta p}{(H - h)\,\Delta p + bH}$

- ❖ The Parallax difference between the top and bottom of a tree is measured as 1.32mm on a stereopair of photos taken at 900m above ground. Average photo base is 88mm. How tall is the tree.

- ❖ In a pair of overlapping vertical photographs the mean distance between two principal points lying on the datum is 63.5mm. at the time of photography, the aircraft was 550m above the datum. The camera has a focal length of 153mm. determine the parallax difference for top and bottom of chimney of height 110m, having base in datum surface.

- From a measurement of the co-ordinates of the top(t) and bottom(b) of a monument in a stereo pair, it is found that xt=10.80cm,x’t=1.80cm, Xb=9.90cm, x’b=1.675cm. If the flying height was 1800m andphoto base was 8.125cm, Determine the height of the monument.
- A pair of overlapping photograph was taken from a flying height of 610m above the ground with a 150mm focal length camera x coordinates of base

and top of tree on left photo are 62.5mm and 62.96mm. On right photo x coordinates are -27.45mm and -28.72mm. Determine the height of the tree.

- A pair of photographs was taken with an aerial camera from an altitude of 5000m above m.s.i. The mean principal base measured is equal to 90mm. The difference in parallax between two points is 1.48mm. Find the difference in height between the two points if the elevation of the lower point is 500m above datum. What will be the difference in elevation if the parallax difference is 15.5mm?

- Compute the reduced level of a point A from the following data;

  Height of air above m.s.i. (datum) = 4500m
  Height of known point A above datum = 1765m
  Parallax reading of known point = 245.4mm
  Parallax reading of unknown point = 246.4mm
  Find the elevation of unknown point.

Mean Principal Base:

The distance between principal point of a photograph and the position transferred principal point of its next photograph obtained under fusion through stereoscope is called principal base.

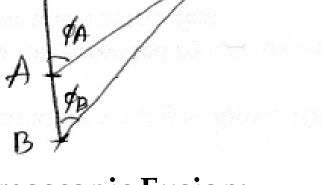
Mean Principal Base is the mean of principal bases of the photographs.

$$B_m = (b+b^1)/2$$

Stereoscopic Vision: The depth perception is the mental process of determining the relative distance of objects from the observer from the impressions received through the eyes. Due to binocular vision, the observer is able to perceive the spatial relations. i.e. the three dimensions of his field of view.

The impression of the depth is caused mainly due to three reasons.

1) Relative apparent sizes of near and far objects.
2) Effects of Light and Shade.
3) Viewing of an object simultaneously by two eyes which are separated in space.



Angle of Parallax:

It is the angle of convergence of two rays of vision

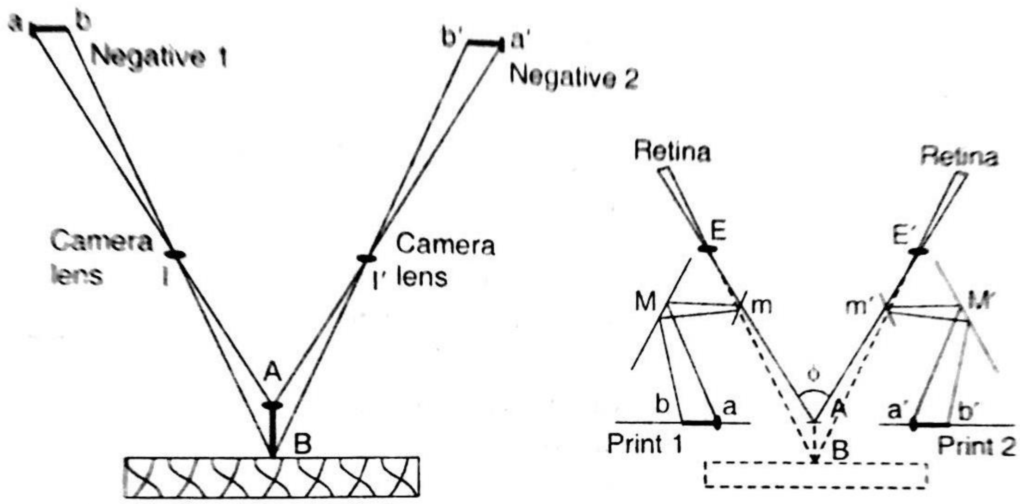
Stereoscopic Fusion:

The principles of stereoscopic vision can readily be applied to photogrammetry. An Aerial Camera takes a series of exposure at regular intervals of time. If a pair of photographs is taken of a region from two different positions of the camera, When viewed by an apparatus such that the left eye sees only left hand photograph and the right eye sees only right hand photograph, the two separate images of the object will fuse together in brain to provide, the observer, with a spatial impression. This is known as Stereoscopic Fusion. The pair of two such photographs is known as Stereo pair.

Stereoscope: It is an instrument used to view stereo pairs. There are two types of Stereoscopes 1) Mirror Stereoscope
2) Lens Stereoscope

They are designed for two purposes:

1) To assist the eyes to get the stereoscopic fusion.
2) To magnify the perception of the depth.



(a) Stereopair of nail (b) Mirror stereoscope

FIG. 14.47. PRINCIPLE OF MIRROR STEREOSCOPE.

MODULE-5: REMOTE SENSING AND GIS

Remote Sensing: Introduction, Principles of energy interaction in atmosphere and earth surface features, Image interpretation techniques, visual interpretation. Digital image processing, Global Positioning system

Geographical Information System: Definition of GIS, Key Components of GIS, Functions of GIS, Spatial data, spatial information system Geospatial analysis, Integration of Remote sensing and GIS and Applications in Civil Engineering(transportation, town planning).

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1. Define remote sensing?

Ans. Remote sensing is the collection of information relating to objects without being in physical contact with them. Thus our eyes and ears are remote sensors

2. ***What are the essential components of a remote sensing system?***

Ans. The essential components of a remote sensing system are

(i) A uniform energy source – This would provide energy on all wavelengths so as to produce high level out put irrespective of time and place.

(ii) A non-interfering atmosphere – This type of atmosphere would not modify the energy from the source.

(iii) A series of unique energy/matter interactions at the earths surface – These interactions would generate reflected or emitted signals which are not only selective with respect to wavelength but also are in variant and unique to each and every earth surface feature.

(iv) A super sensor – A sensor highly sensitive to all wavelengths, yielding spatially detailed data on the absolute brightness (radiance) from a scene as a function of wavelength through out the spectrum.

(v) A real time data handling system – In this system as soon as the radiance vs wavelength responses over a terrain element is generated it would be processed into an interpretable format and then recognized as unique to the particular terrain element from which it is received.

(vi) Multiple data users – These are the people, who have knowledge in greater depth, both in their respective disciplines and in remote sensing data acquisition, analysis techniques.

3. Differentiate active and passive remote sensing system?

	Active RSS	**Passive RSS**
Energy Source	It generates and uses its own energy to illuminate the target and records the reflected energy.	They depend on solar radiation to illuminate the target.

Region of spectrum in which they operate	These systems operate in the microwave region of the electromagnetic spectrum.	They operate in the visible and infrared region of the electromagnetic spectrum.
Wavelength	Their wavelengths are longer than one mm.	Their wavelengths range from 0.4 to 10μm.
Reliance on solar irradiance	They do not rely on detection of solar or terrestrial emissions, as the solar irradiance in the microwave region is negligible.	They rely on detection of solar emission.
Example	Synthetic aperture radar	Any electromagnetic remote sensing system (camera without flash light).

4. What are the general processes involved in electromagnetic remote sensing?

Ans. The two main processes involved in passive or electromagnetic remote sensing are.

(i) **Data acquisition:** The data acquisition processes comprises distinctive elements namely:

a) Energy sources.
b) Propagation of energy through the atmosphere.
c) Energy interactions with the earths surface features.
d) Air borne, space borne, sensors to record the reflected energy.
e) Generation of sensor data as pictorial or digital information.

(ii) **Data analysis:** Data analysis can be broadly classified as

a) Visual image interpretation – This involves the examination of data with various viewing instrument to analyse pictoral data.
b) Digital image processing – When computers are used to analyse digital data then the process is called digital image processing.

5. What are the different platforms used in remote sensing?

Ans. Platforms may be air borne or space borne, depending on the objects under study on the earth surface.

(i) **Air Borne Platforms:** Balloons and aircrafts are broadly grouped under air borne platforms.

a) Balloons – The use of balloons is commonly restricted by meteorological factors such as wind velocity, direction etc. Their application in resource mapping has been significantly useful.

b) Air crafts – They are used to obtain aerial photographs. They are useful in regional coverage and large scale mapping.

(ii) **Space borne platforms:** These are satellites which have proved to be very useful in resource mapping, meteorological and communication applications.

6. What do you understand by the term synoptivity?

Ans. When we get images, as seen from above the earth, the mega patterns with in landscapes, seascapes and icescapes stand out distinctively. This characteristic of satellite data is known as synoptivity.

7. What do you understand by repetivity?

Ans. Repeated images of the same regions, taken at regular intervals over a period of days, years and decades provide database for recognizing and measuring environmental changes. This characteristic of satellite data is known as repetivity.

8. What is EMR?

Ans. EMR stands for electromagnetic radiation. It is the energy emitted/ reflected from ground features and transmitted to the sensing instrument in the form of waves. This emitted energy/ radiant energy is called electromagnetic radiation. The remote sensing of land surface features is based on detection of electromagnetic radiation.

9. What do you understand by electromagnetic spectrum?

Ans. The Entire array of electromagnetic waves comprises the EMR spectrum. The electromagnetic spectrum may be defined as the ordering of the radiation according to wavelength, frequency or energy. The electromagnetic spectrum can be explained as the continuum of energy that ranges from meters to nanometers in wavelength, travels at the speed of light and propagates through a vacuum like the outer space .

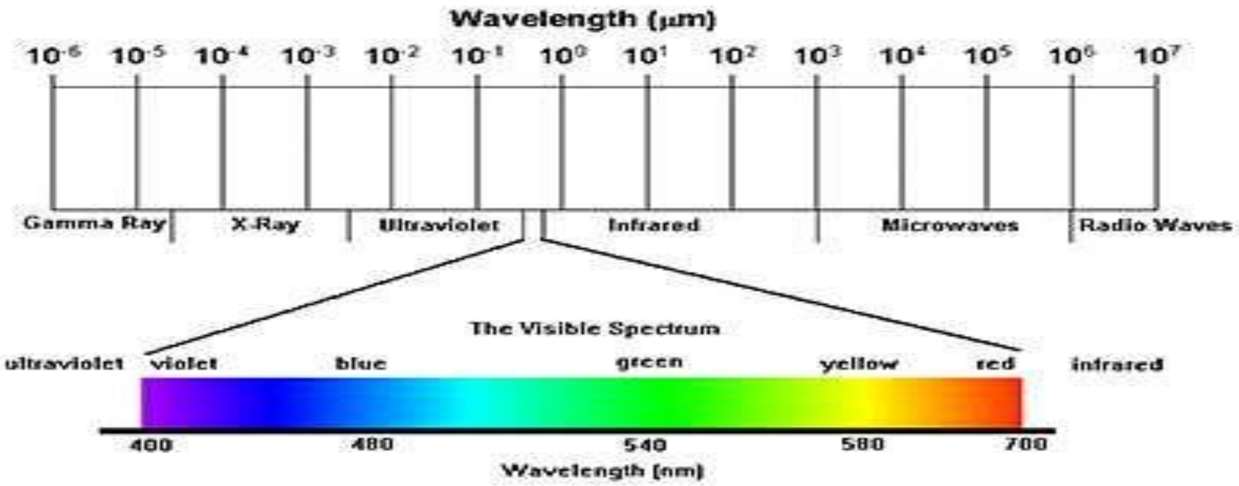
10. What is black body radiations?

Ans. A black body transforms heat energy into radiant energy at the maximum possible rate. This radiation is known black body radiation. For example, if the sun were to be a perfect emitter, it would be an ideal black body. A black body is hypothetical, ideal radiator that absorbs and reemits all energy incident on it.

11. What are the ranges of wavelength's in the different E.M.R spectrum?

Ans. The different ranges of wavelength in the E.M.R. spectrum are as follows:

Region	Wavelength
Gamma rays	< 0.03 μm
X rays	0.03 – 0.3 μm
Ultraviolet rays	0.3 – 04. μm
Visible region	0.4 – 0.7 μm
Infrared region	0.7 – 1.0 μm
Reflected infrared band	0.7 – 3.0 μm
Thermal infrared band	3.0 – 5.0 μm
Radar	0.1 to 30 cm
Radio waves	> 30 cm



12. What are the advantages of using remotely sensed data?

Ans. The major advantages of remotely sensed data for resource surveys are as follows:

(i) Satellite images are permanent records, providing useful information in various wavebands.

(ii) Large area coverage enables regional surveys on a variety of themes and identification of large features.

(iii) Repetitive coverage allows monitoring of dynamic themes like water, agriculture etc.
(iv) Easy data acquisition at different scales and resolutions.
(v) A single remotely sensed image can be analyzed and interpreted for different purposes and applications.
(vi) Amenability of remotely sensed data for fast processing using a computer.
(vii) The images are analyzed in the laboratory thus reducing the amount of field work the analysis from remote sensing data therefore is cost effective.
(viii) Map revision at medium to small scales is economical and faster.
(ix) Color composite can be produced from three individual band images, which provide better details of the area than a single band image or aerial photograph.
(x) Stereo satellite data may be used for three dimensional studies.

13. What are the disadvantages of using remotely sensed data?

Ans. The disadvantage of using remotely sensed data are as follows:

(i) Expensive for small areas, particulars for one time anlysis.
(ii) Requires specialized training for analysis of images.
(iii) Large-scale engineering maps cannot be prepared from satellite data.
(iv) Aerial photographs are costly if repetitive photographs are required to study the dynamic features.

14. What are the basic interactions that take place on the Earth's Surface?

Ans. When the electromagnetic radiations is incident on the earth's surface, the basic interactions with the features take place.

$$E_1 (\lambda) = E_R (\lambda) + E_A (\lambda) + E_T (\lambda)$$

The proportions of energy that are absorbed, radiated and transmitted vary depending on the type of material with which the energy interacts and also depending on the wavelength of the energy. These proportions of energy that are absorbed, transmitted and radiated are unique to each and every earth feature and this unique spectral reflectance property is explained as the spectral signature of the earth feature.

15. What do you understand by spectral signature?

Ans. Spectral signature is a set of characteristics by which an object on any satellite imagery within the given range of wavelength can be identified. Spectral signatures are also used to denote the spectral response of the target.

16. What are spectral signature curves?

Ans. Spectral reflectance curves are also called as spectral signature curves. These are the curves in which the variation of percentage reflectance with reference to the wavelength in the X-axis is plotted.

17. What is reflectance?

Ans. Reflectance is defined as the ratio of incident flux on the surface to the reflected flux from the surface. Reflectance with respect to the wavelength is called spectral reflectance. Spectral reflectance is assumed to be unique for each and every object.

$$\rho_\lambda = \frac{E_R(\lambda)}{E_1(\lambda)}$$

ρ_λ is the spectral reflectance expressed in %

$E_R(\lambda)$ = Energy of the wavelength λ reflected from the object.

$E_1(\lambda)$ = Energy of the wavelength λ incident on the object.

18. What are atmosphere windows?

Ans. These are certain regions of the electromagnetic spectrum, which can penetrate through the atmosphere without any significant loss of radiation. Such regions are called as atmospheric windows. In these regions the atmospheric absorption is low (i.e.) the atmosphere is particularly transmissive of energy.

Sensing	Atmospheric windows (Wavelength)
Visible	0.38 - .72μm
Photography	0.4 – 0.9 μm
Near and middle infrared	0.72 – 3 μm
Thermal infrared sensing	8 – 14 μm
Multi spectral scanning	Thermal spectral region
Radar sensing	1 mm – 1m

19. What is the significance of atmospheric windows?

Ans. The atmosphere compounds the problems introduced by energy source variation. It restricts us from identifying the target spectrally. In the case of atmospheric windows as the penetration of the electromagnetic radiation take place with very negligible loss of radiation, these are very suitable for remote sensing, Remote sensing of the earth's surface take place through the atmospheric windows.

20. What is a Satellite?

Ans. Satellite are devices that use sensor to observe the earth and our solar systems. Satellites are also used to observe the Earth's atmosphere, surface and oceans.

21. What are sun synchronous satellites?

Ans. Sun synchronous satellites are located at much lower altitudes, generally a few hundred to a few thousand kilometers from the earth surface. The orbit in which they rotate is a special case of polar orbits, these satellites travels from north to South Pole as the earth turns below it. These satellites pass once the same part of the earth roughly the same local time each day making communication and collection of various forms of data more convenient. Most of the earth resource satellites are sun synchronous satellites.

22. What are geo-stationary satellites?

Ans. These satellites orbit at an elevation of approximately 35790 km because that produces an orbital period equal to the period of rotation of the earth (23 hrs 56min 4.09 secs). The satellite appears stationary as it is orbiting at the same rate in the same direction as that of the earth. These satellites provide a bigger view of the earth, thus facilitating coverage of weather events. These satellites, as they are in the equatorial plane.

23. What are polar orbiting satellites?

Ans. Polar orbiting satellites orbit at near polar inclination, at an altitude of 700 to 800 km. They cover parts, which are difficult to cover such as Antarctica. These satellites operate in sun synchronous orbit. These satellites pass through the equator and each latitude at the same local time each day, enabling regular data collection, consistently and facilitating long-term compromises.

24. What are earth resources satellites?

Ans. Earth resources satellites are usually sun synchronous or polar orbiting satellite used to study and access the earth's resources. Their aim is to provide multispectral image for better information regarding the earth's resources, environmental change and impacts of human activities. In India this work is done by IRS series. These satellites are also useful in monitoring of earth's resources, climatic and land use changes. The landsats of the America and SPOT of France, JERS of Japan are also other kind of ERS.

25. What are sensors?

Ans. Sensors are remote sensing instruments designed to measure the photons. The detectors in the sensors are charges plates made of light sensitive material. They emit electrons when they are subjected to beam of photons. The magnitude of the electric current produced is directly proportional to the light intensity. The charges in the electric current may be used to measure changes in photons and the electrons are used as signals from the sensors to the ground station. Sensors are devices used to record the reflected EMR from the objects on the earth's surface. These sensors convert the radiations into electrical signals.

26. What are the different types of resolutions used as parameters of sensor?

Ans. The different types of resolution used as a parameter of sensor are:

(i) **Spatial Resolution.** The minimum detectable area on the ground by a detector placed on a sensor is called spatial resolution.

LANDSAT – MSS – 80M

- TM – 30 M

SPOT - (Multispectral Scanner) – 20M

– PAN – 10 M

IRS 1A/B – LISS I – 72.5 M

– LISS II – 36.25 M

IRS 1C/D – PAN – 5.8M

(ii) **Spectral resolution.** The smallest amount of spectral change that can be detected by the sensor is termed as spectral resolution. The finer the spectral channels, the better are the spectral resolution. The satellite data recorded in the narrower spectral bands are used for natural surveying and mapping purpose.

(iii) **Radiometric Resolution.** The presence of gray levels defines the radiometric resolution.

LANDSAT TM – 256 Gray levels (0 – 255)

IRS LISS II – 128 Gray levels (0 – 127)

(iv) **Temporal resolution**: Temporal resolution is the smallest period, we can obtain repetitive coverage of the same area. This mainly depends upon the revisit period.

LANDSAT – 18 days

IRS – 20 days

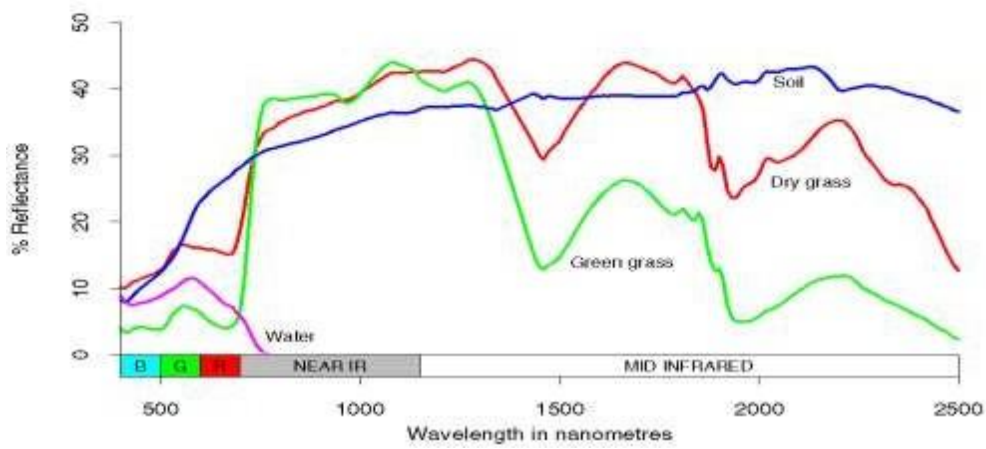
SPOT – 04 days

27. What are false colour composites?

Ans. False colour composites are nothing but the reflectance characteristics of the surface features in different bands. The reflectance characteristics of the same features in different bands are assigned different colours, thus giving composite image called false colour composites.

28. How Satellites Acquire Images

Satellite sensors record the intensity of electromagnetic radiation (sunlight) reflected from the earth at different wavelengths. Energy that is not reflected by an object is absorbed. Each object has its own unique 'spectrum', some of which are shown in the diagram below.



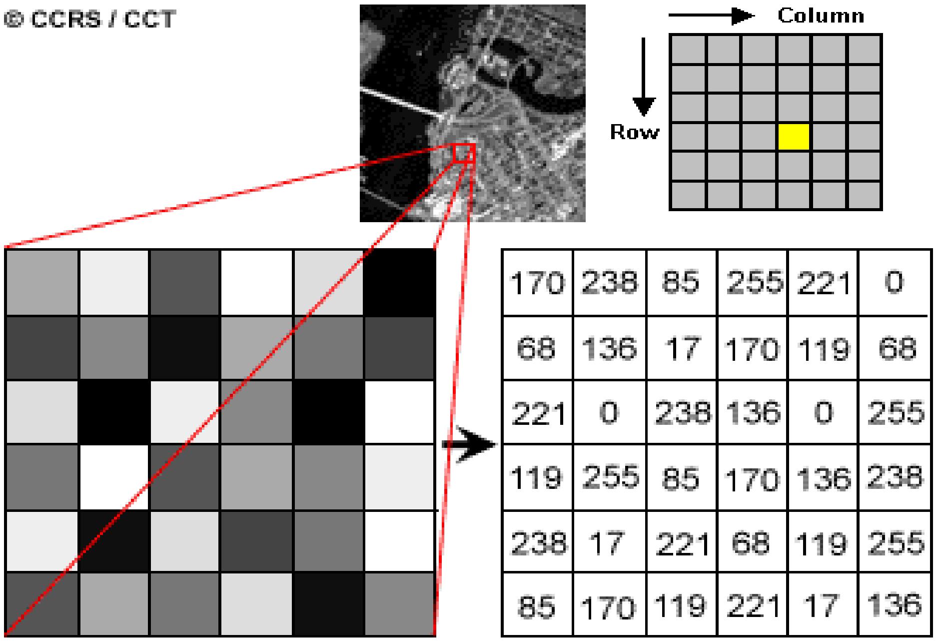
Remote sensing relies on the fact that particular features of the landscape such as bush, crop, salt-affected land and water reflect light differently in different wavelengths. Grass looks green, for example, because it reflects green light and absorbs other visible wavelengths. This can be seen as a peak in the green band in the reflectance spectrum for green grass above. The spectrum also shows that grass reflects even more strongly in the infrared part of the spectrum. While this can't be detected by the human eye, it can be detected by an infrared sensor.

Instruments mounted on satellites detect and record the energy that has been reflected. The detectors are sensitive to particular ranges of wavelengths, called 'bands'. The satellite systems are characterised by the bands at which they measure the reflected energy. The Landsat TM satellite, which provides the data used in this project, has bands at the blue, green and red wavelengths in the visible part of the spectrum and at three bands in the near and mid infrared part of the spectrum and one band in the thermal infrared part of the spectrum. The satellite detectors measure the intensity of the reflected energy and record it.

Image Processing

Pictures are the most common and convenient means of conveying or transmitting information. A picture is worth a thousand words. Pictures concisely convey information about positions, sizes and inter-relationships between objects. They portray spatial information that we can recognize as objects. Human beings are good at deriving information from such images, because of our innate visual and mental abilities.

Analog and Digital Images



An image is a two-dimensional representation of objects in a real scene. Remote sensing images are representations of parts of the earth surface as seen from space. The images may be analog or digital. Aerial photographs are examples of analog images while satellite images acquired using electronic sensors are examples of digital images. Digital image is a two-dimensional array of pixels. Each pixel has an intensity value (represented by a digital number) and a location address (referenced by its row and column numbers).

Pixels

A digital image comprises of a two dimensional array of individual picture elements called **pixels** arranged in columns and rows. Each pixel represents an area on the Earth's surface. A pixel has an **intensity** value and a **location address** in the two dimensional image.

The **intensity value** represents the measured physical quantity such as the solar radiance in a given wavelength band reflected from the ground, emitted infrared radiation or backscattered radar intensity. This value is normally the average value for the whole ground area covered by the pixel.

The **intensity** of a pixel is digitised and recorded as a digital number. Due to the finite storage capacity, a digital number is stored with a finite number of bits (binary digits). The number of bits determines the **radiometric resolution** of the image. For example, an 8-bit digital number ranges from 0 to 255 (i.e. 2^8 - 1), while a 11-bit digital number ranges from 0 to 2047. The detected intensity value needs to be scaled and quantized to fit within this range of value. In a Radiometrically Calibrated Image, the actual intensity value can be derived from the pixel digital number.

Multilayer Image

Several types of measurement may be made from the ground area covered by a single pixel. Each type of measurement forms images which carry some specific information about the area. By "stacking" these images from the same area together, a multilayer image is formed. Each component image is a layer in the multilayer image. Multilayer images can also be formed by combining images obtained from different sensors, and other subsidiary data. For example, a multilayer image may consist of three layers from a SPOT multispectral image, a layer of synthetic aperture radar SAR image, and perhaps a layer consisting of the digital elevation map of the area being studied.

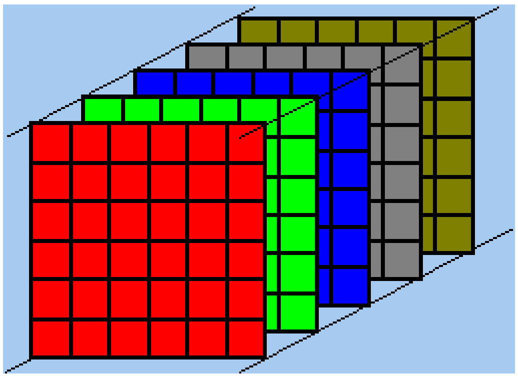


Fig:An illustration of a multilayer image consisting of five component layers.

Multispectral Images

A multispectral image consists of several bands of data. For visual display, each band of the image may be displayed one band at a time as a grey scale image, or in combination of three bands at a time as a colour composite image. Interpretation of a multispectral colour composite image will require the knowledge of the spectral reflectance signature of the targets in the scene. In this case, the spectral information content of the image is utilized in the interpretation. The following three images show the three bands of a multispectral image extracted from a **SPOT** multispectral scene at a ground resolution of 20 m. The area covered is the same as that shown in the above panchromatic image. Note that both the **XS1 (green) and XS2 (red)** bands look almost identical to the panchromatic image shown above. In contrast, the vegetated areas now appear bright in the **XS3 (NIR)** band due to high reflectance of leaves in the near infrared wavelength region. Several shades of grey can be identified for the vegetated areas, corresponding to different types of vegetation. Water mass (both the river and the sea) appear dark in the XS3 (near IR) band.

Visual Interpretation

Analysis of remote sensing imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features, which consist of points, lines, or areas. Targets may be defined in terms of the way they reflect or emit radiation. This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of ***tone, shape, size, pattern, texture, shadow,*** and ***association***.

1- **Tone** refers to the relative brightness or colour of objects in image. Generally, tone is the fundamental element for distinguishing between different targets or features. Variations in tone also allow the elements of shape, texture, and pattern of objects to be distinguished.

2- **Shape** refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

3- **Size** of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target sizecan direct interpretation to an appropriate result more quickly. For example, if an interpreter had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

4- **Pattern** refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Orchards with evenly spaced trees and urban streets with regularly spaced houses are good examples of pattern.

5- **Texture** refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas some of the textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

6- **Shadow** is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

7- **Association** takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. In the example given above, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields. In our example, a lake is associated with boats, a marina, and adjacent recreational land.

Application of Remote sensing techniques for Agricultural survey

The specific application of remote sensing techniques can be used for

i) Detection ii) Identification iii) Measurement
iv) Monitoring of agricultural phenomena.

• Crop identification • Crop acreage • Crop vigor • Crop density • Location of canals	• Crop maturity • Growth rates • Yield forecasting • Soil moisture	• Water quality • Irrigation requirement • Insect infestations • Disease infestations

Applications in Hydrology

Hydrology is the study of water on the Earth's surface, whether flowing above ground, frozen in ice or snow, or retained by soil. Hydrology is inherently related to many other applications of remote sensing, particularly forestry, agriculture and land cover, since water is a vital component in each of these disciplines. Most hydrological processes are dynamic, not only between years, but also within and between seasons, and therefore require frequent observations. Remote sensing offers a synoptic view of the spatial distribution and dynamics of hydrological phenomena, often unattainable by traditional ground surveys. Radar has brought a new dimension to hydrological studies with its active sensing capabilities, allowing the time window of image acquisition to include inclement weather conditions or seasonal or diurnal darkness.

Examples of hydrological applications include:

- Wetlands mapping and monitoring,

- Soil moisture estimation,
- Snow pack monitoring / delineation of extent,
- Measuring snow thickness,
- Determining snow-water equivalent,
- River and lake ice monitoring,
- Flood mapping and monitoring,
- Glacier dynamics monitoring (surges, ablation)
- River /delta change detection
- Drainage basin mapping and watershed modelling
- Irrigation canal leakage detection
- Irrigation scheduling

Town Planning and Urban Development:

To achieve the objectives of making metropolis cities more livable and of international standard, a co-coordinated and integrated approach among the various agencies involved in urban development and provision of services are needed including participatory process in planning and implementation at local body levels. As well as to have planned and organized disposal of population through growth centres, which will acts as counter-magnets to the cities growth. This growth may not able to withstand the existing infrastructure, traffic, road, drainage and utility networks etc. Advance urban planning is required for a planned development of the area for which up to date real time and accurate information are the vital important. Geographical Information system & Remote Sensing is inevitable technology in the development of national Infrastructure and planning and they provide solution related to many environmental.

Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

GPS was created and realized by the U S Department of Defence (USDOD) and was originally run with 24 satellites. It was established in 1973 to overcome the limitations of previous navigation systems.

Basic concept of GPS

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include

- The time the message was transmitted
- Precise orbital information (the ephemeris)
- The general system health and rough orbits of all gps satellites (the almanac).

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of trilateration, depending on which algorithm is used, to compute the position of the receiver. This position is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

Three satellites might seem enough to solve for position since space has three dimensions and a position near the Earth's surface can be assumed. However, even a very small clock error multiplied by the very large speed of light, the speed at which satellite signals propagate results in a large positional error.

Therefore receivers use four or more satellites to solve for the receiver's location and time. The very accurately computed time is effectively hidden by most GPS applications, which use only the location. A few specialized GPS applications do however use the time; these include time transfer, traffic signal timing, and synchronization of cell phone base stations.

Although four satellites are required for normal operation, fewer apply in special cases. If one variable is already known, a receiver can determine its position using only three satellites. For example, a ship or aircraft may have known elevation. Some GPS receivers may use additional clues or assumptions (such as reusing the last known altitude, dead reckoning, inertial navigation, or including information from the vehicle computer) to give a less accurate (degraded) position when fewer than four satellites are visible.